The effects of inflation on economic growth and on its macroeconomic determinants

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This thesis is dedicated to my brother:

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Introduction Générale

Les économistes ont de très longue date, porté un intérêt prononcé à l'étude de la relation existante entre le inflation et le croissance économique. Au cours de ces dernières décennies, cet intérêt s'est semble-t-il intensifié, en témoigne le nombre important de débats, tant dans la sphère académique que politique, autour des effets de l'inflation sur la croissance. Une des premières préoccupations a ainsi été de caractériser la nature de la relation entre croissance et inflation, et vérifier la stabilité de celle-ci dans le temps. En particulier, on s'est demandé si l'inflation avait des effets transitoires ou bien permanents sur la croissance économique. Aussi, cela a amené à des discussions sur les canaux de diffusion de l'inflation à la croissance. Les débats au sein de cette littérature ont également porté sur d'autres dimensions et conduit à se demander, d'une part, si la relation demeurait identique dans le temps et dans l'espace, d'autre part, si les conditions macroéconomique s'étaient susceptibles d'intensifier ou au contraire de limiter les effets sur la croissance d'un niveau donné d'inflation, mais encore, quelles étaient les conséquences de l'expansion monétaire sur le bien-être d'un agent représentatif, les décisions de production d'une firme ou encore l'efficience allocative globale d'un pays.

Ces interrogations sur les effets de l'inflation sur la croissance économique, ont donné lieu à un grand nombre de travaux de recherche. L'attention toute particulière portée à cette problématique remonte au début du 20ème siècle, période à laquelle certains économistes ont fait valoir qu'il existait de fortes relations entre croissance économique et inflation. Parmi ces économistes, Keynes affirme notamment : « As the inflation proceeds and the real value of the currency fluctuates widely from month to month, all permanent relations between debtors and creditors, which form the ultimate foundations of capitalism, become so utterly disordered as to be almost meaningless; and the process of wealth-getting degenerates into a gamble and a lottery (Keynes, 1920 p.220) ».

L'exposé de Keynes, et l'intuition que l'inflation aurait des effets adverses sur la croissance, ne put toutefois être empiriquement établie ; en cause la relative stabilité macroéconomique de la période. L'indice des prix à la consommation en 1943 était ainsi inférieur à celui de 1810 (voir Haslag, 1997, note 1). La situation évolua toutefois très significativement après la seconde guerre mondiale et dans une plus grande mesure encore après le choc pétrolier de 1973, à la suite duquel on observa simultanément une forte inflation et une faible croissance économique.[1]

Sur le volet théorique, on observa de nombreux développements importants au cours de la période 1960-1980. L'imposante littérature théorique qui en découla, peut a posteriori être divisée en trois courants distincts, selon la nature de la relation établie entre croissance et inflation. D'une part, les modèles développés par Mundell (1963) et Tobin (1965) concluent que l'inflation exerce un effet positif sur la croissance économique. Dans ces modèles, l'inflation réduit le taux d'intérêt réel ; conduisant dès lors les agents à préférer à la détention d'encaisses réelles, l'accumulation de capital. En définitive, l'augmentation de l'accumulation de capital, induite par l'inflation bénéficiera à la croissance économique. Les effets attribués à l'inflation sont tout autre dans le modèle de Sidrauski (1967), puisque ce dernier souligne la super-neutralité de la monnaie en termes de croissance économique. Selon Sidrauski la croissance de la monnaie n'a d'influence sur les variables réelles (par exemple, le stock de capital et la croissance économique) que dans le court terme. Dans le long terme l'évolution de ces variables demeure indépendante de la quantité de monnaie en circulation. Enfin, Brock (1974) et Stockman (1981), à l'origine du troisième courant de cette littérature, présentent des modèles dans lesquels l'inflation a une incidence négative sur le stock de capital. L'inflation induit en effet des modifications des taux d'intérêt réels, qui conduisent à une augmentation des coûts liés à la détention d'encaisses. Les encaisses détenues diminueront par conséquent, ce qui aura des effets néfastes sur l'accumulation du capital et la croissance de la production.

Néanmoins, les arguments majeurs en faveur de l'existence d'une relation négative entre inflation et croissance ont essentiellement pour origine les contributions de Friedman (1969 ;1971) et de ses disciples. Cette école de pensée défendit le postulat selon lequel, étant donné que la monnaie est sans coût de production, l'utilisation de celle-ci ne devrait pas être taxée. Tout niveau positif du taux d'inflation suppose en effet des taux d'intérêt positifs qui selon Friedman réduisent la demande de monnaie sous son niveau socialement optimal. Dès lors, les agents sont incités à garder leurs actifs sous forme non monétaire afin de bénéficier de taux d'intérêt positifs, ce qui augmente les coûts des transactions et réduit le bien-être. Enfin, selon la « misperception theory » de Lucas(1973), l'inflation induit une dispersion des prix relatifs, à l'origine d'une allocation sous optimale des ressources entre les différents secteurs, et conduit de ce fait à une détérioration de la croissance économique.

[1]Nous présenterons l'évolution au cours du temps de cette littérature dans les chapitres 1 et 2.

L'ensemble des trois points de vue divergents ont été très largement étayés et confirmés dans les travaux théoriques et empiriques ultérieurs portant sur la relation entre inflation et croissance économique.

Quels sont les coûts de l'inflation?

Dans la littérature économique, de nombreux éléments théoriques expliquent de quelle manière l'inflation réduit la croissance et le bien-être. Fischer (1984 ; 1996) identifie ainsi plusieurs canaux par lesquels l'inflation exerce une influence sur la croissance. En premier lieu, la monnaie reste à ce jour la principale source de transaction dans le monde, et une insuffisance de l'offre de monnaie a indubitablement une influence sur le bien-être d'une économie. Les agents dans un tel cas de figure sont en effet contraints de limiter leurs transactions, ce qui implique des pertes de bien-être. Les tenants d'une inflation modérée arguent toutefois que la perte de bien-être serait restreinte du fait notamment que l'inflation permet la taxation de nombreuses activités illégales, et aurait par ce biais des effets redistributifs positifs. En outre, les pertes de bien-être seraient limitées en raison du développement des nouvelles technologies de transactions qui réduisent les besoins de monnaie. Néanmoins, l'inflation aurait d'autres coûts, en augmentant notamment la fréquence des transactions entre les agents. En effet, étant donné que l'inflation réduit la valeur des encaisses réelles, les agents accéléreront la vitesse de transaction et consacreront davantage de temps à celles-ci. Cet aspect particulier des effets de l'inflation est connu sous l'expression « shoe-leather » dans la littérature. Néanmoins, il est avéré que des taux d'inflation faibles ou modérés ne sont pas en mesure d'augmenter la fréquence de transaction. Seuls les épisodes d'hyperinflation y sont susceptibles.

A travers ses effets sur les taux d'intérêt et l'imposition effective (charge de l'impôt), l'inflation présenterait d'autres coûts en termes de bien-être. Celle-ci implique tout d'abord une réduction du taux d'intérêt réel perçu par les déposants, dans la mesure où les taux d'intérêt nominaux ne s'ajustent généralement pas immédiatement au taux d'inflation. Aussi Fischer affirme que le taux d'intérêt nominal offert par les institutions financières, peut, dans certain cas, ne pas s'ajuster librement, du fait qu'il existe dans les plupart des systèmes bancaires des plafonds de taux, qui peuvent dès lors décourager l'épargne et provoquer une mauvaise allocation des ressources. Cela étant, ces effets ne se bornent pas aux taux d'intérêt, puisque le montant des encours des créanciers est également affecté. En conséquence, cela conduit à une redistribution de la richesse entre créditeurs et débiteurs, favorisant la seconde catégorie d'agent. Enfin, l'inflation accentuerait également la charge fiscale supportée par les agents étant donné qu'il serait délicat pour les administrations de mettre en place une indexation parfaite de l'impôt. Ainsi, sans indexation, l'assiette imposable s'étendra, réduisant l'activité économique.

La discussion sur les coûts de l'inflation serait assurément incomplète sans mentionner les effets de celle-ci sur l'intermédiation financière. De façon générale, les institutions financières ont besoin d'information sur les projets d'investissement et sur leurs rendements. Cependant, l'inflation déprécie la qualité de ces informations, compliquant dès lors le processus d'intermédiation financière. L'inflation réprimerait au demeurant également la croissance du secteur financier en décourageant les contrats à long terme entre emprunteurs et préteurs ; les institutions financières préférant conserver leurs actifs sous forme liquide. L'inflation peut en définitive contraindre à la mise en place de politiques monétaires restrictives, enrayant la croissance du secteur financier (Rousseau et Wachtel, 2002; Yilmazkuday, 2011).

L'inflation a donc un ensemble d'effets néfastes sur le développement du secteur financier, ce qui déprime non seulement la formation du capital physique mais également la formation du capital humain, en réduisant notamment la disponibilité des fonds prêtable salloués aux dépenses d'éducation. Par ailleurs, l'augmentation induite par l'inflation du taux d'escompte aura des conséquences similaires sur les deux types d'accumulation du capital.

Pourquoi les économies ont-elles recours à l'inflation?

L'ensemble des aspects de l'inflation avancé auparavant suggère que l'inflation est coûteuse, en tout temps et tout lieu. Compte tenu de l'existence d'un vaste consensus sur les coûts liés à l'inflation, nous pouvons nous demander pourquoi les économies ont recours à l'inflation. Une première explication avancée est que l'inflation offre un revenu de seigneuriage aux gouvernements, et l'augmentation dans certains cas substantiels des revenus qui en découlerait réduirait la contrainte budgétaire de ces derniers. La littérature économique, s'appuyant sur l'article fondateur de Phelps (1973), reconnaît d'ailleurs le rôle majeur des revenus de seigneuriage pour les dépenses publiques. Ces conclusions sont été établies sur l'idée que le seigneuriage agit comme une taxe parmi d'autres pour les gouvernements et que la politique optimale devrait lisser les taux d'imposition dans le temps. Le lissage fiscal entraîne également des co-mouvements entre les impôts et le taux d'inflation, ce qui génère un lien à long terme entre les deux variables (voir Evans et Amey, 1996).

L'inflation pourrait également avoir des effets bénéfiques sur la croissance économique à travers le canal du taux d'intérêt nominal. Ci maintient en effet des taux nominaux de court terme positifs ce qui affranchit la politique monétaire de certaines contraintes et lui permet en conséquent de répondre plus efficacement aux chocs d'offre et de demande, auxquels une économie fait face. Ainsi, une politique monétaire expansionniste peut maintenir le taux d'intérêt nominal à court terme en dessous de l'inflation attendue. Cela permet de garder le taux d'intérêt réel négatif et stabiliser l'économie suite à des chocs. Par ailleurs, si le taux d'inflation est d'ores et déjà à un niveau très faible, la politique monétaire est susceptible de se heurter à la contrainte de non négativité des taux d'intérêts. Les économistes citent souvent comme illustration des effets négatifs de cette borne, l'exemple de l'économie japonaise au cours des années 90. Dans ce cas, les taux d'intérêt nominaux, structurellement proches de zéro, limitèrent en effet très substantiellement l'efficacité des instruments traditionnels de politique monétaire, une fois l'économie entrée en récession.

Une autre explication de la préférence pour un taux d'inflation positif repose sur les craintes déflationnistes, ancrées dans l'esprit des décideurs publics. La déflation est en effet à l'origine de phases de sévères contractions et a des effets durables sur la croissance économique. Elle a notamment des effets sur la dynamique de la dette puisqu'elle entraine une augmentation de sa valeur réelle ainsi que des coûts de son service. Dans le même temps, la déflation engendre une diminution de la valeur nominale des actifs, accentuant de ce fait les difficultés des créanciers. La baisse de la valeur des actifs, simultanément à l'augmentation de la valeur de la dette contraint en effet les créanciers à vendre leurs actifs, même à faible prix, du fait que les vendeurs sont bien plus nombreux que les acheteurs en de telles circonstances. La sévérité de ces phénomènes peut conduire à une augmentation du nombre de défaillances bancaires (voir Billi et Kahn, 2008). Une fois entré dans ce cercle vicieux, les auteurs mentionnent que les outils de politique monétaire conventionnels deviennent totalement inefficaces pour sortir l'économie de cette spirale.

Plusieurs autres facteurs permettent également de justifier la préférence pour des taux d'inflation positifs plutôt qu'une stabilité parfaite des prix ou la déflation. Les plus importants d'entre eux sont l'existence de rigidités ainsi que d'inhérentes erreurs de mesure de l'inflation. Les néo-keynésiens tout d'abord prônent des taux d'inflation positifs, en raison des rigidités des prix et des salaires. En effet, en présence de rigidités et en cas de choc d'offre, l'arbitrage de court terme énoncé par la courbe de Phillips s'étend au long terme (voir Graham et Snower, 2008). La préférence des banques centrales pour un taux d'inflation positif peut par ailleurs s'expliquer par le fait que les estimations de l'inflation surestiment généralement les vraies valeurs des prix à la consommation, en particulier du fait des ajustements imparfaits des indices des prix à la consommation, des modifications de la qualité des produits ou encore de l'apparition de nouveaux produits. Bien que ces erreurs de mesures aient été réduites avec la sophistication continue des indices, l'influence de celles-ci demeure non négligeable. En conséquence, en raison de ces erreurs de mesure, la stabilité des prix de jure peut mener de facto à un taux d'inflation négatif.

Taux d'inflation optimal : huile dans les rouages ou grain de sable ?

Les précédents développements ont permis de clarifier deux aspects de l'inflation : celle-ci est couteuse pour la croissance de long terme mais ne peut toutefois pas être égale au niveau énoncé par la règle de Friedman. En présence de rigidités, l'inflation ferait office « d'huile dans les rouages » du marché du travail et faciliterait les ajustements aux chocs. Tobin mit en evidence, sans les expliciter de tels effets, puisqu'il écrivit notamment: « Higher prices or faster inflation can diminish involuntary disequilibrium unemployment, even though voluntary, equilibrium labor supply is entirely free of money illusion » (Tobin, 1972, p.2). D'autre part, il apparait toutefois qu'une forte inflation perturberait les ajustements des prix relatifs entre les secteurs économiques et serait donc « un grain de sable dans les rouages ». Suite à un choc nominal (par exemple, une forte inflation inattendue), les entreprises – en raison des coûts de menu ou des contraintes de temps – seraient dans l'incapacité de répondre immédiatement à ce choc, ce qui exacerberait la variance intra-marché des prix et des salaires, et provoquerait en définitive une mauvaise allocation des ressources, aux effets négatifs sur la croissance économique. Le poids relatif de ces deux effets antinomiques dépend notamment dans les faits du niveau de l'inflation. Ainsi, cela augure pour chaque niveau d'inflation, un niveau particulier de bien-être.

Dans la littérature néo-keynésienne, ces deux effets sont les éléments clé de la relation inflation-croissance et permettent de déterminer la représentation de long terme de la courbe de Phillips. Cette littérature souligne en particulier que ces effets antagonistes apparaissent systématiquement lorsque le taux d'inflation passe d'un niveau faible à un niveau plus élevé. En présence de rigidités de marché, l'effet « huile dans les rouages » prévaut lorsque le taux d'inflation est bas et joue en ces conditions un rôle important en modifiant les effets des chocs sur l'activité économique réelle. Cependant, passé un certain seuil d'inflation, l'effet « grain de sable » tend à dominer l'effet « huile dans les rouages » et conduit en conséquence à une amplification des effets des chocs sur la croissance économique. En définitive, ces différents effets suggèrent une représentation de la courbe de Phillips en U inversé (courbe non linéaire). La mise en évidence d'effets non-linéaire entre inflation et croissance de long terme est par ailleurs très largement confortée par les travaux théoriques récents (voir Graham et Snower, 2008, P.429 pour d'autres références).

La littérature s'intéressant aux mécanismes de transmission entre inflation et écart au potentiel de croissance a également défendu la non-linéarité à long-terme de la courbe de Phillips. Cette littérature explique en effet que l'inflation aura des effets asymétriques sur les différences de croissance par rapport au potentiel de l'économie. Ainsi, un écart positif vis-à-vis du potentiel de croissance (phase de boom économique) serait davantage inflationniste qu'un écart de même ampleur négatif (phase de récession) serait désinflationniste. Selon Morgan (1993), deux facteurs peuvent expliquer cette asymétrie : les contraintes de crédit et les rigidités à la baisse des prix. Sur le premier point, il apparait qu'une augmentation des taux suite à une phase de restriction monétaire, en renforçant les problèmes d'asymétries d'information, dégradera la qualité des portefeuilles bancaires. Les banques préfèrent dès lors sous de telles conditions rationner l'offre de crédit plutôt qu'augmenter les taux débiteurs ; et la contraction du crédit qui en résulte s'avère plus importante que celle qui aurait eu lieu du fait de la seule hausse des taux. En revanche, l'effet d'un assouplissement monétaire peut être modéré si l'économie est en phase de ralentissement et les perspectives d'investissement faibles. Cela implique par conséquent une politique monétaire volontariste et de nature pro-active afin d'éviter d'être confronté à la borne limitant à zéro les taux d'intérêt nominaux (voir aussi Schaling, 2004).

Le célèbre arbitrage de Taylor entre variabilité de l'inflation et variabilité de l'écart au potentiel de croissance (voir Phelps et Taylor, 1977 ; Taylor, 1979) peut également justifier dans une certaine mesure l'optimalité d'un taux d'inflation modéré. Cette littérature qui prend également en compte les rigidités de salaire et de prix, soutient que la règle de politique monétaire doit minimiser les fluctuations de l'inflation, de la croissance économique et du taux d'intérêt. Une des conclusions majeures de cette littérature est que la présence de rigidités nominales conduit, en cas de stabilité des prix, à une volatilité excessive de la production. Or, une politique optimale doit stabiliser la fluctuation des agrégats (voir Williams, 1999). En outre, Akerlof et al.,(1996) soutiennent qu'en raison de l'existence d'illusion monétaire de la part des travailleurs, un niveau d'inflation modéré permettrait d'atteindre à long terme un niveau d'activité supérieur au niveau d'activité en présence de prix parfaitement stables.

Développements empiriques

Si la littérature théorique a avancé différentes relations possibles entre inflation et croissance, la littérature empirique n'en fut pendant longtemps pas en reste en parvenant également à des résultats hétérogènes au sujet de cette relation. Néanmoins, cette tendance évolua suite à la contribution de Fisher (1993) qui souligna la non-linéarité de la relation entre inflation et croissance. De nombreuses contributions confirmèrent par la suite cette non-linéarité pour les économies développées et en développement, en mettant en évidence que le taux d'inflation optimal se situerait pour les premiers entre 2 et 4 pour cent, contre entre 8 et 18 pour cent pour les seconds (voir Sarel, 1996; Khan et Senhadji, 2001; López-Villavicencio et Mignon, 2011 ainsi que le chapitre 2 de cette thèse).

Ces résultats académiques divergent avec la pratique des banques centrales, dont les politiques monétaires ciblent des taux d'inflation bien en deçà des seuils empiriques optimaux observés. Une explication possible de cette contradiction factuelle réside dans le fait que les banques centrales à travers le monde utilisent des modèles DSGE dans lesquels sont prises en compte les rigidités à travers l'introduction de firmes en situation de concurrence monopolistique, mais également des viscosités dans l'ajustement des prix et des salaires. L'existence de ces rigidités rend ainsi les chocs inflationnistes plus sévères en termes de variabilité de la production et de l'emploi. Par conséquent, les méfaits de l'inflation en termes de bien-être sont beaucoup plus importants dans les modèles DSGE, qu'ils ne le sont dans les modèles macroéconomiques conventionnels. Aussi, cela permet d'expliquer que les taux d'inflation optimaux édictés par les banques centrales soient systématiquement inférieurs aux résultats observés dans les études mentionnées ci-dessus.

Une brève discussion de cette littérature empirique révèle que les premières études sur les déterminants de la croissance économiques (entre les années 1960 et 1980) ne considèrent pas l'inflation comme une variable importante. Comme le soulignent Bruno et Easterly, l'inflation ne fait pas partie des 10 principaux déterminants de la croissance économique évoqués par Barro et

Sala-i-Martin (1995). Ces derniers listent également un ensemble de 14 variables, potentiellement corrélées à la croissance de l'activité économique, là encore, sans que l'inflation ne soit mentionnée. Par ailleurs, sur cette période, les analyses empiriques menées sur des cas pays conduisent à des résultats disparates. En conséquence, il est difficile d'en déduire des conclusions manifestes et précises concernant la relation inflation-croissance (cf. Bruno et Easterly, 1996 pour une discussion plus approfondie).

Les chocs pétroliers de la décennie 1970 et la stagflation qui s'en est suivie ont considérablement affecté la perception qui prévalait jusque-là. En particulier, l'idée de l'existence d'une relation négative entre inflation et croissance économique devint de plus en plus admise. Cependant, la nature de cette relation demeure loin de faire l'unanimité parmi les chercheurs. Levine et Renelt (1992) par exemple soulignent que les effets négatifs de l'inflation sur la croissance résultent en réalité de l'omission d'un certain nombre de variables lors de l'estimation de cette relation. Les auteurs montrent qu'en incluant ces variables omises (il s'agit de mesures d'accumulation du capital humain et du capital physique) dans l'estimation d'une équation de croissance, l'effet de l'inflation disparait car le coefficient qui lui est associé perd sa significativité. Ceci suggère également que la relation inflation-croissance n'est pas indépendante de la fréquence des données utilisées dans les analyses empiriques. Les données à haute fréquence (annuelles par exemple) mettent en exergue une forte corrélation entre inflation et croissance, alors que les séries à plus faible fréquence (moyennes sur 5 ou 10 ans par exemple, ou analyses en coupe transversale) semblent suggérer une corrélation beaucoup moins importante, sinon inexistante. Du reste, étant donné que les séries à plus haute fréquence ne corrigent pas pour les effets des fluctuations dans les cycles économiques, l'impact de l'inflation qui résulte de ce type d'étude ne décrit certainement pas un phénomène de long terme.

En plus de ce paradoxe portant sur la fréquence des données, d'autres contradictions apparaissent dans la littérature empirique sur la relation inflation-croissance. L'une de ces contradictions tient par exemple du fait que l'effet de l'inflation sur la croissance semble être robuste principalement dans le cas d'études en coupe longitudinale, et non pour les analyses en coupe transversale. D'après Bruno et Easterly (1996; 1998), la robustesse de l'impact de l'inflation dans le cadre d'analyses en coupe longitudinale s'explique surtout par l'existence de quelques périodes de très forte inflation. Bruno et Easterly (1998) illustrent cela en estimant la relation inflation-croissance avant, pendant et après des périodes de crise d'inflation ; lorsque celle-ci est supérieure à 40%. A l'issue de cette analyse, les auteurs concluent que l'existence d'une relation inflation-croissance tient aux périodes de forte inflation. En effet, lorsque l'inflation retrouve son niveau d'avant crise, la croissance économique rebondit, compensant la précédente chute liée à la crise.

Une seconde contradiction dans cette littérature repose sur l'hypothèse sous-jacente concernant la forme fonctionnelle de la relation inflation-croissance. L'hypothèse de linéarité semble être contraire, non seulement aux faits, mais également aux prédictions théoriques (Phillips, 1958). En effet, s'il est vrai que les changements de prix affectent l'efficacité de l'allocation des ressources, la nature de cette relation n'est pas indépendante du niveau effectif de l'inflation. En dépit de ces arguments théoriques suggérant l'existence de différents régimes dans la relation inflation-croissance, avant Fisher (1993) les études empiriques reposaient sur l'hypothèse d'une relation linéaire entre l'inflation et la croissance économique (et donc d'un effet qui serait le même quel que soit le niveau d'inflation). A la suite de Fisher (1993), cette hypothèse de linéarité a été remise en cause et plusieurs travaux de recherches montrent que, selon son niveau, l'effet de l'inflation sur la croissance de l'activité économique peut être différent (Ghosh et Phillips, 1998 et Khan et Senhadji, 2001 en sont les premières références). Comme autre limite de cette hypothèse de linéarité, notons que les premiers travaux sur la relation inflation-croissance supposaient (implicitement) que l'effet de l'inflation sur la croissance est le même pour tous les pays, indépendamment de l'hétérogénéité qui peut les caractériser. Étant donné que les niveaux d'inflation sont très différents entre pays développés et en développement (du fait de différents degrés d'indépendance de la banque centrale, du cadre budgétaire, et de l'effet Balassa-Samuelson), les études empiriques traitent, notamment à la suite de Khan et Senhadji (2001), séparément ces groupes de pays et arrivent à des résultats distincts selon le groupe considéré.

Les résultats des travaux empiriques sur la dynamique de la réponse de la croissance de l'output à l'inflation sont d'une importance particulière. Ces résultats, en accord avec l'effet « huile dans les rouages » versus « grains de sable », suggèrent que l'effet de l'inflation sur la croissance n'est pas négatif partout et en tout temps. Ils ont également d'importantes implications en termes de politique économique : ils militent en faveur de stratégies visant à augmenter l'inflation jusqu'à ce que l'effet « grains de sable » l'emporte sur l'effet « huile dans les rouages ». A la suite de Sarel (1996), les économistes se sont attelés à rechercher ce point de retournement, considéré comme le niveau optimal d'inflation. Toutefois, cette non-linéarité a été jusqu'alors assez mal appréhendée. Par exemple, Sarel (1996) teste la stabilité de l'effet de l'inflation de part et d'autre d'un seuil exogène fixé 8%. La littérature existante ne contrôle pas non plus pour les changements dans la relation inflation-croissance au cours du temps. En effet, la sensibilité de l'output à l'inflation peut varier dans la mesure où le niveau de développement des pays n'est pas statique.

Principaux objectifs de la Thèse

Ces difficultés empiriques des travaux antérieurs nous poussent à réfléchir sur plusieurs questions aux quelle cette thèse essayera d'apporter des réponses. A cet égard, nous essayons d'estimer une relation à deux dimensions (temporelle et individuelle) entre l'inflation et la croissance. Nous nous intéressons également à l'examen de la manière par laquelle les développements macroéconomiques des pays émergents déterminent la sensibilité de l'inflation à la croissance économique. Une telle démarche nous permet d'isoler la non-linéarité qui pourrait être liée aux caractéristiques institutionnelles des différents pays.

En repérant une relation non linéaire, nous passons à notre second objectif qui consiste à tester le mécanisme de transmission existant derrière cette non-linéarité. La théorie économique s'avère unanime sur le rôle de l'accumulation du capital dans l'explication du comportement dynamique de la croissance vis-à-vis des changements de l'inflation. Nous réexaminons donc la question du taux d'inflation optimal d'un point de vue microéconomique. Notre objectif étant de trouver un niveau d'inflation qui minimise les perturbations nominales et réelles à un niveau sectoriel.

Afin d'élaborer ces points, et dans la première étape de notre analyse empirique, nous souhaitons déterminer la nature exacte de la relation non linéaire entre l'inflation et la croissance économique. Notre travail est principalement inspiré des travaux d'Omay et Kan (2010) et de López-Villavicencio et Mignon (2011) qui (bien que s'intéressant à un nombre restreint de pays) ont estimé des seuils d'inflation en utilisant des modèles PSTR (panel smooth transition regression). L'étude d'Omay et Kan (2010) utilise par exemple des données pour 6 pays industrialisés alors que celle de López-Villavicencio et Mignon (2011) se réfère à 42 pays développés et émergents. Dans notre travail, nous étendons leurs analyses et nous testons cette relation en prenant un échantillon relativement large composé de 100 pays développés et émergents. La taille de notre échantillon nous permet d'obtenir des estimations plus précises des seuils d'inflation que ce soit en prenant cet échantillon dans sa totalité ou encore en divisant celui-ci en plusieurs sous-échantillons.

Il est à noter à ce niveau que la différence systématique des seuils d'inflation entre les pays développés et en voie de développement qui a été démontrée dans les analyses précédentes mérite une attention particulière. Visiblement, la principale cause de cette différence s'avère le niveau hétérogène du développement institutionnel. En d'autres termes, il s'agit du niveau de développement des institutions financières et politiques (et non pas seulement du niveau de revenu) qui façonne le seuil d'inflation et explique par exemple pourquoi les économies avancées sont plus sensibles aux changements d'inflation.

Ghosh et Phillips (1998) attirent l'attention sur le rôle de l'hétérogénéité institutionnelle dans la détermination de la sensibilité de la croissance à l'inflation. Par exemple, en présence d'inflation, des pays ayant un degré d'ouverture au commerce élevé font face à des conséquences plus sérieuses que des pays à degré d'ouverture faible étant donné que l'inflation affecte les taux de change, les flux de capitaux et la balance des paiements, etc. Il est donc clair que l'ampleur de l'effet d'inflation, quelque soit son niveau, devient plus large pour le premier type de pays.

D'autre part, des niveaux différents de dépenses publiques peuvent également conduire à des hétérogénéités de même ordre, en termes de sensibilité de la croissance à l'inflation. En effet, les économies avec une part importante de dépenses publiques seront davantage dépendantes des revenus de seigneuriage. Ces économies trouveront donc intérêt à pratiquer davantage d'inflation, au delà du niveau optimal. L'effet (négatif) de l'inflation sur la croissance sera donc accru dans de telles économies. Enfin, le niveau de l'accumulation du capital s'avère également une variable potentielle qui conditionne la nature de la relation inflation-croissance, tel que soulevé par Ghosh et Phillips (1998). Dans ce travail, nous testons la manière dont l'ouverture commerciale, les finances publiques et l'accumulation du capital influence la sensibilité des effets de l'inflation sur la croissance.

Etant donné l'émergence d'un consensus sur le fait qu'il existe une relation non linéaire entre l'inflation et la croissance, l'étape suivante consiste à repérer les mécanismes figurant derrière cette non-linéarité. Cette question est importante du point de vue des décideurs politiques étant donné que, sans la compréhension de ces mécanismes, il n'est plus possible de conduire une politique raisonnée. Dans ce contexte, les études théoriques insistent principalement sur le rôle de l'accumulation du capital humain et physique comme facteur expliquant la réponse dynamique de l'inflation à tout changement de croissance. La thèse principale liée à cette littérature consiste à considérer que c'est les facteurs d'accumulation et du réalignement qui rendent bénéfique un taux d'inflation modéré pour la croissance et que les effets négatifs d'un taux d'inflation élevé apparaissent également à travers ces canaux. Par exemple, lorsque le taux d'inflation est à son plus bas niveau, une augmentation de son niveau réduira le taux d'intérêt réel et augmentera l'accumulation du capital physique et la croissance économique : c'est l'effet Tobin. Néanmoins, le même raisonnement ne s'applique pas en présence des niveaux moyens ou élevés d'inflation dans la mesure où l'effet signal d'un changement des prix est mal perçu, ce qui se traduira par une mauvaise allocation des ressources et réduira l'accumulation du capital physique : c'est l'effet Tobin à reversé.

L'inverse de ce raisonnement s'applique en cas d'accumulation du capital humain. En effet, lorsque le taux d'inflation est à son plus bas niveau, la faiblesse du taux d'intérêt réel agit positivement sur l'intensité du capital physique et décourage l'accumulation du capital humain. A l'inverse, lorsque l'inflation augmente et dépasse un certain seuil, la participation des travailleurs se trouve réduite (vu la faiblesse des salaires réels) et ce, en dépit d'un coût d'opportunité d'accumulation du capital plus faible. Ceci peut aussi expliquer pourquoi le coût marginal de l'inflation est décroissant.

Notre tâche consiste essentiellement à repérer la nature de la réponse de l'accumulation du capital humain et physique à tout changement d'inflation et de voir si leurs interconnections sont liées à l'existence d'une relation non linéaire entre l'inflation et la croissance. Si l'effet positif du Tobin s'avère maintenu pour l'accumulation du capital physique à un taux d'inflation faible et pour l'accumulation du capital humain à un taux élevé, la non-linéarité peut être supporté par les facteurs de réalignement et d'accumulation.

Il est important de noter que l'existence de cet effet Tobin pour le développement du capital physique et humain exige un fonctionnement adéquat du système financier. Pour le capital humain, un système financier solide permettra en effet par exemple de lisser les flux de crédit destinés aux agents pour des fins d'éducation. Nous analyserons par conséquent si l'existence d'un système financier solide a également une influence sur la nature de la relation entre l'inflation et l'accumulation du capital.

Notre dernier objectif dans cette thèse consiste à assurer la cohérence entre les estimations empiriques du taux d'inflation optimal et les cibles de taux actuelles affichés par les banques centrales. De ce fait, malgré un consensus irréfutable consistant à considérer que la relation inflation-croissance est non linéaire pour tous les pays développés et émergents, les seuils estimés diffèrent largement entre les groupes de pays. En particulier, ces seuils sont trop élevés pour les pays émergents alors qu'en réalité, les banques centrales de ces pays préfèrent maintenir des taux d'inflation comparables à ceux figurant dans les pays développés. Certainement, un seuil d'inflation fixé à 17% par exemple est de loin supérieur aux zones d'inflation préférées de ces banques centrales. La question qui se pose donc est d'expliqué ce manque de cohérence existe entre les propositions avancées par les chercheurs et les pratiques actuelles des banques centrales.

La réponse possible à cette question est que la littérature empirique utilise des modèles à vocation macroéconomique et examine le niveau d'inflation à partir duquel le recul de la croissance économique apparaît. Néanmoins, ce type d'analyse macroéconomique est contraire aux techniques DSGE utilisées par les banques centrales. Dans les modèles néokeynésiens, l'inflation est couteuse dans la mesure où elle affecte négativement le processus d'allocation optimale des ressources. La raison qui explique une forte préférence pour un objectif de stabilité des prix tient au fait que l'inflation crée une mauvaise perception de la part des producteurs et réduit par conséquent la synchronisation de leurs prix à des changements de volume de production (Lucas, 1973). Ceci exacerbe la variabilité de l'output et des prix entre les secteurs. Dans un tel scénario, les décideurs se trouvent inciter à chercher un niveau d'inflation qui minimise la dispersion sectorielle des prix et de l'output. C'est à cause de ces préférences que les banques centrales des pays cribleurs d'inflation répondent d'une façon plus agressive à toute déviation de l'inflation de sa valeur cible.

Nous essayons donc ici de déterminer le taux d'inflation optimal en se basant sur une approche microéconomique, qui repose sur l'analyse de la variabilité des prix et de la croissance de la production au niveau sectoriel. Finalement, nous observons si l'adoption des régimes spécifiques de politique monétaire (caisse d'émission versus ciblage d'inflation) influence les fluctuations sectorielles des prix et d'output. Les partisans de ces deux régimes bipolaires avancent leurs prétentions étant donné la capacité de ces deux derniers à réaliser la stabilité macroéconomique. La crédibilité de ces prétentions peut être désormais testée et ce, en analysant le succès de chacune de ces dernières en termes de réduction de la variabilité sectorielle des prix et de l'output.

Méthodologie et structure de la Thèse

Pour répondre à toutes ces interrogations, nous divisons cette thèse en 4 grands chapitres. Dans le chapitre I, nous discutons les principaux développements théoriques et empiriques figurant dans la littérature.

Notre chapitre II a pour objet l'estimation du taux optimal d'inflation pour un panel large de pays développés et émergents. Nous analysons également le rôle des conditions macroéconomiques dans la détermination des effets marginaux de l'inflation sur la croissance économique de long terme.

L'avant dernier chapitre analyse les effets de l'inflation sur l'accumulation du capital humain et physique et essaye d'expliquer la non-linéarité entre l'inflation et la croissance à travers les effets de l'inflation sur les facteurs de réalignement et d'accumulation.

Le dernier chapitre essaye de résoudre le problème de manque de cohérence entre les taux optimaux d'inflation déterminés à partir des modèles macroéconomiques et les préférences des banques centrales basées sur des modèles « DSGE ».

Dans le chapitre I, nous présentons l'évolution temporelle de l'inflation et nous expliquons comment celle-ci a commencé à menacer la stabilité macroéconomique durant les périodes de l'après seconde guerre mondiale. Nous décrivons à cet effet les positions divergentes des deux principales écoles de pensée économiques (Friedman versus nouveau keynésien) quant aux effets d'un taux d'inflation modéré. Notre objectif étant de comprendre pourquoi les suggestions Friedmaniennes d'un taux d'inflation négatif (taux d'intérêt nominal nul) ne sont pas valides dans le monde réel. L'optimalité d'un taux d'inflation négatif dans la règle de Friedman assure l'existence des taxes non distortionnaires pour les recettes publiques. Etant donné que ce type de taxes est inexistant dans le monde réel, la taxation Ramsey (1927) soutient l'optimalité des taux d'inflation positifs pour les besoins budgétaires du gouvernement. De plus, nous passons en revue les principaux arguments théoriques derrière l'existence des rigidités des prix et des salaires et les évidences empiriques complémentaires des différents pays. Ceci dit, la présence de ces rigidités nominales combinée avec une présence fréquente des chocs d'offre justifie le point de vue des économistes nouveaux keynésiens, basée formellement sur des modèles DSGE (Modèles d'équilibre général dynamique stochastique). Nous décrivons les développements chronologiques de la modélisation DSGE, leurs structures de base et plus particulièrement leurs suggestions du taux d'inflation optimal. L'évaluation empirique de ces modèles sera aussi discutée. La littérature utilise la méthode de simulation en utilisant les valeurs des paramètres associées aux variables macroéconomiques mais aussi la méthode d'estimation VAR bayésien. Enfin, une discussion brève du coût d'inflation en termes de bien être nous permet de développer le cas d'un taux modéré d'inflation contre deux cas alternatifs à savoir la stabilité des prix et un taux d'inflation élevé.

Dans le chapitre 2, nous nous intéressons à la question de non-linéarité entre l'inflation et la croissance et nous estimons le niveau d'inflation qui maximise la croissance du PIB par tête. Pour ce faire, nous discutons d'abord les principales recherches théoriques et empiriques en la matière. Ceci nous aide à comprendre les liaisons théoriques fondamentales et les déficiences empiriques des études passées. Le problème majeur de ces études passées s'avère être le traitement économétrique de la relation non linéaire entre l'inflation et la croissance. Nous essayons dans ce cadre de résoudre ce problème en utilisant un modèle PSTR. L'avantage majeur de cette technique est qu'elle permet une détermination endogène des points seuil pour le taux d'inflation et pour d'autres variables conditionnelles. En plus, les modèles PSTR permettent d'estimer des seuils de taux temporels et individuels, ce qui rend possible pour une économie de changer d'une position à une autre à travers le temps.

Malgré ces avantages potentiels attribués aux modèles PSTR, les résultats peuvent être affectés par un problème d'endogénéité. En effet, ce problème potentiel figure souvent dans les régressions cherchant à expliquer la croissance et ce, à cause d'une double causalité entre la variable dépendante et les variables explicatives. Pour résoudre ce problème, nous recourons à une analyse de robustesse en utilisant la technique des variables instrumentales dans le cadre d'une estimation par les doubles moindres carrés (IV-2SLS).

Nous tenons aussi en considération les remarques avancées par Ghosh et Phillips (1998) et nous discutons l'influence des trois variables macroéconomiques conditionnelles (ouverture commerciale, finances publiques et accumulation du capital) sur la sensibilité de la relation inflation-croissance. Nos résultats complètent ceux de la littérature récente au sujet de la non-linéarité entre l'inflation et la croissance et reconnaissent le rôle crucial des conditions macroéconomiques dans la détermination de la sensibilité des effets d'inflation sur la croissance de long terme.

Après avoir examiné au chapitre 2 l'existence d'une relation non linéaire entre l'inflation et la croissance, le chapitre 3 essaye de trouver le mécanisme potentiel expliquant cette non-linéarité. Dans une première étape, nous développons les arguments théoriques et nous essayons de trouver la liaison entre la non-linéarité entre l'inflation et la croissance et les effets possibles de l'inflation sur l'accumulation du capital physique et humain. Etant donné que l'accumulation du capital physique et humain est déterminée conjointement, la méthode des MCO pourra être critiquée dans la mesure où les résultats pourront être biaisés et incohérents. Pour éliminer ce problème, nous utilisons encore une fois l'estimation double moindre carré (IV2SLS). Au cours de l'étape suivante, nous cherchons si les effets d'inflation sur l'accumulation du capital physique et humain sont identiques pour les différents niveaux d'inflation. Cette tâche est menée en se basant sur la technique d'estimation « rolling » qui est fréquemment utilisée dans la littérature récente sur la croissance. Nous testons également la manière dont l'ampleur de l'effet Tobin ou de l'effet Tobin renversé sur l'accumulation du capital humain et physique dépend de niveau du développement financier. Nous trouvons principalement quelques connections robustes et non linéaires entre l'inflation et les deux types d'accumulation du capital et nous identifions également l'importance de l'influence du niveau du développement financier sur l'ampleur de ces connections. Ces résultats sont remarquablement cohérents avec les conclusions des chapitres précédents et nous aident à comprendre les canaux à travers lesquels l'inflation influence la croissance de long terme.

Dans le chapitre 4, nous réexaminons la question du taux d'inflation optimal d'un point de vue microéconomique. En effet, la relation non linéaire entre l'inflation et la croissance considère qu'un taux d'inflation positif modéré est optimal. Les seuils d'inflation sont pourtant différents des préférences actuelles des décideurs de politiques économiques. Comme indiqué auparavant, ces décideurs se basent sur des modèles nouveaux keynésiens de type DSGE et décident du niveau d'inflation qui tient compte de l'efficience allocative. Nous analysons les effets de l'inflation sur la variabilité relative sectorielle des prix et de l'output pour les économies développés et émergents.

Etant donné que la problématique abordée demeure sensiblement identique à celle du chapitre 2, les techniques économétriques aux quelle nous avons eu recours sont semblable à celui-ci. Dans une première étape, nous testons les effets de l'inflation sur la variabilité relative des prix en utilisant des modèles effets fixes et IV2SLS. La théorie économique identifie également le rôle séparé des taux d'inflation anticipés et non anticipés dans la variabilité relative des prix entre les secteurs.

Dans le cadre de nos analyses non linéaires, nous utilisons la technique de régression « rolling » afin d'identifier le niveau d'inflation qui minimise les perturbations sectorielles des prix. Etant donné que notre échantillon comprend des pays ayant des régimes monétaires bipolaires, notamment le ciblage d'inflation versus caisse d'émission, nous testons la capacité de ces régimes dans l'atténuation de la variabilité des prix. Pour ce faire, nous conduisons quelques régressions « rolling » spécifiques aux pays et nous présentons les différences systématiques des deux régimes à travers la comparaison de la capacité de ces deux derniers à contrôler les perturbations relatives des prix. Dans une seconde étape, nous répétons le même exercice pour la variabilité sectorielle de l'output. Ici, les seuils d'inflation sont estimés en utilisant un modèle PSTR. Dans les deux cas, nos résultats estimés soutiennent l'existence des effets de l'inflation sur la variabilité relative des prix et de l'output. Dans son ensemble, les effets « huile dans les rouages » de l'inflation sont visibles dans la mesure où nos résultats montrent qu'un taux d'inflation positif est nécessaire pour la minimisation de la variabilité relative des prix et de l'output. Il est à noter que le choix du régime de change s'avère important, surtout pour les pays émergents. Nos résultats offrent dans ce cadre un véritable arbitrage. Si la variabilité des prix nominaux est suffisamment contrôlée par un régime de change spécifique, la variabilité de la croissance de l'output peut l'être davantage par un autre régime de change.

En définitive, nos recherches sur le taux d'inflation optimal ont conduit à mettre en évidence aussi bien à un niveau microéconomique que macroéconomique, l'importance d'un taux d'inflation positif modéré. Le niveau particulier de ce seuil d'inflation est certainement déterminé par le niveau du revenu du pays et par d'autres facteurs économiques et politiques. Pour le cas spécifique des pays émergents, le niveau d'analyse microéconomique, qui soutient l'hypothèse d'une faiblesse des seuils d'inflation, aide à comprendre la réticence des décideurs envers un taux de croissance monétaire excessif.

General Introduction

Economists have a long history of interest in the investigation of the relationship between inflation and output growth. One of the main objectives was to get robust evidence on the sign of this relationship and its stability overtime. The later tests whether inflation has transitory effects on output growth or it is also relevant for the long-run growth of a country? The existence of any types of relationship would make it necessary to investigate into main channels (mechanisms) behind this nexus. Some other important issues include: Does the nature of this relationship remain same always and everywhere? Which macroeconomic conditions intensify or appease the growth effects of any particular level of inflation? And, what are the consequences of money growth on the welfare of a representative agent, on the production decisions of a firm and on the overall allocative efficiency of a country?

Among the earliest investigations of the relationship between inflation rates and output growth, is the one by Keynes (1920): "*As the inflation proceeds and the real value of the currency fluctuates widely from month to month, all permanent relations between debtors and creditors, which form the ultimate foundations of capitalism, become so utterly disordered as to be almost meaningless; and the process of wealth-getting degenerates into a gamble and a lottery* (Keynes, 1920 p.220)". These early views of Keynes on the adverse inflation–growth relationship, however, did not trigger a lot of empirical research; mainly because the overall macroeconomic environment at that time was comparatively stable. For instance, the U.S producer price index in 1943 was slightly below its 1810 value (see Haslag, 1997, endnote 1). The situation changed after World War II and particularly after the oil price shocks of 1973 when severe inflation rates were observed along with low output growth.[2]

On the theoretical fronts, some important developments were made between the 1960s and1980s.This theoretical literature can be divided into three categories based on their views of the inflation–growth relationship. In the first group, Mundell (1963) and Tobin (1965) presented models indicating a positive effect of inflation on the output growth. In these models, inflation reduces the real interest rate and makes a substitution of consumers' assets from real balances to capital accumulation. A higher capital accumulation subsequently fastens the output growth. Second important views came from Sidrauski's (1967) model, indicating a super-neutrality of

[2]The temporal evolution of this literature is presented in Chapters 1 and 2.

money with respect to output growth. In the Sidrauski's views, money growth only affects the real variables (e.g., the capital stock and the output growth) in the short-run; whereas the long-run evolution of these variables is independent of the money stock. Lastly, Brock (1974) and Stockman (1981) present models indicating a negative effect of inflation on the capital stock. In these models, inflation induced changes in the nominal interest rate increases the cost of holding the cash balances, which are important for the capital accumulation and output growth.

During the 1960s and 1970s, the most profound arguments on the adverse inflation–growth connections came from Friedman (1969; 1971) and his followers. That school of economic thought posits that as money is costless to produce; its use must not be taxed. Any positive level of the inflation rate is essentially attached to a non-negative interest rate, which diminishes the demand for money from its socially optimal level. Agents are induced to keep their assets in the non-monetary form to benefit from a positive interest rate. In turn, this increases the transaction cost and reduces welfare. Lastly, the "*misperception theory*" of Lucas (1973) posits that inflation induced relative price dispersions creates misallocations of resources among different sectors and exerts a negative influence on the output growth. All of these competing views have been comprehensively substantiated in the subsequent theoretical and empirical research on the inflation and output growth.

How does it cost to inflate?

In the economic literature, several factors explain how inflation lowers the output growth and welfare. Fischer (1984; 1996), for instance, identifies several channels through which inflation can exert a substantial cost on output growth. First, since money remains the most important source of transactions in modern world, changes in its supply influence the welfare of an economy. Agents economize the use of money for transaction purposes which consequently entails welfare losses for the country. The proponents of high inflation, however, establish that these welfare losses are not so important because money is used for many illegal transactions and therefore taxing its use has some important re-distributional effects. Further, these welfare effects are also small because the use of money has become limited after the innovation of new transaction technologies. Second, inflation is considered costly because it increases the frequency of transactions among agents. As real balances lose their value quickly in inflation, to avoid this loss, agents make rapid transactions and spend more time on these activities. This particular aspect of effects of inflation is named as "*shoe-leather*" cost in the literature. Nonetheless, this frequency of transaction is not influenced at low or moderate levels of inflation rate. Only hyperinflation influences this frequency.

The other important cost of inflation appears through its effects on interest rate and tax burden. Inflation reduces interest rate earnings of the depositors and these losses are particularly large when the nominal interest rate is not adjusted accordingly. Fischer posits that the nominal interest rate paid by the financial institutions exhibits certain controls or has some ceilings in most of the banking systems, which discourages the deposits and causes resource misallocation. In fact, these effects are not only confined to interest rates but also transferred to the principal amount of creditors. A redistribution of wealth takes place between creditors and debtors in favor of the latter group. Further, inflation also increases the tax burden of agents since it is hard to implement complete tax indexation, due to administrative problems. This leaves space for inflation to bring more people in the tax nexus, based on their nominal income, which discourages economic activity.

The discussion of the cost of inflation is incomplete without mentioning the effects of inflation on financial intermediation. Financial institutions need information about investment projects and returns. The availability of such information becomes hard in inflation, which complicates the process of financial intermediation. Inflation also represses the financial sector growth by discouraging the long-term contracts between borrowers and lenders. Financial institutions prefer to keep their assets in liquid form. Moreover, inflation undermines the usefulness of money assets and forces policy makers to take actions that disrupt the financial sector growth (Rousseau and Wachtel, 2002; Yilmazkuday, 2011). All of these adverse effects of inflation on the financial sector's development depress not only the formation of physical capital but also human capital formation by reducing debt availability to young agents for their education motives. Inflation also increases the consumers' rate of time preferences and undermines both types of capital accumulation.

Why do countries inflate?

Contemplating all of the above-mentioned aspects of effects of inflation lead us to conclude that inflation is costly; always and everywhere (?). Given this vast consensus on the cost of inflation, the question then arises why countries opt for a positive inflation rate. The main argument favoring a positive inflation rate is the revenue it generates to fulfill governments' fiscal requirements. High powered money, along with the credit creation by the commercial banks, constitutes a sizeable part of public revenues. Economic literature, starting from the seminal paper of Phelps (1973), acknowledges this pivotal role of "seigniorage" revenues for the government expenditures. This research has been established on the notion that seigniorage acts as a tax for governments along with the other taxes, and an optimal policy should smooth these tax rates over time. Phelps assumes a distortionary nature of all types of taxes and the fiscal policy that aims at minimizing the overall distortions from all sources of revenues, results in a positive inflation rate. Besides, the tax smoothing overtime causes a co-movement between taxes and inflation, establishing a long-run connection between the two variables (see Evans and Amey, 1996).

Inflation has also been supported for its positive effects on the output growth through the channel of nominal interest rate. In fact, inflation keeps the short-run nominal interest rate positive, which leaves space for the conduct of an active monetary policy. As the real world economies face several types of demand and supply shocks, an active monetary policy is concerned with modifying the effect of these shocks on output growth. For instance, with both inflation and interest rate at their positive levels, a monetary expansion which focuses on the economic stabilization, can keep the short-run nominal interest rate below the expected inflation level. This will bring the real interest rate to a negative level and stabilize the economy from shocks. On the other hand, if the inflation rate is already at a very low level, the nominal interest rate is likely to hit a zero bound and monetary expansion cannot take place. Economists usually quote the example of the Japanese economy during the 1990s when their nominal interest rate was at zero percent during the recession. Therefore, the traditional monetary policy instruments could not be used to rescue the economy from the downturn.

Another reason behind the inflation preference among policy makers is the fear of deflation. It is particularly attached with severe recessions and exerts a long-lasting effect on the output growth. An important effect of deflation appears through debt dynamics. Deflation increases both real value of debt and its servicing cost. By contrast, the value of nominal assets erodes, adding to the difficulties of the debtors. Falling assets' value and increasing debt value forces the debtors to sell off their assets, albeit, at a low price because of the large numbers of sellers and few buyers in the market. The severity of this situation can increase the number of bank defaults and can consequently trigger a banking crisis (see Billi and Kahn, 2008). The authors mention that once an economy falls into this vicious circle, the conventional monetary policy tools cannot be used to pull it out of this deflationary situation.

Several other factors justify why countries would go for a positive inflation rate rather than the complete price stability or deflation. The most important are the real world rigidities and measurement errors of inflation indices. The New-Keynesian economists defend the case of a positive inflation rate based on wage and price rigidities. In the presence of real world rigidities and supply shocks, the conventional short-run Phillips curve trade-off extends over a long period of time (see Graham and Snower, 2008). Lastly, a positive inflation rate preference of the central banks can also be driven by the fact that the actual inflation estimates usually overstate the true values of consumer prices, especially because of the inadequate adjustments for the products' quality and the inclusion of new goods in these indexes. Although these measurement errors have been reduced by the advanced and quality adjusted price indices, their influence on the consumer price index (CPI) is still not negligible. Due to these measurement errors, a *de jure* price stability can imply a *de facto* negative inflation rate.

Optimal inflation rate: grease versus sand effects

The above snapshots of previous research clarify two aspects of the effects of inflation. First, it is costly for the long-run output growth, and second it cannot be brought down to the level of Friedman rule. In the presence of real market rigidities, inflation 'greases the wheels' of labor markets and facilitates their adjustments following the shocks. These grease effects were informally argued by Tobin (1972): "*Higher prices or faster inflation can diminish involuntary disequilibrium unemployment, even though voluntary, equilibrium labor supply is entirely free of money illusion*" (Tobin, 1972, p.2). On the other hand, a high inflation rate also disrupts the adjustment of relative prices among sectors and 'throws sand' in the wheels of the economy. When a nominal shock (e.g., unexpected high inflation) hits the country, firms – due to the menu cost or timing constraints – cannot make synchronized changes in their prices and wages. This lack of synchronization exacerbates the intra-market variance of prices and wages, and results in a misallocation of resources, causing a reduction in the average output growth. The relative strength of these effects, albeit, depends upon the particular level of inflation. This consequently determines the net welfare effects of any specific inflation rate.

In the New-Keynesian literature, both of these effects are key elements of the inflation–growth relationship and determine the slope of the long-run Phillips curve. In fact, this literature shows that these competing effects appear systematically when the inflation rate moves from its lower to higher levels. In the presence of real market rigidities, the grease effect is mainly attached with a low inflation rate and plays an important role in modifying the effect of shocks on the output growth. However, when inflation reaches at certain inflexion points, this grease effect is taken over by the sand effect and inflation amplifies the adverse effect of shocks on the output growth. This establishes an inverse U-shaped (or a nonlinear) slope of the long-run Phillips curve. This nonlinear slope has been comprehensively supported by the recent theoretical work on inflation and long-run output growth (see Graham and Snower, 2008, p.429 for further references).

This nonlinear long-run Phillips curve has also been explained by the studies that study transmission mechanisms between inflation and output gap. More precisely, this literature explains asymmetries in the behavior of the output gap with respect to inflation changes. Positive deviations of the output from the potential (economic booms) are more inflationary than the negative deviations (recessions) which are deflationary. To Morgan (1993), two factors explain this asymmetry; first, credit constraints that augment only in tight monetary policy and second, downward price rigidities. On the credit constraints: in a monetary policy contraction, when interest rate increases, it raises the borrowers' obligations to banks, creates an asymmetry of information and reduces the quality of banking portfolio. Banks respond to this situation by rationing the credit supply to riskier borrowers which limits spending by the borrowers and leads to a larger decline in it than would stem from a higher market interest rate alone. By contrast, when an expansionary policy diminishes the interest rate, the effect may not be as large if the economy is slowing down and investment prospects are not very promising. For the conduct of monetary policy this implies the view of having an active, and rather aggressive monetary policy to avoid the risk free zero interest rate bound in recessions (see also Schaling, 2004).

Another factor behind the optimality of a moderate inflation rate is the famous Taylor's trade-off between inflation variability and output gap variability (see Phelps and Taylor, 1977; Taylor, 1979). This literature also takes into account wage and price rigidities and proposes a monetary policy rule which minimizes the fluctuations in inflation, output and interest rate. A general finding of this literature is that in the presence of nominal rigidities, complete price stability is attached with excessive volatility of output. An optimal policy is the one that stabilizes the fluctuations of all these aggregates (Williams, 1999). Akerlof et al. (1996) further support this argument by claiming that in the long-run a moderate inflation rate assures the level of economic activity which is higher than the one under complete price stability.

Empirical developments

While the theoretical and earliest empirical literature have advanced competing possibilities for the relationship between inflation and output growth, the empirical work by Fischer (1993) marked shift in this trend. Fischer (1993) showed the existence of a non-linear relationship between inflation and output growth. This nonlinearity has been confirmed for several developed and developing economies with threshold inflation rates of 2-4 % for the first group and 8-18 % for the later (see Sarel, 1996; Khan and Senhadji, 2001; López-Villavicencio and Mignon, 2011 and a detail discussion in Chapter 2 of our thesis). This contradicts the actual stance of central banks according to which the monetary policy mainly focuses on the levels of inflation rate which are well below these empirically advanced thresholds. A possible explanation behind this contradiction lies in the fact that central banks around the world use the New Keynesian models whose prominent features include the introduction of real rigidities via monopolistically competitive firms and infrequent adjustments of wages and prices in the market (Ambler, 2008). The presence of these rigidities makes the inflationary shocks more severe in terms of dispersions in both input and output markets. Consequently, in this New Keynesian literature, the welfare effects of inflation become much larger than the ones proposed by the macro based models of inflation and output growth. For the same reason the optimal inflation rate becomes lower than the one proposed by the above-mentioned studies.

The early growth literature (e.g., the studies of 1960s till 1980s) did not consider it important to incorporate the inflation rate as covariate in the growth regressions. Bruno and Easterly note that a survey study of Barro and Sala-i-Martin (1995) on the growth determinants discusses 10 covariates for a basic growth regression. Inflation is not among them. Barro and Sala-i-Martin then reported 14 other covariates of output growth. Inflation was not in the list either. In the studies where inflation rate was included at that time, the results of country-specific papers were sometimes completely different from each other, and therefore the competing theoretical possibilities could not be narrowed down to develop any concrete view on the inflation–growth nexus (see Bruno and Easterly, 1996 for references).

The oil price shocks of the 1970s and a subsequent stagflation changed economists' perception and also the results of contemporaneous empirical literature. This reduced skepticism in the negative inflation–growth relationship. Nevertheless, dissenting views could still be observed in the literature. These include the results of Levine and Renelt (1992) who find that this adverse inflation–growth relationship appears due to some omitted variables and the inclusion of these growth determinants renders the inflation coefficient insignificant. To illustrate, the authors incorporate the measures of human and physical capital accumulation and find that inflation coefficients are fragile with respect to these important growth determinants. That being said, the results of the inflation–growth literature were also frequency-dependent. High frequency data showed some strong correlations whereas low frequency data (e.g., five year average, ten year average or the cross-section studies) showed a weak or no correlation between the two variables. As high frequency data does not account for business cycle fluctuations, the strong correlation between the two variables could not be used for developing a long-run causal link between inflation and output growth.

Apart from this frequency paradox, the empirical inflation–growth literature has also carried some other contradictions. The first incongruity appears from the fact that the negative relationship mainly turned robust in the pooled studies but not in the cross-sectional experiments. Bruno and Easterly (1996; 1998) explained that the robust results of pooled studies were basically driven by some high inflation observations – conventionally named outliers. To empirically support this view, Bruno and Easterly (1998) define the high-inflation episodes as inflation crises – when the level of inflation exceeds 40 % – and analyze the inflation–growth relationship before, during and after these crises periods. Their results show that the inflation–growth relationship is mainly explained by these high-inflation episodes. Once the inflation rate turns back to its pre-crisis level, growth bounces back rapidly, compensating the losses made during the crisis.

The second contradiction of the literature was its assumed functional form which was not only inconsistent with the actual behavior of the inflation rate but also with theoretical predications (see Phillips, 1958). Indeed, if price changes generate signal for efficient resource allocation, their ability to do so does not remain the same when inflation is too high. Despite these strong theoretical grounds for a regime-specific relationship, the empirical literature before Fischer (1993) assumed a linear functional form of the inflation–growth nexus, implying the same magnitude of the effects of inflation at its different levels. However, the research following

Fischer started questioning this linear functional form and found different inflation coefficients for low and high inflation samples (see Ghosh and Phillips, 1998 and Khan and Senhadji, 2001 for earlier empirical examples). A complementary drawback of the linear functional form was that countries with heterogeneous inflation experiences have had the same marginal effect of inflation on growth. Given that developed and emerging economies have systematically different levels of inflation tolerance – due to differences in their degrees of central bank independence, fiscal systems and the Balassa-Samuelson effects – the studies following Khan and Senhadji (2001) started separating these two groups and found heterogeneous nature of the relationship between these two groups.

The dynamic response of output growth with respect to the levels of inflation is indeed a very important finding of the empirical research. This is consistent with the above-mentioned '*grease*' versus '*sand*' effects of the theoretical literature. It implies that inflation is not bad for growth always and everywhere. It also has strong policy implications for the central banks: it favors the policy which increases inflation to a level where the *grease* effect is taken over by the *sand* effect. Economists following Sarel (1996) started searching for this inflexion point, traditionally called the optimal rate of inflation. However, most of the previous research on this subject treated this nonlinearity improperly. For instance, Sarel assumed an exogenous threshold of inflation at 8% and then tested whether the inflation coefficients vary below and beyond that threshold. The literature did not either control for the changes in the inflation–growth relationship over time. As a country's level of development does not remain same over time, the sensitivity of the output growth with respect to inflation rate also varies accordingly.

Main objectives of the thesis

The empirical difficulties highlighted by previous works take us to the main objectives of our thesis. We want to estimate the time and country specific, relationship between inflation and output growth. We are also interested in examining how the macroeconomic developments of an economy determine the sensitivity of the inflation effects on the economic growth. This enables us to isolate the nonlinearity which appears from the institutional characteristics of different countries. Having established the nonlinear relationship, we move on to our second objective and test a possible transmission mechanism behind this nonlinearity. The economic theory unanimously supports the role of capital accumulation for explaining the nonlinear behavior of output growth to inflation change. We then reexamine the question of the existence of an optimal inflation rate from a microeconomic perspective. Our objective is to find the level of inflation which minimizes real and nominal disruptions at sectoral level.

To elaborate on each of these points, in the first step of our empirical analysis, we want to determine the exact nature of the nonlinear relationship between inflation and output growth. Our work is mainly motivated by Omay and Kan (2010) and López-Villavicencio and Mignon (2011) who estimate these inflation thresholds by using a panel smooth transition regression (PSTR) model, albeit, for a limited set of countries. While the study by Omay and Kan uses the data from six industrialized economies; López-Villavicencio and Mignon conduct their analysis on 42 developed and emerging countries. We expand their analysis and test the relationship for 100 developed and emerging economies. Our large sample-size allows us to get a more precise estimate of the inflation thresholds both for the global sample as well as various income-specific sub-samples.

That said, the systematic differences of the threshold inflation rate between developed and developing countries, shown by previous research on this subject, deserve special attention. Certainly a major factor explaining these threshold differences is their heterogeneous levels of institutional development. Put differently, it is not only the level of income but also the level of development of political and financial institutions that explains why advanced economies are more sensitive to inflation changes. Ghosh and Phillips (1998) draw attention to the role of institutional heterogeneity in determining the sensitivity of inflation effects on growth. For instance, countries with the higher degrees of trade openness face more serious consequences of inflation than the closed economies as inflation more severely affects their exchange rates, capital flows and balance of payments, and so forth. Hence, the magnitude of the effect of inflation at any particular level of inflation becomes larger for these countries. Similar heterogeneity in inflation effects can be observed for countries with different levels of public finance. Economies with a high level of public finance have usually a heavy reliance on inflationary taxation. Since marginal seigniorage collection decreases after certain inflation levels, the adverse effects of additional inflation become more severe for economies with a large public size. The level of capital accumulation becomes another important conditional variable in the inflation–growth relationship, as shown by Ghosh and Phillips (1998). We test how different levels of trade openness, public finance and capital accumulation across countries influence their sensitivity

Given a growing theoretical and empirical consensus on the nonlinear inflation–growth relationship, the next task is to unfold the channels through which this nonlinearity occurs. This issue is important from the view point of policy making since a purposeful policy can be formulated only after a clear understanding of this mechanism. In this context, the theoretical studies mainly appoint at the role played by human and physical capital accumulation for explaining the dynamic response of output growth to inflation changes. The main thesis of this literature is that it is the factors' realignment and accumulation that makes the moderate inflation rate beneficial – or at least impotent – for growth. Moreover, the adverse effects of a high inflation rate also appear through these channels. For instance, if the initial level of the inflation rate is very low, a marginal increase in its level will decrease the real interest rate and ramp up physical capital accumulation and output growth. This effect is called the "Tobin effect". However, this Tobin effect only holds for initially low inflation rates. In the case of medium or high initial inflation rates, the signaling channel of price changes is badly affected and a resource misallocation impedes the accumulation of physical capital, i.e. a reverse-Tobin effect.

The opposite is true for the accumulation of human capital, at the lower levels of inflation rate; an upward marginal change in its level lowers interest rate and mainly favors physical capital intensity in the production process. The accumulation of human capital is not encouraged in this environment. When the inflation rate exceeds certain threshold levels, participation of workers in labor market decreases due to lower real wages; albeit, this lower opportunity cost of human capital increases its accumulation. This can also explain why the marginal cost of inflation reduces with its level. Our main task is to find the response of human and physical capital accumulation to changes in the inflation rate and to see if their inter-connections match with the inflation–growth nonlinearity. If the Tobin's positive effects of inflation hold for the accumulation of physical capital at a mild inflation rate and for the accumulation of human capital at a high inflation rate then the nonlinearity can be supported by the factors' realignment and their accumulation. It is important to note that a Tobin effect for both physical and human capital development essentially requires a well-developed financial system. For the human capital, a strong financial system facilitates the credit flow to agents for education purposes. We intend to see if the existence of a sound financial system determines the nature of relationship between inflation and capital accumulation.

The last objective of this thesis is to bring coherence between the empirical estimates of the optimal inflation rate and actual targets of central banks around the world. In fact, despite an overwhelming consensus of the recent research that the inflation–growth relationship is nonlinear for all developed and emerging economies, the threshold estimates largely differ between various income groups. Particularly, these estimates are alarmingly high for emerging countries while in reality the central banks of these countries prefer to keep their inflation rates in line with the developed economies. Certainly, an inflation threshold of 17 % is well above the preferred inflation zones of these central banks. The question then arises why this lack of coherence exists between the propositions held by researchers and the actual policy practices of central banks in these countries.

One possible answer to this question is that empirical literature uses macro-based models and investigates into the level of inflation where it starts retarding the overall GDP growth. Nonetheless, this macro-based analysis is in contrast with the New-Keynesian technology, used by the central banks of developed and emerging economies. In the New-Keynesian models, inflation is costly due to its adverse implications for the efficient resource allocation. The rationale behind the anti-inflationary stance of policy makers is the fact that inflation creates '*misperception*' for the producers and confounds the synchronization in their price and production changes (Lucas, 1973). This exacerbates the price and output growth volatilities across sectors. In this scenario, policy makers are interested to probe into the level of inflation which minimizes the sectoral dispersion of prices and output growth. It is due to these preferences that the central banks of inflation targeting countries respond more aggressively when their actual inflation rate goes beyond their targets. We address the optimal inflation rate from this micro perspective by estimating the inflation level which minimizes the uncertainties of sectoral prices and output growth. At the end, we see whether the adoption of a specific monetary policy regimes e.g., currency board versus inflation targeting of our selected economies, influence their price or output growth fluctuations. The proponents of both bi-polar regimes make their claims regarding the ability of these regimes in bringing macroeconomic stability. The validity of these claims can be tested by analyzing their success in reducing the sectoral price and output growth variability.

Methodology and structure of the thesis

To answer all of these questions, our thesis is divided into four main chapters. In the first chapter, we mainly discuss all of the major theoretical and empirical developments in the literature. Our second chapter aims at estimating the optimal inflation rate for a large panel of developed and emerging countries. We also analyze the role of macroeconomic conditions in determining the marginal effects of inflation on the long-run output growth. The third chapter analyzes the effects of inflation on human and physical capital accumulation and tries to explain the inflation–growth nonlinearity through the effects of inflation on the factors' realignment and accumulation. The fourth chapter addresses a lack of coherence between the optimal inflation rates of macro based models and the actual monetary policy preferences of central banks based on the New-Keynesian models.

In the first chapter, we start our discussion by presenting the temporal evolution of inflation and explaining how the later started posing problems to macroeconomic stability during the post-World War-II periods. We then describe the divergent stance of two main schools of economic thought (e.g., the Friedman rule versus the New-Keynesian economics) on the effects of a moderate inflation rate. Our particular emphasis is to understand why the negative inflation rate suggestions of the Friedman rule – to maintain a zero nominal interest rate – do not hold in the real world. The optimality of a negative inflation rate in the Friedman rule assumes the availability of non-distortionary taxes for public revenues. Given that non-distortionary taxes are not available, Ramsey taxation (1927) calls for the optimality of positive inflation rates for governments' budgetary requirements. Moreover, we survey the main theoretical arguments behind price and wage rigidities and complementary empirical evidence from different countries. That said the presence of these nominal rigidities together with the frequent occurrence of supply shocks justify the view point of New-Keynesian economists, detailed formally by the DSGE models. We describe the chronological advancements in the DSGE modeling framework, their basic structure and, more importantly, their suggestions on the optimal inflation rate. The empirical evaluation of these models has also been discussed. The literature uses both the simulation method, by using the parameter values of different macroeconomic variables, and more recently, the estimation method in a Bayesian VAR framework. Lastly, a brief discussion of the welfare cost of inflation allows us developing the case of moderate inflation rate against both the complete price stability and high inflation rate.

In Chapter 2 we address the question of the inflation–growth nonlinearity and estimate the level of inflation that maximizes the growth of per capita income. To proceed, we first discuss the main theoretical and empirical research on this issue. This helps us understanding the main theoretical linkages and empirical deficiencies of the previous studies. The major problem of the previous research on this subject is the econometric treatment of the inflation–growth nonlinearity. We address this problem by applying a PSTR model. The main advantage of this technique is that it permits an endogenous determination of the threshold points of the inflation rate and other conditional variables. Moreover, the PSTR model estimates time and country specific threshold rates, making it possible for a country to change its place over time.

Despite these potential advantages of the PSTR model, the estimated results can be affected by endogeneity problem. In fact, the endogeneity is a potential problem of the growth regressions due to a country-specific correlation between the dependent variable and the right side covariates. To discard any such influence on our estimated results, we conduct a robustness analysis by using an instrumental variables two stage least square (IV-2SLS) model. We also take into account the remarks made by Ghosh and Phillips (1998) and discuss the role of three macroeconomic conditional variables; namely, trade openness, public finance and capital accumulation, in influencing the sensitivity of the inflation–growth relationship. Our results complement the recent literature on inflation–growth nonlinearity and acknowledge a crucial role of macroeconomic conditions in determining the sensitivity of inflation effects on long-run economic growth.

After testing for the presence of the nonlinear inflation–growth relationship in Chapter 2, the subsequent chapter tries finding a possible mechanism to explain this nonlinearity. In the first step, we develop theoretical arguments and try to draw some parallels between the inflation–growth nonlinearity and the possible effects of inflation on human and physical capital accumulation. A substantial amount of theoretical literature explains how inflation could possibly influence the agents' decision for investing in human and physical capital accumulation. Some limited numbers of empirical studies can also be found for a complementary support on this issue. Given that human and physical capital accumulations are jointly determined, the OLS method could be criticized for its biased and inconsistent results. To avoid this possibility, we again use an IV-2SLS estimation technique. In the next step, we test if the effects of inflation on human and physical capital accumulation remain same at all levels of the inflation rate. This task is handled by a rolling regression method which is frequently used technique in recent growth literature for studying the nature of functional relationship between the two variables. We also test how the magnitude of the Tobin or the reverse-Tobin effects on human and physical capital accumulation depends upon the financial development of a country. We mainly find some robust and nonlinear connections between inflation and the two types of capital accumulation and also identify the relevance of financial development in altering the magnitude of these relations. These results are strikingly consistent with the previous chapter's findings and help us comprehending the channels through which inflation influences the long-run output growth.

In Chapter 4, we reexamine the question of optimal inflation rate from a micro perspective. Indeed, the nonlinear inflation–growth relationship supports the optimality of a moderate positive inflation rate. The threshold levels of inflation rates are, albeit, different than the actual preferences of policy makers. As mentioned earlier, policy makers rely upon the New-Keynesian DSGE models and decide about the level of inflation keeping in view the allocative efficiency. We analyze the effects of inflation on relative price variability and sectoral output growth variability for both developed and emerging economies. Since the question under investigation remains consistent with the previous chapters, our econometric techniques are also similar. In the first step, we test the effects of inflation on relative price variability by using the fixed effect and IV-2SLS models. Economic theory also identifies separate role of expected and unexpected inflation rates in influencing relative price variability across sectors.

For a nonlinear analysis we use the rolling regression model to identify the level of inflation that minimizes the sectoral price disruption. Given that our selected list of countries includes bi-polar monetary regimes, namely, the inflation targeting countries versus currency board economies, we test the ability of these regimes in appeasing price variability. To do this, we conduct some country-specific rolling regressions and report systematic differences in the two regimes in regards to their ability for controlling relative price disruptions. In the second step, we repeat the same exercise for sectoral output growth variability. The threshold inflation rates for the sectoral growth variability are estimated by using a PSTR model. Our estimated results in both of the cases support a strong impact of inflation on relative price variability and output growth variability. On the whole, the *grease* effects of inflation are supported here as well since our results show that a positive inflation rate is required to minimize the price and output growth variability. One particular finding is the choice of exchange rate regimes for emerging economies. Our results offer an interesting trade-off between real and nominal uncertainties. If nominal price variability is well controlled by a specific exchange rate regime, output growth variability can be better tackled by the other.

All in all, with regards to our main question of the optimal inflation rate, both micro and macro level findings support a moderate positive inflation rate. The particular level of this inflation threshold is certainly determined by countries' income and other economic and political institutions. Specifically for the emerging economies, the micro level analysis, which supports lower inflation thresholds than the macro based results, helps understanding policymakers' reluctance for excessive money growth.

Chapter 1 Review of Literature

1. Evolution of inflation over time

It has been mentioned by several authors (e.g., Reid et al., 2012: Haslag, 1997) that until few decades back inflation was not considered a serious threat for economic growth. In contrast, several countries were experiencing deflation before the beginning of 20th century. Though the use of paper money for the transactional purposes has a long history, its excessive creation was only confined to periods of wars and uncertain times. In normal times of economic activity, currency creation had been fully backed by Gold and U.S dollars and there was no incident of persistent inflation. After the collapse of Bretton Woods systems, countries started to inflate for their fiscal requirements. Reid et al. (2012) describe the journey of inflation over the last several centuries. In the following graphs, the authors show a slow evolution of prices until the start of last century and one could notice only a few episodes of high inflation in the world.

Figure 1-1Evolution of prices over time (Source Reid et al., 2012)

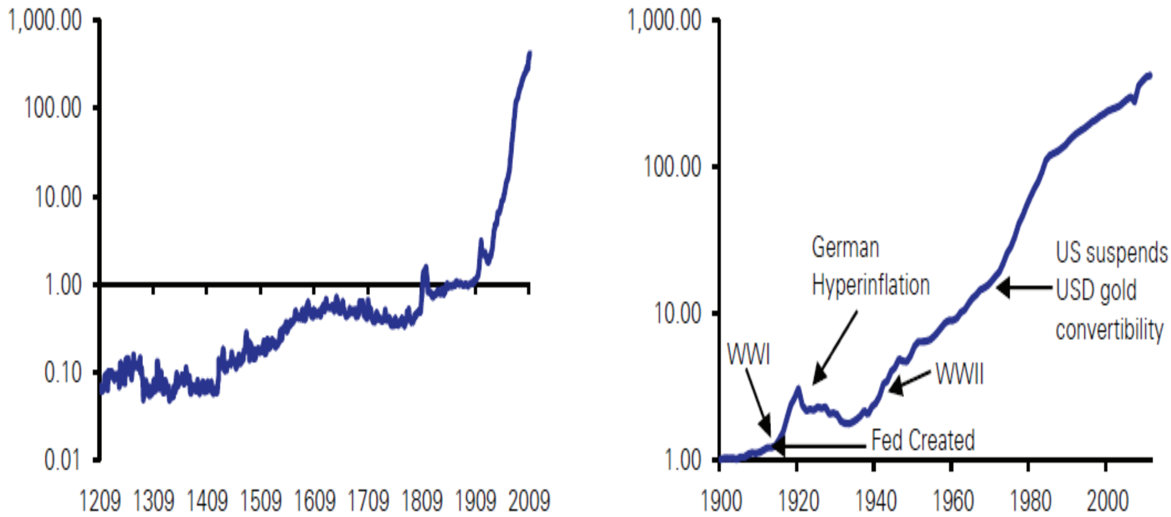
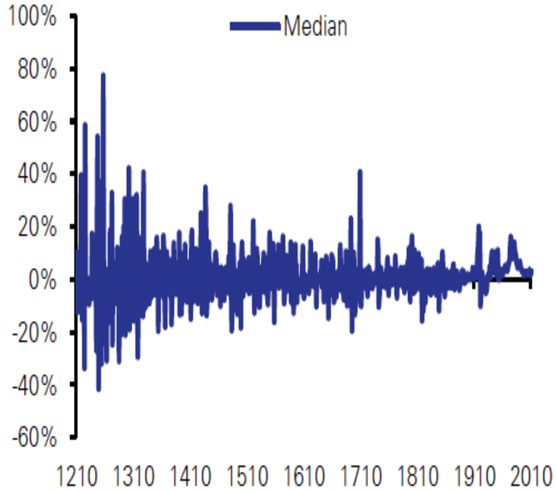


Figure 1-2 Evolution of Inflation over time (Source Reid et al., 2012)



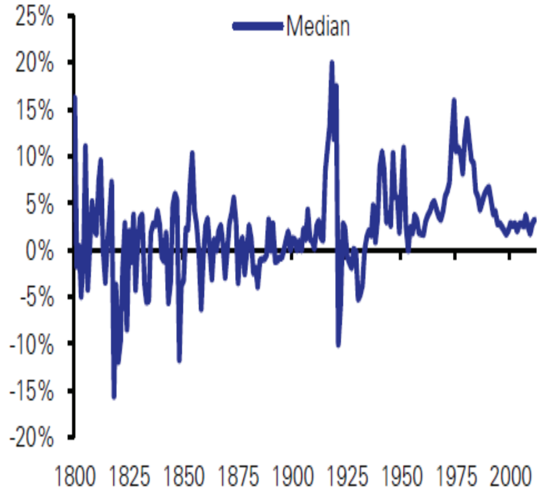


Figure 1.a shows the overall evolution of prices since 1209 (left) and 1900 (right). Similarly, the yearly inflation changes have been reported in Figure 1.b. As can be noticed from Figure 1.b, prior to the 19th century deflationary episodes were as frequent as the high inflationary periods. If we leave aside the periods of World War I and World War II, this trend continued until the periods of 1970s. Table 1-1 shows the decadal average of inflation and output growth for the panel of developed and emerging economies that we use for our empirical analysis in Chapter 2. Average inflation rate observed an upsurge over the decades of 1970s and 1980s, followed by a reduction to its level of 1960s. From 1970s afterwards, the average output growth was inversely related to the inflation rate for the whole period.

Similar observations were reported by Haslag (1997) where the authors explains that the pre World War II history showed bouts of inflation followed by temporary deflation. Inflation was expected to rise at the time of boom and fall during the recessionary periods. However, there was no persistent behavior of inflation or deflation in the world before the WW-II. A sudden change in the inflation behavior, starting from early 1970s has been explained by the fact that money creation by central banks had no proportional backing of Gold or the U.S dollar for the post Bretton Woods era. Moreover, weak financial market regulations of the private financial institutions also fuelled this process. As inflation was not a serious problem in the pre-World War II era, economic theories also did not focus on analyzing the real effects of inflation.

Table 1-1 Decadal Summary Statistics on inflation, Growth

(Five Year Average: 1963-2012)

Variable	Mean	Standard Deviation	Minimum	Maximum	No. of Observations
1963-1972					
Inflation Rate	1.6342	0.6985	-0.1533	5.4257	146
Growth Rate	0.0317	0.0325	-0.0512	0.1794	185
1973-1982					
Inflation Rate	2.6275	0.6186	1.1035	4.9287	164
Growth Rate	0.0179	0.0321	-0.0889	0.1349	192
1983-1992					
Inflation Rate	2.3179	1.2442	-1.4945	6.9266	185
Growth Rate	0.0101	0.0296	-0.0895	0.0897	194
1993-2002					
Inflation Rate	1.8651	1.0508	-1.0164	7.0931	194
Growth Rate	0.0138	0.0236	-0.0802	0.0974	197
2003-2012					
Inflation Rate	1.6584	0.7408	-0.1973	6.9069	197
Growth Rate	0.0207	0.0235	-0.0771	0.1044	197

Note: The data set includes 100 developed and emerging economies. Number of observations is based on 5-year average frequency, consistent with our analysis in Chapter 2.

As an illustration, early classical and Keynesian economists hardly believed in the ability of inflation to inflict any damage on the output growth. Consequently, most of the empirical and theoretical literature is based on the post World War II period. The contemporaneous economic studies showed diverse effects of inflation on growth with some papers indicating a positive effect while the other supporting a negative effect of persistent inflation on growth. Mundell (1963) was the first study supporting a positive impact of inflation on growth. To Mundell, inflation reduces the real wealth of agents, forcing them to save more which diminishes the real interest rate. Output growth increases following a rapid capital accumulation and low interest rate. Tobin (1965)'s neo-classical model reports similar results where one time inflation enhances the accumulation of capital due to its effects on portfolio management. Tobin assumes that agents' capital portfolio composed of both real balances and physical capital. When the inflation rate goes up, they substitute money for the capital good. This consequently increases the capital stock and output growth in an economy. However, Tobin argues that these positive effects of inflation on growth have only temporary effects and a persistent high output growth can only be observed from technological innovations. Friedman (1969) casts some serious doubts on the direction of these positive effects of inflation on output growth. Friedman argues that inflation restrains output growth at its all positive levels and therefore must be avoided altogether. This view was empirically supported by some high-inflation episodes during the early 1970s which were followed by lower growth in the developed economies. This was the time of stagflation and a burgeoning literature started questioning the – then well accepted – Phillips curve relationship.

Here we discuss some major theoretical and empirical advancements of the literature which can be mainly divided into two branches; Friedman rule versus the new-Keynesians. We analyze their views on the cost of inflation and their suggestions regarding the optimal inflation rate. We are also interested to examine how a mild inflation rate and not a negative inflation rate of Friedman is the feasible option for central banks that face real world rigidities.

2. On the optimality of the inflation rate: Friedman versus New-Keynesians

2.1. Friedman Rule

Friedman rule (1969) suggests a negative inflation rate for a zero nominal interest rate. As marginal cost of producing money is almost zero, any positive interest rate decreases the transaction demand of money.[3] Agents prefer to keep lower amount of liquid assets in monetary form to benefit from this positive interest rate. This consequently represses transaction demand for money and raises the price of consumption services from its socially optimal level and therefore causes a welfare loss in the economy. Therefore the optimal inflation rate is found to be

[3] Lacker (1996) calculates manufacturing and operating costs for coin and currency of approximately 0.2% of face value.

negative for a zero nominal interest rate. To support this view, Friedman conjectures that an active monetary policy that focuses on the current inflation rate is unsuitable since any changes in the monetary policy would affect the inflation rate after one lag. Monetary policy that focuses only on the expected inflation can also contain errors because policymakers will rely on the estimated structural relationships linking monetary policy to inflation (e.g., IS, LM and Phillips curve relationships). The policy actions based on these structural relationships will be misleading. The welfare analysis of Friedman (1969) proposes an increase in the money supply of around 2% for the U.S economy that undergoes an average output growth of 3-4% per annum.

2.1.1. Friedman rule under first best taxation

In fact, the negative inflation propositions of Friedman rule do not consider the role of inflation to finance public expenditures. A basic reason behind this view is that all types of taxes are assumed to be non-distortionary, and a representative government does not depend on seigniorage revenues for its public expenditures. This assumption is denoted as 'first best taxation' in the subsequent literature. Various studies have tried to probe into the existence of first best taxation and the robustness of Friedman's optimal inflation rate propositions under the rejection of this assumption. To support the presence and feasibility of the first best taxation, Friedman (1971) states that although a positive inflation rates may help a government to meet its expenditures by taxing the cash balances yet they repress the other tax collection; resulting in no additional resources for the economy. To get these results Friedman uses the following money demand function:

$$m^d = f(y, g_p) \tag{1}$$

Here m^d is per capita demand for real balances (e.g., $m = M/PN$ with P = Price level and N= Population) whereas y stands for real income per-capita and g_P is rate of price change – both actual and anticipated. Seigniorage tax comes from two sources in the model: a tax on the existing cash balances; and provisions of additional cash balances that are demanded when income rises. The author shows that although inflation increases the tax revenue from the first source it diminishes the revenue collection from the second source rendering the positive inflation rate sub-optimal. Friedman assumes two different cases regarding the state of an economy, a stationary level and a growing economy. In the first case, the stationary economy with zero population and income growth rates and a policy maker who aims for maximizing the revenues from inflation will select value of g_P where the elasticity of real per capita demand for money balances with respect to price changes is one:

$$g_P.\frac{d\log m^d}{dg_P} = \eta m g_P = -1 \qquad (2)$$

Similarly, for a growing economy, the optimal inflation rate is further lower since with an increase in the income level, seigniorage revenue collection reduces with inflation. As general price level increases, income velocity also increases which results in lower additional revenues from inflation.

Friedman (1971) does not include interest rate in the money demand function, though the author acknowledges the fact that inflation alters the interest rate and money demand. Lucas (1994) uses the ratio of real balances to consumption as a function of nominal interest rate to examine how this ratio responds to marginal interest rate changes at its very slight positive rates. Using these specifications the calibrated results of the U.S economy show that while moving the inflation rate from zero percent to Friedman's (deflation) rule, consumption increases substantially. Moreover, the demand for real balances increases to infinity when nominal interest rate approaches to zero. In Wolman (1997) model, money economizes the transaction time of the agents and therefore agents prefer to hold a greater quantity of real balances to save their time. The welfare analysis indicates that with a reduction of the inflation rate from 5 percent to Friedman rule, income level will increase by about 0.6 percent. However, both these studies assume the availability of lump-sum taxes to get these optimal inflation rate results.

Some recent studies reasoned that the first best results of Friedman rule are subject to certain assumptions about the inter-temporal resource transfers. To illustrate, Bhattacharya et al (2005) explain that both infinitely lived representative agents' models and overlapping generation (OLG) models come up with divergent policy prescriptions regarding the optimal money supply. The authors note that a basic difference between the two modeling frameworks is that in the overlapping generation models, the monetary regimes channelize intergenerational transfers involving money. This intergenerational wealth transfer influences savings and capital intensity in the OLG setup and increases capital gains following unexpected reductions in the money growth. This undermines the optimality of the Friedman rule. In the infinitely lived representative agent models, by contrast, inflation does not exert any re-distributional effects and therefore Friedman rule is optimal in the presence of first best taxation (see also Abel, 1987).

Similarly, in the theoretical literature, the optimality of Friedman has been analyzed under different assumptions about the role of money. These models include economies where money is used as a final good in the utility function. The utility function of an infinitely lived household is mentioned in the following way:

$$\sum_{t=0}^{\infty} \beta^t V(c_t, \frac{M_t}{P_t}, h_t) \tag{3}$$

where c_t, M_t, P_t and h_t represent respectively consumption in period t, money balances held from period *t* to period *t+1* and leisure in period *t*. A second type of modeling arrangement requires real balances to purchase at least one good, usually the consumption good. This cash-in-advance constraint is represented in the following way:

$$p_t c_t \leq m_t \tag{4}$$

The literature shows that the optimality of Friedman rule varies in these modeling arrangements (Gahvari, 2007). The author observes that in an OLG framework and in the presence of non-distortionary taxation, both MIUF and CIA models recover the optimality of Friedman rule though this optimality is not a unique outcome in the CIA model. This is because opportunity cost of holding money is different in two types of modeling arrangements. In the MIUF model, for instance, money growth influences the value of real balances that explicitly appear in the utility function. This change does not confer any direct influence on relative prices of intertemporal consumption goods. On the contrary, in CIA models, money growth influences the intertemporal relative prices of consumption goods – same like the other commodity taxes. In this scenario, obtaining the optimal inflation rate in the MIUF models requires two undistorted prices – no distortionary commodity taxes and a zero nominal interest rate – to characterize the first best. On the other hand, the first best in the CIA models can be obtained by only one undistorted price, that is, relative prices of intertemporal consumption goods. As central banks have two instruments, commodity taxes and the rate of money growth, the first best taxation can be obtained by using a wide range of combinations of these two instruments.

2.1.2. *Friedman rule under second best taxation*

As can be drawn from the above discussion, Friedman supports a zero inflation tax in the presence of lump-sum taxes. This is at odds with the fact that almost all of the central banks around the world generate revenues from seigniorage taxation.[4] Indeed, the optimal inflation rate propositions of Friedman (1969) have also been criticized on several grounds. The most important criticism has been raised by Phelps (1973) who argues that when lump-sum taxes are not available and a government is forced to raise a specific amount of revenues through distortionary taxes (such as income tax), the optimal inflation tax becomes non-negative. Phelps uses Ramsey (1927) taxation framework where consumption taxes are imposed in such a way that tax rate on a particular commodity is inversely proportionate to price elasticity of demand for that good. Phelps further notices that Friedman rule does not include consumption and labor supply functions in the analysis. Therefore, the role of taxes for influencing consumption and labor supply decisions is missing. Using a differential taxation approach (e.g., by keeping the total tax constant and replacing one type of tax with another) the author shows that the optimal inflation tax is positive. To illustrate, Phelps takes following money demand function:

$$M/p_{\circ} = L(Y, r_k + \pi, K + D/P) \qquad (3)$$

Here $r_k + \pi$ is the nominal interest rate, K is the capital stock and D/P is the outside wealth in the model. In the given money demand function: $d(iM/P)/\pi > 0$ if demand for real balances is interest rate inelastic, Phelps argues that this inelastic liquidity demand in the neighborhood of zero inflation rate supports a positive inflation rate to be optimal. Further this positive inflation creates a wedge between social marginal cost of producing money and its marginal valuation which is interest rate. This further helps agents to divert resource from consumption to capital accumulation, causing high output growth in inflation. Helpman and Sadka (1979) also support the second best taxation by positing that it gives policymakers an opportunity to finance public expenditures via an interest-free seigniorage and also enables government to control its expenses by lowering both the real values of interest rate and principal amount of public debt.

The second best taxation of Phelps has been supported by several theoretical studies under different assumptions. Barro (1987) posits that inflation tax may be the only way of revenue collection in an underground economy. Mankiw (1987) argues that as marginal social

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[4] Click (1998), in a large cross-section of countries, observes seigniorage revenues as a percentage of GDP ranged from 0.3% to 14% and as percentage of government spending ranged from 1% to 148%.

cost of revenue collection is increasing in the world of distortionary taxes, revenue collection must be made smooth over time. The smoothening of tax revenues makes them a random walk and when this principal is applied on seigniorage it implies that both inflation and nominal interest rate must be kept smooth as well. The smoothening of both these series means that they take positive values in some cases while negative in the others. To get some empirical evidence on this assumption, Mankiw tests whether money growth, inflation and nominal interest rate vary with government revenue requirements. The empirical results for the U.S economy show a positive impact of government revenues collection on interest rate and inflation (see also Romer, 1993).

Some other evidence on the optimality of a positive inflation rate in distortionary tax environment includes Siegel (1974) and Stiglitz and Dasgupta (1971). Drazen (1979) notices that the results of all this literature are based on partial equilibrium framework and changes in the inflationary taxation only affect the demand for money, leaving aside the overall welfare effects of inflation. Although Phelps (1973) and Siegel (1974) claim that their results are valid for the general equilibrium framework under distortionary taxation, Drazen shows that these results are only one among several possibilities; and not the only one. The general equilibrium framework gives a package of policy rules where it is possible to experience a negative interest rate in some cases. It takes resources out of capital which increases the marginal product of capital. In a unit elasticity of money demand case ($E_{M^d} = -1$), an increase in inflationary tax will not decrease other distortionary taxes and the optimal level of inflation tax does not deviate from the Friedman rule.

Somewhat consistent results to the above have been shown by Kimbrough (1986.a) where the Friedman rule is optimal in the presence of distortionary taxes. The author uses a shopping time model where money helps consumers for their transaction purposes. Theoretical analysis of the study shows that when inflation exhibits an increasing transaction cost, the slope of Phillips curve becomes positive and this results in both production and employment loss for an economy. That said, in high inflation environment, consumption of all goods (including leisure) decreases. Decrease in leisure is the result of more transaction time spent during high inflation. The solution to the consumer program shows that taxing money à la Phelps (1970) is not an efficient solution to deal with government budget problem since it causes more losses to consumer welfare, compared with the normal goods taxation.

Faig (1988) tests and compares the welfare implications of inflation tax and other distortionary taxes in a shopping time technology. This transaction technology explicitly includes money in the transaction function $F^{h}(M^{ht}, C^{ht}, p^{t})$. Here M^{ht} is the amount of money that individual *h* has to spend in period *t*, C^{ht} is a vector of goods to be purchased at prices p^{t}. The opportunity cost of the time spent on transactions is the leisure forgone. As money enters in the transaction function, it assumes the character of an intermediate good and the Diamond and Mirrlees (1971) taxation rule of intermediate goods taxation excludes the possibility of inflationary finance. The optimal inflation rate is, therefore, zero despite the presence of distortionary taxation. The author shows that a positive inflation rate is optimal only if the transaction technologies are increasing returns to scale in the shopping time model.

These results were supported by the subsequent literature under various assumptions about the role of money. Kimbrough (1986.b) takes a case of MIUF model and observes that the Friedman rule is optimal if the consumer preferences are homothetic in money and the consumption good and weakly separable in leisure. Chari et al. (1996) extend this work and use different models: a cash-credit model, a MIUF model and a shopping time model to test the optimality results of Kimbrough under different economic settings. The author shows that both homotheticity and separability justify the optimality of Friedman rule in all of these cases. Moreover, these conditions of homotheticity and separability are important as they make some connections between the Friedman rule and the intermediate good taxation in all three monetary economies. Correia and Teles (1996) support the Friedman rule in a second best environment where the inflation tax induces time distortions in transaction process. Unlike Faig (1986) when Friedman rule is optimal for a transaction function which is homogenous of degree greater than one, the authors get these results for the homogeneity of all levels.

Woodford (1990) shows that Kimbrough (1986.b)'s results are fundamentally based on the assumption that money is used in the transaction process and agents optimize its use for this purpose. Woodford shows that this assumption is incorrect since in the same shopping time model, the Friedman rule is sub-optimal with different technologies. Precisely, the author classifies the implications of the Friedman rule into two theses for its general validity. In its weak form, the Friedman rule states that there does not exist any asset whose returns exceed the return of money. A strong form of this rule implies that the growth rate of money supply should be set negative to make the nominal interest rate zero. The study shows that the weak form of the Friedman rule is generally valid while its strong form is valid only under some specific conditions. A certain types of market imperfections have been shown to suffice the invalidity of Friedman rule. To summarize the above discussion, the theoretical literature on optimality of Friedman rule presents some conflicting results regarding the optimal inflation rate. Below we study the role of nominal rigidities and examine how they influence the optimal inflation rate.

2.2. Nominal Rigidities: the New-Keynesian Perspective

The above discussion shows that monetarists do not believe in the growth enhancing effects of a positive inflation rate. However, this is not a consensus view in the literature. The New-Keynesian economists support a positive long-run Phillips curve relationship between inflation and growth for a moderate level of inflation. Several empirical studies report these desirable effects of inflation on the long-run growth. Based on this robust support, Blanchard and Fischer (1989) noted: "*Most economists who came to accept the view that there was no long-run trade-off between inflation and unemployment were more affected by a priori argument than by empirical evidence*". Graham and Snower (2008) present a large survey of empirical literature that supports a positive long-run Phillips curve relationship for the post-world war II data set.

The New-Keynesian models focus on providing micro foundations for the key Keynesian concepts e.g., inefficiency of aggregate fluctuations and market rigidities – price and wage rigidities – and their implications for the conduct of monetary policy. The literature on the nominal rigidities cannot be strictly restricted to the Keynesian economics since some early analysis of Hume (1752) also note that due to slow adjustment of prices an increase in money stock influences real output growth after some lags. This is because the real effects of changes in the money supply are not immediately dispersed in the economy. As price changes are sluggish in the short-run, any changes in the money supply entail real effects on output and employment (see also Lucas, 1996). Given this long historical belief on the importance of real rigidities, a general consensus exists that in the presence of the real world rigidities, a sluggish response to monetary policy changes will provide a policy space for the monetary authorities for increasing output growth in the short-run.

Hume explains this phenomenon in the following way, "*When any quantity of money is imported into a nation, it is not at first dispersed into many hands but is confined to the coffers of a few persons, who immediately seek to employ it to advantage. Here are a set of manufacturers or merchants, we shall suppose, who have received returns of gold and silver for goods which they* *have sent to Cadiz. They are thereby enabled to employ more workmen than formerly, who never dream of demanding higher wages, but are glad of employment from such good paymasters. [The artisan] ...carries his money to the market, where he finds everything at the same price as formerly, but returns with greater quantity and of better kinds for the use of his family. The farmer and gardener, finding that all of their commodities are taken off, apply themselves with alacrity to raising more...It is easy to trace the money in its progress through the whole commonwealth, where we shall find that it must first quicken the diligence of every individual before it increases the price of labour." (p. 38*)"

To further illustrate, a tight monetary policy to control inflation will not result in lower wages since working class do not accept reduction in their nominal wages. As a result, the optimal inflation rate becomes higher than the Friedman rule. In fact, far from the negative inflation prescriptions of Friedman, some recent monetary models including Faia (2004) oppose any strict inflation target as a policy rule. Faia presents a model with sticky prices, matching frictions and real wage rigidities. Matching frictions, in addition to the other rigidities – detailed below – can result in excessive vacancy creation and unemployment, depending upon the share of surplus distribution among labors and firms. Monetary policy, under these conditions, is expected to target unemployment and/or vacancies to avoid variation in the labor market. This develops a conventional unemployment/inflation trade-off and the optimal monetary policy becomes the one which focuses on unemployment targeting, instead of strict inflation targeting objectives of the New-Keynesians.

Another important characteristic of the New-Keynesian models is that with the incorporation of downward nominal rigidities, these models yield a nonlinear Phillips curve relationship between inflation and output growth. This asymmetric Phillips curve implies that positive inflationary shocks increase the inflation and output gap more quickly than the negative shocks of same intensity. For instance, Cover (1992) shows that the positive demand shocks increase inflation more than output whereas the negative ones do the reverse. This particular phenomenon also contains some strong implications for the optimal monetary policy rules. Dolado et al. (2003) show that a monetary policy-maker should increase the interest rate by a larger amount when inflation or output is above its target rate than the amount he will lower when these variables are below their target. In short, the nominal rigidities exert a certain influence on the conduct of monetary policy. Discussion below tries to analyze how different nominal rigidities have been incorporated in the macroeconomic literature and focuses on their implications for the welfare cost of inflation.

2.2.1. Price rigidity and the optimal inflation rate

Theoretical Literature

As mentioned earlier, the negative inflation rate of Friedman (1969) did not get any practical support since in policy debates of central banks around the world it is widely believed that a complete price stability obstructs the efficiency of price system when the economy is open to supply shocks (see, for example, Edey, 1995). Moreover, the opponents of zero inflation rates argue that sectoral shocks call for price adjustment and a complete stability will cause price or wage reduction for some firms and increase them for the others to ensure adjustment. In other words, downward price and wage rigidities inhibit the adjustment of shocks in stable price environment while in high inflation regimes, by contrast, this adjustment takes place even if all nominal prices (wages) are increasing (Andersen, 2002).

In the theoretical literature, the nominal price rigidities have been generated by a variety of models. Mostly, nominal rigidities come from information problems, pricing points, fair pricing, implicit coordination and adjustment costs, among other factors. To illustrate, models with information problems get motivation from Lucas (1972) misperception theory where individual firms are less informed about the aggregate shocks and do not change their prices immediately to respond these shocks. Mankiw and Reis (2002) develop a costly information model where firms are not always updated about the factors that affect their optimal prices because doing so requires permanent expenditures on information gathering. At a given point in time, a fraction of firms update their information about the new pricing strategy while the others use previous knowledge to set the next period prices.

Pricing points theory, propounded by Kashyap (1995), states that firms set prices equal to specific values even if the optimal price differ from these numbers. The author names them as pricing points and note that they usually end up in a nine. For example, the firm will charge 5.49 when the optimal price is 5.51 or 5.47. The impact of this strategy is that pricing points have a larger duration than the other prices. Some time-specific elements are also influential in the price setting. For instance, the frequency of price changes is higher than the average in the beginning of calendar year than in December. All of these aspects of price rigidity have been observed by the empirical consumer price data of monthly or quarterly frequency (see Dhyne et al. 2009, for a literature survey).

Fair pricing theory developed by Rotemberg (2005) links price changes with consumers' anger. The author conjectures that consumers analyze price behavior of firms from the view point of fairness. Any unjustified price changes are panelized by not patronizing the firm in future. This fairness factor restrains firms to change their prices frequently even if it is justified in some cases. Nevertheless, in high inflation environment, as consumers are observing the overall price changes and they don't consider it unfair when individual firms change their prices, it becomes easier for firms to change prices frequently and, therefore, price rigidity obliterates in inflation.

Another factor behind price rigidity is that it appears from firms' effort to get information (Ball and Cecchetti, 1987). Precisely, firms prefer to keep their prices in line with the other firms. Keeping this preference in view, they get maximum information about price changes of the other firms. If all of the price changes take place simultaneously, each firm has ambiguities about these changes because it does not know the adjustment made by the other firms. Hence, each firm prefers to wait and see the magnitude of other firms' changes. This tendency among firms makes a uniform distribution of price adjustment dates. In this situation price staggering turns out to be an equilibrium outcome and it is socially optimal despite being attached with high output fluctuations. This idea was originated by Okun (1981) in the context of wage adjustment. Okun argues that firms' curiosity about their relative wages accompanied by their ignorance about the other firms' plan leads to a wage staggering. The author conjectures:

"[T]he inability of firms to assess relative wage prospects would destabilize the synchronized situation. Every employer would like to make a decision in full light of decisions that others had made, but would also like to respond promptly. So an employer would want to move a bit behind the schedule followed by the others. As a result, some employer would decide to shift the wage adjustment date to February 1, in order to observe what all of the other employers had done. Others would also want to make such a move, but obviously everyone cannot exercise the preference to bat last. The likely result of this 'time-location' problem is analogous to that of some spatial location problems. It generates a tendency to spread the distribution of wage adjustment dates around the calendar." (p. 95)

The most pertinent and widely discussed factor behind the nominal price rigidity is menu costs of price changes.[5] This idea is basically originated from the work of Tobin (1972) where the author supports the role of a positive inflation rate in reducing the unemployment through sectoral reallocation. On the basis of Tobin's support for the high inflation rate, Sheshinski and Weiss (1977) formally developed a theory of optimal price adjustment for anticipated inflation when fixed cost of price adjustment is involved. The authors take the case of a monopolistic firm that faces a fixed cost of price adjustment. The study examines how an expected rate of inflation influences the frequency and magnitude of price changes. In the presence of adjustment cost, firm uses (s, S) pricing rule where the prices are adjusted only if inflation lowers the real price to s. The results show that inflation increases the gap between the two price bounds while the effects of inflation on the frequency of price adjustment are ambiguous. A larger gap between the two price bounds could affect the consumer welfare. As the actual prices remain lower than the average prices before a price change period and higher than the average in the period following price changes, consumers observe a welfare gain in the first period and a loss in the later period.

Danziger (1988) analyzes the net welfare gains and losses of a slight positive inflation rate that incur to consumers as a result of this price rigidity. The author shows that a slight positive inflation rate, which causes infrequent price changes, is welfare maximizing. The reason is that while a price increase after the adjustment period is slightly higher than average prices, the overall price of the whole period is lower since price reductions in the later periods are larger in magnitude than the earlier period's increase. Therefore, a slight positive inflation rate is preferred over a complete stability as it yields a larger consumer surplus.

In the literature on nominal price rigidity, an important distinction has been made between price rigidity and price stickiness. Prices are sticky if they do not change regularly. They are rigid when a change in demand or cost is not fully transmitted to prices. Price stickiness does not have strong policy relevance whereas price rigidity can influence the optimal inflation rate. Menu costs theory, when analyzed in this context, does not provide any prima-facie evidence of downward price rigidity since this cost applies to both downward and upward price rigidity. Tsiddon (1991) takes this issue at the firm level and tests whether menu costs do imply qualitatively different responses to price increases and decreases of expected inflation. The author finds that downward price rigidity exists in the presence of menu cost. The results note that while during inflationary times a firm may resist increasing its price, in case of deflation it

[5] Some other reasons behind the price rigidity include strategic interaction among firms where an individual firm's decision to change prices depend upon its competitors (Anderson, 1994).

will increase its own price. This happens when the firm faces no prior commitment about price changes and when price setter knows that real price will go down rapidly in the expected low inflation environment. In this case, the future benefits of increasing prices exceed the immediate losses. This strategy, when adopted by majority of the firms, generates downward price rigidity. The results are generalized by Peltzman (2000) for a large number of producers and consumers goods under low inflationary environment.

This micro behavior of firms has been aggregated by Caballero and Engle (1989) and Caplin and Leahy (1991) to see whether it translates into an overall price rigidity at economy level. In fact, the earlier literature that connects micro level rigidity with aggregate price rigidity assumes external timings of price adjustment. In Caplin and Leahy (1991) price adjustment is endogenously determined and timings of these price changes can be affected by monetary shocks. The authors opine that large monetary shocks can reduce time interval between successive price adjustments which appeases price rigidity in inflation. The assumptions of initial uniform distribution of firms' prices and endogenous timings of the price stickiness cause relative price adjustment across firms with no aggregation at economy level.

Nevertheless, these results did not go unopposed in the literature. A competing view states that firm level price rigidity essentially translates into industry level rigidity (Bhaskar, 2002). Bhaskar argues that as price rigidity comes from implicit coordination among firms within an industry, a strong coordination among firms creates an environment where they increase prices after a positive demand shock while resist price reductions after a negative shock. The presence of 'menu cost' forces firms to keep downward price rigidity at the industry level. This also results in multiple equilibriums at industry level where output only responds to positive inflationary shocks. This asymmetric behavior of prices at industry level further implies an asymmetric behavior of output adjustment to demand shocks at the economy level. Regarding the optimal inflation rate, the simulation results of the study show that inflation inhibits this price asymmetry and output loss; although the effect is not so large. A more elaborated analysis of the optimal inflation rate has been provided by Anderson (2002) where, in equilibrium, economic activity responds to inflation in the following way:

$$\frac{\partial x}{\partial \pi} \geq 0 \quad \text{and} \quad \frac{\partial x}{\partial \pi} \to 0 \text{ for } \pi \to \infty \qquad (4)$$

Here x represents the economic activity. The effects of inflation on the economic activity are nonlinear. Up to certain points higher inflation leads to a higher economic activity, consistent with the findings of Tobin (1972). This relationship ensures the optimality of a positive inflation rate. A zero inflation rate is opposed on the grounds that it strengthens the price rigidities in an environment where adverse supply shocks require frequent price changes.

Empirical evidence

The theoretical literature shows that nominal rigidities exist in the output markets and optimal inflation rate, under these rigidities, is higher than the Friedman rule. These findings of the theoretical literature have laid foundations to a sizable empirical literature that probes into the existence of price stickiness and downward price rigidity for different countries. This literature uses different types of data sets e.g., consumer price data, producer price data and survey studies by using firm based information.[6] These various categories of data set provide micro-foundations for developing the empirical price setting models of different economies. For example, on the consumer price data, a seminal paper has been developed by Cecchetti (1986) for the U.S. The author takes the data of newsstand prices of American magazines and tests the presence of a gap between the overall price changes and magazines' price. Furthermore, the study also investigates into inflation dependence of the frequency of price changes. The main findings support price stickiness since nominal prices decrease by one quarter before the implementation of fixed price change. The degree of price stickiness, however, diminishes with the rate of inflation. This indirectly supports a moderate inflation rate in the presence of downward price rigidity.

Several studies in the last two decades have tested robustness of these findings for a large number of countries. Baudry et al. (2004), for instance, test consumer price rigidity for France based on 13 Million observations of price records that are used for CPI calculation. The results show that on average price changes of 8 months interval and this duration strongly varies across sectors. Downward price rigidity has not been reported since price increase and decrease appear at the same frequency. Aucremanne and Dhyne (2004) identify the same kind of differences in sectoral price rigidity in Belgium. In addition to the sectoral differences of price rigidity, the study shows that the later varies within same sector for different product categories. The median duration of price change is 13 months with no considerable evidence of downward price rigidity for the Belgian economy. Dhyne et al. (2005) present a summary of the previous studies based

[6] In fact, these are the three broad categories that have been widely tested in the empirical literature. Studies with the other types of data set include Kashyap (1995) on catalogue prices, Levy et al. (1997) on supermarket prices and Genesove (2003) on apartment prices.

on the consumer price data.

While the consumer price data helps the researchers in understanding the behavior of the manufacturer indirectly, the producer price data provides direct evidence on price rigidity. Carlton (1986) presents a seminal paper using the producer price index. The author uses the individual transaction price data of the U.S and tests the effect of monetary and non-monetary factors behind the price rigidity. The main results indicate the presence of various degrees of price rigidity across industries though downward price rigidity has not been recorded. To explain this price rigidity, Carlton argues that it is positively related with the factors like buyer-seller association and level of industrial concentration. Moreover, there also exists a difference in the price changes of homogenous products showing the importance of non-market forces for determining the price rigidity. Nevertheless, the magnitude of these price changes is small which shows that menu cost does not create obstacle for a quick price adjustment. The higher price rigidity at individual product levels lead to a larger aggregate price rigidity following the nominal shocks (see also Blanchard, 1999).

A third stream of literature manipulates survey based information about the price rigidity, following the seminal work by Blinder et al. (1998). Álvarez et al. (2005) argue that the main advantage of this data set is that it underscores certain aspects of firms' policies which are important to test the price rigidity. For instance, firms' response to cost versus demand shocks can inform about the relative strength of real versus nominal rigidities at the time of price revision. The empirical survey based studies include Blinder et al. (1998) for the U.S and Hall et al. (2000) for the U.K. To illustrate, Hall et al. (2000) take the survey of Bank of England in order to analyze price stickiness in 654 U.K companies. The authors focused on testing the time versus state dependence of price movements. Briefly, the first explains the effects of menu cost and expected inflation whereas the second explains the relevance of monetary and real shocks. The results show that in most of the cases prices changes were time dependent. Blinder et al. (1998) complement these results by finding that most of the firms make 'periodic price reviews' for their price changes. The authors also observed a considerable degree of downward price rigidity that varied with the degree of competition in the market. This degree of downward rigidity makes the positive inflation rate an optimal choice. More competitive markets have undergone frequent price changes compared with the less competitive ones. This also explains how the optimal inflation rate depends upon the degree of market competitiveness. Fabiani et al. (2005) present a summary of the previous empirical work based on the firms' survey data.

The empirical research shows that product and time dependence of price rigidity varies remarkably among countries (Dhyne et al., 2005). Time dependence also implies that monetary shocks that appear during certain times are more influential for prices and output than the other shocks of same magnitude. Taking into account the importance of time dependence in the monetary models, Olivie and Tenreyro (2007) advanced the first work which confirms that the effects of monetary shocks are time dependent. Their results of a quarter dependent VAR model show that the effect is stronger in the first quarter than in the second one. A direct implication of these results for price rigidity has been shown by Nakamura and Steinsson (2008) for the U.S economy. More precisely, the frequency of price movement increases in the last and first quarters of a calendar year (especially in January). Since prices and wages are less rigid in the first quarter of the calendar year – due to wage contracts' renegotiations – the effect of shocks on output during this time is systematically lower than in the other quarters.

Although most of the above-cited literature did not find any evidence of downward price rigidity, yet many other studies including Karrenbrock (1991) and Jackson (1997) support asymmetric adjustment of prices. The study of Karrenbrock uses the data of U.S gasoline prices and tests their movement with the overall oil prices. The results show that within industry prices behave asymmetrically with respect to time. Retail prices increase quickly and decrease after some time. However, the price rigidity does not exist with respect to the amount of retail price changes following a shock. Jackson (1997) links price rigidity with the degree of market concentration for his empirical investigation of consumer deposits. The study proposes a non-monotonic relationship between price rigidity and the degree of market concentration in the deposit markets of the U.S Banks. For lower and higher degrees of market concentration, the response of deposit rate to changes in the market return is asymmetric. A reduction in the market return decreases the deposit rate immediately while an increase in the market return pushes it up after one lag. Both these studies provide micro-foundations for the asymmetric price adjustment. As mentioned earlier, a higher degree of downward price rigidity affects the optimal inflation rate. The optimal inflation rate becomes positive to accommodate the supply shocks when prices are rigid.

2.2.2. *Wage rigidity and the optimal inflation rate*

Theoretical Literature

A second and perhaps more important source of nominal rigidity is wage rigidity. In one stream of literature both price and wage rigidities are jointly discussed. As wages are an important element of the cost of production, part of the price rigidity is assumed to be coming from wage rigidity. This view is strengthened by the fact that services sectors which are more labor intensive face higher price rigidity. Moreover, as shown by Christiano et al. (2005) for his theoretical analysis of the inertial behavior of inflation and persistence in aggregate quantities, it is wage rigidity that mainly causes inflation inertia and output persistence in response to a monetary shock. The author shows that though wage rigidity is not so strong and lasts only two to three quarter; its influence to exacerbate the effect of monetary shocks on the U.S output is substantial.

Before we go into a detail discussion of wage rigidity and its interaction with inflation, we present a basic framework for wage adjustment, propounded by Taylor (1979). The author takes a situation where wage contract lasts for one year with two evenly staggered decision dates: half in January and the rest in July. A one year wage contract equation for period t and t+1, set at the start of period t takes the following form:

$$x_t = bx_{t-1} + d\hat{x}_{t+1} + \gamma(b\hat{y}_t + d\hat{y}_{t+1}) + \varepsilon_t \quad (5)$$

Here x_t is the log of the contract wage, and y_t represents excess demand. The "hat" over a variable represents its conditional expectation based on period *t-1* expectation. The parameters *b*, *d* and γ are all positive with the sum of *b* and *d* is one. The relative strength of *b* and *d* respectively determines the backward and forward looking in the wage contract. For a higher value of *b* the persistence of wage fluctuation increases, while for a higher value of *d* wages become more forward looking. The later assures wage stability with a minimum loss in output. When forward looking expectations are more important in wage contracts' formulation, an aggregate demand policy that aims to stabilize inflation will cause lower output fluctuations.

In the theoretical literature, downward wage rigidity has been justified on several grounds. Some key factors include long-term wage contracts, strong labor market institutions, minimum wage laws – mainly in the developed economies, efficiency wages and hiring and firing cost, etc. To fix ideas, Holden (2005) discusses three main justifications for the downward wage rigidity, namely, co-ordination failure, fairness and legal restrictions. The idea of co-ordination failure dates back to Keynes (1936) who argues that workers take care of their relative wages and resist a reduction of their nominal wages because it decreases their reward compared with the other workers. In this situation, firms who face a negative demand shock cannot make downward adjustment in their wages. Akerlof (1984, p.82) reviews a large amount of literature in supporting this view and the author concludes: 'Not all of these studies reproduce the result that "overpaid" workers will produce more, but, as might be expected, the evidence appears to be strongest for the withdrawal of services by workers who are led to believe that they are underpaid'.

The fairness argument, on the other hand, states that nominal wage reduction is avoided by firms because both employers and employees consider it unfair. To define the fair wages Akerlof and Yellen (1990) note, "*if workers' wages are below their perceived fair wage, then their effort depends on the ratio of their wages to their perceived fair wage*". In other words, efforts put by the workers reduce when the actual wages fall short of perceived wages. In fact, the fairness argument contains some interesting implications regarding the optimality of positive inflation rate as shown by Kahneman et al. (1986). The authors conduct a survey study where they put two questions on the fairness of wage changes in recessions. In the first case, recession is responded by reducing the real wages by 7% while in the second case a 5% wages increase is made when inflation is at 12%. In response to these questions 38% respondents favored the first change and 78% supported the second one. However, this view is doubted by many researchers since it involves money illusion and therefore not supported by the rationality considerations.

The legal restriction argument states that certain markets have strong legal requirements to change the existing wages and making them rigid downward. For instance, MacLeod and Malcomson (1993) illustrate that in the European labor markets, legal framework only allows wage changes after the mutual consent of both parties. In contrast, in the U.S market no such legal barrier exists. Some complementary evidence has been provided by Holden (2002) who finds that the legal restriction is the key institutional variable that explains the wage rigidity. The results show that in the presence of these legal restrictions, inflation stability comes at a very high cost in the European countries. This reinforces the role of moderate inflation rate in an environment where downward rigidity exists in the presence of strong legal restrictions.

Apart from the above discussed factors, wage negotiation by itself can be a factor of downward wage rigidity. As discussed by Holden (1994), the wage negotiation process takes time and can cause 'holdout' situation for signing the new contracts. This holdout situation has certain macroeconomic implications in terms of downward wage rigidity. For example, the wage rate settled in one contract is influential for the next period wage. If firms and labors are unable to make new contract in the beginning of new period, the workers maintain holdout threats and work on constant wages of the previous period. A higher labor demand in the holdout period will therefore result in high output and employment, opening the possibility for a firm to fulfill union demand of higher wages. These contractual obligations on the firms give labors a comparative advantage over firms for their wage determination negotiations and establish downward wage rigidity.

The central question for the present discussion is how inflation helps the firms to make adjustment of real wages when nominal wages are rigid downward. To answer this question Holden (2005) presents four main arguments in favor of moderate inflation rate. First, the conventional argument holds that in a stable inflationary environment nominal wage cuts are difficult even if they are desirable to accommodate the shocks. Second, since wage contracts are signed in nominal terms, inflation affects the way these contracts are adjusted and also the way in which wages are set in a forward-looking manner. Third, incomplete contracts between firms and labors provide the later a capacity to incur extra cost without breaching the original contracts. This forces the firms to increase the nominal wages of their workers. In these circumstances, inflation provides a space for the minimum wage growth and lowers unemployment. Fourth, workers' efforts also depend upon their wages relative to the reference wage. If both workers and firms underweight inflation while updating the reference wage, a positive but moderate inflation may appease wage pressure.

The question of the optimal inflation rate or monetary policy choice under the presence of downward nominal wage rigidity has also been analyzed from the point of view of wage indexation.[7] Ball and Cecchetti (1991) present a seminal paper where they assume staggered wage setting to analyze the positive and negative effects of inflation through employment generation and wage dispersion respectively. Wages, in their model, are fixed for two periods keeping in view the average inflation of current and future periods. The authors show that inflation increases the wage dispersion among labors and exerts welfare losses. However, if

[7] Theoretically indexation has two opposing effects on the average inflation; on the one hand, indexation protects labors from the adverse inflationary shocks and, hence, instigates the policymakers to increase inflation. While, on the other hand, indexation reduces the employment effects of surprise inflation and therefore incentive for the policymakers to inflate.

partial wage indexation is practiced by the firms to protect their employees from inflation surprises, the optimal inflation rate becomes positive (see also Waller and Vanhoose, 1992). These results were complemented by Diana and Méon (2008) for an asymmetric wage indexation case when wages are rigid downward and indexation applies only to a situation where positive productivity shocks hit the economy.

Lastly, the literature on the nominal wage rigidity has also focused on the question of whether an economy can be insulated from the effects of monetary and other shocks in the presence of these rigidities. The response to this question has been given in the form of wage indexation. The literature shows that in the presence of downward nominal wage rigidity, wage indexation limits the adverse effects of both real and monetary shocks on the real output fluctuations. Although the question of indexation has been addressed since long in the literature (see, for example, Fisher, 1922), most of the studies have focused on analyzing the effects of monetary shocks on macroeconomic fluctuations in the presence of wage indexation. This literature shows that wage indexation appeases the effects of monetary shocks on the real output. Full indexation of nominal wages is assumed to eliminate the macroeconomic disturbances emanating from the monetary shocks. Gray (1976) expands this literature and analyzes the effects of real and monetary shocks in the presence of wage indexation. Gray uses a simple neoclassical model where the role of wage rigidities has been incorporated through a wage indexation parameter. The value of this parameter moves between zero and one – with zero for no indexation and one for full indexation. The results show that an economy with both real and nominal shocks, the effects of monetary shocks can be minimized in full indexation. However, the effects of real shocks become higher in complete indexation. Partial indexation is suggested to be an optimal solution for the minimization of both real and nominal shocks.

Despite the strong policy implications of Gray (1976)'s results, the question of how indexation changes the persistence of real and nominal shocks has not been sufficiently treated in the subsequent literature. The exception includes the work from Ascari (2004) who discusses the relevance of price indexation for the New-Keynesian models.[8] Briefly, the author notes that most of the New-Keynesian models assume Calvo-price setting environment and log-linearize the inflation rate around a zero steady-state. However, the later assumption ignores the fact that the actual inflation rates are positive in most of the developed and developing economies. Ascari

[8] A detail discussion of the New-Keynesian models has been provided in the next session. Here we only focus on the role and the optimal degree of indexation in these models.

posits that the problems coming from a positive trend inflation rate can be avoided by introducing full indexation in the Calvo-price setting model. Nevertheless, indexation is attached with its own problems. For instance, in most of the cases, both wage and price contracts are hard to observe. Most of the prices and wages are adjusted within a year. Moreover, as discussed by Gray (1976), a full indexation is not possible and a partial indexation does not remove the nuisance. The indexation does not eliminate the '*menu cost*' of price changes which has certain influence on the optimal inflation rate.

Although Ascari (2004) discusses the role of indexation for the optimality of positive inflation rate in the New-Keynesian model, the question of optimal indexation has not been addressed in the paper. This issue has been investigated by Schmitt-Grohé and Uribe (2007) and Ascari and Branzoli (2010) who incorporate the idea of optimal indexation of Gray (1976) in a micro founded New-Keynesian model. Schmitt-Grohé and Uribe (2007) focus only on the price indexation parameter by keeping its value between 0 and 1 and testing for the optimal Ramsey steady state inflation. Their results show that with an optimal degree of indexation between the two extreme values, the steady state inflation rate is higher than the Friedman rule. Similarly, Ascari and Branzoli (2010) try to find the specific parameter values of both wage and price indexation that maximizes the steady state welfare of a representative household. The optimal indexation parameter values are found to be 1 and 0.88 for wage and price adjustment respectively. For this reason, a complete indexation is welfare enhancing for wages but not for prices. Nevertheless, very low values of price indexation are also not optimal because in that case firms reset their prices above their marginal cost which, consequently increases the average mark-up and reduces welfare.

Empirical Evidence

The above-mentioned theoretical literature on downward wage rigidities has attracted a large numbers of empirical papers on this topic. The empirical work, however, does not go beyond the recent past because of the data problems. Moreover, most of this work has been confined to the U.S data set (see McLaughlin, 1994). Most of the studies during the 1990s did not find any strong evidence of downward wage rigidity. Kahn (1997), for example, finds a very modest impact of downward wage rigidity using the Panel Study of Income Dynamics (PSID) database. The PSID data set contains micro level information of the U.S labor market, developed on the basis of longitudinal interviews of same individuals for different years. A comparison between different labor categories shows that downward rigidity exists more for the wage earner groups but not for the salaried groups. This earlier literature, however, does not find small and frequent wage changes mainly because these changes incur administrative cost to the firms such as menu cost of wage adjustment. In general, wage rigidity existed in this literature but not to the extent which has been indicated by the theoretical literature.

This weak evidence of the downward wage rigidity has not held uncontroversial in the empirical literature. The subsequent studies including Altonji and Devereux (1999) and Lebow et al. (2003) report a very strong evidence of downward wage rigidity. Lebow et al. (2003) argue that a weak support of downward rigidity in the earlier literature is mainly because of data problems in these studies (see also Akerlof et al. 1996). The PSID data set which was mainly used by the previous research on this subject contains measurement errors coming from personal biasedness of the interviewers, and therefore hides the true magnitude of downward rigidity. To overcome this deficiency, Lebow et al. (2003) use Bureau of Labor Statistics' employment cost index (ECI) data set, which contains quarterly based information of around 5000 U.S employers. The main results show a strong evidence of downward rigidity. Nevertheless, its magnitude decreases when the additional benefits are included in nominal wages. Wilson (1999) uses a long payroll record data of two U.S firms and evidences strong downward wage rigidity.

Fahr and Goette (2005) posit that the earlier evidence of a weak downward rigidity mainly resulted from the inclusion of high inflationary periods in these studies. For example, the study of McLaughlin (1994) is based on the time period where average inflation was around 7.4% in the U.S. To probe into the existence of downward wage rigidity during stable inflationary environment, Fahr and Goette (2005) take the case of Swiss economy, over the period of 1990-97. Their main results support the presence of downward wage rigidity which caused additional unemployment in Switzerland. The authors also note that this downward wage rigidity is positively affecting the unemployment rate of different Swiss industries. These results are supported by Dicken et al (2006) for a bigger data set of sixteen countries over the period of 1970-2000. The authors find a non-normal distribution of both nominal and real wages. Moreover, strong labor unions also play a significant role for explaining this downward rigidity. Almost similar results have been reported by Blinder and Choi (1990) based on a survey of 19 U.S firms. The managers of almost all firms responded that it is hard to justify nominal wage reduction, compared with a decrease in real wages that stems from price increase.

However, the view that nominal wage rigidity is more effective at the low inflation rate is not unanimously accepted either. Some studies show an absence of nominal wage rigidity even in the stable inflationary environment. These studies include Card and Hyslop (1996) and Lebew et al. (1995). Briefly, the study of Card and Hyslop (1996) uses a micro level panel data from Current Population Survey (CPS) and Panels Study of Income Distribution (PSID) and show that nominal wages do not become more rigid with decreasing level of inflation in the U.S. Similar results have been obtained by Kimura and Ueda (2001) for Japanese economy over the period of 1976-1998. Despite the fact that their sample includes recessionary episode of the 1990s for Japan, downward rigidity has not been evidenced during this time.

Other studies focusing on the relation between inflation changes and the degree of wage rigidity include Bauer et al. (2007) who find different signs of changes in real versus nominal wages at various inflation rates in the German labor market. The study mainly focuses on interpreting the difference between real versus nominal wage changes based on the individual wage data. The results relevant to the present discussion show that lower inflation decreases real wage rigidity but increases the nominal wage rigidity. These results support the view that a moderate inflation is required to appease the wage rigidity, and the adverse effects of shocks on output and employment. Crawford and Harrison (1998) find similar results using micro data set of the Canadian economy. Their main findings show that in low inflationary periods, nominal wages are more likely to remain constant during a contract. In contrast, the high inflation rates shorten the tenure of wage contracts and increases the chances of wage adjustment during the contract periods.

Downward wage rigidity in the developed countries is usually explained by minimum wage laws. However, there are two views about the impact of these minimum wages on employment in the OECD countries. One point of view notes that these effects are insignificant. The empirical support for this hypothesis is mainly based on the U.S data (Card and Kruger, 1995). Yet there are cases where these effects are found to be negative (Neumark and Wascher, 1992). To further probe into this issue, Dolado et al. (1996) analyze the effects of minimum wage on the selected European countries, namely, France, Netherlands, Spain and the U.K. and compare them with the U.S to see the effectiveness of minimum wages in these countries. Their estimated results, based on a Kaitz index – proposed by Kaitz, 1970 – show that minimum wages in the Europe are about 50-70% of the average index; while in the U.S, they are only about 33%. Nevertheless, the adverse economic effects of these minimum wages are not severe for the

European economies. The study also shows that in France, where minimum wages are most effective among the selected countries, an increase in minimum wages increases the proportion of people with actual wages around this minimum level. This shows that the minimum wage law is effective though its net impact employment and output is not quite large.

Abowd et al. (2000) confirm these results by comparing the minimum wage evolution in France and U.S over the recessionary period of 1980s. The author notes that in France minimum wages have increased progressively while in the U.S they decreased during this time. Further, the micro-based evidence shows that minimum wage effects are significant though confined only to young workers. These minimum wage increases, however, come at the cost of a high probability of losing job in France. An upward shift in the minimum wage also increases unemployment in France but not in the U.S. In the later, a reduction in minimum wage over time has increased the probability of hiring unemployed workers. Both these results show that demographic effects of minimum wages on employment are significant. Nickle (1997) presents another evidence for the OECD countries where the author shows that generous and long-run unemployment benefits cause higher unemployment while downward wage rigidity only affects the unemployment of the young workers.

Another question that has been relatively less addressed in the literature is whether nominal rigidity is affecting the optimal inflation rate or it is an outcome of high inflation. As we have seen before, the mainstream literature considers nominal rigidities a factor influential in the determination of the optimal inflation rate. As nominal rigidity is usually high in low inflationary periods, it favors a moderate inflation rate. However, against this general consensus, some dissenting views support an endogeneity between wage rigidity and average rate of inflation (see Ball and Mankiw, 1994; Gordon, 1996). In these studies, high inflation results in downward rigidity while a stable macroeconomic environment favors natural growth of output and employment. Once the agents start realizing the fact that the central bank is focusing on long-run price stability policy, their behavior becomes more accommodative. A credible inflation rate policy therefore wipes out wage rigidity and makes a slight positive inflation rate an optimal choice for long-run output growth.

3. Dynamic Stochastic General equilibrium (DSGE) models

3.1. Evolution of the DSGE

The above-mentioned literature evidences nominal price and wage rigidities in real world markets. Both these frictions justify the role of money growth for impacting the output growth. The existence of these nominal rigidities led macroeconomists to revisit the conventional quantitative macroeconomic models of the Keynesian economics. From the policy makers' point of view, it implies that the effect of monetary policy intervention or any other type of shocks will depend upon how it affects the behavior of agents (both consumers and producers) and their response to these shocks. This issue questioned appropriateness of the Keynesian models for the conduct of monetary policy. This structural invariance of the Keynesian models was underscored by several economists during the late 1970s and early 1980s (see Lucas, 1976; Sargent, 1981). The famous Lucas critique puts this issue in the following words,

". . . [T]he ability to forecast the consequences of "arbitrary", unannounced sequences of policy decisions, currently claimed (at least implicitly) by the theory of economic policy, appears to be beyond the capability not only of the current-generation models, but of conceivable future models as well" (Lucas, 1976, p. 41).

The econometric implication of Lucas critique is further stressed by a study of Sargent (1981) which shows how agents' behavior will change when their constraint alters following different policy actions. The author argues that changes in constraints will affect the way they make their choices based on the existing information. Since macroeconomic models only focus on the overall response of any policy intervention, leaving aside its impact on the agents' expectations, the behavior of agents can determine the success of any policy intervention. To address this deficiency and to develop a macroeconomic framework suitable for forecasting and policy analysis, the real business cycle (RBC, from here onward) models were utilized. The main advantage of the RBC models is that they allow a direct comparison of utility gains or losses from different possible policy actions. Moreover, they incorporate the actual effect of policy and other shocks in a well specified set up (Goodfriend and King, 1997).

The RBC models are based on a general equilibrium framework with two (simultaneous) optimization programs for consumers and producers respectively. The consumer optimization includes ingredients of consumption and labor supply while producers have to decide about investment and labor demand for the objectives of profit maximization. The general equilibrium analysis incorporates all of these plans while deciding about the optimal prices and quantities for all agents. This basic structure of the general equilibrium models is based on flexible price environment; as shown by Kydland and Prescott (1982). Particularly the authors introduce a time lag between investment decisions and final output to show how agent's information about the dynamics of an economy can explain cyclical movement of investment and output. In other words, representative agent's behavior – explained by the growth theory – was embedded into the RBC models and agent's response to technology shocks was analyzed to explain the observed economic fluctuations of the actual data set (Rebelo, 2005).

In Kydland and Prescott (1982) model, there was no role of monetary shocks in influencing real side of the economy. The main focus was to analyze the role of productivity shocks on the economy. However, in the subsequent literature including King and Plosser (1984) monetary sector was explicitly included to test for a cyclical correlation between money and output growth when productivity shocks hit an economy. Nevertheless, the authors did not explicitly test the relevance of money for business cycle fluctuations. In fact, money does not play any active role in this model and inflation-output nexus is explained by assigning different roles to money such as inside and outside money. Lucas and Stockey (1987) discuss the role of money separate from the technological shocks but the authors do not provide any quantitative estimates on output effects of inflation.

Cooley and Hansen (1989) is the first study that explicitly acknowledges the role of anticipated inflation in generating fluctuations in aggregate output. Money works as inflation tax in their model which forces agents to substitute away from consumption activities, requiring money toward leisure activities which do not demand cash balances. Money is embedded into the model via a CIA constraint which applies only to the consumption good while leisure and investment are credit goods. With these assumptions Cooley and Hansen get the following equilibrium price equation:

$$\hat{p} = d_{20} + d_{21} z + d_{22} \log g + d_{23} K \quad (6)$$

Here $\hat{p} = p/M$ whereas z, g and K represent technological shocks, nominal growth rate and capital stock respectively. The simulation results of the model show that when money is supplied at a constant growth rate, the steady state properties of the RBC model are unaffected by the inclusion of money. The role of money for the real sector growth is relevant only when its supply becomes erratic – a pattern that is more or less consistent with the actual money growth in the U.S. Even though quantitative impact of inflation is small, the magnitude of this effect increases with the level of inflation. The authors, however, do not discuss the role of unanticipated money or price stickiness in their model.

Cooley and Hansen did not discuss the role of nominal rigidities in their model. A separate stream of literature incorporates it to analyze the impact of monetary shocks on output growth. The inclusion of these nominal rigidities in the RBC models laid foundation to a new school of economic thought, called, the New-Keynesian economics. Some early works on this side include sticky price model of Gordon (1982) and a rigid wage contract model of Taylor (1980). To illustrate, in Gordon (1982)'s model, prices do not adjust to nominal shocks in the short-run and the effect of these shocks partly appears through output changes and partly through the price changes. The estimated price equation of the model has been expressed in the following form:

$$\pi_t = \lambda(L)\pi_{t-1} + G(\log Y_t - \log Y_{t-1}) + ps_t + \eta_t \tag{7}$$

where $\pi_t = \log P_t - \log P_{t-1}$ represents inflation, $\lambda(L)$ shows autoregressive process while $\log Y_t - \log Y_{t-1}$ is the nominal growth rate, and ps_t captures the nominal shocks. The estimated results show that a complete price adjustment took more than one year after the shock. The paper does not estimate wage rigidity equation since it is assumed that both types of rigidities follow the same pattern.

On the other hand, the New-Keynesian model of Taylor (1980) explains the persistence of shocks through wage rigidity. The wage contracts are signed for a fixed time span taking into account wages being paid by other firms. However, not all of the firms fix their future wages at the same time, for instance, if some firms adjust their wages in the current time period the rest will make this adjustment in the future. Hence wage adjustment takes place keeping in view both pervious and expected future wages or implicitly the expected prices. As an illustration, a contract of J-period has to take into account the expected prices, $(1/J)\sum_{j=0}^{J-1} E_t \log P_{t+j}$; the labor market tightness [represented as $(h/J)\sum_{j=0}^{J-1} E_t e_{t+j}$, here e_t is labor market tightness for period *t* and *h* shows the wage response to this tightness] and the wage shock (v_t). Incorporating all of these elements gives the following wage equation:

$$\log W_t^* = \frac{1}{J}\sum_{j=0}^{J-1} E_t \log P_{t+j} + \frac{h}{J}\sum_{j=0}^{J-1} E_t e_{t+j} + v_t \tag{8}$$

In this model labor market tightness is related to output such as $e_t = g_1 \log y_t$ and price determination is based on average wages of previous periods under the assumptions of constant marginal cost and fixed markup:[9]

$$\log P_t = \frac{1}{J}\sum_{j=0}^{J-1} \log W^{*}_{t-J} \qquad (9)$$

Apart from the interdependence of wages and prices that has been shown by equations 8 and 9, money supply is also responded to demand shocks in the Taylor model (such as $\log M_t = g_2 \log P_t$). Here g_2 shows the degree of monetary policy accommodation to shocks. Hence money supply does not become the source of fluctuations, it responds to these shocks through accommodative changes. This develops a trade-off between output and inflation uncertainties.

The above-mentioned literature on the RBC and the early New-Keynesian models were developed separately. On the one hand, the RBC theory facilitates a micro level analysis to explicitly quantify the consumer behavior in an optimization program (Prescott, 1986). These models, however, do not acknowledge the role of money or financial factors in influencing the real sectors' fluctuations. On the other hand, the New-Keynesian models provide microfoundations to the main Keynesian concepts e.g. nominal rigidities, non-neutrality of money and persistent aggregate fluctuations. Nevertheless, the development of this literature was not characterized by a dynamic environment, feasible for the quantitative analysis of the real world data. Naturally, these deficiencies of New-Keynesian models and their lack of coherence with actual data could be addressed by developing a synthesis between the New-Keynesian and the RBC models. This transformation of the existing New-Keynesian models that aims at explaining the macro phenomenon through the lens of micro behavior of individual agents is explained by Gali (2002) in the following way:

"... [New-Keynesian] models integrate Keynesian elements (imperfect competition, and nominal rigidities) into a dynamic general equilibrium framework that until recently was largely associated with the Real Business Cycle (RBC) paradigm. They can be used (and are being used) to analyze the connection between money, inflation, and the business cycle, and to assess the desirability of alternative monetary policies" (Gali, 2002, p. 1).

[9] See Goodfriend and King (1997) for a detail discussion on the earlier New Keynesian models.

The aforementioned work of Taylor (1980) and Gordon (1982) lays foundation to more general New-Keynesian models of subsequent literature. The main policy relevance of this modeling framework comes from three main ingredients: money, monopolistic competition and nominal rigidities. The most significant among these is the assumption of monopolistic competition because it allows analyzing the effects of the other two elements – as shown by Goodfriend and King (1997). For instance, at an individual firm level, it is only due to monopolistic competition that a firm can set its prices and make adjustment in response to any shock. In perfect competition models, on the other hand, individual firm is a price taker and cannot adjust its price in response to any shock. In this way, building any model that is capable of providing microfoundations to the existing macroeconomic phenomena essentially demands monopolistic competition.

Price stickiness is also an important element of the New-Keynesian models. These rigidities make the nominal shocks more important for explaining the fluctuations of real variables. This view has been mainly advanced by Mankiw and Romer (1991) who show that the nominal rigidities exist even if the frictions preventing full flexibility are very small. This is because firms depend upon other firms for their output decisions, a phenomenon later named as 'strategic complementarities' in subsequent literature. As a result, rigidity in one firm's prices enhances rigidity in others. Therefore, some very slight levels of rigidities at an individual firm level can cause higher rigidities at the aggregate level. Though the effects of these nominal rigidities are not large for individual firms, their cumulative effect on social welfare is quite high. The New-Keynesian models incorporate these rigidities in their analysis of the business cycle fluctuations.

In the New-Keynesian models, the presence of imperfect competition and price stickiness essentially requires an active monetary policy to control inflation. In fact, in this modeling framework, shocks are managed through monetary policy changes. Analyzing the micro-foundations of the model makes it clear that price determination of an individual firm takes into account future monetary policy changes. Moreover, as argued by Goodfriend and King (1997), monetary policy influences the real output growth through its influence on average markup of a firm. For instance, an active monetary policy which increases the aggregate demand results in a high marginal cost of production and lowers the average markup of firms. This variation in the marginal cost affects the factor response to shocks and exerts a similar influence as real variables (e.g. total factor productivity) in the RBC theory. Hence, monetary policy intervention increases the average output and employment and works like a tax reduction in the RBC model. However, the effectiveness of monetary policy is not same at all inflation levels. For instance, an inflation rate close to zero cannot influence average markup of firms and the influence of monetary policy on inflation-output trade-off remains inconsequential. Similarly, Rotemberg and Woodford (1997) advance a monetary business cycle model based on the nominal rigidities and imperfect competition to test the effect of policy changes on the private agents' decision rule. Their simulated results, based on the actual parameter values of the U.S economy, show a strong impact of monetary disturbance on real output fluctuations.

Indeed, the crucial role of monetary policy in demand management of an economy is widely acknowledged by the subsequent literature of the New-Keynesian economics. For example, in Clarida et al. (1999), expectations about the future inflation rate which are judged by policy actions of monetary authorities, determine current period prices at a firm level. The log-linear approximation about steady state aggregation of individual firm pricing decision takes the following form:

$$\pi_t = \lambda x_t + \beta E_t \pi_{t+1} + u_t \tag{10}$$

here x_t represents output gap while π_{t+1} shows next period inflation. The microeconomic implications of this pricing behavior state that a representative firm takes into account the expected inflation rate while adjusting its current period prices. u_t is the error term of the model and can also be considered as markup shocks (see Clarida et al., 1999 footnote 14 for details). Policy makers understand the fact that agents form their expectations based on their policy commitment and therefore they prefer to keep inflation under control. A strong policy commitment results in lower inflation without any loss in production.

To summarize the above-mentioned literature, the New-Keynesian models of 1990s were able to develop some strong connections between real world rigidities and role of money in explaining the output fluctuations. These small scale models (see Goodfriend and King, 1997; Rotemberg and Woodford, 1997) were then extended to incorporate other real world constraints and to make them more useful for central banks' policy analysis. This work includes some workhorse models produced by Woodford (2003) and Gali (2008). Woodford (2003), for example, shows that monetary changes exert a certain influence on output fluctuations when price setters face a specific degree of strategic complementarities for their price changes. Precisely, the strategic complementarities of firms' price changes mean that a marginal upward movement in the level of one firm's price forces other firms to increase their prices as well. The author shows that the money neutrality in the RBC models (e.g., Chari et al., 2000) appears due to their assumed strategic substitutability among firms for their nominal price changes. Moreover, the strategic complementarities in Woodford (2003) also explain the persistence effects of a monetary shock because it restrains full adjustment of prices by firms following shocks. Firms take into account behavior of their competitors and follow a slow adjustment of prices making the effects of shocks more persistent.

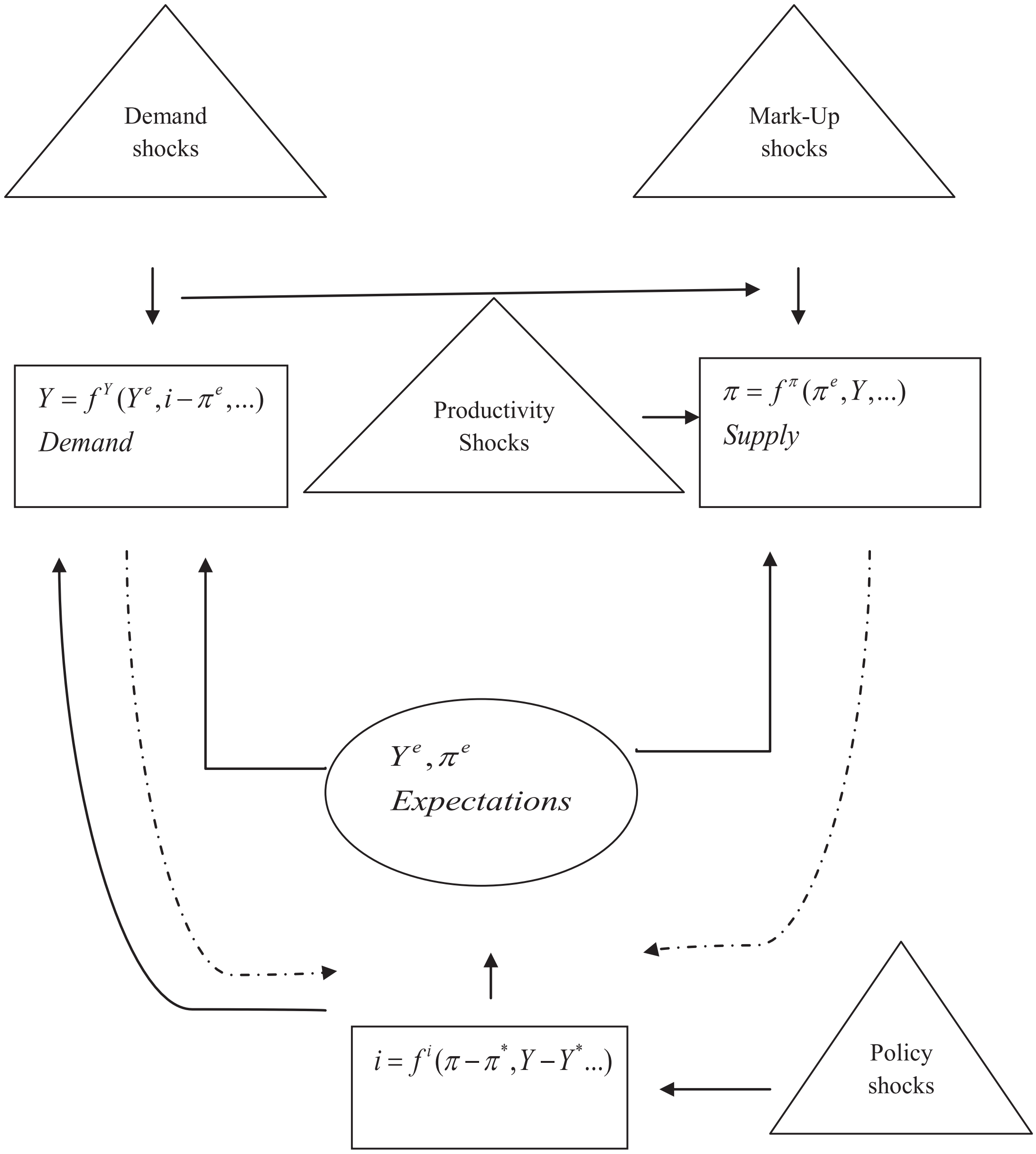
3.2. The basic structure of the New-Keynesian DSGE model

A graphical representation

To better understand the basic building blocks of the DSGE framework and the channels through which monetary policy can influence output growth, Sbordone et al. (2010) use a graphical method which has been reproduced in Figure 1-3. The authors divide the model economy into three blocks; the demand block resulting from the optimal behavior of households, the supply block explaining the optimal behavior of a firm and a monetary policy block showing policy organs. In each block basic structure of the model is represented by relevant equations. As mentioned in the above cited benchmark New-Keynesian models, these equations are based on some explicit assumptions about the behavior of households, firms and a government; three key elements of the New-Keynesian models. The interaction of all of these actors makes it a general equilibrium model; as mentioned by Sbordone et al (2010).

In Figure 1-3 the demand block explains that the actual output Y depends upon the expected output Y^e and real interest rate, explained as the difference between the nominal interest rate, as well as the expected inflation $(i-\pi^e)$. This demand function shows a negative relationship between real interest rate and output. This negative relationship appears from the fact that when real interest rate increases, saving increases and consumption and capital accumulation decreases. On the other hand, an increase in expected output would ramp up the current real activity of the economy. This captures the essence of rational expectation model where agents' decisions are influenced more by future prospects than by the past behavior.

Figure 1-3 The Basic Structure of DSGE Models (source; Sbordone et al., 2010)



Regarding the dimension of the effects of any shock originating from the demand block, the arrow pointing to the supply shock shows how the actual output Y will determine the inflation rate. Indeed, these are the expected output Y^{e} and the inflation rates π^{e} that affect the actual inflation rate π today. Moreover, the supply block contains an inflation function where the actual inflation rate is positively influenced by the expected inflation rate π^{e} and output Y. In other words, the inflation function shows how the general price level can be affected by the aggregate demand side of the economy. Evidently, a higher aggregate demand requires firms to produce more which consequently increases factors' demand and their rewards. All of this creates upward pressure on the inflation rate.

The third block of the Sbordone et al. (2010)'s DSGE framework is concerned with monetary policy. It is certainly affected by the demand and supply sides of the economy, as shown by the dotted arrows of the figure. The interest rate function shows that central bank's monetary policy is based on Taylor rule function where it minimizes the deviation of the actual inflation rate from the targeted rate along with aggregate demand stability. Central bank, through its interest rate tool affects expected inflation π^e and expected output Y^e to complete the chain of effects in the system. In short, the central bank has one tool which is interest rate and it minimizes the deviation of the inflation rate (π) and the output growth (Y) from their potential levels π^* and Y^* respectively.

As has been particularly emphasized in this benchmark model, expectations about the future inflation rate and output play a key role in the New-Keynesian DSGE model. This indirectly highlights the forward looking behavior of the firms in their output and factors' price determination decision. By the same token, central bank's policy actions aim at influencing the expected inflation and real activity. It is through this expectation channel that the central bank controls actual real activity.

A formal representation

A voluminous amount of literature has produced the similar basic structure of the DSGE models with rational expectations about agent behavior (see Woodford, 2003; Gali, 2008). Here we present some important functional relations of the model by Schmidt and Wieland (2012) that closely follows this literature. Their model includes households, monopolistically competitive firms, a monetary authority and a government sector.

Households decide about their consumption and labor supply for their lifetime utility. A representative consumer's choice about consumption, labor and real money balances can be denoted as:

$$E_0 \sum_{t=0}^{\infty} \beta^t \left[U(C_t, M_t/P_t) - V(H_t) \right] \tag{11}$$

here C_t denotes the consumption of differentiated goods, M_t, P_t and H_t show money supply, price of consumption good and leisure, respectively. The consumption basket C_t contains differentiated goods $C_t \equiv \left[\int_0^1 C_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right]^{\frac{\varepsilon}{\varepsilon-1}}$, where $\varepsilon > 1$, and the price index P_t with minimum expenditures for household on a unit of C_t is $P_t \equiv \left[\int_0^1 P_t(i)^{\frac{\varepsilon-1}{\varepsilon}} di \right]^{\frac{\varepsilon}{\varepsilon-1}}$. Here $P_t(i)$ denotes price of good *i*.

Total expenditures are shown as $P_t C_t = \int_0^1 P_t(i) C_t(i) di$ and

$$C_t(i) = \left(\frac{P_t(i)}{P_t} \right)^{-\varepsilon} C_t \tag{12}$$

The period utility function is increasing in all its argument $U(C, M/P)$ while $V(H)$ is increasing and convex. The budget constraint takes the following form:

$$P_t C_t + M_t + E_t Q_{t,t+1} B_t \leq W_t H_t + M_{t-1} + T_t + \Gamma_t \tag{13}$$

B_t is government bond with price $E_t Q_{t,t+1}$, the later being equal to $1/R_t$. R_t is the nominal interest rate, W_t, T_t and Γ_t stand for nominal wage, lump-sum transfers of the government and firms' profits distributed to the households. Schmidt and Wieland get the following first order conditions of the household program:

$$\frac{1}{R_t} = \beta E_t \frac{U_C(C_{t+1}, m_{t+1}) / P_{t+1}}{U_C(C_t, m_t) / P_t} \tag{14}$$

$$\frac{V_H(H_t)}{U_C(C_t, m_t)} = w_t \tag{15}$$

$$\frac{U_m(C_t, m_t)}{U_C(C_t, m_t)} = \frac{R_t - 1}{R_t} \tag{16}$$

here $w_t = \frac{W_t}{P_t}$ shows real wages while U_C and U_m (with *m* being real money supply e.g. $m = \frac{M}{P}$) denote the marginal utility of consumption and real money balances respectively. V_H represents marginal disutility of labor.

On the production side of the model, there is a continuum of firms of measure one with the following production technology for a firm that uses labor as only factor of production:

$$Y_t(i) = A_t N_t(i) \tag{17}$$

where A_t shows technology shock and $N_t(i)$ represents labor demand by firm *i*. Demand for good *i* is $Y_t(i) = C_t(i) + G_t(i)$. $G_t(i)$ explains the part of output demanded by government. Government demand satisfies:

$$G_t(i) = \left(\frac{P_t(i)}{P_t}\right)^{-\varepsilon} G_t \tag{18}$$

The authors assume Calvo (1983) price settings with the probability $(1-\theta)$ of a firm to change its price $P_t(i)$. Thus at a given time period a fraction $(1-\theta)$ of firms make price adjustment while the other fraction θ keep the previous prices. As labor is the only factor of production, cost minimization production technology yields:

$$MC_t(i) = \frac{W_t}{A_t} \tag{19}$$

this equilibrium states that marginal cost (MC_t) of a representative firm *i* equal wage divided by marginal product of labor. The firm's optimization problem for current and expected future prices can be expressed as:

$$\max_{p_i(i)} \sum_{j=0}^{\infty} E_t Q_{t,t+j} \theta^j Y_{t+j}(i) \left[P_t(i) - MC_{t+j} \right] \tag{20}$$

subject to household and government demand functions, that is equations (12) and (18) respectively. The first order condition of a profit maximizing firm becomes:

$$\sum_{j=0}^{\infty} E_t Q_{t,t+j} \theta^j Y_{t+j} P_{t+j}^{\varepsilon} \left[P_t^*(i) - \frac{\varepsilon}{\varepsilon - 1} MC_{t+j} \right] = 0 \tag{21}$$

Note that optimal price in this sticky price environment is a markup over weighted sum of current and expected future marginal costs.

Next, as mentioned earlier, government consumes part of the production $Y_t = C_t + G_t$ and has to follow its budget constraint:

$$P_t G_t + B_{t-1} = \frac{B_t}{R_t} - T_t + M_t - M_{t-1} \tag{22}$$

As can be noticed, public expenditures are financed through bonds, lump-sum taxes and seigniorage revenues. Monetary authority is also assumed to control money supply through short-term nominal interest rate R_t. The central bank fixes an interest rate target through a monetary policy rule that depends upon inflation and output gap:

$$\frac{R_t}{R} = \left(\frac{\pi_t}{\pi}\right)^{\tau_\pi} \left(\frac{Y_t^{gap}}{Y^{gap}}\right)^{\tau_Y} \upsilon_t \tag{23}$$

here Y_t^{gap} is the deviation of actual output from its natural level and υ_t is monetary policy shock. The variables without subscript represent the same variable at their steady state value.

The solution of the model imposes market clearing on labor market; real money balance market and government bonds market. This system of equations and its variant forms have been solved by using several log-linear and nonlinear methods (see Schmidt and Wieland, 2012). The main interest has been to get a functional relation of the main variables of interest and to test the magnitude and persistence of monetary shocks on real output fluctuations. Our following discussion focuses on empirical developments and their main outcome using the DSGE models.

3.2.1. Empirical Evaluation

The empirical literature on the real effects of monetary shocks has evolved on same lines as the above-mentioned theoretical models. The earlier real business models did not consider money as a source of output fluctuations and a major part of output variability in the actual data was assigned to real factors like productivity shocks. Prescott (1986), for example, suggests that around 75% of fluctuations in the U.S data can be explained by real factors. These findings and the others results in the RBC theory were also doubted since some important fluctuations in the actual data were left unexplained. For instance, on the labor market dynamics, the RBC theory could not explain why the magnitude of fluctuations in these markets is larger than the productivity shocks. Besides, the literature could not identify any correlation between these two variables. In the presence of this puzzle the role of money has become vital for explaining the real output fluctuations. As reasoned by Cooley and Hansen (1995), the interaction between money and real variables is irrefutable on empirical grounds.

These theoretical justifications along with the developments in the New-Keynesian DSGE models have triggered a voluminous mount of recent empirical papers focusing on the effects of monetary shocks on inflation and aggregate variables of the rigid markets. The underlying issue in the literature was to see if – in the occurrence of nominal rigidities – monetary shocks can explain persistence in inflation and other variables. On empirical side, the relevance of monetary shocks has been tested by using two distinct methods; calibration and estimation. The calibration technique mainly focuses on quantifying the theoretical New-Keynesian models. In RBC literature, this technique has been first used by Kydland and Prescott (1982) for estimating the effect of technology shocks, clearly in absence of money. In this calibration method, parameter values of the included variables are taken from other studies of applied econometrics or from general facts about national accountings (see Hoover, 1995 for a detailed discussion). The estimation method is standard in econometric literature. Mainly calibrated results are compared with Vector Autoregressive (VAR) models to check if the DSGE model best represents actual data.

The empirical literature till the earlier 1990s was mainly based on the calibration method (Kydland and Prescott, 1982; Prescott, 1986). For instance, Chari et al. (1996) compares the effects of monetary shocks on output fluctuations in exogenous versus endogenous price stickiness. Their exogenous price stickiness assumes yearly price changes where one-fourth of the firms change their prices in each quarter. Their calibrated results show that in the exogenous price rigidity, the output response to a monetary shock is substantial. For instance, a 1% increase in the money supply causes 3.3% increases in output. Nevertheless, the persistence in this change is not high because the output growth bounces back to its original level after one year. The study also endogenizes price rigidity by taking a situation in which prices are set as a linear function of past and future prices and sum of future outputs. When price rigidity is endogenized, money supply changes do not exert any influence on output growth.[10]

The work by Chari et al., (1996) analyzes micro-foundations of the Taylor (1980) work by

[10] The author assumes this price setting behavior in spirit of Lucas (1980)'s wage setting behavior where wages are set in as a function of both past and future wages and of the sum of future outputs. However, the results are not consistent with Lucas since the later finds a very strong effect of monetary shocks on output growth.

endogenizing price rigidity at firm level, though it does not address the same issue for wage rigidity. Ascari (2000) extends this work for wage rigidity and analyzes the effects of Taylor's wage rigidity in a general equilibrium framework. Interestingly, the author develops a situation when at zero steady state inflation rates; the ability of staggered wages to generate persistence effect of shocks depends upon the other parameters' values. Particularly, in this case, this relationship is shown to depend upon the responsiveness of wages to various factors like business cycles, income effects and intertemporal elasticity of substitution of labor. For some specific parameter values of all of these variables, staggered wages can increase the persistence of output response to money changes.

The above-mentioned studies are based on the calibrated models. However, in the last decade, research in this domain has made a considerable progress and policy makers are able to estimate these models by using the Bayesian estimation techniques (Benes et al. 2009). These estimated DSGE models are also helpful in analyzing the uncertainty of macroeconomic forecasting and policy analysis. Empirical work has also shown that combining the DSGE models with the Bayesian VAR models provides a good forecast performance (see Del Negro and Schorfheide, 2004). With all of these empirical developments, a host of recent evidence used both calibrated and estimation techniques to check the robustness of their results regarding the effects of shocks. To illustrate, Leeper and Sims (1994) use both methods for testing the ability of the RBC model in replicating actual data of consumption, investment and working hours for the U.S economy. In the first step, they use a calibrated method and then for robustness purposes, they manipulate unrestricted VAR model. Interestingly, the performance of the calibrated model for data fitting and forecasting is not different from the estimated model results. Rotemberg and Woodford (1997) extend this analysis and explicitly observe the effect of monetary shocks on inflation and output fluctuations. Their simulated results for the U.S economy are sufficiently consistent with the actual paths of output, inflation and interest rate over the selected period of 1980:1 to 1995:2.

Over the years, the empirical side of the New-Keynesian DSGE models has also held improvements by incorporating some additional real world frictions. The objective was to make this research program closer to the real world and to see if the persistence in output fluctuations after a monetary shock remains relevant after incorporating these changes in the model. One important development on this side is a model of Christiano et al. (2001) which includes variable capital utilization in the New-Keynesian DSGE framework. The theoretical intuition behind this channel states that a monetary shock positively affects the utilization of capital when output increases following a shock. As the services of capital are considered flexible, its reward does not increase in the same ratio. This partially absorbs the impact of shock on prices. The price level does not increase immediately following the shock while consumption remains high. This results in persistence in output response after the shock. The authors note that with the assumption of variable capital utilization, even some moderate level of wage and price rigidities are sufficient to explain movements in investment, consumption, employment, profits and productivity.

Although Christiano et al., (2001) is the first study that discusses the role of variable capital utilization in determining the output persistence in a micro based framework, its importance as a key factor behind output fluctuations has been acknowledged since long. Notably, Keynes (1936) argues that it is due the shocks to marginal efficiency of capital that output fluctuations are frequently observed in different countries. On a similar note, the importance of these shocks to explain fluctuations in the RBC literature has been focused by Greenwood et al. (1988). In their model, a positive shock to the efficiency of investment enhances the formation of “new” capital and accelerates the depreciation of “old” capital. This generates persistence in the effects of these shocks and explains a pro-cyclical behavior of capital accumulation.

The results of Christiano et al. (2001) were extended by Smets and Wouters (2003) with the same Calvo (1983) price and wage mechanism along with some additional cost push and monetary policy shocks. Precisely, the model analyzes the effects of various shocks including household’s discount factor, labor supply shocks and shocks to investment adjustment cost function. Their benchmark results, based on the DSGE parameters estimation remain robust in the VAR method environment. Their main findings show an adverse effect of a negative monetary shock on inflation and output growth – through the higher real and nominal interest rates. These results are consistent with the previous results for the Euro area economy (see Peersman and Smets, 2001). Moreover, the authors note that degree of price rigidity is also higher in the European data than in the U.S economy; reported by Christiano et al. (2001).

A general feature of the above-mentioned literature is that the overall price rigidity has not been reported very high. In fact, the degree of price rigidity in Christiano et al., (2001) and other studies falls between two to three quarters. This is in contrast with the fact that at the macroeconomic level, inflation behavior is inertial and the effect of shock takes time before being fully absorbed. This paradox between micro and macro level rigidity differences has been solved by Altig et al. (2005) through imperfect capital mobility across firms. The authors assume a situation in which firm's capital is pre-determined in each period and capital does not move freely across firms (see also Woodford, 2003 on a firm-specific capital). This assumption implies that firm's marginal cost increases with output. At a lower output level, marginal cost goes down which encourages the firm to produce less. This opposing force to inflation pushes the firm to make small price adjustments following a change in inflation and the effect of inflationary shock becomes inertial.

In fact, there exist a number of other studies that explain persistence of monetary policy shocks and relevant monetary policy issues using the New-Keynesian DSGE framework (see Smets and Wouters, 2007 and their references). The above-mentioned papers are mainly based on the U.S data set and they mainly accentuate how in the presence of rigidities, monetary shocks trigger the real sectors' growth in the U.S economy. Keeping in view the importance of these models, a large number of central banks around the world have estimated country-specific DSGE models by taking their own set of assumptions and parameter values. Table (1) presents the results of some selected developed and emerging economies from this unexhausted series of papers on the subject. A detail survey can be viewed in Haider and Khan (2008). Briefly, these results show how the money supply shocks along with the other domestic and external supply shocks exert an influence on real sectors' growth. The results show that central banks with precise and transparent inflation targets are better able to control the effects of supply shocks.

Table 1-2 Summary of some country-specific Empirical evidence on DSGE

Country	Author(s)	Model Description	Data Description	Estimating Technique	Concluding Remarks
Developed Economies					
Iceland	Seneca (2010)	The study develops a DSGE model for Iceland to check the performance of inflation targeting regime. The paper assumes endogenous capital accumulation subject to investment adjustment costs, variable capital assumption, habit formation and other frictions.	Quarterly data of the Iceland economy has been used over the period of 1991-2005. The selected variables include consumption, CPI, exports, government spending, GDP, foreign interest rate and foreign inflation.	Both calibration method and Bayesian estimation technique have been adopted for this small open economy. The effect of monetary shocks are on all of the selected variables are analyzed.	The results show that about 50% of the fluctuations in the Iceland economy come from technology shocks and rest from all of the other factors putting together. Furthermore, the Iceland economy shows a high exchange rate pass-through to domestic prices.
England	Harrison and Oomen (2010)	The authors use their own judgment to select the short-run and long-run value of the main parameters and then predict the relationship between these variables. The authors then compare these variables with the actual UK data to identify the missing key features. These features are named as structural shocks and the authors find they are important for a model match reality.	A large macroeconomic data of the U.K economy is taken from 1955-2007. The included macroeconomic series include output, consumption, investment, total hours worked, real wages, the short-term nominal interest rate, and inflation.	Mainly Bayesian estimation technique has been used, consistent with the other literature. The authors introduce shocks to consumption and labor (in the form of preferences in the utility function), to investment (capital adjustment) and to inflation (mark-up).	The authors compare the model's prediction with the actual data and find that their estimated relationship between the variables is stronger than the true relationship in the data. The calibrated results show a poor matching of the DSGE to reflect the actual data.

New Zealand	Benes et al., (2009)	The model technology composed of several sectors of the New Zealand economy such as non-tradable sector, tradable sector, residential investment sector, investment sector. The authors test the sensitivity of different sectors to shocks in the domestic and foreign sectors.	The macroeconomic data on all of these variables is taken over the quarterly periods of 1992Q1-2008Q4.	The model is estimated using the Bayesian technique based on the information from the previous studies.	The authors show the response of macroeconomic variables to changes in endogenous and exogenous shocks. Their results show that the price changes are more responsive to endogenous shocks. Moreover, monetary shocks transmit more quickly to non-tradable sectors.
Canada	Dib et al., (2008)	A DSGE model is developed for the Canadian economy to see whether the developed framework reproduces the actual data and provides an efficient forecast to be used for the policy making.	The selected sample consists of the period from 1981:1 to 2004. The model uses the data set on output in terms of domestic demand, inflation, a short-term interest rate and money balances.	The study uses a New-Keynesian DSGE technique, albeit, with some minor differences. For example, the authors mainly focus on the estimating and forecasting the long levels of the data rather than for detrended series.	The estimated results show a divergent forecasting power of the model with respect to the selected variables. For example, on one hand, output and interest series are well forecasted by the model while, on other hand, the forecast of inflation is imprecise.
Emerging Economies					
India	Levine and Pearlman (2011)	The paper develops a two country open economy- India versus rest of the World- DSGE model to examine how different monetary and fiscal policy rules e.g., domestic versus foreign inflation targeting interest rate rules and fixed versus flexible exchange rate. The authors particularly analyze the situation in the presence of financial frictions that cause capital adjustment cost.	The authors take the calibrated parameters values that have been used for both India and U.S. These calibrated parameter values are based on the quarterly observations for both these economies.	The DSGE framework is empirically evaluated through calibrations estimated by the Bayesian approach utilizing information from the previous studies as priors.	The main results of the paper favor inflation targeting regimes over the other policy rules. The comparison of fixed and flexible exchange rates shows that flexible exchange rates assure the lower inflation rates and higher welfare compared with the fixed regimes.

China	Zhang (2009)	The study evaluates the comparative strength of two monetary policy rules; namely, the money supply rule and the interest rate rule for macro management of the Chinese economy. China’s central bank uses both these tools simultaneously to get the objective of more stability and growth. The micro-based DSGE model tests their usefulness for these objectives.	The paper mainly uses the Quarterly data of the variable sample periods subject to the data availability for any particular equation of the macro model.	Based on the estimated parameter values of the model, simulation method has been used to see the effect of inflation and output growth variables following different shocks e.g., money growth, technology and wages, etc. In the presence of these shocks the performance of money supply rule and interest rate rule has been compared.	The main results favor the use of interest rate rule against the money supply in the advent of most of the shocks. Both inflation and output face fewer fluctuations when the central bank uses interest rate rule. For a better macro management of the Chinese economy, an aggressive interest rate response inflation rate has been suggested to the central bank.
Pakistan	Haider and Khan (2008)	The paper replicates the open economy DSGE models with foreign productivity and real interest rate related shocks.	Quarterly data of Pakistani economy over the period 1984Q1-2007Q4 is used for inflation and other macroeconomic variables.	The paper uses Bayesian estimation technique to test the impact and persistence of the shocks’ effects.	The results are consistent with the other emerging market studies. The paper’s best contribution is a large survey of the previous empirical literature.
Low-Income-Countries	Peiris and Saxegaard (2007)	The DSGE framework used in the model tries to evaluate monetary policy regimes’ tradeoff in low-income countries under certain assumptions. The model tests the assumptions for Mozambique and sub-Saharan except South Africa.	The model manipulates the quarterly data over the period 1996:1 to 2005:4. The selected variables include GDP, consumption, exports, imports, inflation, M2, government spending.	Both calibration and estimations are used by using different parameter values. The estimated model utilizes the Bayesian approach, consistent with the other literature.	The study claims to be the first attempt for the sub-Saharan Africa using the DSGE model. The estimated results- which are claimed as benchmark results for the developing countries- show that pegged regimes are less efficient than inflation targeting at stabilizing the output growth.

3.2.2. Welfare cost of inflation

Theoretical literature

Our discussion so far focuses on the presence of real world rigidities and role of monetary policy in bringing macroeconomic stability. This is in spirit of the popular view which posits that inflation induced output fluctuations entail huge welfare cost and optimal policy is the one that minimizes these fluctuations. There are two relevant questions that remain unanswered in the above analysis. First, what if a central bank deviates from its price stability objective; does it have to pay a huge welfare cost in case of deviation from complete stability? And second, do central banks face a stability tradeoff between inflation variability and output growth variability or a unique optimal monetary policy rule is sufficient to control both types of fluctuations. These two questions are equally important to take the above discussion to a logical conclusion about the optimal inflation rate. However, here we address the first question – regarding the welfare cost of inflation – and leave the second one, concerning the threshold level of inflation, for the next chapter.

On the welfare cost of inflation, Bailey (1956) is the first study that empirically estimates these effects by assuming that the welfare cost can be measured through the area under liquidity preference curve. The liquidity demand curve, in their model, is a standard downward sloping convex curve where demand for liquidity goes down with interest rate. Inflation increases the cost of holding money and reduces its demand by forcing the agents to switch to any other way of transaction including barter system. Since barter transactions are costly and demand exact match between buyer and seller, inflation exerts a welfare loss for an economy. This welfare cost is quantified by taking into account the differences in demand for money under low and high inflationary periods. Friedman (1969) makes some important contribution to these views by estimating losses in consumption and real money holdings caused by inflation. This definition of welfare cost of inflation which measures the welfare cost as area under the inverse demand function – or consumers' surplus which could be gained by reducing the inflation rate to zero – has been used by the subsequent literature (see Fischer, 1981).

Both Fischer and Lucas, nevertheless, find some negligible gains in terms of GNP (e.g., 0.3% and 0.45% respectively) when inflation moves from 10% rate to a complete stability. In Lucas (2000), the welfare cost of inflation is estimated through the fraction of income that people would require as compensation in order to make them indifferent between living in a steady state (constant) positive interest rate r and another identical steady state with a zero interest rate. The author estimates the welfare cost function for different parameter values of the U.S economy over the period of 1900-1994. The results show a very high welfare cost of moderate inflation rate. In fact, a slight positive interest rate is attached with 0.05 value of income compensation parameter to keep an agent indifferent between the actual interest rate and zero percent rates.

Chadha et al. (2001) use the definition of Bailey and estimate high welfare cost for the U.K over the period 1870-1994. Interestingly, the authors show different welfare gains at different levels of inflation rate. For example, a reduction in interest rate from 10 percent – which includes 7% inflation and 3% real interest rate – to 5% yields 0.15% welfare gains in terms of GNP while a reduction of nominal interest rate from 5% to Friedman rule generates the welfare gains of 1.15% magnitude of GNP. However, as lower money growth means lower seigniorage revenues, this reduces the net welfare gains of price stability. The results of Chadha et al. (2001) show that net welfare gains from price stability are positive after accounting for the seigniorage losses.

Another important aspect of the welfare results of Chadha et al. (2001) is that their welfare gains are systematically different under logarithmic and semi-logarithmic money demand functions. The above-mentioned welfare estimates are based on the logarithmic function. This functional form has been increasingly used to estimate the welfare effects in spirit of Lucas (2000). The author finds that a log-specification is most appropriate to represent the actual interest rate and money supply dynamics of the U.S data. Ireland (2008) finds that empirical results of Lucas are mainly based on two clusters of abnormal periods – post World War II era 1945-1949 and financial deregulation period 1979-1982 – and do not represent the actual long-run U.S monetary strategy. Ireland uses the U.S data set from 1900 to 2006 and shows that a semi-log functional form best represents the actual money demand relationship for normal times. The results, based on a semi-log money demand function, do not support high welfare cost of inflation below its 2 percent level.

The RBC model of Cooley and Hansen (1989) estimates the welfare cost of inflation based on an increase in consumption that an individual would require to be as well off as under the Pareto optimal allocation. Since the authors use a CIA constraint in their consumer program, the Pareto optimal allocation is the one where CIA constraint is not binding. The estimated results, based on this criteria, show that welfare cost of a moderate inflation rate is 0.39 percent of GNP. Imrohoroglu and Prescott (1991), argue that the general equilibrium model of Cooley and Hansen does not analyze the consumption smoothing effects of inflation because in this model money enters in the utility function through a CIA constraint and facilitates only the transaction process. The authors assume a situation where agents have to smooth their consumption in the presence of idiosyncratic income shocks and interest bearing assets are the only form of liquid assets available in the market. In other words, Imrohoroglu and Prescott focus on consumption smoothing role of money in their computable general equilibrium model. The liquidity constrained households use these assets for self-insurance purposes. The authors show that in economies with a history of high inflation, agents are forced to work more. Consumption increases but at the cost of high consumption volatility. Consequently, agents have to increase their average consumption by, for example, 0.5 percent to remain at the same level of consumption when the inflation rate moves from zero to 5 percent.

Dotsey and Ireland (1996) expand the general equilibrium framework of Imrohoroglu and Prescott by incorporating several other distortions that could increase the cost of inflationary taxation. For instance, in this model inflation forces agents to inefficiently substitute out of market activity and into leisure. Second, the agents lose their productive time by indulging into the activities which economize their cash holdings. Moreover, inflation also makes a substitution of work effort from goods production to the financial sector activities. Next, the model also accounts for the allocative effect of inflation that could possibly hold back the output growth. All of these distortions, despite being small in their individual capacity, provide a very significant welfare cost of inflation when combined together. The calibrated results, based on the U.S economy parameters, show that an inflation change from zero to 10% decreases output by 0.92% when money is defined as currency and by 1.73% when money is defined as M1.

As discussed in the previous section, the earlier New-Keynesian literature assumed only price rigidity in their analysis of the welfare consequences of inflation (see Goodfriend and King, 1997; Ireland, 1997 and Rotemberg and Woodford, 1997). In these models, monetary authorities obtain the Pareto-optimal welfare with a constant inflation rate that minimizes the output gap variability. Inflation changes in all of these models induce a relative price variability and therefore inefficient dispersion of output levels. Erceg et al. (2000) contributes to this literature by adding staggered wage contracts of the labor market in addition to the price rigidity of previous research. Wage stickiness in this model generates inefficiencies in the labor market and exerts an inefficient distribution of employment among households. In the presence of both types of rigidities, the welfare maximizing inflation rate is the one that allows flexibility in price setting following the shocks. A strict inflation targeting reduces welfare since it generates excessive volatility of nominal wages in the advent of shocks. This welfare loss increases with the length of wage contracts.

In the DSGE literature, the welfare cost of inflation is estimated through various channels and the results crucially depend upon a specific mechanism through which it influences the output growth. For instance, Burstein and Hellwig (2008) estimate and compare the welfare cost of inflation in two alternative channels. In the first case, relative price fluctuations, driven by the inflation rate, cause inefficiency of production in a rigid price environment. These relative price distortions are nevertheless minimized when inflation is zero percent (see also Woodford, 2003). In the second case, the authors follow Friedman (1969) and Lucas (2000) and estimate the welfare consequences of inflation through its impact on cost of holding money. The calibrated results show that the first channel has a minimum contribution in the welfare cost, while the real effects come from second channel when inflation increases the cost of holding real balances. Moreover, the authors show that staggered price models – where price rigidity is determined exogenously – overstate the welfare cost of inflation compared to the studies where price rigidity is determined endogenously (see Levin et al., 2005). When firms can choose about the timing of price adjustment, it reduces relative price distortions.

In the empirical literature of the last two decades, several country-specific studies have aimed for estimating the welfare cost of inflation by assuming both semi-log and double-log money demand specifications. As an illustration, Eckstein and Leiderman (1992) use Sidrauski-type MIUF model to analyze the welfare cost of inflation for Israel. The authors test quarterly data of the U.S economy over the period 1970:Q1 to 1988:Q3 and estimate the parameters of the MIUF model using the Generalized Methods of Movements (GMM) estimation technique. The welfare cost of 10% inflation rate is found to be 1% loss of GNP. López (2000) uses the same model to analyze the welfare consequences for Colombia. The estimated results based on a GMM parameter estimates over the period 1977:II to 1997:IV show that inflation strikes a GDP loss of 2.3% when it moves from 5 to 20% and 1% loss of GDP when it moves from 10% to 20%. The other empirical studies include Mulligan and Sala-i-Martin (2000); Attanasio et al. (2002) and Calza and Zaghini (2010). Mulligan and Sala-i-Martin (2000) use the U.S micro level data from 1989 Survey of Consumer Finances (SCF) to see whether inflation instigates a substitution of households' assets from real money balances to interest bearing assets. The study uses four different specifications of shopping time models and assumes a specific adoption cost of shifting from money to interest bearing assets. Given that a large majority of households do not hold any interest bearing financial assets, the welfare cost of a low inflation rate is nominal.

Attanasio et al. (2002) expand the work of Mulligan and Sala-i-Martin (2000) by using a 2-years frequency microeconomic data on cash holding for Italy over the period of 1989-95. The micro level data allows them to estimate the households' elasticity of money with respect to interest rate after controlling for various financial assets, the adoption and use of a new technology, as well as consumption and income flows and demographic and occupational variables. Empirical results show that the welfare gain of a decrease in inflation rate from 5 percent to zero percent is only 0.06 percent increase households' income. This small magnitude of inflation effect is due to the fact that with the use of automated teller machine (ATM), the demand for real balances and, the consequent shoe-leather cost of inflation has declined in recent years. Moreover, the availability of different interest-bearing options also decreases the welfare cost of inflation. Similarly, Calza and Zaghini (2010) estimate the sectoral welfare cost by using the data of households and non-financial firms and find a very low welfare cost of inflation consistent with Fischer (1981) and Lucas (2000).

Although most of the above-mentioned papers show a negligible welfare cost of a moderate inflation rate, these findings have not been unanimously acknowledged by the literature. For instance, Ascari (2004) presents conflicting evidence by supporting a large welfare cost of a moderate inflation rate. For some standard parameter values of the U.S economy, the results show that an increase of annual inflation rate from 0 to 10 percent will incur an output loss of 26 percent. This output loss declines when inflation moves towards 0 percent. For instance, the steady state trend inflation rates of 8 percent and 5 percent result in 10 percent and 3 percent output losses respectively; compared to the 0 inflation rates. These large differences from the standard results are explained by the fact that, in most of the cases, the steady state is log-linearized around zero inflation rates. This assumption does not match with the observed inflation rates of developed economies.

The aforementioned literature estimated the long-run cost of inflation by comparing the steady state values of consumption and output at different levels of inflation. However, inflation certainly has some transitional effects on production; as mentioned by Burdick (1997). The author argues that these transitional effects are important since, by definition, steady state is never a case in the sense of monetary policy. The study uses a DSGE framework where individuals face idiosyncratic income uncertainty and their consumption smoothing has to take place in the absence of loan markets. In this scenario, agents are forced to keep some positive amount of money. The simulated results show that the welfare cost of 10% inflation rate during the transitional dynamics is 35% higher than the steady state inflation (from 1.27% of GDP to 1.72%). Interestingly, for some specific parameter values, the transitional welfare cost of inflation is about 120%. All this indicates the relevance of transitional welfare effects of inflation beside the steady state effects.

To conclude our discussion in this chapter, there seems to have a consensus in the literature that the negative inflation rate suggestions of Friedman rule are not feasible in absence of non-distortionary taxes and in presence of price and wage rigidities. On the other hand, the case of higher inflation has also been unanimously rejected in the literature for its undesirable distributional and welfare effects. This narrows down the policy choices for monetary policy makers and their task remains constraining the inflation rate to a moderate rate. However, the term *moderate* does not have the same meaning for different countries and even for a same country over time. In the next chapter, we discuss this issue at length and present the main theoretical and empirical results of previous studies on the subject.

Chapter 2 On the Nonlinear Relationship between Inflation and Economic Growth

1. Introduction

The relationship between inflation and economic growth has long been a debatable issue between policy makers and researchers. The idea that inflation influences growth – in either way – had not been taken seriously in the early postwar growth literature. One of the main reasons is the fact that most studies at that time were based on time series data of both pre- and post 'Great Depression' periods. The great depression resulted in a structural transformation of the developed countries' economies from classical market based economies – pre-crisis – to Keynesian Governments' mixed economies – post crisis – and this made it hard to interpret the results of these studies. At that time, almost all political and monetary institutions underwent some major changes; complicating the distinction between the effects of prices on output growth from the effects of these structural changes. As a result, price changes and output growth were either considered to be determined independently from one another or their interrelationship (if any) was taken on a country-specific basis and could take any sign depending on that country's other macroeconomic developments (see for example Bhatia, 1960). In consequence, the cross sectional studies until 1970s found this effect insignificant in most of the cases (Sarel, 1996).

Nevertheless, the early 1970s faced a new phenomenon of stagflation. These high-inflation episodes were driven by severe oil price shocks that lowered aggregate demand and caused macroeconomic instability as well as balance of payment crises. Regression analyses of these inflationary episodes were different from the previous ones and inflation started appearing a significant variable in the growth regression with a negative sign. This led macroeconomists to question the conventional independence of output growth and inflation rate. Moreover, some exceptionally good performance of the East Asian economies at that time was also accompanied by price stability in these countries. Consequently, consensus started to emerge among macroeconomists that accelerating inflation inhibits long-run growth. On the other hand, due to the aforementioned nominal rigidities in real world markets, Friedman's negative inflation rate suggestions were also considered non-applicable by policymakers of various central banks around the world.[11] In this scenario, a slight positive inflation rate remained the only policy option to assure long-run growth and stability. However, some questions concerning this mild inflation rate remained unanswered in the literature. First, at what level does inflation start inhibiting long-term growth? Second, are the detrimental effects of inflation on economic growth immune to the level of development of an economy? And lastly, what country-specific characteristics alter the direction and intensity of inflation's effects on economic activity?

In theoretical literature, most of the developments have revolved around the first question: the optimal rate of inflation. This work is based on three main pillars; Tobin (1965)'s positive effects; Sidrauski (1967)'s super-neutrality of money and Stockman (1981)'s negative effects of inflation on growth. The main difference in the results of all of these models comes from the role they assume for money. Although the experience of the 1970s strongly supported Stockman's views – which have also been recovered by several subsequent papers – they albeit do not imply a zero inflation rate as a long-term policy objective. The main complication arises from the downward rigidities, which state that in the presence of shocks, complete stability may ossify the structure of relative prices. The presence of nominal rigidities characterizes nonlinearity of the inflation–growth relationship.

Moreover, the optimality of the positive inflation rate also appears from the fact that there are several channels through which inflation may inhibit or otherwise foster growth (see Temple, 2000). If the effects of different channels overlap each other, or appear in such a way that the overall effects of inflation become significant only after certain levels of the inflation rate, then the relationship will exhibit certain thresholds (Vaona, 2012). This nonlinearity is evidenced in theoretical models that explicitly focus on unemployment in the Phillips-curve framework (Akerlof, 2000). In these models, a low inflation rate ensures a level of unemployment that is lower than the one at complete price stability or zero percent inflation rates. All of these theoretical developments took the literature to a point where the case of a positive moderate inflation rate could be defended against the alternative policy options.

Despite these remarkable achievements on the theoretical side and an overwhelming consensus in favor of a moderate inflation rate, the question of optimal inflation level is fundamentally an empirical issue. Empirical progress on this question is still very opaque. Earlier

[11]Recent outcome of the deflationary phase of 1990's, for the Japanese economy, shows that by adopting zero nominal interest rate, central bank loses its policy tool to respond the adverse supply shocks in the economy.

empirical literature supported all of the above-mentioned possibilities of Tobin, Sidrauski and Stockman effects under different modeling specifications and time periods studied. However, subsequent studies identified several deficiencies of the empirical analysis of these papers. These include an improper functional form, the inclusion of several relevant but less important covariates, and a mixture of heterogeneous cross-sections (Hineline, 2007). This turned the relationship weak and rather fragile with respect to model changes and sample specifications. A robust inflation–growth relationship has only been reported in the last two decades where the effect is found to be negative; favoring Stockman's views. Further, studies following Fischer (1993) have also shown that the relationship between these two variables is nonlinear complementing contemporaneous theoretical predictions.

On the empirical grounds, this nonlinear treatment has nevertheless suffered from several problems. The studies in the early 1990s tried to find a unique threshold of inflation rate for all countries. However, this threshold could certainly be influenced by the level of economic development in these countries because inflation tolerance throughout different countries is significantly different, because of several reasons. First of all, a country's level of development varies from one time period to another. This can also influence its inflation tolerance since it experiences different growth stages. Moreover, most of the previous studies have first assumed an exogenous inflexion point for this nonlinearity and then empirically tested for its validity.[12] These all imply country-specific and time-specific structural breaks in the inflation–growth relationship (Khan and Senhadji, 2001). Finally, these authors advance the view that because inflation could be considered a characteristic of an underdeveloped economy, this structural break is higher for developing economies than for their more advanced counterparts.

The lack of consensus kept this avenue open for further empirical investigation. As inflation's effects on growth are subject to certain macroeconomic developments that can vary substantially from one country to another, the same is true of other macroeconomic environments that condition this nonlinearity. These macroeconomic conditions include different institutional developments and choices such as trade openness, public expenditures and capital accumulation, among others. For instance, a higher degree of trade openness exacerbates the cost of inflation through exchange rate volatility and exports competitiveness. Trade openness increases the cost of opportunistic behavior for monetary policy makers and leaves little space for them to exploit the Phillips curve trade-off. By the same token, a higher level of public expenditure results in an

[12]See Fischer (1993); Bruno and Easterly (1998) and Burdekin et al. (2004).

inescapable inflation through seigniorage tax and cost overruns on public projects, reinforcing the adverse effects of inflation on growth. Inflation also hinders capital accumulation by pushing down the real interest rates and savings. Countries with a higher level of capital accumulation have to face a larger cost of inflation, due to signaling channel of investment and inefficiency in allocating resources, than the economies with low levels of capital accumulation. All of these country-specific characteristics condition the inflation–growth nonlinearity. Nevertheless, the effect of these conditional variables on the inflation–growth relationship has been overlooked by the above-mentioned previous research.

That said, as mentioned earlier, a prominent reason behind the imprecise threshold determination is the fact that, in the majority of previous studies, the threshold level has first been assumed exogenously and then tested for its empirical relevance. Omay and Kan (2010) and López-Villavicencio and Mignon (2011), have resolved the drawbacks of external threshold determination by using a panel smooth transition regression (PSTR) model for 6 and 44 countries, respectively. Nevertheless, their studies focused only on limited sets of countries and ignored the country-specific characteristics discussed above. Our paper fills these gaps by enlarging the data set and analyzing how the degrees of trade openness, capital accumulation and government expenditures can influence the nonlinearity of the inflation–growth relationship.

Another shortcoming in the existing literature is that most of studies are based on the assumption that the inflation–growth relationship can only be affected by cross-country variations in the level of inflation.[13] Consequently, these studies neglected the changes that occur in inflation and economic environments over time. To overcome these deficiencies, we use a PSTR model that authorizes a smooth transition for a weak number of thresholds over a continuum of regimes. This approach has two main advantages. First, a PSTR model enables us to transcend variation among countries and over time. This provides a simple way to appraise the heterogeneity of the inflation–growth relationship by country and over time. Second, this approach allows a smooth change in country-specific correlations, depending on the threshold variables. Our last contribution is to analyze the role of income level in determining the nonlinearity of the inflation–growth relationship by splitting the data into sub-samples of countries based on their per capita GDP.

[13] Exceptions include the above-mentioned studies by Omay and Kan (2010) and López-Villavicencio and Mignon (2011). However, their analyses are based on limited number of countries and focus only on the direct effects of inflation.

Our main findings support the results of the previous studies concerning inflation–growth nonlinearity and propose various thresholds for advanced economies, upper-middle-income countries and the emerging countries. Consistent with the previous studies, our estimated thresholds are lower for the developed countries and higher for the two later groups. Similarly, the estimated threshold results show marked differences for the inflation threshold of the first two groups from the emerging economies. Our findings for the macroeconomic developments show the validity of these channels and the overall effects of inflation are different for countries with heterogeneous conditions with respect to these variables. To illustrate, these results show that the adverse effects of inflation are low in countries with higher levels of capital accumulation, supporting Tobin's views that inflation reduces the real interest rate and increases capital accumulation. Similar differences are observed for the other two channels- trade openness and government expenditures- for the whole sample as well as for income-specific sub-samples.

The rest of chapter is organized as follows. Section 2 summarizes previous theoretical and empirical research and provides a brief discussion of the role of country-specific characteristics on the inflation–growth relationship. Section 3 presents our PSTR and 2-SLS model settings and the specifications tested. Section 4 and 5 present the data and the empirical findings, respectively. Lastly, Section 6 offers conclusions.

2. Review of the literature

2.1. Theoretical developments

The existing theoretical literature has come to conflicting conclusions both about the determinants of inflation and the effects of inflation on growth. On the first issue – the role of different factors in determining the level of inflation – two opposing views persisted in the literature. One view stated that inflation is mainly a cyclical phenomenon. It increases during the boom periods of economic activity and reduces during the recessionary periods. According to this view, inflation is influenced by the degree of slack in goods markets, services markets and factors' markets. In the recessionary periods of a business cycle, when there are sufficient supplies of all these resources, price pressure remains low. In contrast, when employment conditions ameliorate and demand of all of these factors rises, firms competing for scarce resources offer more prices and high inflation occurs.

A second (and perhaps more widely acknowledged) view in the literature states that inflation is mainly a monetary phenomenon. To this view, inflation is the excess of money supply over the money demand by the wealth owners and, therefore, inflationary changes are mainly caused by monetary factors. Tatom (1978) tests the relative strength of both these views for explaining the post World War II recessions of the U.S economy. The author finds a very consistent rise and fall of inflation with the business cycles till the late 1960s. Inflation was high during the period immediately prior to a cyclical peak and lower during the recession. However, the relation in the earlier and late 1970s did not remain same as during these years inflation was lower in the post recessionary periods than in the recessionary years. Lastly, for the whole sample period, inflationary changes could be well explained by money growth changes. Thus inflation was mainly found to be a monetary phenomenon. These findings have also been supported by the subsequent literature (see e.g., Crowder 1998). This led economists to conclude that money growth is the principal factor behind changes in the long-run inflation rate for an economy.

That said on the role of inflation in affecting the output growth, the monetary growth literature offers conflicting views. There could be three possible dimensions of the relationship between inflation and growth: a lack of a robust relationship, a positive relationship and, perhaps an adverse relationship between these two variables. Interestingly, all of these possibilities have found partial support in previous studies. The classical economists, for instance, do not acknowledge the role of inflation in influencing the real economic activity. Output growth, in these models, is determined by real factors while nominal factors (e.g., money stock) are only important for the nominal price level.

The first study articulating the real effect of inflation was Mundell (1963) where agents' wealth melts away due to inflation and to accumulate the desired wealth the agents respond by increasing their saving rate. This additional saving brings down real interest rate. Greater savings also increase capital accumulation and subsequently, the output growth. Mundell's views were further substantiated by Tobin (1965) in a neoclassical model. To obtain these positive results of money growth, Tobin introduces the role of monetary assets in the investor's asset portfolio. Government externally determines the supply of these assets and they offer fixed rate of return to their holders. The following simplified version of the neoclassical model characterizes Tobin's economy:

$$k_{t+1} = (1-\delta)k_t + i_t, \text{ and} \quad (1)$$

$$i_t = s_k \pi, \quad (2)$$

where k is the capital stock; i is gross investment spending; δ is the constant rate of capital depreciation; s_k is the fraction of output saved to acquire capital stock and; π is the inflation rate. The term s_k comprises both monetary assets and real capital stock and their relative weight in this portfolio can be influenced by inflation. When inflation increases, agents substitute away from money and towards capital stock. Higher inflation reduces the real return on monetary assets which consequently encourages a substitution of money for real investment. All this ends up with higher capital deepening and faster long-run output growth of an economy. As Tobin's model uses a neoclassical framework, inflation only affects output growth during the transition from low to high level of capital stock. A persistent increase in growth can therefore be driven only by technological change.

Sidrauski (1967) represents another major development within this neoclassical framework, where inflation does not have any real effects on the economy. These findings are denoted as Sidrauski's 'super-neutrality' of money in the subsequent literature. Briefly, in Sidrauski's model real money holding increases the agents' happiness and therefore saving decisions incorporate the objective of utility maximization. Based on these assumptions along with utility maximizing families as the basic unit of the economic system, Sidrauski note that money growth only affects the real variables in short-run. The long-run growth of capital stock is actually independent of the rate of monetary expansion in an economy. Therefore, at steady state levels of production, money growth is "super neutral" regarding its real effects on growth. Fischer (1979) argues that Sidrauski's results are valid only for the steady state level of capital stock while the transition to this steady state can be affected by the rate of money growth.

The theoretical environment assumed by Sidrauski is based on the Solow-Swan exogenous growth model with a fixed saving rate:

$$S = sY^d \quad (3)$$

where S is net real savings and Y^d is net disposable income. These 'super neutrality' results have been recovered by a variety of empirical monetary growth models. Lucas (1980), for instance, uses the U.S data set from 1955-75 on prices, money growth (M1) and inflation and shows that all of these variables move together during this period. Expected monetary changes influence prices and interest rates in the same proportion, leaving no space for the adjustment of real variables. These results have been supported by Geweke (1986) using a long run data series for the U.S over the period of 1870-1970. The results demonstrate a structural neutrality of money with respect to output growth and real interest rate, though a non-neutrality of money holds with respect to its velocity.

In contrast, Tobin's positive effects of inflation are also supported by later research. The studies supporting this view include Freeman and Huffman (1991) and Ireland (1994). Freeman and Huffman (1991) introduce the concept of inside and outside money where the first represents bank deposits which are used to create capital while the second stands for fiat money. The return on the second type of money is lower than the first but people are forced to keep it because of a flat fee being charged on capital holding. In equilibrium the returns on both types of money are equal. An increase in money supply will change this equilibrium in favor of inside money as people will substitute away from fiat money and towards real capital accumulation.

Ireland (1994) also supports the Tobin effects of inflation though valid only for the short-run. In Ireland's model, these results come from the consumption-saving decisions of agents. A representative agent faces a cash-in-advance constraint with two different modes of payment including money or credit. The holding of credit goods comes with a particular cost which increases with the quantity held at time *t* and decreases over time. This over time reduction in this cost represents the effects of financial innovations. Insofar as agents have to keep money one period in advance, inflation reduces the purchasing power of money. The holding of money decreases in inflation and the use of credit goods increases. Higher capital accumulation comes from the fact that people may retard their consumption in the current period and may wait till the use of credit good become less costly. This intertemporal substitution increases the accumulation of capital. However, these effects do not change the long run steady state output growth.

In addition to the positive Tobin effects and Sidrauski's superneutrality of money, Brock (1974), Stockman (1981) and Fischer (1983) posit an adverse relationship between inflation and output growth. Brock (1974), for instance, introduces money as an argument in the utility function beside consumption good and leisure and analyzes the behavior of consumers for the use of all of these variables, following a change in the real money balances. Moreover, Brock's model differs from Sidrauski's in that the author assumes adaptive expectations and analyzes the effects of anticipated inflation on output growth. Thus expected future changes in money supply – a notification from the government confirming the supply of additional money in the next period – will force agents to consume more and work less in the current period. The higher consumption in the current period is motivated by the fact that they expect higher prices in future. On the other hand, lower work effort is the outcome of high (nominal) future income in the next period, explaining an intertemporal work-leisure arbitrage. Lower work efforts reduce the output growth.

The adverse relationship of Stockman (1981) comes from a lower capital accumulation in inflation. To arrive at these results the author imposes a cash-in-advance (C-I-A) constraint on both consumption and investment expenditures of a representative individual and agent's liquidity constraint become:

$$\frac{m_{t-1}}{P_t} \geq C_t + K_{t+1} - (1-\delta)K_t, \tag{4}$$

where m_{t-1} is the previous period money supply and δ shows depreciation of capital. The steady state effects of monetary expansion are negative both for consumption and for capital accumulation, consistent with Friedman (1977). The inter-temporal substitution from consumption to capital accumulation à la Tobin (1965) is not possible here because this option is feasible only if higher future income can be converted into consumption through the holding of additional money stock. As money is costly to hold in inflation, the net return from investment is lower. Therefore, the relationship between inflation and capital stock becomes negative at the steady state.

Fischer (1983) modifies Sidrauski's model in two dimensions; first, the author introduces money in the production function and second, seigniorage is used to finance government expenditures. The incorporation of money in Fischer's neoclassical model yields the following production function of a representative firm:

$$y_t = f(k_t, m_t) \tag{5}$$

where k and m are per capita capital and money stocks, respectively. An increase in the growth rate of money diminishes both k and m and therefore equilibrium output. Moreover, in contrast with Sidrauski, the growth rate of capital stock is falling along the transition path between two steady states. Feldstein (1976) supports these negative capital accumulation and inflation connections through a tax mechanism. The author assumes non-adjustment of tax system for inflation and capital return after tax diminishes with inflation. This, in turn, reduces capital intensity and output growth.

Following Stockman, several endogenous growth models with cash-in-advance constraints on consumption goods have been presented showing negative effects of inflation on output growth. These include the paper by Jones and Manuelli (1993) and Marquis and Reffett (1995) among others. More precisely, Jones and Manuelli (1993) compare two endogenous growth models with and without human capital and conclude that the inclusion of human capital changes Sidrauski's money neutrality results into Stockman's negative effects. Inflation distorts relative prices of consumption and leisure goods and, therefore, inhibits growth. Moreover, as inflation affects investment decisions in an economy, it is never growth neutral, due to its marginal tax effects on capital. The empirical results of the study show that the effects of inflation on growth are modest for its relatively moderate levels and strong when it goes beyond certain thresholds. Marquis and Reffett (1995) introduce a cash-in-advance constraint on both consumption and investment goods and generalize the previous findings of adverse effects of inflation on growth through these channels.

In the real business cycle theory, as discussed in Chapter 1, money usually plays no role (see Kydland and Prescott, 1982). The exception includes Cooley and Hansen (1989) where money represses growth because of the cash-in-advance constraint. Endogenous growth theory, on the whole, explicitly acknowledges the role of money and its influence on long-run output growth. The theoretical position of all of these schools of economic thoughts concerning the direct inflation–growth relationship has already been discussed in the Chapter 1. Here we mainly focus on some prominent studies on the optimal inflation rate and/or the nonlinear relationship between inflation and output growth.

One possible implication of this nonlinear inflation–growth relationship is that it implies a non-zero optimal inflation rate. Indeed, the possibility of a moderate positive inflation rate being optimal for monetary policy cannot be ruled out theoretically. Phillips (1958) is usually considered seminal paper documenting a nonlinear relationship between real wage and unemployment for the British economy. Keynes (1936, p.314) however is the first study to document an asymmetric response of macroeconomic variables to shocks. Economic slowdown appears to be sudden while recovery takes some time to reach pre-crisis levels. The asymmetric response of the economy to different shocks means that a decrease in average output after a negative shock is greater than an increase that follows a positive shock. This supports an active demand management policy that may tolerate a positive inflation rate to minimize output fluctuations (see Bradford et al, 1988).

Some further theoretical justifications to this nonlinear effects of inflation on growth have been advanced by Fukuda (1996) and Itaya and Mino (2003). Fukuda (1996), for example, manipulates a monetary growth model with cash-in-advance constraint on consumption under the assumption of increasing returns to scale of labor and capital. With these assumptions about the factors' behavior, effects of inflation on growth depend upon the degree of returns to scale of social technology. They are positive for increasing returns to scale social technology and negative for decreasing returns to scale. Second, the study tests the inflation–growth interaction with a one sector endogenous growth model. The results slightly differ with the endogenous growth framework where the study offers two alternative balanced growth paths – a high and a low growth path – and positive effects of inflation on growth emerge when economy is on a low balanced growth path. These results are an important theoretical development in a sense that they complement the contemporaneous empirical findings supporting the view that the inflation–growth relationship can be positive for low inflation rates (see Fischer, 1993; Gomme, 1993).

In Fukuda's monetary endogenous growth model, cash-in-advance constraint applies only to consumption. Itaya and Mino (2003) extend this analysis for two alternative monetary growth models: a pecuniary transaction cost model and a shopping time technology. The authors posit that the assumed technologies have important implications for results because agent's labor-leisure choice becomes endogenous. The first implication of these technologies is that inflation influences the labor-leisure choice of agents, which consequently violates Sidrauski (1967)'s superneutrality of money. Second – and consistent with Fukuda (1996) – long-run effects of inflation on output growth depend on whether the steady state is determinate or indeterminate. In some cases, for instance, positive effects also appear when the steady state is indeterminate. The assumed nature of the production cost function or shopping-time technology also influences the effects of inflation on growth. On the whole, the authors arrive to the same results of the nonlinear relationship between the two variables.

Klump (2003) provides micro-foundations of this nonlinear inflation–growth relationship has been provided by Klump (2003) through the effect of inflation on efficient allocation of resources by firms. His work, based on a constant elasticity of substitution (CES) production function, shows that inflation disrupts the factor substitution in production process and entails a welfare cost. This cost is higher for rich economies where the role of money as an institution is strong for resource allocation and factors' substitution, while in low-income economies working under conventional sectors have low cost of inflation in terms of loss in allocative efficiency. This explains why the optimal inflation rate decreases with the level of development of that economy. Factors' substitution is highly elastic in developed economies making their optimal inflation rate lower than emerging economies.

The menu cost models provide further theoretical justifications of this nonlinear inflation and growth relationship. In these models a costly adjustment to demand shocks implies that the relationship between inflation and growth varies with the level of inflation. As an illustration, Ball et al. (1988) show that in the presence of menu cost, the response of different firms will be asymmetric to demand shocks. When the level of inflation is low, price adjustment to shocks becomes slower and output responds more strongly than prices. However, when inflation increases, the adjustment process becomes quicker and output becomes less responsive to demand shocks. The behavior of output growth to demand shocks makes the higher inflation rate more costly. Dupasquier and Ricketts (1998) present another implication of firms' menu cost on the inflation–growth nonlinearity. To them, in a low inflationary environment, firms make longer contracts with workers to avoid the cost of adjustment. These long-term contracts result in lower wage changes during demand shocks, even if the wages and prices are fully flexible. This induces a higher sensitivity of output response to price changes in a low inflationary environment than in high inflation periods.

As discussed comprehensively in Chapter 1, Friedman's rule considers a negative inflation rate as an optimal monetary policy. The new Keynesian literature, on the other hand, discusses about the price and wage rigidities and analyzes the impact of these rigidities on the optimal inflation rate. The nominal rigidities alter the optimal inflation rate in these models. For instance, in presence of nominal wage rigidities, if firms experience a favorable shock in one period and an unfavorable shock in the next period, it is easy to adjust in response to the former shock but not in response to the latter (see Akerlof et al, 1996). This exerts a negative impact on their production capacity and consequently on the overall employment. A onetime shock, if not absorbed through real wage change, can reduce output growth permanently. Akerlof et al. (1996), in their general equilibrium framework, show that a moderate inflation rate offers a solution to this problem. Their simulated results for the U.S economy show that a 3% inflation rate comes along a 5.8% unemployment rate and reducing inflation rate to 0% substantially increases the U.S unemployment rate.

These results are further substantiated by Akerlof et al. (2000); Dolado et al. (2003). Akerlof et al. (2000) posit that agents' projections about the future wages and prices are incomplete and that they underestimate anticipated inflation. This near-rational behavior of agents has some consequential effects for the optimal inflation rate and the trade-off between inflation and unemployment (see also Graham and Snower, 2008). Blanchard and Fischer (1989) write: "*Most economists who came to accept the view that there was no long-run trade-off between inflation and unemployment were more affected by a priori argument than by empirical evidence*". Dolado et al. (2003) compare the Phillips curve relationship between the U.S and the European Union (EU). The authors find that in the EU countries with strong downward wage rigidities, the Phillips curve relationship is nonlinear, whereas in the U.S the relationship is linear. This supports the view of having a positive inflation rate in the presence of downward rigidities.

Last but not least, the state of the art new-Keynesian DSGE models also advance a trade-off between real (output) and nominal (inflation) variability. In these models, due to wage and price rigidity it is hard to stabilize both inflation and output gap (see e.g., Gali and Monacelli, 2005; Blanchard and Gali, 2007; Duval and Vogal, 2012). A stable output growth requires flexible prices that are only possible if the existing inflation rate is positive. Monetary policy that aims to stabilize output growth in the presence of shocks is essentially attached with positive long-run inflation rates. Certainly these inflation rates will not be high enough to decrease output growth through allocative inefficiency. Therefore, a nonlinear relationship between inflation and output growth can be conjectured from their main findings.

To summarize the above discussion, there seems to be an overwhelming consensus in the theoretical literature that the overall effects of inflation on growth are negative. However, consistent with Stockman (1981), these negative effects unfold only when inflation surpasses certain thresholds. Below these inflexion points, the effects of inflation are either positive or innocuous. The determination of these particular inflexion points is fundamentally an empirical issue and can be different among countries or for the same country over time.

2.2. Empirical advancements

2.2.1. The linear inflation–growth models

The above-mentioned theoretical literature triggered a large empirical literature on testing the direct relationship between inflation and output growth. Interestingly, the empirical work has faced an evolution over time similar to its theoretical counterpart. For instance, until the mid 1970s the empirical work did not provide guidance to policy makers regarding the nature and the sign of the inflation–growth relationship. One underlying factor was that, as mentioned earlier, there was no evidence of systematic high inflation rate before the early 1970s except some country-specific hyperinflation outbursts such as the one in Germany during the interwar years. However, this reason was not valid for all countries since several emerging economies were facing a high inflation rate e.g., Latin American economies with double digit inflation at that time. Despite this, the empirical work for these countries also did not provide any guidance about the nature of interaction between inflation and growth. To illustrate, Galbis (1979) tested the effect of inflation and real interest rate changes on income and investment behavior of 19 Latin American countries over the period of 1961-73. The main findings of the study show absence of any significant relationship between inflation and capital formation or income growth in most of the countries. The same type of ambiguity in the inflation–growth relationship can be found in other contemporaneous studies such as Dorrance (1966) for IMF member countries over the period of 1953-61.

These studies were based on relatively short periods of pre-oil price shocks. The occurrence of supply shocks has had very strong effects on monetary policy dynamics around the world. Moreover, a lack of robustness also resulted from the fact that different studies during this era were using different functional forms (see Levine and Renelt, 1992). Intuitively, for the same variable of interest, changing the theoretical functional form or conditioning set of information can yield completely different results.[14] Indeed, this was the case for the empirical inflation–growth relationship. For instance, Levine and Renelt (1992) and Hineline (2007) tested the robustness of this relationship and found that the inflation–growth nexus is brittle; it changes with the model specification. To get these results, Levine and Renelt (1992) use extreme-bound analysis for a cross-sectional data over an average of 30 years and tested the robustness of the coefficient estimates under alternative sets of control variables, included in different linear models. Their main results show that the inflation–growth relationship is specification and

[14] See Levine and Renelt (1992; footnote 3).

frequency dependent and it fades away if inflation is replaced by its instrument. Empirical models also faced omitted variables problems, which rendered their results biased and inconsistent. For instance, different institutional variables could affect both inflation and output growth, making the relationship between these variables spurious.

The absence of a robust inflation–growth relationship in this earlier literature did not stop the empirical investigation into the existence of this relationship. One reason was that theoretical literature after Stockman (1981) repeatedly mentioned a robust negative relationship between these two variables. Macroeconomists were convinced that prudent macroeconomic policies with balanced budget and low inflation were conducive to growth. Fischer (1993), for instance, describes and compares the case of Latin American countries where high growth in Chile and Mexico was accompanied by disciplined budgetary policies and low inflation while the economic turmoil of Brazil coincides with high inflation. However, these non-econometric evidences are not compelling because some low inflation countries of franc zone could also be found with low inflation and yet a very low output growth due to their other institutional problems such as political instability, imprudent fiscal policies and a low level of financial development.

On the empirical grounds, one main factor complicating the identification of the inflation and economic growth relationship is the fact these variables are endogenous. To address this endogeneity problem, proper instruments are difficult to find and the relation becomes ambiguous in many cases. However, studies using the central bank's independence as an instrument of inflation (Cukierman et al. 1992; De Long and Summers, 1992) concluded that with the use of proper instruments, inflation does have a significant negative effect on the output growth. Since central bank independence can also be correlated with changes in country's unmeasured institutional features, later studies (Barro 1996) have tried to include some other explanatory variables like an index of rule of law in the regression framework. Lower inflation in all of these cases is associated with higher long-run output growth.

The lack of a robust relationship between inflation and growth could also result from an improper functional form. The theoretical literature of the last few decades- discussed earlier- has persistently stressed on the fact that the relationship could be nonlinear while the empirical literature mainly focused on testing a linear relationship between these two variables. This lack of coherence between theoretical and empirical research was one possible factor why the adverse effects of inflation could not show up in the empirical literature. Intuitively, if the effects of inflation on growth appear after certain levels then averaging the high and low inflation values can undermine the true magnitude of its influence. This motivated researchers to test this relationship by using alternative functional forms.

2.2.2. The nonlinear inflation–growth models

The asymmetric Phillips curve relationship of the theoretical literature could be well captured by using nonlinear functional forms. Therefore the empirical research starting from the early 1990s has mostly used nonlinear models. Levine and Zervos (1993) are among the first studies separating the effects of low and high inflation on output growth. Levine and Zervos use cross-sectional data of 102 countries over the period of 1960-89. The authors find two important relations between inflation and growth; first, for countries working at moderate inflation rates, rapid inflation changes limit growth and second, high-inflation countries have systematically lower growth than low inflation regimes; ceteris paribus. In other words, the authors show that only high inflation values could explain cross-section correlations between inflation and output growth. The correlation loses its significance with the omission of these high inflation cross-sections.

Fischer (1993) is considered as the first paper testing the inflation–growth relationship for both cross country and panel data sets. Fischer argues that as primary effects of inflation on growth appear through investment uncertainty, investment should be lower in high uncertainty environments and it can only be noticed in the time series data. To estimate the nonlinear relationship the author estimates a spline function with breaks at 15% and 40% inflation rates. The estimated results confirm the nonlinear relationship as intensity of the negative relationship between inflation and growth decreases at the higher inflation rate. These results helped subsequent researchers on the exact functional form of the relationship and several papers in the following years could be found estimating the nonlinear relationship.

The above results are also supported by Barro (1995) for a larger data of more than 100 countries. The frequently cited paper of Barro takes five years average of the annual data over the period of 1960-90 and uses Instrumental Variable (IV) estimation technique. The author tests different specifications including three sub-samples with respect to time (1960-70; 1970-80 and 1980-90) and the other three sub-sample with respect to inflation regimes (low inflation up to 15 percent, moderate inflation between 15-40 percent and high inflation above 40 percentage point).

The estimated results show that an increase in inflation inhibits annual growth by about 0.2 - 0.3 percent. The study controls for the effect of institutional factors and initial conditions to get these results. Barro argues that these small annual effects have huge impact on the long-run welfare of a society. For instance, the results show that a monetary policy change that increases the long-term inflation rate by 10 percent point affects GDP after 30 years by 4-7%. Gylfason (1999) also shows that higher inflation rate is significantly reducing the long-run growth. Their main findings show that an increase of inflation from 5% to 50% diminishes output growth by 2.3% per year; ceteris paribus.

The above-mentioned studies and other contemporaneous empirical work reached at two broad results, first, the overall long-run relationship between the two variables has been found negative and second, the intensity of the relationship strongly depended on the data frequency. In the high frequency data set – using annual or five years average – the relation is found to be strong and robust, whereas in a cross sectional environment – using e.g., 30 years average – the relationship is weak or inexistent. Bruno and Easterly (1998) test this frequency dependence of the inflation–growth relationship by analyzing the pattern of output growth before, during and after the high-inflation episodes. High-inflation episodes are periods where inflation exceeds 40 percent. The relationship is tested with cross-section, five years average and pooled annual data sets. The results show that significance of the negative relationship strongly depends upon high inflation observations. Growth is low during crisis periods and high in both pre-crisis and post crisis periods. As recovery towards high growth is quite rapid, a cross-sectional data with longer time duration cannot detect this effect.

Following Fischer (1993), an excessively large amount of literature has focused on the nonlinearity question of the inflation–growth relationship and tried to identify threshold points for the level of inflation. An obvious reason behind finding the structural break in this relationship is the fact that the threshold inflation rate has strong policy implications for any developed or emerging economy. It gives an upper bound of inflation for the conduct of monetary policy. Sarel (1996) is among the early attempts to specify any threshold point in this relationship by doing a panel regression and combining a nonlinear treatment of inflation and growth. Sarel takes the data set of 87 developed and developing economies over the period of 1970-90. The results show that a structural break exists at 8% inflation; below this level inflation is innocuous (rather beneficial) and above this it is harmful for growth. Ghosh and Phillips (1998) later on found a rather low threshold of 2.5% for a sample of 145 IMF member countries during the period of 1960-1996. The negative inflation–growth results are confirmed by both time series and cross-section dimensions of the data set.

Ghosh and Phillips also report that negative effects of inflation on growth and their structural break are stronger at lower inflation rate than in high inflation regimes. For instance, the growth reduction associated with inflation is higher when it increases from 10 percent to 20 percent than when it increases from 40 percent to 50 percent. These results are different from Barro (1995) where the differences among coefficient values at different levels of inflation are not distinguishable. The results also differ from Bruno and Easterly (1998) where the authors find that the negative effects of inflation are only relevant for high inflation observations of their selected countries. Ghosh and Phillips' findings are, however, complemented by several other studies that include Fischer (1993), Burdekin et al. (2004) and Gillman and Harris (2010). Gillman and Nakov use the data set of 13 transition economies over the period of 1990-2003 and apply a fixed effects panel approach to get these results. Their log specification of inflation implies that the effects of inflation decrease at higher inflation levels.

Burdekin et al. (2004), by contrast, use a spline function to figure out the structural breaks and find the marginal growth cost of inflation after these breaks. Their results show that the coefficient of the marginal cost of inflation falls by nearly three-quarters above the break. Fischer (1993) finds that the coefficient of inflation between 15% and 40% is substantially higher than the one after 40%. Levine and Zervos (1993) argue that a persistently high inflationary environment makes the agents inured to it and enables them to develop a host of mechanisms for coping with inflation. On the other side of the argument, in a very low inflation environment, inflation has to reach a certain level before resources need to be reallocated. Therefore, in both extremely low and high inflation environments, growth moves independently of inflation. It is only under moderate inflation regimes that the marginal inflation changes are growth reducing.

The empirical studies of the late 1990s (e.g., Sarel (1996); Ghosh and Phillips, 1998) used log-linear specification to account for the fact that marginal effects of inflation diminish at higher inflation rates. However, these studies and the other above-mentioned papers including Fischer (1993) and Barro (1995) did not distinguish between developed and developing countries. While Fischer shows that the effects are different when inflation moves from moderate to high inflation regimes, the author does not conduct a sub-sample analysis with respect to the level of economic development of the included economies.[15] Certainly the level of economic development affects the actual inflation impact and determines the importance of seigniorage revenues in a country. By the same token, other macroeconomic and political institutions of both categories also determine the inflation tolerance and its adverse effects. The optimal inflation rate or the structural break in the inflation–growth relationship, therefore, differs between the two categories. This motivated later empirical works to treat the developed and developing economies separately.

Kim and Willet (2000) show that mixing up both developed and developing economies produces unreliable estimates of inflation thresholds. Khan and Senhadji (2001) take this point and conduct two sub-sample analyses for both developed and developing economies. The study uses nonlinear least square (NLLS) where the minimum value of a residual sum of squares for a likelihood ratio test gives the threshold inflation level. The results show two different inflation thresholdsat 1 and 11 percent, for both the developed and developing economies respectively. Below these inflexion points, the effects of inflation on growth are positive in both cases and beyond these levels inflation inhibits long-run growth. Burdekin et al. (2004) make a similar distinction between developed and developing countries and find their respective thresholds. The authors notice that for developed economies inflation has increasingly negative but (statistically) insignificant effects up to 8%. For developing economies, by contrast, the effects are positive and significant up to 3%.

The threshold results till the early 2000's studies differ from one paper to another, though not to a large extent. Hineline (2007) tests the robustness of these results. Hineline addresses the same concerns as Levine and Renelt (1992), however, unlike Levine and Renelt who treat this question for linear cross-section models, the author also tests the robustness of the panel results of nonlinear models. Precisely, the study focuses on pointing out whether the lack of robustness in Levine and Renelt is due to improper specification or because of low data frequency. The robustness of the inflation–growth results is tested by using a Bayesian Moving Average (BMA). The study shows that the inflation–growth relationship is robust with respect to models or specifications changes for the panel data with fixed effects whereas, for cross-section data the results are fragile. On the basis of these findings, Hineline argues that the lack of robustness in Levine and Renelt is due to data frequency and not due to their linear specification.

[15] In fact the study of Ghosh and Phillips (1998) compares the upper and upper-middle group with lower and lower-middle-incomegroup and evidences larger coefficients for the first group, yet the differences between the two groups fade away with log specification.

Another aspect of these nonlinear models is the way nonlinearity has been tested in this literature. Traditional approaches to take into account these nonlinearities have either exogenously determined the threshold level or came up with an improper treatment of the endogenous threshold. This provides unreliable estimates of the threshold inflation rate. This directed some recent authors, including Omay and Kan (2010) and López-Villavicencio and Mignon (2011), to use a recently developed modeling technique called panel smooth transition regression (PSTR) models, advanced by Gonzalez, Terasvirta and van Dijk (2005) and Fok, Van Dijk and Franses (2005). The key characteristic of this modeling technique is that the threshold level of inflation is determined endogenously. The paper by Omay and Kan (2010) is based on a small panel data for six industrialized economies (namely, Canada, France, Italy, Japan, UK and US) using an annual data over the period of 1972-2004. The results show a critical threshold level of inflationfor these countries at 2.52 percent. Furthermore, these threshold values change with the inclusion of new variables although the effect is minor on the coefficients and their t-values. Some further contribution came from López-Villavicencio and Mignon (2011) for a relatively large data set of 42 developed and developing economies based on same PSTR and dynamic GMM approach. Their threshold estimates are 2.7% and 17.5% for the developed and developing economies respectively.

2.3. Country-specific characteristics and the inflation–growth nonlinearity

Inflation-growth literature shows systematically different results for developed and emerging countries. The optimal inflation rate is lower for the first group compared to the later. Certainly, the level of income in a country determines agents' asset composition and therefore their sensitivity to inflation changes. This consequently translates into a strong inflation effect for high income economies. However, some other variables can also determine the differences of effects of inflation on growth from one country to another. A major factor explaining this systematic difference is the level of institutional and other macroeconomic developments. As emerging economies are working at a lower level of developments with respect to these variables, harmful effects of inflation unfold only at its higher levels for these countries making their optimal inflation rate higher than that of developed economies. This implies that effects of inflation can be different between two relatively comparable economies with different levels of macroeconomic environments. In other words, economies with heterogeneous level of financial development, capital accumulation or trade openness will face dissimilar consequences of the same level of inflation in terms of output growth.

Indeed, there can be a number of factors that can influence sensitivity and/or sign of the relationship between inflation and output growth. Nonetheless, surprisingly, these factors have rarely gained any attention in the discussions about the inflation–growth relationship. The empirical literature only focused on the income differences between different countries to find their inflation–growth interaction. Consequently, the literature put countries under two umbrellas of developed and emerging economies assuming homogeneity of these groups with respect to these variables. Ghosh and Phillips (1998) is the only exception in the literature highlighting the importance of these "conditioning" variables. They share this view in the following way, "*...there may be rich and important interactions between inflation and the other determinants of growth. For example, the marginal effect of inflation on growth may differ according to the level of physical and human capital in the country. With growth having many possible determinants, it may be difficult to model such interactions…"* (Ghosh and Phillips, 1998 p-673).

Several justifications can be made for this lack of interest on the empirical investigation into these variables. Firstly, the number of conditioning variables can be very large with their own relative importance in determining this interrelationship between inflation and growth (see Levine and Renelt, 1992). Second, and perhaps more importantly, as maintained by Ghosh and Phillips, growth is influenced by many factors and selecting the set of appropriate control variables becomes difficult especially when theoretical literature does not provide any prior help on it. Nonetheless, this argument of Phillips and Ghosh is relatively less important now since empirical work of the last decade is using almost same set of covariates (see Omay and Kan, 2010; López-Villavicencio and Mignon 2011). The inclusion of some specific set of covariates certainly does not undermine the effect of other variables; rather it allows us analyzing main "conditional" variables that need primary attention for this treatment. We make a first attempt and consider the role of some major conditional variables including the degree of trade openness, the level of public expenditures and the level of capital accumulation for the sensitivity of effects of inflation on growth. Here we present some important theoretical connections and empirical support on all of these factors to examine how these macroeconomic developments can possibly change the behavior of effects of inflation on growth. It is important to mention that although in the empirical section we will test the effects of all of these channels for both developed and emerging economies; their theoretical connections are more valid for the second groups.

2.3.1. Trade openness and the inflation–growth relationship

In the literature on trade and economic growth, openness is considered a source of macroeconomic stability and a high growth for an economy. Open economies have a strong level of economic interaction with the outside world forcing them to follow disciplined monetary and fiscal policies. Imprudent macroeconomic policies of the open economies can cause fluctuations in financial markets making them more fragile to different shocks. This implies that in open economies policy makers tend to have more concerns for macroeconomic stability and lower inflation than their closed counterparts. On the other hand, closed economies invite opportunistic behavior of the policymakers where they can exploit short-run advantages of seigniorage and employment by generating inflation. Similarly, the cost of inflation in these economies is not so high since it does not pose a threat for their international credibility. Moreover, it does not make them vulnerable to terms of trade shocks. All this makes any level of the inflation rate more costly in the open economies than in their closed counterparts since its adverse effects are stronger in the first group compared to the second one.

This robust theoretical connection between trade openness and macroeconomic stability has invited lots of papers to model this relationship theoretically and then to conduct the empirical tests accordingly. For instance, on the direct relationship between trade openness and inflation, Dexter et al. (2005) argue that for a monopolistically competitive closed economy, an excess demand affects the level of inflation. As the degree of trade openness increases for that country, the excess demand gap is filled by the imported substitutes. This not only breaks the relationship between the excess demand and inflation but also between inflation and capacity utilization of firms. On the other hand, trade openness is also a prominent factor behind the 'Goldilocks' situation - with both low inflation and low unemployment - of the U.S economy in 1990s (Gordon, 1998). Hence trade openness resulted into lower cyclical movements and a higher output growth despite inflation. Putting differently, the direct adverse effects of inflation on output growth can be attenuated with higher degrees of trade openness. Effectively, higher degree of trade openness increases the cost of inflation uncertainty and diminishes the average desirable inflation for the long-run output growth (Granato et al., 2007).

Similarly, the undesirable effects of inflation on capital accumulation also vary with the degree of trade openness in a country. Cohen et al. (1997) share these views, where the authors report that in a closed economy environment, inflation tax equally erodes the corporate profits of producers and interest earning of representative agents. Nevertheless, in an open economy case, profits and savings are not taxed equally because of FDI flows. Nominal interest rate earnings are taxed via domestic fiscal policy, whereas profits of foreign investors are taxed in their parent economies. This discourages savings by increasing the cost of capital accumulation by the shareholders and reduces investment in an open economy. Therefore, openness exacerbates the adverse effects of inflation in terms of capital accumulation and the growth reducing effects of inflation become larger.

This finding, nevertheless, contrasts with Hartman's (1979) that inflation increases the capital intensity in an open economy. The study assumes perfect capital mobility across markets and argues that inflation increases interest earning in the economy, compared with rest of the world. This fosters the capital flow towards that country and stimulates capital accumulation. Desai and Hines (1997) further expand this work and specify the share of domestic and international investors in the capital accumulation. To them, when a uniform inflation tax is imposed on domestic and foreign firms, foreign savers can deduct exchange rate losses from their taxable income due to depreciation of inflating country's currency while domestic savers cannot deduct these losses, and hence face a net loss of inflation. This, in turn, decreases domestic savings and investment, although the overall capital accumulation increases. Moreover, rapid inflationary changes result in larger deadweight losses for the inflating country due to the distortions attached with capital movements. Therefore, inflation tax yields distortions that are much higher for an open economy than for a closed economy. This complicates the link between inflation and international capital inflow in open economies.

The relationship between trade openness and inflation also appear from exchange rate stability. Exchange rate volatility produces balance of payment problems and halts investment decisions by domestic and international investors. Romer (1993) posits that open economies want to keep exchange rate stable to avoid undue burden of essential imported goods. Unanticipated increases in the money supply cause a depreciation of the real exchange rate and increases price of imported goods. As imports make an important contribution in open economies' domestic inflation, higher overall prices force workers to demand higher wages which, consequently, diminishes the domestic firms' competitiveness. Hence the negative effect of inflation on growth, after some levels, becomes stronger in open economies making the similar inflation rates more costly for these countries compared to the closed economies. Terra (1998) presents counter evidence by showing that Romer's results are driven by 1980s' post crisis data of highly indebted developing economies. Pain et al., (2006) provide empirical substantiation to Romer's findings by showing that with the increasing openness in the OECD countries after 1980s, import prices became an important factor of the domestic inflation. Sachsida et al., (2003) and Lane (1997), for instance, also support these results.

On the other hand, closed economies usually generate unexpected inflation to exploit short-run trade-offs, as mentioned earlier. This increases their long-run average inflation rate. However, the evidence on this negative openness–inflation relationship is inconclusive as a parallel strand of literature contradicts these results.[16] To summarize, the literature on the openness-inflation relationship is mixed and requires a more concrete analysis on how growth response to inflation changes with higher degrees of trade openness. This justifies our attempt to study the role of trade openness in the inflation–growth nonlinearity. If the increasing degree of trade openness makes that country more sensitive with respect to effects of inflation, then the adverse effects of the same level of inflation should be higher in open economies compared with closed countries.

2.3.2. Government expenditures and the inflation–growth relationship

Consistent with the above discussion, the level of government expenditures can also condition the sensitivity of effects of inflation on growth. In the literature, the relationship between inflation and public finance appears mainly through seigniorage taxation. A large and unsustainable long-term public deficit forces central banks to inflate for the purpose of deficit financing (Sargent and Wallace, 1981). This is especially relevant for emerging economies where conventional tax revenues to finance government expenditures remain volatile because of the fluctuations in economic activity. The emerging markets' governments also face some borrowing constraints as they require a substantial amount of resources to develop infrastructure and to invest in the public projects such as health and education. This increases their dependence on seigniorage for financing the budgetary deficits.[17] Consequently, their money growth rate remains high and also exhibit volatility over time (see Bowdler and Malik, 2005). The magnitude of seigniorage revenues depends upon the extent to which governments want to smooth these revenue fluctuations and their external borrowing constraints - along with the

[16] See Pehnelt (2007), for a brief literature on this issue.

[17] It is important to mention that seigniorage is not always strongly correlated with inflation; as discussed by Aisen and Veiga (2008). Their results show a very weak correlation between the two variables at high inflation rates. The authors argue that factors determining the both variables may differ and a unique level of seigniorage might result two different levels of inflation in a well-defined Laffer curve.

other factors such as central bank independence. In this context, the effects of inflation on growth are also determined by tax composition of a country and her ultimate reliance on seigniorage revenues. On the other hand, countries with strong conventional tax networks have a low dependence on inflationary taxes and the adverse effects of inflation remain high for these economies.

Some authors also confirm a direct relationship between public expenditures and inflation. Undue public expenditures exacerbate excess demand, crowd out productive investment and increase the overall price level. Bhatia (1982), for instance, based on critical limit hypothesis shows that when government expenditures exceed 25% of the total economic activity, high inflation is natural outcome. These findings have been supported by some recent studies for both developed and developing economies which include the work of Ezirim and Ofurum (2003) for Nigeria and Ezirim et al. (2008) for the U.S. In all of these studies, a high public expenditure to GDP ratio translates into an accelerating long-run inflation. Han and Mulligan (2008) contradicts these results by showing that a positive relationship between inflation and finance is only valid for transitory public expenditures, whereas permanent expenditures do not influence the inflation rate. The study takes the data of 80 countries over the period 1973-1990 and defines defense expenditures in war as transitory expenses and non-defense expenditures as permanent one. The results show a very weak negative relationship between non-defense expenditures and inflation rate while a slight positive relationship between defense spending and inflation was documented.

Click (1998) shows a strong correlation between transitory government spending and inflationary finance for the cross-section of 90 developed and developing countries over the period of 1971-90. The study posits that although average government expenditures do not explain the level of seigniorage revenues, yet changes in the government spending do influence it. This relationship between changes in public expenditures and seigniorage illustrates the inefficiency of conventional taxation to accommodate short-term changes in public spending. It can also result from the volatility of tax collection. The average seigniorage revenues are shown to be 10.5 percent which implies that inflationary taxes are considerably important source of revenues, especially for those economies that are credit constrained because of their lower creditworthiness (the ability to repay in foreign currency). Click also argues that if large public expenditures are supported by debt, they can lead to an excessively high growth of public debt which requires unanticipated inflation changes to reduce it. Inflation, in these circumstances, does not necessarily play a negative role for growth or at least its adverse effects can be lower for economies with a large public size and a poor fiscal management.

The effects of inflation on growth appearing through public expenditure channel, are bi-directional; public expenditures not only augments the level of inflation but can also be influenced by the level of inflation – through cost escalation.[18] In short, the relationship between inflation and growth can be affected by the size of public expenditures. However, previous studies did not discuss the role of public size for the inflation–growth nonlinearity. If the size of government expenditures affects both inflation and its volatility then growth inhibiting effects of inflation should be different for two countries with different sizes of public expenditures.

2.3.3. Investment and the inflation–growth relationship

The most prominent channel through which inflation affects the output growth is capital accumulation. High inflation mars the signaling channel which is important for long-term investment decisions of agents. Inflation has also been considered as an indicator of macroeconomic instability (see Heylen and Pozzi, 2007) which may cause a delay in the actualization of potential investment projects. Similar problems can arise for agents who are net savers as they may opt for a portfolio adjustment of their savings leading a lower capital accumulation. In the presence of free international capital mobility this macroeconomic instability may also lead to an outflow of capital from high-inflation countries to the stable ones. A counter argument to this states that inflation raises the interest rate and provokes an outflow of capital from low to high inflation economies.

These and many other channels explain the widely discussed inflation and investment relationship. These theoretical connections are represented by several models and also investigated in the empirical literature. However, we will not present a summary of these discussions here as they have been comprehensively addressed in the next chapter. As effects of inflation appear mainly through allocative efficiency and investment, the actual degree of capital accumulation can also determine the magnitude of effects of inflation on growth. In countries with a high degree of capital accumulation, the effects of inflation on growth can be very different from those with a low investment to GDP ratio. In the previous research, Li (2006)

[18] Direct effect of public expenditures on growth has been widely addressed by the previous research (Barro, 1991, and Barro and Sala-i-Martin, 1992).

analyzes how inflation influences growth through its effects on the efficiency of investment (measured as growth rate of TFP) as well as the level of investment (measured as investment/GDP). The results indicate that the detrimental effects of inflation on growth mainly appear through efficiency channel of investment. By contrast, the positive (Tobin) effects have been supported by several studies including Barro (1995) and Lioui and Poncet (2008).

Gillman and Kejak (2011) argue that Tobin effect may increase capital intensity because of lower interest rate in inflation but they do not affect the overall capital accumulation and therefore output growth may fall in the long-run. Certainly, all of these competing effects of inflation on the capital accumulation and growth depend upon a country's actual level of capital accumulation. Economies with a high level of investment to GDP ratio will respond more severely to inflation changes and the effects of any particular level of inflation on capital accumulation and growth will be larger compared to low investing countries where capital accumulation may be mainly driven by productivity factors than by the real interest rate channel. Our empirical analysis will focus on how the inflation–growth nonlinearity is conditioned by the degree of capital accumulation of that country.

To summarize the above discussion, the inflation–growth relationship is not simple and the effects of inflation on growth can be determined by various other country-specific factors that can play a role of conditional variables for this relationship. All of this complicates the conceptual framework as well as the empirical investigation into this relationship. This requires a broader analysis by including main macroeconomic conditions that are influential for this bi-variate inflation–growth relationship. Our paper makes a first attempt to investigate into some main conditional variables.[19] More precisely, we aim to analyze how different levels of macroeconomic developments including trade openness, capital accumulation and level of public expenditure can bring an additional impact on the sensitivity of the inflation–growth relationship and for the optimality differences across samples.

[19] A few other important country-specific characteristics such as total factor productivity, public debt and human capital accumulation are left for consideration in future research (see also Yilmazkuday, 2012 for some interesting discussion on this topic).

3. Empirical methodology

3.1. PSTR model specification

To investigate the nonlinear relationship between inflation and economic growth, we use the Panel Smooth Threshold Regression (PSTR) model proposed by Gonzàlez, Teräsvirta and van Dijk (2005) and Fok, van Dijk and Franses (2005). To illustrate the inflation–growth relationship, let us suppose the simplest case of a PSTR with two extreme regimes and a single transition function:

$$y_{it} = \alpha_i + \beta_0^{'}\pi_{i,t-1} + \beta_1^{'}\pi_{i,t-1}\Gamma\left(q_{it};\gamma,c\right) + \delta_0^{'}z_{it} + \varepsilon_{it}. \tag{1}$$

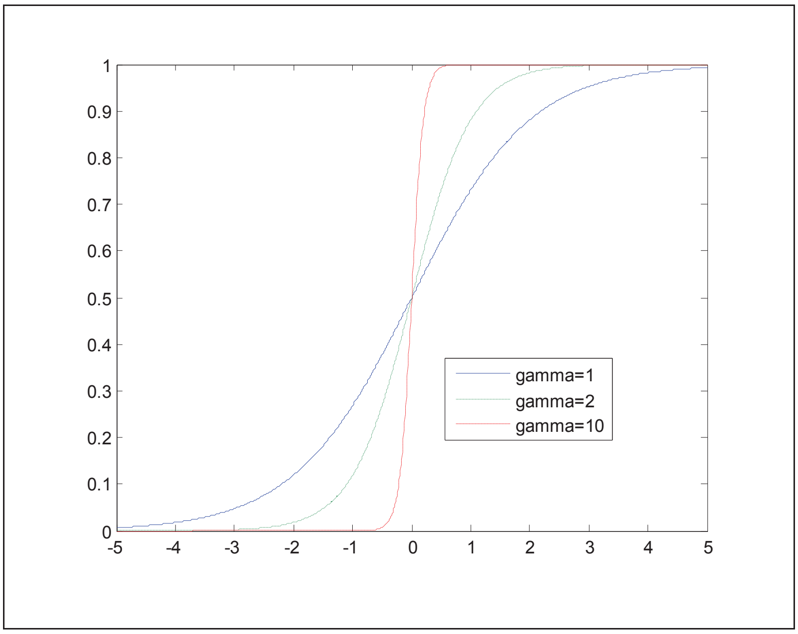
for $i = 1,\ldots,N$ and $t = 1,\ldots,T$, where N and T denote the cross--sectional and time dimensions of the panel, respectively. The dependent variable y_{it} is a scalar and denotes the growth rates of GDP, $\pi_{i,t-1}$ is the first lagged value of the inflation rate,[20] and z_{it} is a *k*-dimensional vector of control variables usually considered in the growth literature. α_i represents the individual fixed effects, and ε_{it} is the error term. The transition function Γ is continuous and depends on the threshold variable q_{it} and on $c = \left(c_1,\ldots,\ c_m\right)'$ which is a vector of location parameters and the parameter γ determines the slope of the transition function. Following Granger and Teräsvirta (1993), González et al. (2005) consider the following logistic transition function:

$$\Gamma\left(q_{it};\gamma,c\right) = \left[1 + \exp\left(-\gamma\prod_{z=1}^{m}\left(q_{it} - c_z\right)\right)\right]^{-1}, \quad \gamma > 0, \quad c_1 < \ldots < c_m. \tag{2}$$

In Figure 2.1, the transition function is displayed for various values of slope parameter γ. For a high value of γ, the transition becomes rougher and the transition function $\Gamma\left(q_{it};\gamma,c\right)$ tends towards the indicator function $\Gamma\left(q_{it};c\right)$. Hence, for every value of m, when γ tends towards infinite, the PSTR model reduces to Hansen's (1999) two-regime panel threshold regression (PTR) model. In the opposite case, when γ is close to 0, the transition function $\Gamma\left(q_{it};\gamma,c\right)$ is constant and the PSTR estimation becomes a panel with fixed effects. Lastly, low and high values of q_{it} correspond to the two extreme regimes.

[20] We use the lag of the inflation rate to treat the problem of endogeneity between inflation and economic growth.

Figure 2-1 Transition functions. Sensitivity analysis to the slope parameter ($m = 1$ and c =0)



In comparison with the previous specifications (panel analysis or PTR), the use of PSTR methodology yields some theoretical advantages. A main advantage of the PSTR is that it allows the inflation–growth coefficient to vary with respect to time and countries. Moreover, the coefficients can take different values, depending on the value of another observable variable. The PSTR model allows individuals to move between groups and over time depending upon changes in "threshold variables". The PSTR method also provides a parametric approach of cross-country heterogeneity as well as time instability of the inflation–growth coefficients, causing a smooth change in these variables with respect to threshold variables. For instance, if the transition variable q_{it} is different from the inflation rate $\pi_{i,t-1}$, the sensitivity of growth to inflation rate for the i^{th} country at time t is defined as follows:

$$\frac{\partial y_{it}}{\partial \pi_{i,t-1}} = \beta_0 + \beta_1 \frac{\partial \Gamma}{\partial \pi_{i,t-1}} \left(q_{it}; \gamma, c \right) \tag{3}$$

According to the properties of the transition function, we have $\beta_0 \leq e_{it} \leq \beta_0 + \beta_1$ if $\beta_1 > 0$ or $\beta_0 + \beta_1 \leq e_{it} \leq \beta_0$ if $\beta_1 < 0$ because $0 \leq \Gamma\left(q_{it}; \gamma, c\right) \leq 1$. We notice that the elasticity of growth to inflation can be defined as a weighted average of parameters β_0 and β_1. Thus the PSTR model allows a precise assessment of the impact of inflation on economic growth.

Another advantage of the PSTR model is that the elasticity of growth to inflation rate can be different from the estimated parameters for the extreme regimes, for example, β_0 and $\beta_0 + \beta_1$. As illustrated by Eq. (3), these parameters do not directly correspond to a direct impact of inflation rate on growth. For instance, the parameter β_0 corresponds to a direct effect of inflation on growth only when the transition function linear model $\Gamma\left(q_{it};\gamma,c\right)$ tends towards 0. In contrast, when $\Gamma\left(q_{it};\gamma,c\right)$ tends towards 1, the elasticity of growth to inflation is equal to the sum of β_0 and β_1 parameters. Between these two extremes, there are infinite numbers of elasticity parameters of growth to inflation, which are defined as a weighted average of β_0 and β_1.

The PSTR model can be generalized to $r+1$ extreme regimes as follows:

$$y_{it} = \alpha_i + \beta_0^{'}\pi_{i,t-1} + \sum_{j=1}^{r}\beta_j^{'}\pi_{i,t-1}\Gamma_j\left(q_{it};\gamma_j,c_j\right) + \delta_0^{'}z_{it} + \varepsilon_{it}, \tag{4}$$

where the r transition functions $\Gamma_j\left(q_{it};\gamma_j,c_j\right)$ depend on the slope parameters γ_j and on the location parameters c_j. In this specification, if the threshold variable q_{it} is different from the inflation rate π_{it}, the elasticity of growth to inflation rate for i^{th} country at time t is defined by a weighted average of $r+1$ parameters β_j associated with $r+1$ extreme regimes:

$$\frac{\partial y_{it}}{\partial \pi_{i,t-1}} = \beta_0 + \sum_{j=1}^{r}\beta_j\frac{\partial \Gamma_j}{\partial \pi_{i,t-1}}\left(q_{it};\gamma_j,c_j\right), \forall i, \forall t. \tag{5}$$

When the transition variable is same as exogenous variable, the elasticity expression is different. For instance, if $q_{it} = \pi_{it}$, the elasticity of growth to inflation is then defined as follows:

$$\frac{\partial y_{it}}{\partial \pi_{i,t-1}} = \beta_0 + \sum_{j=1}^{r}\beta_j\Gamma_j\left(\pi_{i,t-1};\gamma_j,c_j\right) + \sum_{j=1}^{r}\beta_j\frac{\partial \Gamma_j\left(\pi_{i,t-1};\gamma_j,c_j\right)}{\partial \pi_{i,t-1}}\pi_{i,t-1}, \forall i, \forall t. \tag{6}$$

Although those expressions of the elasticity allow some configurations for the inflation–growth relationship, several questions related to estimation and specification tests persist. Our discussion below tries to answer these questions.

3.1.1. *Estimation and specification tests*

The PSTR model estimation begins with elimination of individual fixed effects α_i by removing individual-specific means and then applying nonlinear least squares to the transformed model.[21] Gonzàlez et al. (2005) propose a testing procedure in the following order: (i) test the linearity against the PSTR model, and (ii) determine the number r, of transition functions. The test of linearity in the PSTR model (Eq. 1) can be done by testing: $H_0 : \gamma = 0$ or $H_0 : \beta_1 = 0$. However under the null hypothesis, the test will be non standard in both cases, and the PSTR model contains unidentified nuisance parameters. A possible solution is to replace the transition function $\Gamma(q_{it};\gamma,c)$ by its first-order Taylor expression around $\gamma = 0$ and to test an equivalent hypothesis in an auxiliary regression. We then obtain the following:

$$y_{it} = \alpha_i + \theta_0^{'}\pi_{it} + \theta_1^{'}\pi_{it}q_{it} + \delta_0^{'}z_{it} + \varepsilon_{it}^{*}. \qquad (7)$$

Because θ_i parameters are proportional to the slope parameter of the transition function γ, testing the linearity of inflation – growth model against the PSTR consists of testing $H_0 : \theta_1 = 0$ versus $H_1 : \theta_1 \neq 0$.

Let SSR_0 be the panel sum of squared residuals under H_0, and let SSR_1 be the PSTR model with m regimes. The corresponding $F-$statistic is then defined as follows:

$$LM_F = \frac{(SSR_0 - SSR_1)/mK}{SSR_0/(TN - N - mK)} \sim F(mK, TN - N - mK), \qquad (8)$$

where T, N and K are number of years, number of countries and number of exogenous variables, respectively. Once the linearity test is used, the next step is to identify number of transition functions. The methodology of sequential tests is generally used. For instance, let us assume that we have rejected a linearity hypothesis. The issue is then to test whether there is one transition function $(H_0 : r = 1)$, or at least two transition functions $(H_1 : r = 2)$. Let us suppose a model with two transition functions $(r = 2)$:

$$y_{it} = \alpha_i + \beta_0\pi_{it} + \beta_1\pi_{it}\Gamma_1(q_{it};\gamma_1,c_1) + \beta_2\pi_{it}\Gamma_2(q_{it};\gamma_2,c_2) + \delta_0^{'}z_{it} + \varepsilon_{it}^{*}, \qquad (9)$$

$\Gamma_1(q_{it};\gamma_1,c_1)$ and $\Gamma_2(q_{it};\gamma_2,c_2)$ are two different transition functions. The logic of the test is

[21] See Gonzàlez et al. (2005) and Colletaz and Hurlin (2006) for more details.

same and consists in replacing the second transition function by its first-order Taylor expression around $\gamma_2 = 0$, and then in testing the linear constraints on the parameters. The model becomes:

$$y_{it} = \alpha_i + \beta_0 \pi_{it} + \beta_1 \pi_{it} \Gamma_1 \left(q_{it}; \gamma_1, c_1 \right) + \theta_1 q_{it} \pi_{it} + \delta_0^{'} z_{it} + \varepsilon_{it}^{*}. \quad (10)$$

The test of no remaining nonlinearity is simply defined by: $H_0 : \theta_1 = 0$. Let us denote SSR_0 as the panel sum of squared residuals under H_0 (. in a PSTR model with one transition function) and SSR_1 as the sum of squared residuals of the transformed model (Eq. 11). As in the previous case, the $F-$statistic LM_F can be calculated in the same way. Given a PSTR with r^* transition functions, we test the null hypothesis $H_0 : r = r^*$ against $H_1 : r = r^* + 1$. If H_0 is not rejected, the procedure ends. Otherwise, the null hypothesis $H_0 : r = r^* + 1$ is tested against $H_1 : r = r^* + 2$. The testing procedure continues until the first acceptance of H_0. Given the sequential aspect of this testing procedure, at each step of the procedure the significance level must be decreased by a constant factor τ, such as $0 < \tau < 1$, in order to avoid excessively large models. As suggested by González et al. (2005), we assume $\tau = 0.5$.

3.2. Robustness tests

For a robustness test, we follow Yilmazkuday (2011) and estimate instrumental variable two stage least square (IV- 2SLS) model. In all the specifications of our IV-2SLS, initial values of each five year period observations are used as instruments. In other words the five years GDP per capita growth is regressed on the initial value of inflation, investment, trade openness and so on. In this way, for all 5-years observations, the values of the initial year serve as instruments in the first stage. We also estimate fixed effect model after controlling for time and country fixed effects. Wooldridge (2001) shows that the fixed effect model with time and country-specific effects removes all possible types of endogeneity in the panel data. Our linear model for the fixed effect model becomes:

$$y_{it} = \alpha_i + \theta_0^{'} \pi_{it} + \delta_0^{'} z_{it} + \varepsilon_{it}^{*}. \quad (11)$$

Then, the addition of an interaction term for inflation and other macroeconomic variable gives a nonlinear specification for both the fixed effects and the IV-2SLS models, as shown in Eq. (7). This equation contains an interaction term to account for the nonlinear effects of the threshold variable q_{it}. It to appraise whether, beyond a certain level, the threshold variable q_{it} becomes more or less important in determining the marginal effect of inflation on economic growth. Therefore, the marginal effect of inflation on growth depends upon threshold variable:

$$\frac{\partial y_{it}}{\partial \pi_{it}} = \theta_0^{'} + \theta_1^{'} q_{it} \tag{12}$$

The previous equation converges to Eq. (3), when the transition function tends towards 1. The fixed-effects and IV-2SLS specifications contain same set of covariates as above while the interaction term will reflect a change in the behavior of inflation and other conditional variables after some structural break.

4. Data and estimation process

For our empirical analysis, we use annual data from 100 countries over the period of 1963-2012.[22] As shown by the previous studies, a variety of factors can influence long-run growth of a country. Therefore, the previous research on growth determinants does not provide any precise direction regarding the set of covariates. However, some key macroeconomic and institutional variables have been frequently used in the previous literature. López-Villavicencio and Mignon (2011) show that all of these variables significantly affect output growth of the developed and emerging economies. We follow the same tradition regarding the selection of covariates in our econometric analysis.

Our selected control variables include initial level of GDP per capita in order to account for the conditional convergence in spirit of the neoclassical growth theory (Solow, 1956; Barro and Sala-i-Martin, 1995). Following the development on endogenous growth theory, we use additional control variables: (i) trade openness, measured as ratio of imports plus exports to GDP, (ii) government expenditure to GDP ratio as an indicator of fiscal policy or public size, (iii) investment, measured as ratio of gross fixed capital formation to GDP, (iv) population growth to incorporate the impact of population dynamics, and then our main variable of interest, the inflation rate, defined as growth rate of the consumer price index (CPI) to measure effect of price instability on the output growth. Our endogenous variable is the growth of GDP per capita in constant 2000 USD prices. Following Levine et al. (2000), Beck et al. (2000) and López-

[22] Selected countries and their respective descriptive statistics are presented in Table 1.

Villavicencio and Mignon (2011), and in order to avoid the influence of idiosyncratic economic dynamics at business cycle frequency as well as to control for the cyclical output movements, we use five-year interval averages.

To have more homogenous samples, we further distribute this data set into different sub-samples depending upon per capita income level of a particular economy. Our sub-samples consist in three income categories; high income countries, upper middle-income countries, and emerging economies which includes lower middle-income and low-income countries. Number of countries in each sub-sample is 33, 21, and 43 respectively. We used the World Bank's classification for this sub-grouping.

4.1. Descriptive Statistics

Table 2-1 shows the descriptive statistics of the data set (averaged over 5-year periods from 1963-2012). As is evident from Table 2-1, the annual per capita income growth rate varies between -9% to 18% while the initial per capita income varies between \$98 to \$36,458 for the selected economies. Similarly, population growth range between -0.87% to 11%, trade openness range between 0.33% to 421%, capital formation range between 2% to 67%, government finance range between 3% to 46%, and the average annual inflation range between -1.5% to 7% over the selected time period. These huge differences between the minimum and maximum values cause high standard deviation of the variables. The results justify the use of PSTR model in our study. As the PSTR estimation takes into account country heterogeneity, our estimated results are not affected by the large standard deviations of the included variables. The correlation across these variables is reported in lower part of Table 2-1. The values of these correlation coefficients are time-averaged across all individuals (within) and are therefore calculated in the following way (x(it) – x(i)). This transformation of the variables is required keeping in view the fact that our PSTR parameters are based on time and country-fixed effects.

The signs of the correlation coefficients are in line with our prior expectations. The high values of explanatory variables such as inflation, and population growth and government expenditure adversely affect the dependent variable; economic growth, whereas more trade openness and capital formation are growth enhancing. Initial GDP is adversely correlated with the actual GDP growth showing the convergence hypothesis. Interestingly, the correlation between inflation and our main conditional variables e.g., trade openness and government expenditure is negative. This shows that price instability has also some indirect adverse effects on growth that appear through these channels. On the other hand, the effect of inflation on investment is positive showing the Tobin type effect of inflation physical capital accumulation. This also validates the analysis of conditional variables in the inflation–growth nexus.

Furthermore, these large differences between the maximum and the minimum values of the selected variables motivate the interest to have more homogenous sub-samples. Table B1 in appendix presents descriptive statistics for the sub-samples with respect to the income levels (high income, upper-middle-income and emerging countries). The sub-sample results show that rich countries tend to be more open for international trade and have a higher ratio of capital formation and government expenditures as percentages of their GDP. The population growth and the inflation rate decrease systematically with income growth in the sub-samples. The income growth and the investment rates are less volatile in the advanced economies compared with the other two groups. One notable point in these statistics is the high mean inflation of upper middle-income countries in comparison with the high income and emerging economies. This is due to some exceptionally high inflation values for some of the included countries e.g., Brazil, Peru and Turkey.

Table 2-1Descriptive Statistics, global sample: 1963-2012

Variable	Per capita Income Growth (%)	Per capita initial GDP	Population Growth	Trade Openness	Investment	Government (% GDP)	Inflation
Mean	0.0187	4535.08	1.8949	70.245	20.972	15.316	2.0167
Standard Deviation	0.0293	6501.53	1.1649	50.991	6.515	6.009	0.9902
Minimum	-0.0895	92.068	-0.8692	0.3326	2.233	3.6498	-1.4945
Maximum	0.1794	36458.8	11.171	421.51	67.454	46.302	7.0931
Correlations							
Per capita income growth (%)	1.000						
Per capita initial GDP	-0.281	1.000					
Population Growth	-0.008	-0.333	1.000				
Trade Openness	0.011	0.515	-0.213	1.000			
Investment	0.267	0.057	0.089	0.184	1.000		
Government (% GDP)	-0.222	0.242	-0.011	0.139	0.036	1.000	
Inflation	-0.108	-0.156	0.101	-0.091	0.148	-0.103	1.000

Note: The country observations for 97 economies are retrieved from the World Bank's *World Development Indicators* (2013). The selected countries are: *High income countries* (Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hong Kong (China), Iceland, Ireland, Israel, Italy, Japan, Korea. Rep, Kuwait, Luxembourg, Malta, Netherland, New Zealand, Norway, Oman, Portugal, Saudi Arabia, Singapore, Spain, Sweden, Switzerland, Trinidad and Tobago, United Kingdom, United States, Uruguay) - *Upper middle-income countries* (Algeria, Argentina, Barbados, Botswana, Brazil, China, Colombia, Costa Rica, Dominican Republic, Ecuador, Fiji, Gabon, Hungary, Iran, Malaysia, Mexico, Peru, South Africa, Thailand, Tunisia Turkey) – *Lower middle and low-income countries* (Bangladesh, Benin, Bolivia, Burkina Faso, Burundi, Cameron, Central African Republic, Chad, Congo, Dem. Republic, Congo, Republic, Cote d"Ivoire, Egypt, Gambia, Ghana, Guatemala, Guyana, Honduras, India, Indonesia, Kenya, Lesotho, Madagascar, Malawi, Mali, Mauritania, Morocco, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Papua New Guinea, Paraguay, Philippines, Rwanda, Senegal, Sri Lanka, Sudan, Swaziland, Syrian Arab Republic, Togo, Zambia, Zimbabwe).

5. Results and discussion

Here we present the main findings of our inflation–growth relationship that have been obtained by the PSTR and IV- 2SLS models. As the PSTR starts with defining the degree of nonlinearity and number of thresholds (no remaining heterogeneity), our preliminary findings guide us to select the number of transition functions. The LM_F statistics of the nonlinearity test reject the hypothesis of linearity in all specifications. Our results, based on the residual sum of squares and the criteria of information show that in the present case both the threshold level and the number of transition functions is one for all cases.[23] This signifies that a weak number of transition functions are sufficient to characterize the nonlinearity between the inflation rate and the economic growth, using various threshold variables. For the IV-2SLS models, in all of the below mentioned specifications, initial values of each 5-year periods of the respective variables have been used as instrument in the first stage.

Table 2-2 presents the results for all of these specifications for the global sample. Our first specification is based on linear fixed effects estimation indicating an overall effect of inflation on the income growth. This linear model is used as a benchmark for the other specifications, and it shows that the overall effects of inflation are negative and significant. Generally speaking, all of the variables are significant with their signs consistent with the economic theory. We can also notice that the sign of control variables are also very robust with respect to the selected models (PSTR, Fixed Effects or IV-2SLS). Our main variable of interest, inflation rate, appears with a negative sign showing the overall adverse effect of inflation on economic growth. As inflation generates uncertainty and halts the production decisions of firms, it diminishes average long-run growth. These overall negative effects have been widely acknowledged by the previous empirical literature. With respect to the other variables of interest, initial GDP growth is significant with negative sign. This negative sign supports conditional convergence hypothesis of the neoclassical growth theory. Keeping the other growth determinants constant, countries with high initial GDP tend to grow slower than their low-income counterparts. The difference between the initial income and steady-state growth is therefore an important determinant of current growth of a country.

The population growth variable also assumes a negative sign, reflecting the burden of overpopulation on the long-run growth of countries. Although it is not significant in the first

[23] Details are provided in Table 2-6

specification, it becomes so in the rest of the models. A rapid growth of population decreases the capital to labor ratio and therefore inhibits growth. In Solow growth model, population growth coefficient is negative. Same is the case with the other neo-classical growth literature where the effect of high population increase is growth reducing. Mankiw et al. (1992) find that an increase in the population growth by 10 percent (e.g., from 3 percent to 3.3 percent) will reduce the steady state income growth by 5 percent. Nonetheless, this does not spare the fact that an opposing view strongly supports a positive impact of population growth on overall income level. Aghion and Howitt (1992) argue that a high population growth creates a demand for technological change and therefore stimulates growth process. A high population density has also been considered suitable for technological spillover and integration of a country with the outside world, which helps fostering economic growth. Romer (1990) posits that the cost of technological innovation does not depend upon the number of people who use it. Therefore, for a constant share of research expenditures, higher population would lead to a more rapid technological change. It is important to mention that the effect of population growth on per-capita income of a country depends on its demographic history. An economy with high population growth rate in recent years may enjoy high labor force participation rate, increasing its savings and economic growth.

Same is the case with government expenditures; a high level of public expenditure drains out most efficient private investment which inhibits output growth (Barro and Sala-i-Martin, 1995). The negative sign of this variable also reflects inefficiency of government expenditures which crowds out productive private investment and impedes economic growth. However, this negative relationship between government expenditure and growth is not unanimously supported by the literature. An opposing view finds growth enhancing role of public expenditures on both theoretical and empirical grounds. Certainly government expenditures are comprised of several elements and the effect of all of these elements is different on consumer welfare and growth. On the one hand, government's military and other non-development expenditures are considered as growth reducing while; on the other hand, public expenses on health, education, infrastructure and law and order are perceived as growth stimulators. Barro (1990) conjectures that the net impact of government expenditures on growth depends upon the nature of these expenditures. Unproductive expenditures will obstruct output growth, while productive expenditures may assume any sign depending upon the governments' behavior and the size of these expenses as proportion to GDP. Our findings complement Barro (1991) for the adverse effects of public expenses on long-run growth.

Next, the investment variable is significant and appears with the expected positive sign in Table 2-2. This shows a one-to-one relationship between physical capital accumulation and output growth. Indeed, earlier growth theories including Solow model show a crucial role of investment in catching up process among countries. Besides, as with the other covariates, the effect of investment on growth is also country-dependent. Cross country differences in investment and output growth relationship come from the actual capital stock of these economies. In countries with already a high level of investment to GDP ratio, additional changes in their saving rates will be less effective to foster their output growth. By contrast, in capital scarce countries the impact of capital accumulation on growth will be strongly positive due to a high marginal propensity of capital in these economies. Trade openness has positive sign explaining the fact that open economies tend to grow faster than their closed counterparts. As open economies receive inflow of physical capital and ideas from abroad, this facilitates their growth process. A high degree of trade openness also facilitates the adoption of new technologies and their spillover in the domestic market. All of this explains their higher growth rate compared with the closed economies.

Table 2-2 Inflation and output growth relationship for global sample, PSTR and IV-2SLS models

	Inflation				Investment		Openness		Gov. Expenditure	
	Linear Model	Fixed Effects	PSTR	IV-2SLS	PSTR	IV-2SLS	PSTR	IV-2SLS	PSTR	IV-2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Initial GDP	-0.0632^{a} (-6.18)	-0.0631^{a} (-6.65)	-0.0671^{a} (-10.97)	-0.0659^{a} (-7.51)	-0.0693^{a} (-11.01)	-0.0687^{a} (-7.26)	-0.0678^{a} (-10.73)	-0.0675^{a} (-7.06)	-0.0666^{a} (-10.34)	-0.0687^{a} (-6.39)
Population Growth	-0.0041 (-1.58)	-0.0043^{c} (-1.66)	-0.0051^{a} (-4.27)	-0.0025^{b} (-2.08)	-0.0061^{a} (-4.41)	-0.0021^{c} (-1.81)	-0.0043^{a} (-3.14)	-0.0021^{c} (-1.74)	-0.0051^{a} (-4.11)	-0.0021 (-0.79)
Investment	0.0017^{a} (4.43)	0.0017^{a} (4.43)	0.0013^{a} (8.11)		0.0012^{a} (6.08)	0.0006^{a} (1.78)	0.0014^{a} (8.43)	0.0003^{c} (1.71)	0.0015^{a} (9.31)	0.0003 (1.48)
Openness	0.0002^{a} (3.15)	0.0002^{a} (3.06)	0.0002^{a} (4.18)	0.0002^{a} (2.96)	0.0002^{a} (3.84)	0.0001^{b} (2.43)	0.0001^{b} (2.37)	0.0001 (1.62)	0.0002^{a} (3.86)	0.0001^{b} (1.97)
Government Expenditure	-0.0012^{a} (-3.71)	-0.0011^{a} (-3.74)	-0.0013^{a} (-6.21)	-0.0007^{a} (-2.87)	-0.0014^{a} (-6.28)	-0.0007^{a} (-2.73)	-0.0015^{a} (-6.51)	-0.0007^{a} (-2.84)	-0.0023^{a} (-5.65)	-0.0001 (-1.17)
Inflation	-0.002^{b} (-2.61)	0.011^{a} (3.34)	0.0293^{a} (6.12)	-0.023 (-1.39)	-0.0132^{a} (-6.87)	-0.029 (1.27)	-0.0114^{a} (-7.22)	-0.0061^{a} (-3.59)	-0.0181^{a} (-4.11)	-0.0041^{c} (-1.71)
Interaction Variable			-0.0425^{a} (-7.71)		0.0083^{a} (3.85)	-0.0001 (-0.94)	0.0099^{a} (3.68)	0.0001 (0.91)	0.0298^{a} (2.63)	-0.0001 (-0.36)
Inflation^2		-0.002^{a} (-5.99)		-0.0004^{c} (-1.83)						
c			3.01		11.74		53.56		23.55	
γ			0.42		0.39		0.045		0.054	
LM_F			0.00001		0.028		0.026		0.008	
R^2	0.35	0.41	0.32	0.39	0.27	0.37	0.28	0.37	0.27	0.37

Notes: The values below the corresponding coefficients are t-values for PSTR models and z-values for the other models. Symbols 'a', 'b' and 'c' show 1%, 5% and 10% level of significance respectively. p-values are reported for LM_F and AR(2) statistics.

As mentioned earlier, the linear specification shows an overall negative impact of inflation on growth. Nevertheless, this linear specification has been widely criticized by empirical research following the nonlinear results of Fischer (1993). To take into account the possible nonlinear effects of inflation, we estimate nonlinear relationship using the fixed effects, the PSTR and the IV-2SLS models. In the second specification of Table 2-2 we add an interaction variable, inflation squared, to capture the nonlinear effects using the fixed effects model. The results of the nonlinear model show that there exists a threshold in the effects of inflation. The inflation squared term is negative and significant. This implies that to a moderate level, inflation exerts a positive effect on long-run growth while beyond the threshold these effects become growth inhibiting. In the presence of nominal wage rigidities, inflation greases the wheels of labor markets by facilitating real wage reductions, in occurrence of a supply shock (see Card and Hyslop, 1996). Our results complement the optimality of a positive inflation rate of previous research on the subject. All of the other variables retain their signs and significance as in the first specification.

However, the nonlinear relationship found in the specification 2 masks some important characteristics concerning the type of nonlinearity. These include the number of possible regimes and a transition from one regime to another. Moreover, it also gives estimates that are fixed for all of the selected countries and time periods. All of these deficiencies of the fixed effects models have been addressed by our preferred PSTR model. The results are reported in the specification 3. The value of the threshold parameter is 3.01 percent, the effects of inflation below this level are positive for our global sample while above this level they are growth inhibiting. This threshold level is however lower than the previous estimates of empirical literature. Thus our results support a very mild level of inflation for a higher output growth. The coefficient in the second regime is β_0 and β_1 in equation (9) is negative; that is 0.0293-0.0425= -0.0132. Stating differently under the inflationary regime (>3.01%), other things being equal, an increase of 1% in the inflation rate diminishes economic growth to 1.32%, whereas the growth effect of inflation is positive for the first regime.[24] Nevertheless, there is a continuum of points between both extreme regimes and the elasticity is defined as a weighted average of the values of the parameters β_0 and β_1 .

[24] Among the selected following countries have their average inflation rates lower than the threshold values over the last five years of the sample period; Algeria, Austria, Belgium, Burkina Faso, Cameroon, Canada, Central African Republic, Chile, China, Congo Republic, Coté d'Ivore, Denmark, Fiji, Finland, France, Gabon, Germany, Hong Kong, Israel, Italy, Japan, Kuwait, Libya, Luxembourg, Malaysia, Mali, Malta, Morocco, Netherlands, New Zealand, Niger, Norway, Oman, Peru, Saudi Arabia, Senegal, Singapore, Sweden, Switzerland, Thailand, Togo, Tunisia, United Kingdom, United States. Rest of the selected economies, detailed in Table 2, is above this threshold.

As aforementioned, the estimated parameters β_j cannot be directly interpreted, but their signs are, for instance, the parameter β_0 is positive while β_1 is negative. This implies that when the inflation rate increases, a link between economic growth and inflation attenuates. The coefficient of our nonlinear instrumental variable-2SLS model (specification 4) behaves in the same way as the PSTR and fixed effects models. The coefficient of the interaction variable is significant with negative sign, confirming the previous findings that the inflation–growth relationship exhibits an inverse U-shaped.

One crucial difference between the PSTR and IV-2SLS models is that in the PSTR model, the non-linear term is a combination of inflation rate variable and a logistic transition function, the later is by definition a nonlinear function. In other words, we relax the linearity condition before estimation which can consequently lead the coefficients to be influenced by the atypical observations of the data set. In this case most of the parameters values will lie only in some selected areas of this logistic function's distribution. On the other hand, in IV-2SLS model, the nonlinearity is estimated from two linear terms ($\pi * \pi$, for instance) and the effect of an increase or decrease will be same for all the distribution of the nonlinear term. This sensibility of PSTR estimates to atypical values can result in larger mean and standard deviation of the error terms compared with the model where nonlinearity is a combination of two linear terms. In the Table 2-6 we compare the country-specific mean and standard deviation of the two models and our results strengthen these apprehensions on the PSTR model for some countries. Nevertheless, since our estimated threshold values are same for the both models, this does not invalidate the PSTR results.

As discussed in section 2, the level of inflation is not the only macroeconomic variable which affects the nonlinear relationship between inflation and growth. There are several macroeconomic mechanisms that can possibly amplify or appease the inverse effects of inflation on the output growth. In other words, certain macroeconomic conditions of a country can play an important role in determining the sensitivity of effects of inflation. Our main focus is to test the relevance of some widely accepted growth covariates (e.g., capital formation, openness to trade and government expenditures) and to see how differences in the level of these conditional variables can change the nature and intensity of the relationship between inflation and growth. The results of all of these channels, from the PSTR and the IV-2SLS models, are reported from column 5-10 of Table 2-2.

The column 5 presents results of the effects of inflation for countries with different levels of capital accumulation. This result stems from the PSTR model show a threshold at 11.74%. The sign of the interaction variable is positive; countries with capital accumulation higher than the threshold level experience less severe effects of inflation than the economies working below this threshold. The value of the slope parameter is less than one indicating a smooth transition between the two regimes. Our results show that the total effects of inflation on growth are 0.83% lower for the economies working above the threshold level of capital formation. As a matter of fact, countries with a higher level of capital formation are the one with strong financial systems. Inflation, in these economies reduces real interest rate which consequently increases capital accumulation.[25] The Tobin effect of inflation can enhance the capital accumulation in economies that are better placed with respect to levels of capital accumulation. In the IV-2SLS model the interaction variable is however insignificant.

The next two models (specifications 7 and 8) show a modifying effect of trade openness for the adverse effects of inflation on economic growth. This confirms an appeasing role of trade openness in determining the sensitivity of relationship between inflation and growth. The effects of inflation are less severe in countries that are more open to international trade. This results contrasts with Romer (1993) where openness increases the cost of inflation and therefore brings down the optimal inflation rate. Our results support the theoretical findings of Hartman (1979) where inflation differences between two open economies generate capital mobility from low to high inflation economy. A higher nominal interest rate in the second country fosters capital accumulation and output growth. The threshold level of trade openness has been indicated at 53.56%. The adverse effects of inflation are 0.99% lower for economies working above this threshold level. A higher degree of trade openness enables them to partially absorb undesirable effects of inflation that are being faced by closed economies with similar macroeconomic conditions. Almost same findings have been reported for the government expenditure channel where a large size of public expenses partially offset the undesirable effects of inflation for that country. This underscores the role of public expenditures in bringing stability and ensuring high growth.

The above results provide a global picture of the nonlinear relationship between inflation and growth. Nevertheless, the impact of inflation on growth and the effectiveness of all conditional variables differ among the sub-groups. On the direct effects of inflation, its optimal level is found to be higher in developing countries than in the advanced economies (see Khan and Senhadji, 2001). The rationale behind is that in most of the developing economies seigniorage works as tax in the emerging economies when other distortionary taxes are hard to come by (Mankiw, 1987). Same is the case with the other conditional variables. Taking the example of government expenditure channel, the size of public

[25] Another way to test these effects can be to include the financial development channel. However, we could not include this channel due to the lack of data for the first few years.

expenditures differs widely among the selected countries (see, for example, sub-sample standard deviation). Similarly, the efficient use of public expenditures also varies between developed and developing countries. Public expenditures are sometimes misused in the developing economies and their role to bring stability becomes questionable. Some other differences among developed and developing economies include their labor market functioning. Weak labor market institutions of the developing economies allow their firms to make frequent changes in prices since wages do not respond quickly to these changes. This also increases inflation tolerance in developing countries compared to developed economies.

Keeping all of these differences in view and to account for effect of income in influencing the inflation–growth nonlinearity, we divided the data set into three groups, namely, high income countries, upper-middle-income countries, and emerging countries (lower middle-income and low-income countries). Based on the findings of previous studies and our descriptive statistics in the Appendix, we expect a higher inflation threshold for the economies working at a lower level of economic development. We also try to unearth differences in the threshold level of the conditional variables that appear due to income heterogeneity of these economies. As the conditional variables show the macroeconomic developments of selected economies, the threshold of the conditional variables is expected to behave accordingly. For example, we do not expect a positive role of public finance in modifying the effects of inflation on growth for the developed economies since seigniorage is not used to finance public expenditures in these economies.

Tables 2-3 to 2-5 in the Appendix provide the results for selected sub-groups. The most notable result is difference in inflation threshold level which justifies our sub-sample division. The estimated threshold parameter is 3.89% for the advanced economies, 4.91% for the upper-middle-income and 16.28% for the emerging economies. Our threshold values are consistent with previous estimates of the empirical literature (see for example Khan and Senhadji, 2001: Omay and Kan, 2010 and López-Villavicencio and Mignon, 2011). For instance, the inflation thresholds in Khan and Senhadji (2001) and López-Villavicencio and Mignon (2011) are 11% and 19% for the emerging economies.[26]

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[26] As discussed by Omay and Kan (2010), the threshold values of the estimated parameters are sometime sensitive to the inclusion of other macroeconomic variables and the value increases with the number of covariates. Our specifications are nevertheless based only on the standard growth covariates and both the sign and significance of our covariates has appeared robust in almost all specifications. Moreover, to test the robustness of our threshold estimates with respect to the included covariates, we ran different models by dropping all of these variables one-by-one. For brevity we did not report these results here. However, they can be provided from the author upon request.

That said the comparison of the sub-sample results with the global findings shows that the threshold inflation estimates of the global data set are more representative of the advanced economies. Our subsample estimates of the upper-middle-income countries and the emerging economies are higher than the estimates of the global data set. The higher inflation threshold of these sub-groups show a very strong Balassa-Samuelson effect for these countries. It can be safely said that a moderate inflation rate does not cause harm for emerging economies. These results show an inverse relationship between inflation threshold and income level. An increase in inflation has more harmful impact on the growth of the high income countries than on the emerging economies. Moreover, the parameter values of inflation variable below the threshold are positive and significant for all sub-samples showing the growth enhancing effects in the first regimes. The value of the slope parameter is less than one explaining a smooth transition between the two regimes.

The specifications 5-10 of all of these Tables show a role of macroeconomic developments in determining the relationship between inflation and growth. Here the sub-sample analysis yields some important differences between developed and developing economies. As an illustration, if we take the findings of PSTR model, Tobin effect that dominates the direct adverse effects of inflation is relevant only for the low-income countries. This can be due to a higher average inflation and the resulting significant reduction of real interest rate in these economies which plays a defining role in physical capital accumulation and growth of these countries. Similarly, for the upper middle-income countries, the interaction effect is negative and significant. Inflation induced disruptions in the factors' market limit capital accumulation for the economies working beyond 19.29% capital accumulation to GDP ratio. For the advanced economies, the effect is significant only in the IV-2SLS specification where coefficient of second regime is very close to zero. Thus the effects of inflation are negative for all economies irrespective of their level of capital accumulation.

The effects of trade openness remain same for all sub-samples. These results are consistent with the global data set. A higher degree of trade openness modifies the adverse effects of inflation on output growth. Government expenditures variable also gives different results in the sub-samples. The sign of the interaction variable is negative for the high income countries and for the emerging economies but not for the upper-middle-income countries. The results of our global sample and emerging economies show that in countries where public expenditures to GDP ratio is above the threshold level – 26% and 11% for both these subsamples respectively – the effects of inflation are strongly negative. As Ezirim and

Ofurum (2003) and Ezirim et al. (2008) show that public expenditures after certain threshold breed high inflation and diminish output growth.

6. Concluding remarks

This study provides new evidence on nonlinearity of the relationship between inflation and growth by applying the PSTR and instrumental variables IV-2SLS models to a broad panel data set for 100 industrialized and developing countries over the period of 1963-2012. The recent literature has confirmed that the relationship between inflation and growth is nonlinear and that there therefore exists a certain threshold above which inflation is harmful and below which it enhances the long-term economic growth. However, a precise estimation of the threshold level and the macroeconomic environments that influences this nonlinearity has not been attempted in previous research.

We have mainly addressed two aspects of this relationship: the threshold estimates for the whole sample, as well as for different sub-samples, and some country-specific characteristics that can possibly affect the degree of sensitivity between inflation and growth. Our first-stage findings confirmed those in the literature that hold that the inflation–growth relationship is nonlinear, and our threshold estimates decrease with the level of income. Our threshold estimates are consistent with the recent work of López-Villavicencio and Mignon (2011) for a relatively small data set of 44 countries and for their investigation into the direct effects only. These results favor the moderate inflation rate over the complete stability of zero percent inflation targets for the central banks of both developed and emerging economies.

With respect to the other country-specific macroeconomic variables that affect the degree of sensitivity in the inflation–growth relationship, our results validate the usefulness of these channels for explaining the differences in the intensity of the relationship between inflation and growth. Indeed, the degrees of trade openness, capital accumulation and government size were found to be the main factors responsible for altering the nonlinearity of inflation–growth relationship over time and across countries. Our evaluation of these factors also highlights the fact that the issues of the welfare cost of inflation and the optimal inflation rate cannot be settled in a vacuum. Effectively, the specific features of the macroeconomic environments related to a certain country determine both its optimal level of inflation and the welfare cost of inflation; once it goes beyond this threshold. For example, the optimal inflation in an open economy can be very different from that in a closed economy, even if both economies are at same level of GDP. Trade openness makes inflation more costly for the later group.

To further elaborate the differences in the optimal inflation rates among our sub-samples, the inflation–growth relationship indicates a relatively higher optimal inflation level for low-income countries. As López-Villavicencio and Mignon (2011) argue, a high optimal inflation rate in these countries appears due to their institutional difference from the developed economies. As the emerging economies have a history of high inflation rate, there exists a widespread indexation in these countries and the net impact price changes on wages and output growth are lower in these economies. Moreover, these countries also observe the Balassa-Samuelson effect which implies that their productivity growth is higher than the one of the advanced economies and, therefore the average price level is higher in these countries. Third, high optimal inflation rate in the emerging countries also stems from their exchange rate policies. Exchange rates are kept undervalued in these countries to increase competitiveness in the export market. Higher exports weaken the adverse effects of inflation on growth. For the upper-middle economies the inflation thresholds are found consistent with the advanced economies. As these countries are increasing their economic and financial integration with the outside world, their optimal inflation rate is diminishing over time. Nevertheless, even if the direct effects of inflation are relatively higher for the emerging countries, contemplating the other macroeconomic conditions makes it clear that adverse effects of inflation can appear through other channels well below this level. Thus, our results suggest that the issue of inflation optimality requires a broader and deeper analysis.

Lastly, our findings also suggest that all of the three macroeconomic conditional variables are not relevant for sub-sample country groups: for instance, Tobin effect of inflation is only relevant for the high income countries and for the emerging economies but not for the upper-middle-income economies of the selected sample. In the developed economies financial markets are well developed and the Tobin's lower interest effects prove effective to bring changes in the capital accumulation. Similarly in the emerging economies, actual inflation rate is quite high and marginal changes from this level are usually quite large and meaningful for the investors. In the upper-middle-income countries, by contrast, the actual inflation rates have been stabilized over the last several decades (see Appendix) and inflationary changes can lead to an outflow of money, explaining the reverse-Tobin effect for these countries. On the other hand, the government expenditure channel explains a positive role of public finance in modifying the effects of inflation for the emerging economies and negative for the other two sub-samples. The results of trade openness are consistent for all of the three sub-samples.

Appendix:

Table B1: Descriptive Statistics, 1963-2012; Sub-samples

Variable	Mean	Std. Dev	Minimum	Maximum
High Income Countries				
GDP per capita Growth	0.0249	0.0269	-0.0829	0.1794
Initial GDP	11398.5	7316.24	1509.23	36458.8
Pop. growth	1.1365	1.3097	-0.7774	11.1715
Openness	86.585	69.461	9.7330	421.501
Investment	22.446	4.841	9.748	39.951
Gov. expenditure	18.069	5.821	4.381	44.43
Inflation	1.659	0.839	-1.016	4.714
Upper-middle-income Countries				
GDP per capita Growth	0.025	0.032	-0.082	0.141
Initial GDP	2153.12	1397.37	92.068	6180.49
Pop. growth	1.883	.875	-0.464	3.983
Openness	62.502	37.487	5.901	210.03
Investment	22.894	5.951	11.779	47.977
Gov. expenditure	13.634	4.308	3.649	27.806
Inflation	2.309	1.129	-0.635	6.926
Emerging countries (Lower-middle income and low-income economies)				
GDP per capita Growth	0.011	0.028	-0.089	0.109
Initial GDP	541.83	305.46	135.99	1512.9
Pop. growth	2.488	0.793	-0.869	6.571
Openness	63.065	35.039	7.821	222.25
Investment	18.786	7.291	2.233	67.454
Gov. expenditure	14.069	6.217	4.181	46.302
Inflation	2.148	0.948	-1.494	7.093

Table 2-3 Inflation and output growth relationship for high income countries, PSTR and IV-2SLS models

	Inflation				Investment		Openness		Gov. Expenditure	
	Linear Model	Fixed Effects	PSTR	IV-2SLS	PSTR	IV-2SLS	PSTR	IV-2SLS	PSTR	IV-2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Initial GDP	-0.0853^{a}	-0.0599^{a}	-0.0646^{a}	-0.0945^{a}	-0.0618^{a}	-0.0951^{a}	-0.0667^{a}	-0.0954^{a}	-0.0586^{a}	-0.103^{a}
	(-3.22)	(-6.91)	(-6.88)	(-4.08)	(-6.41)	(-5.85)	(-7.16)	(-4.01)	(-6.03)	(-4.55)
Population Growth	-0.0068^{a}	-0.0047^{b}	-0.0095^{a}	-0.0102^{a}	-0.0083^{a}	-0.0098^{a}	-0.0077^{a}	-0.0092^{a}	-0.076^{a}	-0.0097^{a}
	(-2.74)	(-1.89)	(-4.11)	(-4.96)	(-3.48)	(-4.63)	(-3.39)	(-2.75)	(-3.18)	(-2.94)
Investment	0.0005	0.0013^{a}	0.0013^{a}	0.0002	0.0010^{b}	0.0001	0.0006^{c}	0.0004	0.0006^{c}	0.0005
	(0.64)	(4.34)	(8.11)	(0.51)	(2.44)	(0.02)	(1.94)	(0.58)	(1.69)	(0.78)
Openness	0.0002^{b}	0.0002^{a}	0.0006^{c}	0.0001^{c}	0.0002^{a}	0.0001^{c}	0.0002^{a}	0.0001	0.0002^{b}	0.0001^{c}
	(2.32)	(2.73)	(1.91)	(1.85)	(3.02)	(1.88)	(2.65)	(1.13)	(2.45)	(1.69)
Government Expenditure	-0.0031^{a}	-0.0012^{a}	-0.0029^{a}	-0.0018^{a}	-0.0031^{a}	-0.0021^{a}	-0.0032^{a}	-0.0022^{b}	-0.0041^{a}	-0.0031^{b}
	(-2.93)	(-4.29)	(-6.77)	(-3.95)	(-6.85)	(-4.35)	(-7.61)	(-2.36)	(-6.19)	(-2.10)
Inflation	0.0016	0.0092^{a}	0.0247^{a}	0.0085^{a}	-0.0012	-0.0067^{a}	-0.0067^{a}	-0.0061^{b}	151.15^{b}	-0.0138^{b}
	(0.51)	(3.16)	(3.94)	(2.91)	(-0.67)	(2.98)	(-3.35)	(-2.35)	(2.15)	(-2.16)
Interaction Variable			-0.0221^{a}		0.0035	0.0002^{c}	0.0115^{a}	0.0001^{c}	-302.32^{b}	0.0004
			(-4.38)		(1.64)	(1.91)	(5.11)	(1.84)	(-2.15)	(1.37)
Inflation^2		-0.0027^{a}		-0.0021^{a}						
		(-6.12)		(-3.42)						
c			3.89		27.12		70.47		26.31	
γ			2.84		745.24		0.375		-0.0001	
LM_F			0.009		0.71		0.07		0.031	
R^2	0.51	0.39	0.42	0.13	0.39	0.13	0.44	0.37	0.39	0.13

Notes: The values below the corresponding coefficients are t-values for PSTR models and z-values for the other models. Symbols ‘a’, ‘b’ and ‘c’ show 1%, 5% and 10% level of significance respectively. p-values are reported for LM_F and AR(2) statistics.

Table 2-4 Inflation and output growth relationship for upper middle-income countries, PSTR and IV-2SLS models

	Inflation				Investment		Openness		Gov. Expenditure	
	Linear Model	Fixed Effects	PSTR	IV-2SLS	PSTR	IV-2SLS	PSTR	IV-2SLS	PSTR	IV-2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Initial GDP	-0.1146^{a} (-6.98)	-0.1121^{a} (-6.31)	-0.1357^{a} (-9.02)	-0.1121^{a} (-6.31)	-0.1441^{a} (-9.48)	-0.0986^{a} (-4.24)	-0.1378^{a} (-9.08)	-0.0966^{a} (-4.01)	-0.1421^{a} (-9.34)	-0.0931^{a} (-3.02)
Population Growth	-0.0194^{a} (-6.22)	-0.0186^{a} (-5.53)	-0.0213^{a} (-6.21)	-0.0186^{a} (-5.53)	-0.0229^{a} (-6.58)	-0.0176^{a} (-3.71)	-0.0213^{a} (-6.12)	-0.0167^{a} (-3.41)	-0.0235^{a} (-6.64)	-0.0163^{b} (-2.44)
Investment	0.0026^{a} (7.43)	0.0025^{a} (7.18)	0.0025^{a} (6.61)	0.0025^{a} (7.18)	0.0033^{a} (7.79)	0.0028 (0.54)	0.0027^{a} (6.91)	-0.0003 (-0.75)	0.0029^{a} (7.52)	-0.0005 (-0.87)
Openness	0.0002^{b} (2.65)	0.0002^{b} (2.18)	0.0002^{a} (2.71)	0.0002^{b} (2.18)	0.0003^{b} (3.02)	0.0004^{a} (3.27)	0.0002^{b} (2.19)	0.0004^{a} (3.12)	0.0002^{a} (2.70)	0.0004^{b} (2.39)
Government Expenditure	-0.0009 (-1.55)	-0.0010^{c} (-1.72)	-0.0013^{b} (-2.43)	-0.0010^{c} (-1.72)	-0.0008 (-1.55)	-0.0004 (-0.71)	-0.0012^{b} (-2.29)	-0.0003 (-0.57)	-0.0022^{a} (-3.25)	0.0004 (0.60)
Inflation	-0.0069^{b} (-2.52)	0.0064 (1.04)	0.0022^{b} (2.37)	0.0064 (1.04)	-0.0051^{a} (-2.68)	-0.0026 (-0.95)	-0.0085^{a} (5.01)	-0.0029 (-1.36)	-0.0081^{a} (-4.85)	0.0002 (0.03)
Interaction Variable			-0.0309^{a} (-3.24)		-0.0042^{a} (-2.84)	-0.0003^{a} (-2.91)	0.0076^{b} (2.26)	-0.0005 (1.44)	0.0072^{b} (2.55)	-0.0004 (-1.18)
Inflation^2		-0.0021^{b} (-2.37)		-0.0021^{b} (-2.37)						
c			4.91		19.29		79.97		17.16	
γ			0.62		989.21		28.81		214.53	
LM_F			0.002		0.0007		0.45		0.63	
R^2	0.55	0.57	0.48	0.57	0.47	0.12	0.46	0.12	0.47	0.12

Notes: The values below the corresponding coefficients are t-values for PSTR models and z-values for the other models. Symbols ‘a’, ‘b’ and ‘c’ show 1%, 5% and 10% level of significance respectively. p-values are reported for LM_F and AR(2) statistics.

Table 2-5 Inflation and output growth relationship for emerging income countries, PSTR and IV-2SLS models

	Inflation				Investment		Openness		Gov. Expenditure	
	Linear Model	Fixed Effects	PSTR	IV-2SLS	PSTR	IV-2SLS	PSTR	IV-2SLS	PSTR	IV-2SLS
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Initial GDP	-0.0297^{b}	-0.0346^{b}	-0.0356^{a}	-0.0345^{b}	-0.0361^{a}	-0.0328^{b}	-0.0324^{a}	-0.0326^{b}	-0.0306^{a}	-0.0296^{b}
	(-2.29)	(-2.62)	(-3.34)	(-2.46)	(-3.31)	(-2.37)	(-2.91)	(-2.43)	(-2.74)	(-2.12)
Population Growth	0.0023	0.0013	-0.0002	0.0036^{b}	-0.0012	0.0036^{b}	0.0007	0.0031^{b}	0.0011	0.0039^{b}
	(1.02)	(0.54)	(-0.11)	(2.36)	(-0.61)	(2.38)	(0.37)	(2.21)	(0.55)	(2.47)
Investment	0.0011^{a}	0.0009^{b}	0.0009^{a}	0.0005^{b}	0.0002	0.0003	0.0011^{a}	0.0004^{c}	0.0011^{a}	0.0005^{b}
	(2.70)	(2.39)	(4.08)	(2.04)	(0.63)	(0.66)	(4.67)	(1.90)	(4.74)	(1.97)
Openness	0.0002^{b}	0.0002^{b}	0.0002^{b}	0.0001	0.0001	0.0001	0.0002^{b}	-0.0002	0.0002^{a}	0.0001
	(2.20)	(2.13)	(2.52)	(1.26)	(1.64)	(1.23)	(2.19)	(-0.24)	(2.96)	(1.55)
Government Expenditure	-0.0008^{b}	-0.0008^{b}	-0.0009^{a}	-0.0006^{c}	-0.0008^{a}	-0.0006^{c}	-0.0008^{a}	-0.0005^{c}	-0.0006^{c}	0.0004
	(-2.46)	(-2.52)	(-3.11)	(-1.74)	(-2.89)	(-1.72)	(-2.86)	(-1.91)	(-1.73)	(0.67)
Inflation	-0.0067^{b}	0.0098^{a}	0.0121^{a}	-0.0026	-0.0013^{a}	-0.0053^{c}	-0.0103^{a}	-0.0123^{a}	-0.0068^{a}	0.0002
	(-2.02)	(3.11)	(3.28)	(-0.92)	(-6.96)	(-1.89)	(5.34)	(-4.20)	(-4.07)	(0.09)
Interaction Variable			-0.0235^{a}		0.0141^{a}	0.0001	0.0031^{c}	0.0001^{b}	-0.0025^{c}	-0.0003^{c}
			(-5.98)		(4.47)	(0.37)	(1.92)	(2.10)	(-1.79)	(-1.83)
Inflation^2		-0.0029^{a}		-0.0002						
		(-7.23)		(-0.79)						
c			16.28		15.42		41.95		11.31	
γ			0.92		0.29		140.96		200.01	
LM_F			0.00005		0.06		0.12		0.82	
R^2	0.31	0.37	0.28	0.13	0.25	0.13	0.21	0.15	0.21	0.12

Notes: The values below the corresponding coefficients are t-values for PSTR models and z-values for the other models. Symbols ‘a’, ‘b’ and ‘c’ show 1%, 5% and 10% level of significance respectively. p-values are reported for LM_F and AR(2) statistics.

Table 2-6 LM- and F-Tests of Linearity

Transition Variable	Full Sample		High Inc. Economies		Upper Middle Inc.		Emerging Econ.	
Inflation	m=1	m=2	m=1	m=2	m=1	m=2	m=1	m=2
LM	53.184	55.188	14.375	2.083	9.063	9.992	29.546	30.544
F	49.771	25.885	4.789	1.334	4.432	2.428	22.566	11.652
Investment	m=1	m=2	m=1	m=2	m=1	m=2	m=1	m=2
LM	12.668	4.858	5.137	4.335	14.314	0.0052	15.916	3.373
F	5.613	4.269	3.028	2.423	3.564	0.0000	5.791	2.371
Trade Openness	m=1	m=2	m=1	m=2	m=1	m=2	m=1	m=2
LM	13.651	4.952	24.417	3.233	5.603	4.557	5.134	0.147
F	6.056	4.352	8.458	2.078	3.139	2.261	2.151	0.102
Gov. Expenditures	m=1	m=2	m=1	m=2	m=1	m=2	m=1	m=2
LM	6.882	6.892	4.666	6.332	5.221	2.565	4.049	1.055
F	6.063	3.031	3.015	2.047	3.011	0.598	2.034	0.919

Table 2-7 Comparison of residuals' mean and standard deviation: PSTR vs. IV-2SLS models

	IV-2SLS		PSTR			IV-2SLS		PSTR	
Country	Mean	SD	Mean	SD	Country	Mean	SD	Mean	SD
Algeria	0.0005	0.0004	0.0404	0.0089	Kenya	0.0018	0.0010	0.0278	0.0058
Argentina	0.0010	0.0009	0.0433	0.0185	Korea, Re	0.0014	0.0010	0.0660	0.0096
Australia	0.0026	0.0011	0.0780	0.0072	Kuwait	0.0043	0.0039	0.0860	0.0249
Austria	0.0025	0.0007	0.0773	0.0042	Lesotho	0.0039	0.0031	0.0227	0.0112
Banglades	0.0030	0.0012	0.0252	0.0042	Luxembour	0.0028	0.0024	0.0752	0.0134
Barbados	0.0005	0.0006	0.0539	0.0100	Madagasca	0.0064	0.0028	0.0171	0.0074
Belgium	0.0022	0.0006	0.0751	0.0047	Malawi	0.0047	0.0024	0.0173	0.0054
Benin	0.0023	0.0012	0.0301	0.0016	Malaysia	0.0003	0.0004	0.0494	0.0098
Bolivia	0.0014	0.0018	0.0298	0.0111	Mali	0.0033	0.0017	0.0259	0.0036
Botswana	0.0011	0.0008	0.0588	0.0052	Malta	0.0016	0.0017	0.0672	0.0087
Brazil	0.0016	0.0013	0.0460	0.0161	Mauritani	0.0031	0.0013	0.0254	0.0051
Burkina F	0.0017	0.0012	0.0305	0.0067	Mexico	0.0007	0.0010	0.0543	0.0108
Burundi	0.0056	0.0046	0.0200	0.0072	Morocco	0.0004	0.0003	0.0394	0.0055
Cameroon	0.0024	0.0037	0.0324	0.0096	Nepal	0.0043	0.0015	0.0206	0.0033
Canada	0.0035	0.0013	0.0813	0.0062	Netherlan	0.0029	0.0009	0.0774	0.0064
Central A	0.0044	0.0017	0.0230	0.0021	New Zeala	0.0024	0.0012	0.0725	0.0074
Chad	0.0034	0.0038	0.0265	0.0122	Nicaragua	0.0018	0.0003	0.0295	0.0021
Chile	0.0006	0.0000	0.0637	0.0000	Niger	0.0052	0.0030	0.0232	0.0084
China	0.0004	0.0002	0.0549	0.0107	Norway	0.0046	0.0021	0.0851	0.0085
Colombia	0.0001	0.0001	0.0463	0.0073	Oman	0.0053	0.0000	0.1046	0.0000
Congo, De	0.0052	0.0023	0.0118	0.0087	Pakistan	0.0013	0.0010	0.0319	0.0045
Congo, Re	0.0020	0.0019	0.0303	0.0084	Papua New	0.0020	0.0019	0.0314	0.0090
Costa Ric	0.0002	0.0002	0.0489	0.0092	Paraguay	0.0013	0.0014	0.0315	0.0065
Cote d'Iv	0.0018	0.0016	0.0329	0.0087	Peru	0.0003	0.0002	0.0409	0.0173
Denmark	0.0043	0.0016	0.0846	0.0058	Philippin	0.0017	0.0017	0.0314	0.0071
Dominican	0.0003	0.0003	0.0460	0.0115	Portugal	0.0012	0.0009	0.0640	0.0100
Ecuador	0.0002	0.0005	0.0439	0.0102	Rwanda	0.0042	0.0046	0.0245	0.0091
Egypt, Ar	0.0006	0.0005	0.0365	0.0053	Saudi Ara	0.0047	0.0063	0.0803	0.0272
Fiji	0.0003	0.0003	0.0426	0.0059	Senegal	0.0025	0.0009	0.0283	0.0037
Finland	0.0033	0.0019	0.0774	0.0101	Singapore	0.0003	0.0004	0.0505	0.0101
France	0.0037	0.0010	0.0813	0.0056	South Afr	0.0003	0.0003	0.0522	0.0097
Gabon	0.0023	0.0028	0.0492	0.0228	Spain	0.0019	0.0010	0.0714	0.0100
Gambia, T	0.0031	0.0018	0.0244	0.0037	Sri Lanka	0.0014	0.0010	0.0323	0.0088
Germany	0.0031	0.0011	0.0794	0.0055	Sudan	0.0010	0.0011	0.0292	0.0109
Ghana	0.0025	0.0016	0.0223	0.0082	Swaziland	0.0006	0.0004	0.0360	0.0063
Greece	0.0020	0.0014	0.0691	0.0160	Sweden	0.0044	0.0019	0.0844	0.0075
Guatemala	0.0003	0.0004	0.0411	0.0074	Switzerla	0.0025	0.0006	0.0788	0.0054
Guyana	0.0040	0.0028	0.0233	0.0060	Syrian Ar	0.0006	0.0008	0.0400	0.0101
Honduras	0.0012	0.0007	0.0328	0.0067	Thailand	0.0005	0.0006	0.0402	0.0077
Hong Kong	0.0007	0.0009	0.0528	0.0098	Togo	0.0049	0.0023	0.0215	0.0052
Hungary	0.0004	0.0004	0.0509	0.0109	Trinidad	0.0013	0.0017	0.0563	0.0173
Iceland	0.0048	0.0026	0.0809	0.0138	Tunisia	0.0001	0.0001	0.0453	0.0073
India	0.0020	0.0017	0.0300	0.0077	Turkey	0.0009	0.0008	0.0511	0.0118
Indonesia	0.0009	0.0016	0.0347	0.0086	United Ki	0.0043	0.0019	0.0857	0.0086
Iran, Isl	0.0014	0.0023	0.0419	0.0209	United St	0.0046	0.0016	0.0882	0.0078
Ireland	0.0018	0.0012	0.0773	0.0124	Uruguay	0.0007	0.0007	0.0454	0.0121
Israel	0.0049	0.0031	0.0778	0.0163	Venezuela	0.0002	0.0000	0.0444	0.0000
Italy	0.0026	0.0010	0.0769	0.0058	Zambia	0.0013	0.0008	0.0237	0.0087
Japan	0.0034	0.0015	0.0859	0.0108	Zimbabwe	0.0027	0.0026	0.0211	0.0118

Chapter 3 Explaining the Inflation-Growth Nonlinearity through Capital Accumulation

1. Introduction

In the previous chapter, we discussed literature on the inflation–growth relationship that widely supports a negative long-run relationship between the two variables for both developed and developing economies. The empirical work, starting from Fischer (1993), also shows that this relationship is strikingly nonlinear and the adverse effects of inflation on growth appear only when it exceeds certain threshold points. A substantial amount of empirical work including the recent panel data studies e.g., Omay and Kan (2010); López-Villavicencio and Mignon (2011) and Jude and Khan (2014) support this nonlinearity and describe several country and time specific inflation thresholds.[27] Similar nonlinearity has been reported in papers where effects of inflation on growth are found stronger in its lower ranges and weaker in its higher ranges (see Ghosh and Phillips, 1998; Khan and Senhadji, 2001 and Gillman and Nakov 2003). For example, Gillman and Nakov (2003) report the nonlinearity by dividing a postwar OECD panel into three sub-samples of inflation ranges of 0 – 10%, 10% – 20% and above 20%. The authors find that the strongest negative effects are attached with the lowest inflation range of 0 – 10% and the weakest relationship exists for the inflation range of above 20 percent.

All of these empirical findings, along with complementary theoretical reasoning of the literature – reported in the previous two chapters – support a dynamic behavior of output growth to inflationary changes and output response particularly depends upon the level of inflation. This dynamic behavior can be explained through many factors such as credibility of central banks at different inflation levels, real market rigidities and signaling channel of price changes as well as inflation history of a country. Beside all of these factors, one principal source which has been identified in the literature is the realignment of factors of production in response to inflation changes (Gillman and Nakov, 2003). To this view, at a very low level of the inflation rate, an upward marginal change in it represses real interest rate which further results in a very strong Tobin effect

[27] Eggoh and Khan (2014) mainly report our empirical results of the previous chapter.

for physical capital. Real wages go up compared to the real interest rate despite their reduction in absolute terms. Both these changes cause factors' realignment; capital intensity increases compared to labor which stimulates the accumulation of physical capital compared to human capital. This signifies that at a very low inflation level, the marginal upward changes can favor the accumulation of physical capital due to the Tobin effects of lower real interest rate. Gillman and Nakov (2003) report… *it is the realignment of factor inputs whereby an increase in the inflation rate increases physical capital-effective labour ratios across sectors. The savings rate rises as well. These are permanent effects on the new balanced-growth path (Gillman and Nakov, 2003 p.440)*.

The aforementioned factors realignment can also favor human capital accumulation when inflation goes beyond certain thresholds. The mechanism comes from opportunity cost of human capital accumulation. As inflation brings down the real wages of agents, the opportunity cost for the accumulation of human capital declines. Investment in human capital therefore becomes an attractive option for young agents due to a lower opportunity cost associated with it (Heylen and Pozzi, 2007). Heylen and Pozzi use the term crisis for high inflation periods and the authors note… *by reducing total factor productivity a crisis negatively affects the return to working and to accumulating physical capital. Agents work less, capital flows out. The real economy declines. Human capital formation, however, becomes more attractive* (Heylen and Pozzi, 2007 p. 1263). Hence the accumulation of human capital increases at a very high level of inflation rate while a reverse-Tobin effect dominates for physical capital accumulation. These desirable effects of inflation on the accumulation of human capital can be a possible interpretation of why inflation is less costly when it exceeds certain threshold levels (see Levine and Zervos, 1993).

To summarize the above discussion, for a small positive inflation rate, Tobin effect dominates for the accumulation of physical capital, making the inflation–growth relationship positive. At a moderate inflation rate both human and physical accumulation diminishes and the inflation–growth relationship becomes strongly negative. At very high inflation levels, accumulation of human capital partially offsets the negative effects of inflation which weakens the growth impeding effects of inflation. In this chapter we empirically test these effects using a large panel data of both developed and developing countries. To the best of our knowledge, this paper is the first attempt to empirically unearth this possible mechanism behind the inflation–growth nonlinearity.

The economic theory provides several arguments to support the influence of inflation on human and physical capital accumulation. On the accumulation of human capital, as discussed above, a lower opportunity cost due to low real wages enhances the accumulation of human capital during inflation.[28] Agents, being optimistic about the future low inflation rate, reduce work efforts and allocate more time for human capital accumulation for better remuneration in the future. However, if decision to accumulate human capital is mainly influenced by income then this income effect forces agents to reduce human capital accumulation in hyperinflation. As real wages decrease with inflation, agent allocate more time to work and less to human capital development, resulting in an adverse connection between inflation and human capital accumulation (see Binder, 1999). Nonetheless, this last possibility can be influenced by the depth of financial institutions. If the financial sector is developed, agents can get loan to smooth their consumption and improve human capital, turning it again into a positive nexus between inflation and human capital development (see Becker, 1975; Harris and Sakellaris, 2003). Hence the decision to accumulate human capital during inflation depends upon income versus substitution effect of work.

On the effects of inflation on physical capital accumulation, three opposing views have been advanced in the literature. First, an increase in inflation decreases real interest rate (Tobin effect) and, consequently, increases the accumulation of capital (Rapach and Wohar, 2005). Moreover, accelerating inflation (or its variability) can also result into higher capital accumulation by increasing the savings of agents for their precautionary motives (Dotsey and Sarte, 2000). Second, and exactly opposite to the first, inflation inhibits the accumulation of capital since increasing price levels increase the value of money for today than tomorrow. Agents increase consumption and reduce savings. Inflation also shortens the planning horizon of entrepreneurs as volatile prices complicate predictions about future costs and effective demand. The fact that most of the long-run investment decisions are flexible with respect to time and irreversible in nature, entrepreneurs hesitate launching long-run investment projects in high inflation regimes (see Chirinko, 1996 and Dixit and Pindyck, 1994). Third, since capital formation is usually channelized by financial institutions, a high inflation rate impairs the efficient functioning of the financial institutions (as reported earlier) and complicates the capital formation.

[28] See Carmichael (1989) for the negative impact of inflation on the real wages.

Our paper tries to address few basic questions concerning the relationship between inflation and (both types of) capital accumulation. First, we try to empirically analyze whether inflation influences the behavior of agents for their accumulation of human and physical capital. Second, we want to see whether this relationship remains linear in all ranges of the inflation rate or there exists certain thresholds that can possibly explain the inflation–growth nonlinearity. The later can be retrieved from the presence of income and substitution effects at alternative levels of the inflation rates. Third, we want to analyze the impact of inflation volatility on the accumulation of both these factors of production. This enables us to test the empirical validity of Lucas (1973)'s views concerning the link between inflation and factors' reallocation. On the one hand, monetarists advance a negative impact of uncertainty on factors' realignment and accumulation whereas, on the other hand, studies like Dotsey and Sarte (2000) and Grier (2005) support a positive effect of inflation on the accumulation of physical and human capital respectively.

Fourth, we are also interested to see whether certain macroeconomic conditions of a country can facilitate the realignment decision of the agents amidst high inflation. In particular, we test whether the presence of a well established financial system of a country can influence the sensitivity of effects of inflation on the capital accumulation. Effectively, a strong financial system channelizes the savings of agents and facilitates capital formation. Thus Tobin effect of real interest rate on physical capital accumulation appears more robustly in strong financial systems. Similarly, a well developed financial system is also required to facilitate agents in the process of human capital accumulation when its opportunity cost is diminished due to lower real wages in inflation. The direct effect of inflation on the financial development is negative in the previous studies as inflation creates misallocation of credit in the financial markets.

Our main findings can be summarized as follows. Inflation negatively influences the accumulation of physical capital and positively influences the accumulation of human capital. This supports a reverse-Tobin view regarding the impact of inflation on the accumulation of physical capital and a substitution effect – from work to education – for human capital accumulation. Our findings for the inflation volatility specifications are consistent with our results of linear inflation–capital accumulation model. Inflation volatility represses the accumulation of physical capital and enhances the accumulation of human capital. Both these relations are nevertheless nonlinear and the benchmark results are valid only when inflation goes beyond certain thresholds. Precisely, the effects of a moderate inflation rate $(\pi < 8.17\%)$ are positive only for physical capital. Similarly, for the high inflation ranges $(\pi > 15.64\%)$ its effects are positive for human capital accumulation. In the middle ranges $(8.17\% < \pi < 15.64\%)$ the effects are strongly negative for both types of capital accumulation. These findings substantiate the theoretical findings of Gillman and Nakov (2003) and provide a channel through which the inflation–growth nonlinearity can be explained by the factors' realignment and accumulation. Next, the effects of inflation on the accumulation of both the factors are strongly moderated in well developed financial systems.

The rest of the chapter is organized as follows. Section 2 summarizes some important previous theoretical and empirical research and provides a brief discussion of financial development and the inflation–capital accumulation relationship. Section 3 presents our fixed effects and IV-2SLS model settings and the specifications tested. Section 4 and 5 present the data and the empirical findings, respectively. Lastly, Section 6 offers conclusions.

2. Review of the literature

2.1. Capital accumulation and growth

Over the last few centuries, economic transformation of the world economy from traditional agriculture based system to a modern industrial based economy has changed production dynamics. In the traditional systems land was considered primary input of production and a main asset of states. Politicians waged wars to acquire land and natural resources for long-run and sustainable output growth of their countries. Population growth was considered an essential complementary factor to get production from the acquired land. Economists, on the other hand, constantly emphasized the importance of capital accumulation as principal factor behind long-run growth. Classical economists acknowledged the importance of physical capital accumulation to fuel production (see Piazza-Georgi, 2002 for detail discussion). Physical capital was defined as an accumulated physical wealth that could be used to produce goods and services in the country.

These classical views are expanded in the post World War II theories by accounting for the contribution of human capital in countries' economic growth. In this literature, physical capital stock or its accumulation is not sufficient for growth objectives of a country unless it is accompanied by a well developed human capital. Human capital includes society's level of education, social norms and interactions, entrepreneurship, organization and culture. Piazza-Georgi (2002) explains in detail all of these aspects of human capital. This definition of human capital is very vast and difficult to handle on empirical grounds. In the growth literature, human capital can be defined as skills required for the innovation and adoption of advanced technologies for the purpose of higher per-capita production. In other words, a well developed human capital is helpful to steer physical capital accumulation.

This interaction between human and physical capital and their contribution in total factor productivity (TFP) give them a prominent role in determining the long-run growth. Therefore, in the modern economic theories of the last few decades, the relevance of both these factors for growth has been widely researched. The importance of the quality of labor force is assured through better skills and production technologies and has been emphasized even more than its quantity. Certainly, the importance of population size (or its growth) cannot be undermined. Nevertheless, its role as a growth stimulator is crucial only when it is well trained and equipped with modern technologies. The unskilled labor force working with conventional production methods limits the possibility of a country to achieve high growth trajectories.

Likewise, a higher level of human capital accumulation increases the flow of physical capital in an open economy and accelerates growth. A skilled labor force increases the productivity of given stock of physical capital that invites foreign investment. This indirect effect of human capital on the accumulation of physical capital is an important channel of human capital effects on growth. Benhabib and Spiegel (1994) accentuate on this point by stating that even if the direct effect of human capital as factor of production is not significant, its indirect effects through physical capital accumulation are strong enough to justify the importance of human capital in growth process.

That said, given the key role of both human and physical capital in long-run growth, factors influencing their accumulation have also been treated at length in the literature. The economic theory suggests that among other factors – e.g., colonial history, access to natural resources, ethnic and religious heterogeneity – country's macroeconomic stability plays an important role in determining both these factors' accumulation (see Grier, 2005). The macroeconomic stability consists of controlling inflation and stimulating output growth. The relevance of monetary policy or inflation changes becomes vital for the accumulation of both these factors of production. This takes our discussion to a point where we need to probe into theoretical connections between inflation and capital accumulation along with the progress made by the empirical studies on this relationship.

The discussion below summarizes the evolution of theoretical literature from the neo-classical economics to the endogenous growth theories and a complementary empirical evidence for both physical and human capital accumulations. We first present the process of human and physical capital accumulation in different theories and then analyze how inflation is found to have influence on both these factors of production.

2.1.1. Exogenous Growth Models

The early neo-classical growth models are based on the exogenous growth theory where long-run output growth is mainly driven by two factors; labor and capital. In this framework, technological progress is incorporated with labor to allow for positive long-run growth. Solow (1956) presents the neo-classical model where technological possibilities are represented by a production function of the form $Y_t = F(K_t , L_t)$, where Y is output, K is capital and L is labor. Solow assumes F as constant returns to scale and all of the inputs inhibit decreasing returns to scale. The community saves a constant proportion s of the income and physical capital accumulation can be expressed as; $\dot{K} = sY$. The long-run growth is only possible through external technological changes that influence the slope of the production function.

Uzawa (1965) modifies this neo-classical production function by explicitly incorporating the technological knowledge in this model. The modified production function becomes; $Y(t) = F(K(t), A(t)L_F(t))$. The technological expertise improves the efficiency of labor. This efficiency can be determined by the number of people employed in education sector and, accordingly, can be improved by more recruitment in this sector.

In these earlier models, human capital does not appear as an independent factor of production. Mankiw et al. (1992) present an augmented Solow model where human capital is introduced as a separate input in the production function. Their Cobb-Douglas production function takes the following form:

$$Y_t = K_t^{\alpha} H_t^{\beta} (A_t L_t)^{1-\alpha-\beta} \quad (1)$$

Here, H is the stock of human capital, along with the other factors of production of the Solow model. The key characteristic of their model is the fact that human capital requires an investment for its development and depreciates at the same constant rate as physical capital. Due to constant returns to scale of the production function, an increase in investment on human capital does not change growth rate; although it changes the level of income (Mankiw et al 1992, p.417). This is shown by a constant share of human and physical capital in steady state growth.

$$
\hat{k}^* = \left(\frac{s_K^{1-\beta} s_H^{\beta}}{n+g+\delta} \right)^{1/(1-\alpha-\beta)}
$$
$$
\hat{h}^* = \left(\frac{s_K^{\alpha} s_H^{1-\alpha}}{n+g+\delta} \right)^{1/(1-\alpha-\beta)} \tag{2}
$$

An increase in S_H and S_K does not affect growth. The steady state rate of growth can only be influenced by technological changes that are considered exogenous in this model – consistent with the original Solow model.

2.1.2. Endogenous Growth Theory

The main problem with the exogenous growth theory is the fact that it does not leave policy space for the long-run growth. Further, the factor rewards and their ratio (*K/L*) are expected to converge across countries in the long-run. This unconditional convergence is at odds with the empirical long-run income differences across countries. This drawback of exogenous growth theory has been addressed by a new approach called 'endogenous growth theory' which, starting from Romer (1986), tried to 'endogenize' growth within the model. Theoretical framework of Romer (1986) relaxed the assumption of diminishing returns to scale, and hence investment increases with larger capital stock. Human capital in these models is either considered as an engine of economic growth or the factor that enhances innovation process and growth.

2.1.3. Human capital as the engine of economic growth

Lucas (1988) presents a model where endogenous growth is mainly driven by the accumulation of human capital. Production function of Lucas (1988) model follows the Solow framework where human capital directly enters in production function along with physical capital and 'effective' labor. It can be written as;

$$
Y_t = AK_t^{\beta}(u_t h_t L_t)^{1-\beta} h_{a,t}^{\gamma}, \tag{3}
$$

Here Y, A, K and L are output, technology, capital and labor, while u represents the individual's time allocated for work, h and h_a represent the skill level of an individual agent and the average human capital of an economy, respectively. Skill acquisition at an individual level is directly proportional to the time allocated for it. This results into positive human capital accumulation over time that is explained in the following way;

$$\dot{h}_t = h_t\delta(1-u_t) \Leftrightarrow \frac{\dot{h}_t}{h_t} = \delta(1-u_t), \tag{4}$$

The evolution of human capital over time depends upon two things, time allocated for education ($1-u_t$) and productivity of schooling δ. Note that here the growth of human capital differs from Mankiw et al. (1992) in two ways, first, as shown by the equation 4, growth of human capital is constant returns to scale throughout an individual's life (see also Aghion and Howitt, 1998 p.330) and second, human capital accumulation requires time instead of investment. Since time allocated for education is the only input for the accumulation of knowledge, growth can be enhanced through investing more in human capital. This leads to a growth mechanism that is mainly driven by investment in human capital.

Similar mechanism has been put forwarded by the endogenous growth model of Rebelo (1991) where, in contrast with the above-mentioned increasing returns to scale production function of Romer (1986), the author assumes constant-return to scale. Cross-sectional growth differences are explained by the countries' taxation policies that influence their reproducible factors of production, namely, human and physical capital accumulation. Rebelo assumes that among the two types of capital, human capital accumulation augments productivity of all of the time endowment of a worker and not only the time allocated for work. A taxation policy that facilitates human capital accumulation via more taxes on physical capital can therefore result into a higher output growth.

2.1.4. Human capital and technological progress

Both of the above-discussed models (Mankiw et al, 1992 and Lucas, 1988) treat human capital as standard input that is equally productive for all sectors. Moreover, the same technological setup can result into higher marginal productivity of human capital for ever. This contrasts with Nelson and Phelps (1966) view that education enables the agents to adapt the advanced technologies and, therefore, facilitates technological diffusion in developing economies. This consequently enhances the speed of convergence between developing and developed economies. This issue has been further addressed by Romer (1990) in an endogenous growth framework where education not only increases the adaptability of the agents with the existing technologies but also enhances the speed of innovation. Unlike Mankiw et al. (1992) or Lucas (1988), it is not the level of education by itself that is important for growth but it's effect on the innovation process as well as the adaptability to the new technologies for further growth (see Benhabib and Spiegel, 1994 for an empirical support on this issue).

Romer's model economy consists of three sectors: a final good sector, an intermediate-goods sector and a research sector. The research sector exploits the existing stock of knowledge for the production of new designs for capital goods. These capital goods are sold to intermediate-goods sector which – with the help of economy's savings – produces intermediate capital goods. These intermediate capital goods are used by the final goods sector along with labor and human capital to get the final output. Final goods' production function takes the following form:

$$Y = H_Y^{\alpha} L^{\beta} \sum_{i=1}^{A} x_i^{1-\alpha-\beta}, \qquad (5)$$

Here Y, L, A and H_Y are output, labor, stock of knowledge and human capital used in the production respectively, while x_i are intermediate producer durables used in the final good production. So the production of x_i in the country directly depends upon the stock of knowledge. Since the process of innovation depends upon the existing stock of knowledge (see Romer, 1990: S83), new designs or technologies evolve in the following way:

$$\dot{A} = \delta H_A A \Leftrightarrow \frac{\dot{A}}{A} = \delta H_A, \qquad (6)$$

Here δ is a productivity parameter that also depends upon the stock of knowledge. Thus, in this Romer's setting, knowledge based economies can enjoy sustainable long-run growth unless the opportunities in research are dwindling with the passage of time.

Concerning the empirical research on the interaction between human capital accumulation and growth, Romer (1990) is among the first studies analyzing the impact of human capital accumulation on growth and finds this effect positive and significant. Another influential work in this domain is Barro (1991) where enrollment rate, instead of literacy rate of Romer (1990), is used as an indicator of human capital. In fact, Barro argues that literacy rate is inconsistent measure of human capital among countries. Barro finds a positive effect of school enrollment on the subsequent growth for both primary and secondary enrollment rates (see also Barro and Sala-i-Martin, 1995). Examples of the country based studies include the work by Ljungberg and Nilsson (2009) which uses enrollment and expenditure on education data for Sweden to look into the causality between education and growth. The results, over a large sample of 1870-2000, show that higher education stimulates growth process by positively influencing the productivity in manufacturing sector.

The above-mentioned two branches of endogenous growth theory (Lucas versus Romer) have also been investigated empirically for testing the relationship between human capital and economic growth. In the Lucas based models, growth rate of human capital is tested for its possible effects on output growth (see Mankiw et al 1992; Klenow and Rodriquez, 1997). These models generally explain a very limited effect of changes in human capital stock on growth across countries. However, the empirical models aimed at testing the Romer's view usually focuses on the effect of stock of human capital on output growth in different countries (see Fuente and Doménech, 2000). The estimated results of the effect of human capital on output growth generally turns out to be more significant in stock terms (Romer view) than in flow terms (Lucas model).

2.2. Inflation and the capital accumulation: Theoretical developments

2.2.1. Inflation and physical capital

The above-mentioned research underscores the importance of physical and human capital accumulation in the growth process. Given the key importance of both these factors in determining the long-run growth, it is important to know how inflation influences their accumulation. The effects of inflation on the accumulation of these factors provide one channel through which these effects can appear. In fact, this channel of effects is so important that all of the direct effects of inflation on growth, described in Chapter 2, appear mainly through the capital accumulation. To this end, the literature presents three possibilities of effects of inflation; the positive effects of Tobin (1965), the superneutrality effects of Sidrauski (1967) and the negative effects of Stockman (1981). All of these effects and their relevance for growth have been discussed in our previous chapter. Here we briefly focus on the direct relationship between inflation and capital accumulation and the relevant theoretical and empirical support to all of these opposing views.

Tobin's positive effects of inflation and Sidrauski's super-neutrality of money have been recovered by several studies. On the positive relationship between inflation and capital accumulation, though the original Tobin's model showed this association for an exogenous growth setting – where money serves no other purpose than a financial capital asset as physical capital – the subsequent studies however reproduced these results using the endogenous growth models. Nevertheless, the original Sidrauski's results were obtained for an infinitely lived agents' model where representative families maximize their life time utility and capital stock grows at a constant rate – determined by the population growth and rate of time preference. Any increase in money growth rate only augments the holding of real balances in long-run but not the per capita consumption or investment of the economy. These results are also found in over lapping generation models and other theoretical settings.

Different studies in the subsequent literature tested these opposing effects of inflation on the capital accumulation and came-up with their divergent views. The studies supporting the Tobin effect include Fischer (1979); Ireland (1994) and Walsh (1998), among other. All of these studies albeit find the positive effects of inflation during the transition to the steady state. To illustrate, Fischer (1979) analyzes the relationship between inflation and capital accumulation for the transition to the steady-state and confirms the presence of Tobin effect. The results show that an economy's selected path to the steady-state is influenced by money growth and, moreover, the capital accumulation positively responds to money-supply changes during this transition. Some indirect support to these results comes from the studies indicating an inverse relationship between inflation and real interest rate. A lower interest rate supports a higher accumulation of capital (see Rapach and Wohar, 2005).

Ireland (1994) compares the short-run and long-run effects of inflation on the capital accumulation and finds that during transition to the steady state, the effects of inflation on the capital accumulation are positive; supporting the Tobin's view, while on the steady state, the effects are negative. Ireland argues that positive effects of inflation appear from the fact that demand for real balances becomes more elastic over-time following the introduction of interest-bearing checkable deposits. A high elasticity of real money balances to interest rate changes means that any inflationary changes reducing the reward of monetary assets will facilitate a substitution of money for the real capital. Further, the Tobin effect also appears from the fact that in high inflation, consumer makes an inter-temporal substitution of consumption causing a lower purchase of consumption good and a higher purchase of capital good.[29] In the long-run, the effects disappear since inflation adversely affects financial sectors. Therefore, in the long-run super-neutrality of money holds. Walsh (1998) complements these temporary Tobin effect in money in the utility function (MIUF) model.

All of these studies support super-neutrality in the steady state. In fact, Sidrauski also acknowledges a short-run positive relationship between money growth and real variables. The long-run growth of capital stock is, however, unaffected by the rate of monetary expansion in a country. Nonetheless, Sidrauski's super-neutrality has also been criticized by many authors by arguing that these results appear from the assumption of MIUF and the stability of these results can be affected by changing the properties of the utility function

[29] Gillman and Kejak (2011) assume the same intertemporal substitution of consumption to get the positive effects of inflation on the capital intensity. The effects of the capital accumulation are, nevertheless, negative in their model.

(Fischer, 1979; Feenstra, 1986). Feenstra tests the functional reliance of Sidrauski's results by entering the money into liquidity costs which appear in individual's budget constraint. The liquidity costs are defined as transaction costs of using real balances and precautionary costs – a penalty in case of future cash shortfall. The author recovers the money neutrality with these different specifications about the role of money. Pemberton (1989) tests the Sidrauski's money neutrality results for a small open economy working with a government sector, a foreign sector and a labor market. The author finds that 'superneutrality' does not exist in the presence of imperfect financial markets and nominal wage rigidity.

Petrucci (1999) notes that Sidrauski's super-neutrality is based on several assumptions and by relaxing these assumptions the results disappear. The author reports his observations in the following way: "*several basic assumptions incorporated into the Sidrauski framework are crucial for obtaining the superneutrality of money……..the most important of them are: the infinite-horizon of consumers, the introduction of money into the utility function, the exogenous labour supply, the fixed discount rate, and the return on physical capital that only depends on the capital-labour ratio. Obviously, if we relax at least one of these hypotheses, we depart in the majority of cases from superneutrality of money*" Petrucci (1999 p.476). Therefore, under heterogeneous specifications, the super-neutrality was rejected against the non-neutrality and one outcome was the Stockman's negative effects of inflation.

Precisely, Stockman's negative effects of inflation on the capital accumulation are retrieved in cash-in-advance models where anticipated inflation reduces the steady state capital stock by forcing the individuals to economize the use of money on both consumption and investment goods. Consumption of household's own produced goods or leisure increases while the capital stock declines. These negative effects of inflation in Stockman's model are essentially valid for the steady state. Fischer (1983) confirms the negative effects of inflation on the capital accumulation in a model where money serves as an input in the production function, namely, money in the production function (MIPF) model. The introduction of money saves the real resources of agents that they would have to allocate for transaction purposes in the absence of money. Inflation forces the agents to economize the use of money, and therefore decreases growth. Abel (1985) analyzes the impact of inflationary changes on the transition path to the steady state and confirms Stockman's results when cash-in-advance applies on both consumption and capital accumulation. Nonetheless, when cash-in-advance applies only on the consumption good, money is super-neutral for the accumulation of capital on the transition path of the steady state.

These negative effects of inflation on the capital accumulation have been supported by a number of other papers through different channels of (adverse) effects of inflation. The examples include Madsen (2003) and Byrne and Devis (2004). To illustrate, in Madsen (2003), the negative effects of inflation on the capital accumulation come from two different channels of user cost of capital. First, inflation reduces the tax depreciation on the existing capital stock because the tax deduction applies on the purchase value of the capital good. As inflation reduces the real value of tax deduction, the user cost of capital increases, causing a lower investment. Second, inflation reduces the accounting profit of firms by increasing the (nominal) interest payments on debt, it represses capital accumulation.[30] Even if these effects of inflation are illusionary, they have some real impact on firms' investment decisions.

The above discussion by no means exhausts the existing literature on the competing possibilities of effects of inflation on the capital accumulation. Further, as discussed by Petrucci (1999), the effects of anticipated inflation on capital intensity are strongly dependent upon the assumed economic environment in the model. For example, the studies using the overlapping generation models (OLG) with the assumption of both infinite horizon families and finitely lived families models show a positive effect of anticipated inflation on (physical) capital intensity and the short-run accumulation of capital.[31] However, in these models the expansionary effect of inflation comes through positive population growth and the assumption of higher saving rate of the young generation, compared to the old. Further, these models make use of the Sidrauski's MIUF assumption and, consequently, the effects of money as production good are not directly taken into account.[32] Petrucci introduces money in the production function for an overlapping generation model and finds ambiguous effects of inflation on the capital accumulation. The OLG nature of the model gives positive effects while the MIPF assumption implies adverse effects of inflation on capital accumulation.

It is important to mention that in the theoretical literature the term capital has been defined in different ways. In some cases capital stands for both human and physical capitals while in the other cases human and physical capitals are taken as two separate factors of production for the analysis of the effects of inflation on their accumulation. For instance, in the aforementioned conflicting theories of inflation–capital accumulation relationship –

[30] See Madsen (2003, p.376) for more references on the adverse relationship between nominal interest rate and capital accumulation.
[31] See, for example, Wiel (1991) for infinite lived assumption models and Marini and Ploeg (1988); for finite lived framework.
[32] Gahvari (2007) takes an overlapping generation framework in a MIUF framework to analyze the effects of inflation changes on capital accumulation.

namely, Tobin's positive effects; Sidrauski's super-neutrality and Stockman's negative effects – the theoretical framework is based on the neoclassical model and the term capital mainly represents physical capital stock only. Nonetheless, there exists some literature showing the effects of inflation on human capital accumulation and similarly a parallel literature on both human and physical capital accumulation together. Consequently, we can find all types of theoretical works in the literature; models with physical capital only, models with human capital only and also models with both physical and human capital.

2.2.2. *Inflation and Human capital nexus*

Turning to the effects of inflation on human capital, as the later is considered very essential factor for long-run productivity growth, the role of money to facilitate its accumulation is given key importance in the research (Chang, 2002). Consistent with the above discussed MIPF models where money decreases the transaction cost of different goods in an exchange economy, it also facilitates the transaction of educational services and promotes human capital accumulation. For similar reasons, inflation forces the agents to economize the use of money for human capital accumulation and deters the long-run growth. The case of human capital is therefore viewed same as physical capital and the effects of inflation also appear through the similar channels as physical capital.

Considering the importance of human capital in the growth process, Wang and Yip (1992) present an endogenous growth model where they analyze the role of money growth on consumption, output and human and physical capital. Consistent with the MIPF, money facilitates transaction process and improves the efficiency of goods production in the model. The accumulation of human capital depends upon the time allocated for education:

$$\dot{h}(t) = \Phi(1 - l(t))h(t), \tag{7}$$

Whereas $(1 - l(t))$ is the non-leisure time allocated for education activities. With these assumptions about the accumulation of human capital, the growth of real variables is independent of monetary changes along the balanced growth paths. Therefore, the super-neutrality of money holds with respect to the accumulation of human and physical capital.

The robustness of these 'superneutrality' results has been tested by Pecorino (1995) in an alternative technology of human capital accumulation where the production function of human capital requires an input for physical capital. Inflation acts as a tax on the input of human capital sector and inhibits the long-run growth. These effects are in addition to the direct adverse effects on physical capital. Nevertheless, the simulation results show that for certain reasonable parameter values of the production function; the magnitude of inflation effect is very moderate. Although lower returns on physical capital reduce the accumulation of human capital and violate super-neutrality of money, the actual inflation rates of the industrialized countries are not harmful for capital accumulation.

Gomme (1993) presents a neoclassical model where long-run growth arises from human capital accumulation. In this endogenous growth framework, the production of human capital requires labor input and physical capital. A representative agent can either work for output production or for human capital accumulation and is free to choose between the two, keeping in view the relative returns of both these activities. Free mobility of labor assures returns' equality between these two sectors. With these assumptions about the factors' mobility, human capital development along with cash-in-advance (CIA) constraint for the purchase of consumption good, inflation not only reduces physical capital accumulation but also exerts a negative influence on the accumulation of human capital. Chari et al. (1996) present complementing evidence in the CIA model while taking into account the distortionary effects of inflation on the labor-leisure choice of agents and the time allocation for work. The lower work efforts and the more leisure decline human capital.

Some contemporaneous evidence to the above on the inflation–human capital accumulation nexus includes Jones and Manuelli (1993); Mino (1999) and Chang (2002). As an illustration, Chang (2002) expands the Wang and Yip (1992)'s MIPF model for a two sector economy where money is useful for the production of goods and human capital accumulation. The production function for human capital accumulation takes the form: $Q = G\left[(1-h)AL, \theta M/P\right]$, where '$\theta$' denotes an index parameter. When the value of $\theta = 1$, the circulation of real balances not only facilitates the production of goods, but also improves the education and R&D activities; consistent with Lucas (1988). The presence of money in the Chang's education function alters the super-neutrality results of Wang and Yip (1992) as inflation adversely affects the real activity in this model.

A more generalized form of monetary policy environment and the effects of monetary expansion on both physical and human capital accumulation have been analyzed by Kaas and Weinrich (2003). They assume a two periods model where a representative consumer can shift his income from first period to the second period in form of different assets e.g., government bond, money and equity of firms. Equity returns are assumed higher and more uncertain than the returns on government bonds. As inflation increases the seigniorage revenues, it helps the government in reducing the bond issuing and consequently bond return decreases. This further raises equity returns and capital accumulation. Same results (of lower bond holding and higher capital accumulation) can be obtained when physical capital is replaced with human capital in the model. Agents, instead of buying bonds, invest their savings in human capital formation to get high wages in the subsequent periods. All this translates into a higher capital accumulation and output growth.

2.2.3. Explaining the inflation–growth nonlinearity through factors' realignment and accumulation

The research on the relationship between inflation and output growth, discussed in Chapter 2 along with our own findings, shows that the inflation–growth relationship is negative and nonlinear. Effects of inflation are positive for the moderate inflation rates and negative for higher inflation regimes. One principal factor explaining this nonlinear relationship is its effects on both physical and human capital accumulation and their realignments. This mechanism has been particularly described in the studies analyzing the effects of inflation on these factors' accumulation. In other words, this literature shows that the nonlinear effects of inflation on growth can be explained through its dynamic effects on factors' accumulation. The nature of effects of inflation on growth also depends upon whether it acts as tax on human or physical capital accumulation (Gillman and Kejak, 2005). The authors also argue the effects of inflation on capital accumulation are relevant for determining both the dimension of inflation–growth relationship as well as its magnitude.

The nonlinear effects of inflation on human capital accumulation are shown in the models where inflation disrupts the efficient functioning of the modern transaction systems and forces agents to spare the productive human capital for transaction purposes. This stream of literature assumes Lucas (1988)'s alternative payment mechanisms that includes cash and credit services and the use of a particular payment system depends upon the cost associated with it. When inflationary shocks hit the economy, agents decrease the use of real balances and replace it with the credit good (Marquis and Reffett, 1994). The authors assume that credit good requires human capital for its production. Human capital is also used for the production of other goods and knowledge (R&D) in the model. Inflation increases the use of human capital for the production of credit goods and reduces its use for the production of other goods, including R&D. This reallocation deters human capital accumulation and output growth. In the high inflationary zones, this reallocation does not happen because the share of real balances in the overall consumption is already low. Hence the effects of inflation on human capital accumulation and growth are nonlinear.

Another example of drawing parallels between the inflation–growth nonlinearity and inflation–capital accumulation nonlinearity is the paper by Gillman and Kejak (2004). To find the coherence between effects of inflation on growth and on capital accumulation, the authors assume Lucas types payment choices of the representative agent (e.g., money and credit). Inflation increases the transaction cost of agents but with the presence of credit good, the magnitude of this increase can be appeased. Similarly, the availability of credit good also affects the labor-leisure choices in inflation. The use of credit good also decreases the substitution away from labor and towards leisure, mainly because of two reasons; first, agents depend more and more on the credit good at the increasing inflation rates and second, as the use of leisure increases, its marginal utility decreases and vice versa for the other goods. The second factor limits the effects of inflation on growth and results in inflation–growth nonlinearity. Increased leisure also reduces human capital accumulation. The authors conjecture that effects of inflation on growth are not only similar but also proportional in magnitude to its effects on the capital accumulation.

In the theoretical literature, the assumed functional form of the money demand also influences the relationship between inflation and the capital accumulation and makes this relationship nonlinear. Gillman and Kejak (2004) argue that if money demand function is semi-elastic with respect to interest rate, the effects of inflation on the money demand are not constant for all ranges of the level of inflation. The interest rate elasticity increases with the inflation rate. The role of credit good is important here as well because it is due to the easy substitution between money and the credit good that the Tobin effect occurs. The assumption of semi-elastic money demand function is also consistent with the actual panel data estimates of 19 developed countries; as shown by Mark and Sul (2002). All this implies a nonlinearity of the behavior of output growth when inflation moves from low to high ranges. Gillman and Kejak (2005) tests and confirms this nonlinearity of different models; physical capital *Ak* models; human capital *Ah* and combine models *Ak* and *Ah* models.

To summarize the above discussion, the effects of inflation on the accumulation of human and physical capital accumulation are unanimously acknowledged in theoretical research. These effects are also shown to behave differently at alternative levels of inflation. The same level of inflation can have divergent effects on physical and human capital accumulation. This last factor appears from factors' realignment in inflation. This factors' realignment may favor the accumulation of one factor and discourages the accumulation of the other at a particular rate of inflation. All this is found to be closely connected to the behavior of output growth at different inflation rates and provides one channel through which the inflation–growth nonlinearity can be explained. The following section reports the empirical advancement on all of these relations between inflation and capital accumulation.

2.3. Inflation and capital accumulation: Empirical developments

2.3.1. Inflation and physical capital

The large theoretical developments on the relationship between inflation and capital accumulation were a natural source of motivation for the empirical economists. This was particularly essential in the presence of opposing predictions of the existing studies; namely, from Tobin's positive effects to Sidrauski's super-neutrality and then Stockman's negative relationship between these variables. Further, the empirical testing of this relationship was also important to analyze the relevance of real balances in influencing the real variables. Despite the key importance of this question and strong ambiguities of the theoretical literature, empirical researchers did not pay heed to overcome these contradictions and to provide compelling evidence on inflation–capital accumulation nexus. This does not spare the fact that the need of empirical work has been stressed since long by Summers (1981, p. 193). Summers reports, "*It is not likely, . . . that theoretical analysis can shed much light on the optimal rate of inflation, until more empirical evidence is available. Reliable estimates of the impact of inflation on capital formation do not yet exist.*" Although Summers highlights this deficiency of only empirical evidence for physical capital accumulation, yet we cannot exclude the accumulation of human capital from this criticism.

One apparent reason behind the insufficient empirical treatment of this relationship is the unavailability of data on capital accumulation. This deficiency has been noticed by studies until recent past. Crosby and Otto (2000), for instance, reports "*One reason for the lack of empirical evidence on the effect of inflation on the capital stock is the general unavailability of reliable measures of capital stocks for the vast majority of countries. The lack of data is particularly severe for developing countries. This is an unfortunate fact, since inflation rates in developing countries tend to be higher and more variable than in developed countries.*" (Crosby and Otto 2000; footnote 1). Despite the dearth of empirical work on this issue, some interesting studies can still be found supporting all of the conflicting possibilities of positive relationship, adverse nexus and an absence of the link between inflation and capital accumulation. Here we briefly discuss this literature.

First, the Tobin effect of inflation on the capital accumulation has been supported by Ahmed and Rogers (2000). To illustrate, Ahmed and Rogers use over 100 years U.S data on inflation, consumption, investment and output growth to test the effects of inflation on investment-output ratio, consumption-output ratio and capital-labor ratio during this period. The empirical results, based on the co-integration method, show a positive effect of inflation on the investment-output ratio and a negative effect on the consumption-output ratio. For instance, a permanent one percent increase in inflation is associated with 2.5 percentage points reduction in the consumption-output ratio and 1 percentage point increase in investment-output ratio. The authors also do sub-sample analysis of pre-World War 1, interwar and post-1949 and find their results consistent for these sub-samples.

An indirect support to these empirical Tobin effect results have been provided by the model that analyze the relationship between inflation and real interest rate. Effectively, if the inflation effect on real interest rate is negative, it will motivate agents to invest more, and capital accumulation will increase in inflation. This indirect channel of Tobin effects has been tested by several papers including Rapach (2003), Rapach and Wohar (2005). The study of Rapach and Wohar (2005), for instance, analyzes the relationship between inflation and real interest rate for the 13 industrialized countries using the quarterly postwar data. To capture the systematic relationship between inflation and real interest rate the authors use Bai and Parron methodology and estimate structural breaks in both inflation and real interest rate series. The results show that for most of the countries, the structural break in both series appear during the same time, supporting the view that changes in monetary regime influence the real interest rate. Rapach (2003) analyzes the effects of permanent increase in the inflation rate on the real interest rate and output growth for the 14 industrialized countries and support the presence of a Tobin effect for these countries. The study uses structural VAR model to get these steady-state effects of inflation on the real variables. An increase in inflation- arising from an increase in the money growth- is associated with lower real interest rate and higher long-run output growth.

A parallel stream of empirical literature supports Sidrauski's super-neutrality of money. This view, that indicates the lack of a robust relationship between inflation and capital stock, is supported by Lucas (1980); Geweke (1986) and Crosby and Otto (2000). For instance, Lucas (1980) uses the U.S data set on prices, money growth (M1) and inflation for analyzing the co-movement of these variables over the period of 1953-77. The study presents the graphic illustration of these variables based on the moving average filtering techniques and comes up with the findings that money growth, prices and inflation move together during this period. An increase in the money supply proportionally affects the inflation rate and nominal interest rate, implying no impact of money supply changes on the real variables. Geweke (1986) test the robustness of these results for a long time series data set of the U.S over the period 1870-1970. The results demonstrate a structural neutrality of money with respect to output growth and real interest rate for the long time, nevertheless, a non-neutrality of money holds with respect to its velocity (see also Stockman, 1988 for some partial support for this view).

Similarly, Crossby and Otto (2000) use the time series data of 34 developed and emerging economies and conduct a structural VAR estimation to examine the relationship between inflation and capital accumulation. The study finds that for almost two-third of the included economies, there is no short-run and long-run relationship between the two variables. For the rest of the countries the relationship does not hold for the long-run. In other words, 'super-neutrality' of money with respect to capital stock holds for most of the countries. De Gregorio (1999) also brings some complementary support to this view for the sample of Latin American countries. Using the data of twelve economies, the author finds that although inflation reduces the efficiency of investment, its effects on overall capital accumulation are insignificant.

The third possibility of the inflation–capital accumulation relationship showing Stockman's negative effects of inflation has also found contemporaneous empirical support in the empirical literature. The examples include Fischer (1993) and Barro (1995). Fischer (1993) uses a large panel data to estimate the effect of inflation on the capital accumulation. The results, based on the GLS estimation method, support the Stockman's view that inflation significantly withholds the capital accumulation. An increase in inflation by 100 basis points reduces the capital stock by 3.7 percentage points. Barro (1995) brings complementary evidence by using the data of 100 countries over the period 1960-1990. A 10 percent inflation rate reduces the investment to GDP ratio by 0.4-0.6 percentage point. The values of the coefficients are higher when inflation is used at the first lag than at its level values. Moreover, the effects of inflation are also larger in magnitude when the high inflation observations are used in the regressions.

The country-specific studies on negative inflation–capital accumulation relationship include Olanipekun and Akeju (2013) who find this relationship for Nigeria over the period of 1970-2010. The authors use two methods, error correction model and co-integration technique to first analyze the adjustment mechanism after inflationary changes and then test the long-run relationship between inflation and capital accumulation. The results of error correction method show that one unit change in three periods lag inflation brings about 0.12 unit changes in the capital accumulation for Nigeria. However, the co-integration results illustrate that a unit increase in inflation is associated with 0.03 unit reduction in the capital stock. The authors also tested the link between narrow money supply (M1) and capital stock and found a strong positive relation between these two variables.

2.3.2. Inflation and human capital accumulation

Consistent with physical capital accumulation, the empirical literature on the inflation and human capital is also very scarce. In fact, it is scarcer than physical capital. The main reason for this lack of attention by the empirical economists is the fact that human capital accumulation is hard to measure because of certain invisible characteristics of this variable. This problem become more severe for a panel data where skills are measured based on the years spent in education. Then, the second important problem is the fact that all of the earlier theories on inflation–capital accumulation relationship explicitly focused on the agents' decision to reallocate physical capital (real balances) in inflation. The factors that influence human capital accumulation, for example, agents' labor-leisure choice have not been focused in these studies. One other reason can be the fact that human capital is a factor which requires long time for its accumulation and cannot be explained by frequently varying nominal variables.

This deficiency of the empirical literature has been, however, filled by some country-specific studies that attempt at analyzing the effects of macroeconomic instability on capital accumulation for both developed and developing countries. Literature on these country-specific studies generally supports the view that for the developed markets the process of human capital development is counter cyclical. Goldin (1999), for example, shows that during the great depression, high school graduation rates in the U.S increased from approximately 30 to 50 percent[33] (see also Black and Sokoloff, 2006). Other studies based on the U.S data set (DeJong and Ingram, 2001, Dellas and Sakellaris, 2003) also show that investment in human capital is counter cyclical and physical capital investment is pro-cyclical. This also shows that investment in both types of capital is taken as substitute in the U.S market. Studies analyzing the role of high inflation on human capital accumulation include Duryea and Arends-Kuenning (2003) where the effect of high inflation on capital accumulation is found to be positive for Brazil.

Some studies use the other indictors of macroeconomic instability such as currency and debt crises to test the effect of instability on human capital accumulation. The examples include Binder (1999) and McKenzie (2003) for Mexico. Binder argues that the debt crisis of

[33] Nevertheless, these studies do not precisely analyze the role of inflation since great depression was basically a deflationary era.

Mexico during 1980 had two opposing effects on human capital accumulation. On the one hand it decreases the opportunity cost of schooling by reducing the opportunity cost of joining the school while, on the other hand, lower national income worsened the condition to invest in human capital. The author tests the relevance of both factors by taking into consideration of post-primary education in Mexico during 1976-1994. The results show that the secondary school enrollment in Mexico is pro-cyclical and the income effect of crisis (lower income and lower enrollment) outweighs its price effect (lower opportunity cost and higher enrollment). The effects on the primary education are nevertheless not significant.

McKenzie (2003) tests the effect of Mexico's currency crisis of 1994 on the household's choices concerning the labor supply, education and consumption. The study uses household data to evaluate the differences in households' strategies and the ultimate impact of crisis on consumption, labor supply and human capital accumulation for the Mexican economy. The study shows that while the effect of crisis on labor supply is found to be insignificant, its effect on human capital accumulation of population aged between 15 to 18 years appears positive. Higher human capital in crisis explains counter cyclical growth of human capital in Mexico. Conversely, there exist some studies indicating a pro-cyclical movement of macroeconomic instability and human capital accumulation. These include the work by Thomas et al., (2004), for Indonesia where the authors find a negative effect of economic and financial crisis of 1998 on the Indonesian spending on education. The results are mainly driven by income effect as the school participation rate of the poor households with older children was more affected by the crisis. However, all of these country-specific studies discuss the role of unanticipated changes in inflation or certain other macroeconomic variables and overlook the long-run relationship between inflation on human capital formation.

Now coming to the panel data studies on the inflation and human capital accumulation, the evidence is further scarce. To our knowledge, only two studies have tried to test the impact of inflation on human capital formation. The first study is Heylen and Pozzi (2007) which addresses the impact of inflation crisis on human capital accumulation. The study uses panel data of 86 countries over the period of 1970-2000 and takes various threshold values of inflation to define crisis. For instance, crisis is defined as the situation where 5-year average inflation value exceeds 25 percent or 40 percent. The estimated results, based on the dynamic GMM model, support the view that inflation crisis enhances human capital development. The study nevertheless focuses on the effects of inflation crisis only and does not evaluate the overall long-run relationship between these two variables. The second attempt is the paper by Yilmazkuday (2012) which investigates into the inflation thresholds for certain growth determinants including financial development, government size, human capital and trade openness. In other words, Yilmazkuday finds threshold inflation value beyond which positive effects of all of these variables on growth disappear. The results show that, among other things, positive impact of human capital on output growth is present, only, when inflation is below 15%. After this inflexion point human capital becomes insignificant in influencing growth.

2.3.3. *Endogeneity between human and physical capital accumulation*

Apart from the fact that empirical work on inflation and capital accumulation is scarce, the above cited studies analyzed the role of human and physical capital separately and did not take into account the endogeneity between both types of capital. In fact, there exists a large stream of theoretical literature starting from Nelson and Phelps (1966) that explains the role of human capital for a better accumulation of physical capital and vice versa. In an environment where human capital is well developed, innovation of new technologies becomes easier, speeding up the process of physical capital accumulation. Same is the case with the diffusion of new technologies; a well developed human capital makes the process of technological diffusion easier. Likewise, a higher stock of physical capital makes human capital accumulation more interesting for agents.[34]

Lucas (1993) reinterprets the Solow growth model and the convergence hypothesis and highlights the joint role of both human and physical capital for explaining the growth differences across world. Greiner (1999) underscores the role of investment to determine a country's stock of human and physical capital. To this view, investment not only increases the level of physical capital but also human capital accumulation justifying the joint treatment of both human and physical capital accumulation. Public policies that lead to increase only one type of capital will not be so helpful in accelerating growth since both types of capitals are complementary in production process. For example, a reduction in taxes that aims to enhance physical capital will result in higher physical capital accumulation but with its lower marginal productivity since labor force is not properly skilled to use it. This reduces the incentive for investing in physical capital accumulation and inhibits growth. A higher accumulation of human capital however accelerates growth through more physical capital. This also explains convergence process across countries.

[34] See Grier (2005) and references therein for detail discussion on this issue.

Empirical evidence on the joint determination of human and physical capital development includes the work by Benhabib and Spiegal (1994) and Grier (2005). More precisely, the study of Benhabib and Spiegal (1994) explains how a well developed human capital encourages investment in physical capital. Their study finds these results for a large data set of above 100 countries and shows that both these factors of production jointly explain a large part of growth difference among countries. Grier (2005), while explaining the growth disaster of Sub-Saharan Africa, highlights the mutual dependence of human and physical capital. Grier argues that physical capital scarcity of these countries can be explained through their lower human capital stock. This makes the existing stock of physical capital optimal since it matches with human capital endowments of these economies. These results and the above discussed findings show a mutual dependence of both types of capital and this motivates us to include physical capital in the accumulation of human capital and vice versa.

2.4. Inflation volatility and capital accumulation

Beside the effects of inflation on the capital accumulation, inflation volatility has also been widely discussed in the literature for its influence on the factors realignment and accumulation. Certainly, if we talk about the monetarists' point of view concerning the effects of inflation, its main emphasis comes from inflation uncertainty channel (see Lucas, 1973). To this view, inflation induced nominal uncertainty obstructs the efficient functioning of the factors' market and reduces their accumulation and long-run output growth. Moreover, inflation and inflation volatility are also found to be positively correlated in this literature. Given the strong correlation between these two variables, some studies have focused on the relationship between inflation uncertainty and accumulation of human and physical capital. This stream of theoretical and empirical literature uncovers some interesting aspects of this relationship and complements the aforementioned inflation–capital accumulation nexus. Here we precisely report the findings of this literature as it is directly connected with our own empirical analysis of inflation volatility and factors' accumulation.

Before we describe the effects of inflation volatility on investment, it is important to mention that all kinds of uncertainty have been usually shown to have a negative influence on investment. It has also been widely held that investment decisions take into account the long-run prospects of the project and are also irreversible in nature; uncertain macroeconomic environment retards these decisions. Pindyck and Solimano (1993) discuss different types of uncertainty and draw attention to the channels through which it depresses the long-run investment plans. The authors argue that uncertainty, irrespective of its nature, increases the required rate of return for the investment projects and therefore impedes capital accumulation. Macroeconomic policies focusing on a rapid capital accumulation should pay more heeds to reducing the uncertainty than altering the tax rate or interest rate. The study discusses two types of uncertainty; monetary uncertainty (e.g., inflation, inflation uncertainty, exchange rate and interest rate changes) and political uncertainty (e.g., political assassination, strike and riots) and finds that the effect of the first group is larger in reducing investment. On the whole, inflation and inflation uncertainty explain a major part of uncertainty in the return of capital and inhibits investment.

Given the key impact of inflation uncertainty on capital accumulation, several studies have analyzed a link between the two variables. The results of this literature are ambiguous as on the one hand, the above-mentioned studies show a negative impact of uncertainty on capital accumulation whereas, on the other hand, studies like Hartman (1979) and Lee and Shin (2000) find a positive relation between uncertainty and capital accumulation. Hartman's theoretical model analyzes the impact of uncertainty of future prices, wage rate and investment costs on firms' investment decisions. The adjustment cost of investment is assumed symmetric and firms produce with a constant-return-to-scale technology. With these assumptions about the production and the adjustment costs, the effect of uncertainty on the value of investment is shown nonlinear and convex where an increase in the first variable increases the later and consequently raises capital accumulation. Lee and Shin (2000) reproduce these results by assuming a variable labor input in the production. The profit function becomes convex for labor intensive technologies and the degree of convexity increases with the labor share, implying a positive relationship between uncertainty and investment.

The other example showing a positive relationship between inflation volatility and capital accumulation are Dotsey and Sarte (2000) and Varvarigos (2008). Dotsey and Sarte posit that a higher inflation volatility forces agents to keep money for precautionary motives and this consequently increases physical capital accumulation. The effects of changes in the average money growth on capital accumulation are nonetheless negative. Varvarigos finds a positive effect of inflation on human capital accumulation in a monetary model where agents live for indefinite time period and require cash-in-advance (CIA) for consumption purposes. The effects of permanent money growth are shown to be different from the short-run changes in its volatility. While the permanent changes in money growth discourage work efforts and human capital accumulation (in line with the standard CIA models), temporary changes in its volatility can encourage both labor market participation and education. The rationale is that higher volatility increases the holdings of real money balances by agents and thereby human capital accumulation.

Similarly, the empirical literature also tested the relationship between inflation uncertainty and capital accumulation for both developed and emerging economies. The examples include Byrne and Davis (2004) and Grier (2005). Byrne and Davis use the quarterly data of the U.S non-residential fixed investment over the period of 1962:Q1 to 1999:Q4. Inflation uncertainty is decomposed into permanent and transitory components by using the Markov switching model and then investment is regressed on both these components. The results show a negative effect of both these components on the capital accumulation with the effect of temporary component larger in size than the permanent inflation uncertainty. Grier (2005) tests the effect of inflation volatility for a panel of Sub-Saharan African countries and finds a negative effect of uncertainty on physical capital accumulation.

The above-mentioned theoretical and empirical survey explains that inflation uncertainty can indeed be a relevant variable for the discussion of inflation and capital accumulation relationship. The theoretical literature also shows ambiguities on the effects of inflation uncertainty on the capital accumulation. Empirical testing of the effects of inflation volatility on both physical and human capital accumulation can be very helpful to validate the authenticity of competing views.

2.5. Country-specific characteristics and inflation–capital accumulation relationship:

As can be drawn from the above description of different theories, the net impact of inflation on physical and human capital accumulation is mainly driven by agents' response to inflationary changes. If agents respond to inflation by lowering the amount of real balances and replacing them for physical capital then, accumulation of the later will increase. Similar results will appear if agents lessen the leisure time in inflation – due to a higher opportunity cost – and substitute it for human capital accumulation. However, to shape the agents' behavior in favor of rapid capital accumulation and growth, better institutional framework is essential. Better institutional framework not only facilitates the agents' decision for any types of capital accumulation in inflation, it also determines the actual level of inflation in that country. Crossby and Otto (2000) accentuate on this later point by arguing; …*a country that has poor political institutions may choose a high inflation rate (for tax revenue) and a high* *effective tax rate on capital. By not controlling for such factors we may obtain biased estimates of the effect of inflation on the capital stock* (Crossby and Otto, 2000 p.250).

This makes it interesting to analyze and compare the Tobin and reverse-Tobin effects of inflation for countries with some specific levels of macroeconomic developments. Certainly several factors can be relevant in determining the agents' response to inflationary changes. The earlier literature (e.g., Grier, 2005) describes the role of factors like political and economic instability, trade policy, democracy, ethnic heterogeneity and financial development. The list of these factors is long and requires several empirical studies to test the relevance of these connections. For present discussion, we take first step in this direction and investigate the role of financial development in determining the effect of inflation on both human and physical capital accumulation. In other words, we try to analyze how the strength of financial institutions determines the effects of inflation on capital accumulation. The following discussion shows the relevance of financial development in the accumulations of physical and human capital.

2.5.1. Financial development and the inflation–capital accumulation relationship

As the effects of inflation on physical and human capital accumulation appear mainly through interest rate changes and assets' realignment, the role of financial institutions in this nexus remains fundamental. Strong financial institutions encourage the assets' substitution from money to physical capital assets in inflation. The positive Tobin effects are only possible if the financial institutions are appropriately developed for this assets' reallocation. Similarly for human capital accumulation, as inflation adversely affects real wages – the opportunity cost of human capital – its favorable results also depend upon well developed financial institutions that provide loans to young agents in inflation. The strength of the financial institutions thereby plays a vital role in determining the effects of inflation on physical and human capital accumulation. Countries with strong financial institutions enable the agents to deal with inflationary shocks more efficiently than their counterparts with underdeveloped financial institutions.

In fact, the role of financial development as a conditional variable is complicated since on the one hand, strong financial system is important for observing any positive effect of inflation on the capital accumulation whereas, on the other hand, inflation directly represses the efficient functioning of financial system. On this later effect, inflation complicates the financial intermediation by obstructing the flow of information regarding the net returns of new investment opportunities (Rousseau and Wachtel, 2002). The lack of information makes it difficult for the intermediaries to evaluate the suitability of projects and therefore results in misallocation of credit. Inflation also forces policymakers to make rapid changes in the monetary policy which distorts financial structure of the economy. Rousseau and Wachtel also note that the usefulness of money as an asset diminishes in inflation which further results in a distortion of the financial intermediation. Similarly, for an open economy, accelerating inflation increases the uncertainty about interest rate and exchange rate and thereby the cost of hedging the financial assets. All of these factors explain how inflation undermines the financial development, and the relationship between finance and (both types of) capital accumulation.

Taking into account the importance of this tripartite relationship, several attempts have been made in the literature to identify the threshold level of inflation above which it represses financial intermediation (Barnes and Duquette, 2006). Choi et al. (1995) develop a model where inflation reduces the average returns on capital and increases their variability in the financial markets. Both these factors create informational frictions in financial system particularly, the adverse selection problem in the capital markets. The authors argue that the degree of this financial market friction increases with the level of inflation. This explains the adverse effects of inflation on the financial development once inflation goes beyond certain thresholds. These adverse effects have been supported by several empirical studies during the last decade. These include Rousseau and Wachtel (2002); Barnes and Duquette (2006) and Rousseau and Yilmazkuday (2009).

All of these studies nevertheless analyze how inflation affects the finance-growth nexus. Their particular focus is to find the level of inflation beyond which the growth enhancing effects of financial deepening cease to exist. Rousseau and Wachtel (2002) for instance use the data of 84 countries over the period of 1965-1990 and show the inflation threshold (for finance-growth nexus) at 13% level of inflation. The authors also show that inflation directly represses the financial intermediation when it exceeds from 10 to 15 percent depending upon the indicator of financial development used. Barnes and Duquette (2006) find the threshold inflation as 14% for the finance-growth nexus. A more recent study of Rousseau and Yilmazkuday (2009) also complements these findings by using the three dimensional graphs – an approach that quantifies the possible growth rates achieved from a continuum of financial development and inflation variables. Their results suggest that for inflation rates between 4 to 19 percent, inflationary changes strongly undermine the beneficial effects of financial development on growth. Moreover, high inflation is also a source of banking crisis as macroeconomic instability makes the financial system more fragile.

Similarly, for human capital accumulation, if agents need resources from the financial institutions for their skill acquisition objectives, the adverse effects of inflation on financial development will be transmitted to human capital development. Agents will face difficulties in getting loan from financial markets at the time when real wages are low and they have incentive to acquire human capital for better rewards in the future. Besides, if the accumulation of human capital involves transaction cost, financial deepening will slash this cost and facilitate the accumulation. Indeed, different studies show that inflation induced lower real wages can favor the skill acquisition when financial institutions extend sufficient resources for this purpose (Becker, 1975; Dellas and Sakellaris, 2003). In short, a sound financial system is a prerequisite for the desirable effects of inflation on human and physical capital accumulation.

The above-mentioned literature shows how financial development is essential for the existence of any positive or negative effects of inflation on capital accumulation. All of this literature has been mainly confined to investigate into the level of inflation beyond which its positive effects on growth become negligible. In other words, the effects of inflation on capital accumulation were considered homogenous irrespective of the actual level of financial deepening. Our empirical testing will focus on a new dimension of this issue. We aim to analyze whether the transmission from inflation to physical and human capital accumulation is same for countries working at various levels of financial development. This will enable us to examine how the strength of financial institutions matters for the accumulation of human and physical capital in inflation.

3. Methodology

The above discussion shows that the accumulation of human and physical capital is influenced by several factors. These factors affect the saving and consumption decisions of agents and both types of capital accumulation. The relevant variables used in the previous research on this subject therefore include GDP growth, population growth, financial development, public size and/or government expenditures on education (see Grier, 2005). A basic structure of our panel equations for human and physical capital accumulation can be expressed as:

$$\Delta H_{it} = \alpha_0 + \alpha_1 \pi_{it} + \alpha_2 \Delta K_{it} + \alpha_3 Z_{it} + \varepsilon_{it} \tag{1}$$

$$\Delta K_{it} = \alpha_0 + \alpha_1 \pi_{it} + \alpha_2 \Delta H_{it} + \alpha_3 Z_{it} + \varepsilon_{it} \tag{2}$$

Equation (1) is human capital accumulation model where ΔH_{it} represents a change in five year average human capital stock and π_{it} stands for the inflation rate. The vector Z_{it} includes different control variables such as GDP growth, population growth, financial development and government expenditures on education. Equation (1) includes a possible impact of physical capital accumulation for the human capital, the joint determination of both types of capital violates the orthogonality condition $E(\Delta K_{it}\varepsilon_{it}) = 0$ and as a consequence ordinary least square (OLS) can yield biased and inconsistent coefficient estimates (see Grier, 2005). Same applies to equation (2) where human capital accumulation has been included as covariate for the accumulation of physical capital. Our response to these problems with the OLS is estimating both equations using the fixed effects model by incorporating the time and county specific effects in the above models. Wooldridge (2001) shows that the OLS with time and country fixed effects remove all of the possible types of endogeneity that includes unobserved heterogeneity and simultaneity bias. The estimated results are therefore free from the endogeneity problem. Our modified equations take the following form:

$$\Delta H_{it} = \alpha_0 + \alpha_1 \pi_{it} + \alpha_2 \Delta K_{it} + \alpha_3 Z_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \quad (3)$$

$$\Delta K_{it} = \alpha_0 + \alpha_1 \pi_{it} + \alpha_2 \Delta H_{it} + \alpha_3 Z_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \quad (4)$$

The last two parameters α_i and λ_t represent country and time fixed effects respectively. For the robustness purposes, the aforementioned unobserved heterogeneity problem is also treated by using an instrumental variables (IV-2SLS) model with initial values of the control variables for each 5-year period serving as instruments in the first stage. Wooldridge (2001) also shows that both the fixed effects and IV- 2SLS models give consistent and comparable results.

So far we have assumed a linear functional form of the relationship between inflation and capital accumulation. Nevertheless, the nature of precise functional form is an important issue since it has some considerable bearings on the optimal inflation rate for both types of capital accumulation. To address these issues, we first conduct a preliminary test with an additional interaction variable of inflation squared in the equations (3) and (4). The objective is to see whether, beyond certain thresholds, inflation becomes more or less important in influencing the capital accumulation. To illustrate, with the additional inflation squared term, equation (3) becomes:

$$\Delta H_{it} = \alpha_0 + \alpha_1 \pi_{it} + \alpha_2 \pi_{it}^2 + \alpha_3 \Delta K_{it} + \alpha_4 Z_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \quad (5)$$

Similar changes will be observed in the equation (4). The inclusion of interaction term allows us to estimate the marginal effects of inflation on the capital accumulation at different levels of the inflation rates. These marginal effects can be calculated by examining the partial derivative of ΔH_{it} with respect to π_{it} :

$$\frac{\partial(\Delta H_{it})}{\partial \pi_{it}} = \alpha_1 + 2\alpha_2 \pi_{it} \qquad (6)$$

Evidently, the marginal effect for a unit change in inflation depends not only on α_1 and α_2 but also on the actual value of π_{it}. The nonlinearity of physical capital accumulation is treated accordingly.

For a more continuous and robust investigation of this nonlinearity of the inflation and capital accumulation relationship, a rolling regression technique has been adopted. The main advantage of this method is that it shows the behavior of inflation coefficients with increasing inflation rates. This makes it a smooth approach to analyze the nonlinearity.[35] To conduct this analysis, all of the observations in the data set are arranged in ascending order of the inflation rate and then a constant window of 150 observations is employed to get the inflation coefficients.

Similarly, to analyze the role of financial development, an interaction term is included in the above models and the resulting equations become:

$$\Delta H_{it} = \alpha_0 + \alpha_1 \pi_{it} + \alpha_3 \Delta K_{it} + \alpha_4 \pi_{it} X_{it} + \alpha_2 Z_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \qquad (7)$$

$$\Delta K_{it} = \alpha_0 + \alpha_1 \pi_{it} + \alpha_3 \Delta H_{it} + \alpha_4 \pi_{it} X_{it} + \alpha_2 Z_{it} + \alpha_i + \lambda_t + \varepsilon_{it} \qquad (8)$$

The interaction variable X_{it} incorporates the financial development in both equations. Putting differently, it shows the effect of inflation on physical and human capital accumulation when the level of financial development changes.

4. Data and estimation process

Our empirical analysis is based on annual data of 105 countries over the period 1971-2010.[36] To remove the business cycle effects and measurement errors from our estimated results, five-year average data has been used. As we have several missing observations for the main variables, our data set can be denoted as 'unbalanced panel' and therefore we never

[35] See Rousseau and Watchel, 2002 and Yilmazkuday, 2012 for a more detailed discussion.

[36] Table (4) in the appendix shows the main descriptive statistics of the included dependent and independent variables.

had a complete panel of 105 countries in our econometric specifications. As described in the previous section, human and physical capital accumulation variables are taken as dependent variables in the analysis. On the control variables, GDP growth of a country directly impacts the capital accumulation as high growth generates surplus income to invest in the capital stock (Keynes consumption theory).

By contrast, a high population growth diminishes the existing stock of capital per worker (Solow, 1956). The effects can nevertheless be positive if this growing population is better skilled and adds to productivity and growth of the country. Our next two covariates democracy and financial development are expected to positively affect both types of capital stock, as shown by most of the above discussed theories. Government expenditures on education are also taken as control variables in human capital accumulation models. Education at primary and secondary level can be significantly determined by public policies and preferences. Concerning the inclusion of physical capital accumulation variable in human capital equation and vice versa, their relevance has been widely discussed in the previous literature (see section 2.3.3 for brief review).

Between the two dependent variables, human and physical capitals, the former is not precisely estimated because it contains many quantitative and qualitative issues. Therefore in this study we use primary and secondary levels of education to represent human capital accumulation (see Barro and Lee, 2010). It is important to mention that both these estimates contain several problems as the indicators of human capital development. Regarding the average years of education, this data set is basically computed from educational attainment distribution for a large amount of countries. These educational attainment distributions allow Barro and Lee to construct a measure of average years of schooling which is widely used in the literature on human capital. However, this method has been severely criticized in several empirical works for a variety of reasons.

Mulligan and Sala-i-Martin (2000) raise three main points on the credibility of this human capital development indicator. First, this measure assumes that in all categories workers are perfect substitute. Second, it assumes that productivity growth increases linearly with the level of education. This is to say that a worker with twelve years of education is three times more productive than a worker with four years of education. Third, employees in various fields and of different demographic groups are considered perfect substitute always and everywhere. For example, a one year of education in arts is assumed equal to a one years of education in engineering. All of these assumptions challenge the credibility of Barro and Lee data set as an indicator of human capital development. Nevertheless, incorporating qualitative factors in human capital variables is difficult and therefore mean years of education still remains the most widely used parameter of human capital.

4.1. Descriptive statistics

Table 3-1 shows descriptive statistics of the data set – averaged over 5-year periods from 1971-2010. As can be viewed from the Table, the values of capital accumulation significantly vary for different countries and goes from -200.69% to 184.51% for the selected economies. Similar variations are recorded for human capital accumulation where the first difference of the average years of primary schooling varies from -4.93 to 3.78 while for the secondary years schooling varies from -5.57 to 1.87. The values of our main variable of interest, inflation – taken in log form – vary between -1.33 and 8.55.[37] The GDP growth varies between -12.11% to 15.27%. Similarly, population growth ranges between -6.22% to 7.41%; private credit to GDP ratio varies between 0.997% to 220.87%; inflation volatility variable range between 0.24% to 229.55%. Education expenditures vary between 0.36% to 10.05% of GDP for the selected economies.

[37] Some authors e.g., López-Villavicencio and Mignon (2011) calculate inflation rate as $\log(1+\pi_{i,t})$ to avoid the negative observations. We did not use this formulation for two reasons: first, our lowest inflation value is not so large (in absolute terms) and second, even if we use the above formulation, it does not assure conversion of all negative values into positive ones. In fact the smallest inflation values of López-Villavicencio and Mignon are still negative after this treatment.

Table 3-1 Descriptive Statistics, 1971-2010

Variable	Physical capital	Primary Education	Secondary Education	Inflation	Inflation Volatility	GDP Growth	Population Growth	Pvt. Credit/ GDP	Education Expenditure
Mean	8.374	0.028	0.029	1.967	6.609	1.682	1.923	42.795	3.481
Standard Deviation	33.472	0.901	0.812	1.104	12.217	3.041	2.419	40.675	1.598
Minimum	-200.698	-4.933	-5.571	-1.331	0.244	-12.105	-6.223	0.997	0.356
Maximum	184.505	3.783	1.871	8.552	229.55	15.273	7.412	220.868	10.051
Correlations									
Physical capital	1.000								
Primary Education	0.037	1.000							
Secondary Education	-0.014	0.162	1.000						
Inflation	-0.052	0.245	-0.024	1.000					
Inflation Volatility	-0.271	0.123	-0.053	0.596	1.000				
GDP Growth	0.024	-0.063	0.071	-0.177	-0.029	1.000			
Population Growth	-0.002	0.438	-0.152	0.202	0.031	-0.148	1.000		
Pvt. Credit/ GDP	0.037	-0.373	0.121	-0.501	-0.269	0.097	-0.421	1.000	
Education Expenditures	-0.062	-0.191	0.101	-0.274	-0.121	-0.004	-0.333	0.301	1.000

Note: Data sources and calculations are given in Appendix. The values of the last five columns are in percentage form. Selected sample includes Algeria, Argentina, Australia, Austria, Bangladesh, Barbados, Belgium, Benin, Bolivia, Botswana, Brazil, Burkina Faso, Burundi, Cameroon, Canada, Central African Republic, Chad, Chile, China, Colombia, Congo. Dem. Rep., Congo. Rep., Costa Rica, Cote d'Ivoire, Denmark, Dominican Republic, Ecuador, Egypt. Arab Rep., El Salvador, Fiji, Finland, France, Gabon, Gambia. The, Germany, Ghana, Greece, Guatemala, Guyana, Haiti, Honduras, Hong Kong. China, Hungary, Iceland, India, Indonesia, Iran. Islamic Rep., Ireland, Israel, Italy, Jamaica, Japan, Kenya, Korea. Rep., Kuwait, Lesotho, Libya, Luxembourg, Madagascar, Malawi, Malaysia, Mali, Malta, Mauritania, Mexico, Morocco, Myanmar, Nepal, Netherlands, New Zealand, Nicaragua, Niger, Nigeria, Norway, Oman, Pakistan, Papua New Guinea, Paraguay, Peru, Philippines, Portugal, Rwanda, Saudi Arabia, Senegal, Sierra Leone, Singapore, South Africa, Spain, Sri Lanka, Sudan, Swaziland, Sweden, Switzerland, Syrian Arab Republic, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, United Kingdom, United States, Uruguay, Venezuela. RB, Zambia

These huge differences between minimum and maximum values further cause a high standard deviation of the selected variables. For some variables the standard deviation is higher than the mean values. The correlation across these variables is also reported in the lower part of Table 3-1. The signs of the correlation coefficients are in line with our prior expectations. Inflation is adversely affecting the accumulation of physical capital while its correlation with the primary education is positive. The correlation value for physical capital accumulation is very low whereas for human capital accumulation it is considerably high. Nevertheless, it is not the same for the secondary education where the correlation value is negative but very close to zero. On the other hand, inflation is adversely affecting the financial development and education expenditures of the government while a high population growth positively influences the overall inflation rate. The negative effect of inflation on education expenditures and financial development shows the effects of price instability on the overall macroeconomic instability in the selected economies. The effects of inflation volatility are showing up positive for the primary education and negative for the capital accumulation.

5. Results and Discussion

Table 3-2 presents our main results that have been obtained by using both fixed effects and instrumental variable-2SLS models. The specification 1 shows a negative and significant effect of inflation on physical capital supporting an overall reverse-Tobin effect on its accumulation. These negative effects are consistent with the previous studies on the subject that have shown adverse effects of uncertain macroeconomic conditions on the investment decisions of firms (Fischer, 1993). Madsen (2003) argues that inflation increases nominal interest rate and reduces the accounting profits of the liquidity constrained firms which, subsequently, results in lower savings and capital formation. Moreover, the author posits that inflation increases the user cost of capital by reducing the real value of tax depreciation that are recorded at the initial price of capital stock. The positive sign of democracy variable highlights the importance of democratic regimes in assuring transparency, securing the property rights and favoring rapid capital accumulation. Indeed, the aforementioned arguments of the previous studies note that strong democratic institutions and political stability generally favors human and physical capital accumulation.

A strong financial system is found to have a positive influence on the capital accumulation through better credit allocation and risk management. In the previous research, financial development is the main factor for savings and capital formation. One unexpected result comes from the fact that human capital accumulation adversely affects the accumulation of physical capital. This explains the fact that more resources for human capital accumulation will cut down resource allocation for physical capital accumulation. This has also been tested for the secondary education level where it turns out to be insignificant, although with the same negative sign. Heylen and Pozzi (2007) explain this phenomenon in the context of uncertainty. According to the authors, an uncertain macroeconomic situation diminishes the returns to work and physical capital accumulation. Total factor productivity and investment reduces but the accumulation of human capital increases. This shows that the agents' behavior for physical and human capital accumulation and their allocation of savings for both factors does not remain same in all conditions. However, we acknowledge the fact that in most of the literature, accumulation of human capital is considered complementary for physical capital accumulation.

The Specification 2 of Tables 3-2 reproduces same results in instrumental variable 2-SLS framework. Here, along with the other covariates, GDP growth variable is significant showing the validity of Keynes consumption theory for physical capital accumulation. The sign and magnitude of all of the other coefficients remain unchanged. Our next model (specification 3) analyzes the same effects for human capital. The results show a positive impact of inflation on human capital accumulation. This supports substitution effect hypothesis where lower real wages or lower opportunity cost of education motivate the agents to acquire new skills during inflationary periods (Heylen and Pozzi, 2007). Lower employment perspectives in inflation can also lead to a higher human capital accumulation if agents are optimistic about the future macroeconomic prospects. DeJong and Ingram (2001) support this view for the U.S where shrinking job opportunities of recessionary periods were accompanied by a higher schooling in the country. That said the effect of democracy or political stability is also reported positive on the dependent variables. As democracy is considered more responsive to public demands, it allocates a larger share of resources for education (see Barro, 1996). One important result is the positive role of physical capital accumulation for enhancing the secondary level education of the selected countries. These capital-skill complementarities come from the fact that higher physical capital increases wage premium of skilled workers and therefore stimulates investment in human capital (Nelson and Phelps, 1966; Grier, 2005). The specification 4 provides similar results using IV-2SLS framework.

Table 3-2 Human and Physical Capital Accumulation regressions, 1971-2010

VARIABLES	(1) Physical Capital	(2) Physical Capital	(3) Human Captial	(4) Human Captial	(5) Secondary Education	(6) Secondary Education
	F.E	IV-2SLS	F.E	IV-2SLS	F.E	IV-2SLS
Human Capital	-0.504***	-0.449***				
	(0.11)	(0.09)				
Physical Capital			0.011*	0.089*	0.011**	-0.002
			(0.006)	(0.004)	(0.005)	(0.004)
Inflation	-2.691*	-2.456**	0.107***	0.057*	0.101**	0.101***
	(1.59)	(1.22)	(0.041)	(0.033)	(0.039)	(0.037)
Democracy	0.633*	0.068	0.017*	0.011	0.003	
	(0.37)	(0.31)	(0.008)	(0.007)	(0.008)	
Financial Dev.	0.142**	0.117**				
	(0.06)	(0.058)				
GDP Growth		0.987***				
		(0.33)				
Population Growth	2.175		0.043	0.005		
	(1.66)		(0.039)	(0.017)		
Education Exp.					0.017	0.091**
					(0.031)	(0.037)
Constant	30.641***		-0.285		-2.34***	
	(6.81)		(0.21)		(0.21)	
Observations	465	366	661	639	524	405
R-squared	0.14	0.19	0.43	0.389	0.31	0.431
No. of Countries	80	64	85	85	78	78

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Time and country specific effects have also been controlled in IV-2SLS specification.

In the last two specifications (5 and 6) we have tested the robustness of our findings with respect to the levels of education. Here we take secondary (mean) years of schooling from the same data stream (Appendix A). In fact, these robustness tests are inspired by Heylen and Pozzi (2007), who argue that it is the secondary or higher levels of education that are more significant in the growth regressions. For our particular argument of the substitution from work to human capital accumulation in inflation, the secondary education is more relevant because it is at this level of education where a substitution from work to education becomes more meaningful and where real wages are a matter of concern in the process of human capital accumulation for poor agents. Our results concerning the positive effects of inflation are in line with the primary education findings. The additional results are the effect of government spending on education which appears significant with positive sign. The results on tertiary education which are not shown here for brevity follow the same pattern.

Table 3-3 Instrumental Variables Capital Accumulation Regressions 1971-2010

VARIABLES	(1) Physical Capital	(2) Physical Capital	(3) Human Captial	(4) Human Captial	(5) Physical Capital	(6) Human Captial
	F.E	IV-2SLS	F.E	IV-2SLS	F.E	IV-2SLS
Human Capital	-0.502***	-0.360***			0.637	
	(0.108)	(0.089)			(0.738)	
Physical Capital			0.011*	0.080***		
			(0.006)	(0.024)		
Inflation Volatility	-0.676***	-0.675***	0.004	0.014***		
	(0.137)	(0.127)	(0.004)	(0.005)		
Democracy	0.656		0.017*	1.178***		0.004
	(0.417)		(0.009)	(0.359)		(0.003)
Financial Development	0.186***	0.079*		0.003	0.170**	
	(0.065)	(0.047)		(0.009)	(0.066)	
Population Growth			0.029		3.926**	0.028**
			(0.037)		(1.647)	(0.012)
Inflation					8.706**	-0.044*
					(3.993)	(0.024)
Inflation Squared					-2.075***	0.008*
					(0.758)	(0.004)
Constant	-33.012***		-1.721***		-16.873**	0.206***
	(5.257)		(0.183)		(7.234)	(0.061)
Observations	418	368	582	483	548	450
R-squared	0.201	0.206	0.383	0.080	0.155	0.077
Number of Countries	74	66	79	78	89	74

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Time and country specific effects have also been controlled in IV-2SLS specification.

Indeed, it is not only the average level of inflation that influences capital accumulation but also a higher inflation variability which is positively associated with it (Lucas, 1973). Fischer (1993) posits that inflation uncertainty reinforces both budget and current account instabilities which undermine growth of capital stock and productivity. The counterview is held by Dotsey and Sarte (2000) who find a positive impact of uncertainty on capital accumulation; as reported earlier. These conflicting results motivate us to test the effects of inflation volatility on capital accumulation. To do this, we have generated an inflation uncertainty variable from quarterly inflation data (detailed in the Appendix) and then tested its effects on both human and physical capital accumulation.

Table 3-3 shows some interesting results on the link between inflation volatility and the accumulation of human and physical capital. The first two specifications show a negative effect of inflation volatility on physical capital, consistent with previous empirical research

(Fischer, 1993; Grier, 2005). These results validate the concerns raised by misperception theory that the most important channel through which inflation deters capital accumulation is through nominal uncertainty. If we combine these findings with the overall effects of inflation on physical capital it can be inferred that it is not only the level of inflation but also its uncertainty which reduces capital accumulation (Table 3-2). On the whole, this negative inflation–physical capital accumulation relationship complements the theoretical findings of Stockman's CIA model. The next two specifications show a positive impact of inflation uncertainty (or volatility) on human capital accumulation, though significant only in the second case. All of the other covariates retain the same signs and significance as they appear in Table 3-2.

All of the above discussed results are based on the assumption of a linear relationship between inflation and capital accumulation. This is not necessarily a true functional form of this relationship as behavior of agents can be different when inflation moves from its lower to higher regimes. Both the nature of relationship as well as its sensitivity can differ across all ranges of the inflation rate. In the last two specifications of Table 3-3, we address nonlinearity between inflation and capital accumulation by estimating equation 5 of the model. Here our additional variable, inflation squared, is significant in both cases showing the presence of inflexion point in the effects of inflation on both types of capital accumulation. Interestingly, for physical capital accumulation the inflation parameter (α_1) is positive while the inflation squared parameter (α_2) is negative which states that the previous adverse effects of inflation are only valid when it exceeds a certain threshold point. This also implies that the inflation–capital accumulation relationship takes an inverse-U shape profile, consistent with the inflation–growth profile of the previous chapter. The threshold value estimated by using equation 6 is $\pi^* = 8.07/2(2.07) \Rightarrow 2.1$. Taking the anti-log of this value yields the threshold value $\pi^* = 8.17\%$. Below this level inflation exerts a Tobin effect on physical capital whereas above this level it holds back capital accumulation.[38]

For human capital accumulation the situation is opposite. Here the inflation rate parameter (α_1) assumes a negative sign whereas inflation squared parameter (α_2) show up with a positive. Therefore, the estimated relationship exhibits a U-shaped profile with a threshold point, calculated in the same method as above, appears at $\pi^* = 15.64\%$. Below this

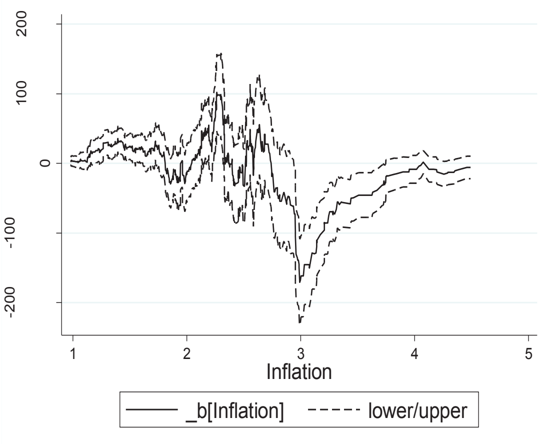
[38] In fact these Tobin effects hold for most of our selected economies since the actual inflation rate for the last five years of our selected data (2006-2010) was lower in most of our selected economies. The countries with higher inflation rate than this threshold were, Argentina, Bangladesh, Egypt, Ghana, India, Iran, Jamaica, Madagascar, Nepal, Nigeria, Pakistan, Sierra Leone, Sudan, Trinidad and Tobago, Turkey, Venezuela and Zambia.

threshold, inflation impedes the accumulation of human capital and beyond this level it favors the later. These findings support our previous results that high inflation volatility discourages physical capital accumulation but not the human capital accumulation. These results support a nonlinear profile of the inflation–growth relationship shown in Chapter 2. In the beginning, the positive effects of inflation can result from Tobin effect of inflation on physical capital accumulation. In middle ranges of inflation, its effects on both human and physical capital accumulation are negative, explaining a strong negative effect of inflation on growth. In the high inflation zones, its effects on human capital accumulation become positive which moderates the intensity of negative effects of inflation on growth. Khan and Senhadji (2000) and Gillman et al. (2001) find that negative effects of inflation on growth are strong when inflation moves from 10% to 20% then its movement from 20% to 30%, for instance. The sign of the population growth variable is positive for both human and physical capital accumulation. This is supported by studies like Aghion and Howitt (1992) where a high population growth creates demand for technological change and Romer (1990) where it diminishes the cost of innovation.

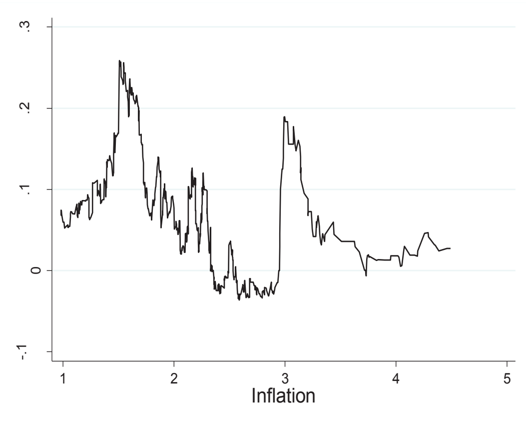
For a more robust and continuous analysis of this nonlinear relationship, we used a rolling regression model. Our results for the inflation threshold in a moving window of 150 observations are presented in Figure 3-1. In the first part of Figure (part a), the effect of inflation on physical capital accumulation has been tested with the observations of increasing inflation. As the figure shows, the effect of inflation is positive and significant in low inflation regimes supporting Tobin's view concerning the effects of inflation on physical capital accumulation. However, when inflation surpasses certain levels, the Tobin effect turns into a reverse-Tobin effect and remains so afterward. In the part b we repeat the same exercise for human capital and show an ambiguous behavior of inflation coefficients for its accumulation. Here the inflation effect is mostly negative other than some middle range coefficients as well as some very high inflation coefficients when the log values of inflation cross 4%. On the right side of the figure, R-squared values are also high for lower and middle inflation observation samples than for extreme (low or high) inflation sub-samples.

Figure 3-1 Inflation thresholds for physical and human capital accumulation

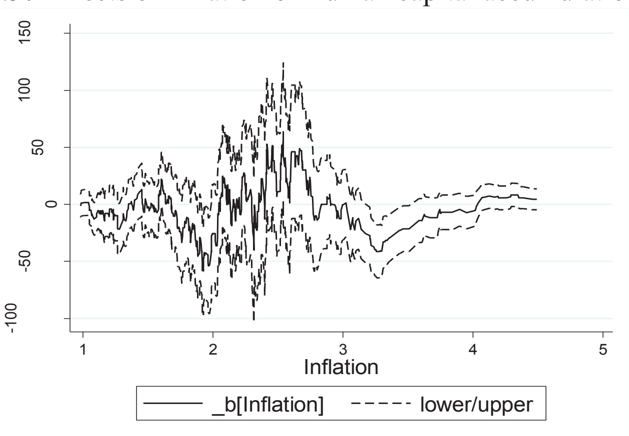
a: Effects of inflation on physical capital accumulation



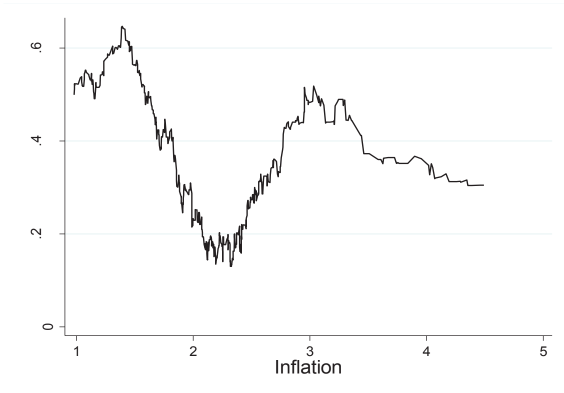
Adjusted R^2



b: Effects of inflation on human capital accumulation



Adjusted R^2



Certainly, these direct effects of inflation on human and physical capital accumulation are not the same for economies working under divergent macroeconomic conditions. A well researched conditional variable is financial development. Its econometric specification has been elaborated in equations 7 and 8 and results using fixed-effects and IV-2SLS models are presented in Table 3-4. The specification 1 of Table 3-4 shows an insignificant reverse – Tobin effect of a given inflation rate after the introduction of interaction term. The effects of interaction term are positive and significant. Obviously, as discussed in section 2.3, the undesirable effects of inflation on physical capital accumulation should be lower for a country with a well developed financial system since an efficient functioning of financial institutions nullifies the direct negative effects of inflation on physical capital accumulation. In fact, the value of inflation parameter explains its stand alone when the level of financial development is zero. This insignificant reversed Tobin effect of inflation becomes positive at higher values of the modifying variable: financial development. As financial intermediation is easy in well developed financial systems, the response of investors in these systems is more extensive and investors can easily inject more money in various new projects which can cause Tobin's capital accumulation in inflation.

Table 3-4 Financial development and Inflation-Capital accumulation regressions; 1971-2010

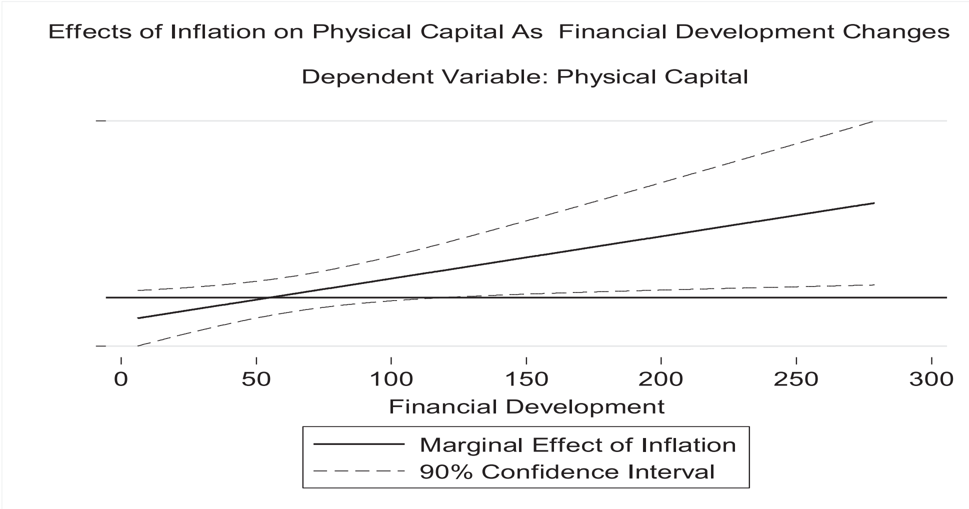
VARIABLES	(1) Physical Capital	(2) Physical Capital	(3) Human Capital	(4) Human Capital
	F.E	IV-2SLS	F.E	IV-2SLS
Human Capital	-0.518***	4.186		
	(0.171)	(6.964)		
Physical Capital				-0.001
				(0.000)
Inflation	-4.984*	-2.752	0.091*	-0.004
	(2.558)	(2.094)	(0.048)	(0.016)
Financial Development	0.088	0.138**	-0.0073***	-0.001
	(0.081)	(0.067)	(0.001)	(0.001)
Inflation*Financial Dev.	0.0571**	0.050*	0.001*	0.001**
	(0.025)	(0.026)	(0.000)	(0.000)
Population Growth		0.339	0.015***	
		(0.399)	(0.005)	
GDP Growth	-0.092	1.448***		-0.002
	(0.087)	(0.504)		(0.003)
Education Expenditures				0.005
				(0.013)
Constant	34.317***		-1.538***	
	(0.001)		(0.307)	
Observations	465	525	546	348
R-squared	0.152	0.165	0.334	0.049
Number of Countries	80	80	82	74

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. Time and country specific effects have also been controlled in IV-2SLS specification.

Similarly, the specification 3 explains a moderating role of financial development for inflation–human capital accumulation nexus. To re-emphasize on the role of financial institutions, they facilitate agents for their accumulation of human capital in inflationary periods. The direct inflation coefficient is, however, insignificant. The well developed financial institutions therefore speed-up both human and physical capital accumulation. Given that all of these interaction variables are continuous, the net impact of the modifying variable and its statistical significance cannot be directly judged based on the estimated coefficients. To get some more precise results, we followed Brambor et al. (2006) and estimated the marginal effects of inflation on the capital accumulation conditional upon the financial development.

Figure 3-2 Financial Development and inflation–capital accumulation relationship, IV-2SLS regressions

a: Financial development and physical capital



b: Financial development and human capital

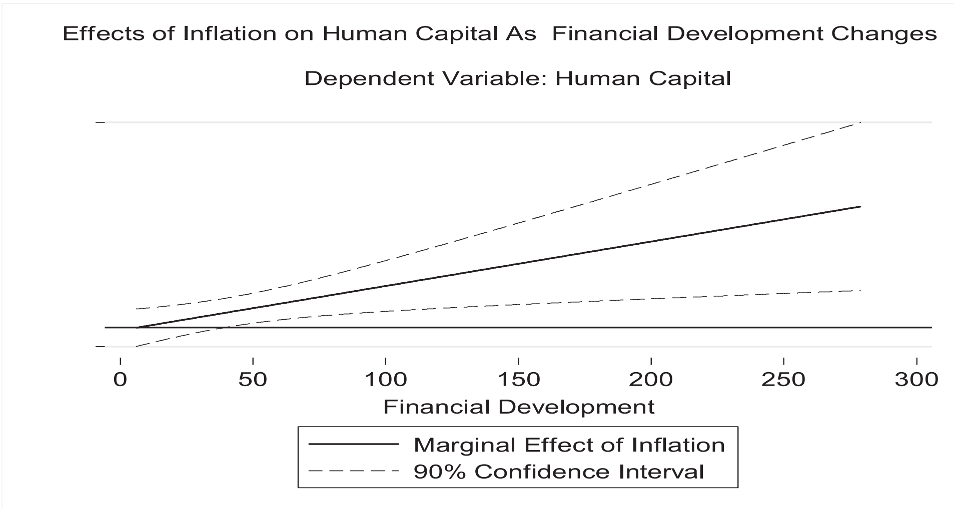


Figure 3-2 (part a) shows that the reverse Tobin effect of inflation on physical capital accumulation is strongly dependent upon that country's level of financial development. The results with 90% confidence interval show that the negative (but insignificant) effect disappears for economies with M3/GDP ratio higher than 50%. More interestingly, the same level of inflation yields a Tobin effect for economies with M3/GDP ratio higher than 120%. Stated differently, the marginal effects of inflation on physical capital are negative but insignificant for M3/GDP < 50%, positive and insignificant for 50% < M3/GDP < 120% and positive and significant afterwards. Similarly, in Figure 3-2 (b) financial development strongly supports the accumulation of human capital for M3/GDP > 40%. Here, although the effects remain positive throughout the range of financial development variable, the positive effects become insignificant in weak financial systems. The overall results indicate that a reverse Tobin effect for physical capital is sensitive with respect to financial development.

6. Conclusions and policy implications

A bulk of recent literature has identified nonlinearity in the long-run relationship between inflation and output growth. The literature also finds that the intensity of these adverse effects of inflation on growth decreases at increasing inflation rates. Gillman and Nakov (2003) argue that this dynamic response of output growth to inflation changes reflects factors' realignment and their accumulation when the later observe any change. Our analysis in this chapter brings some empirical substantiation to this view and probes into the existence of 'Tobin effect' and several other theoretical possibilities in a large panel data of developed and emerging economies.

Our main results confirm a reverse Tobin effect for the accumulation of physical capital and a substitution effect (from work to education) for human capital accumulation. These findings are consistent with the theoretical results of Gillman and Kejak (2005). Moreover, both these effects are nonlinear and are relevant only when inflation reaches to certain threshold points. In other words, after certain inflation levels, it discourages the accumulation of physical capital and encourages human capital accumulation. These findings explain one plausible channel behind the inflation–growth nonlinearity.

Our empirical results imply that the adverse effects of any level of inflation are country-specific and depend upon the factors' endowments of the economy. As the role of inflation tax is significantly different in countries with heterogeneous factors endowments and production technologies as well as institutional arrangements, any policy to curb inflation must take into account these country-specific characteristics of that country. The welfare implications of the same level of inflation can differ among countries with these structural differences. A more clear distinction is made when we study the role of financial development in this nexus. Here, we find that a Tobin effect of inflation on physical capital accumulation is only relevant for economies with strong financial institutions. For financially developed economies, the real interest rate reduction in inflation motivates the investors to take investment initiatives which pushes up physical capital accumulation. Similarly, developed financial institutions are also helpful in making substitution away from work and towards human capital accumulation during the inflationary periods.

It is important to mention that although our results indicate certain levels of inflation where it can favor either human or physical capital accumulation, we do not support any inflationist monetary policy in order to stimulate investment or human capital development. To be more precise, even if a high inflation rate can have some favorable effects for human capital development, countries with poor literacy rates cannot use inflation as a policy tool to foster their school enrollment. This is because the other undesirable effects of inflation including the ones on the relative-price-variability and the consequent misallocation of resources start appearing beyond a very low level of inflation rate. To end, two points need to be re-asserted, first, our estimated results do not contain any direct message for the optimal inflation rate. They only enable us to understand the inflation–growth nonlinearity results of the previous empirical literature. Second, these results also suggest that the existing inflation–growth literature certainly lacks some important dimensions of the effects of inflation. At best, these findings, along with some other results of some recent studies (see Ylimazkuday, 2012; Eggoh and Khan, 2014) state that the optimal level of inflation in a country depends upon several macroeconomic environments and institutional qualities of that economy, and it changes with all these developments.

Appendix: Descriptive Statistics, Data Definitions and Sources

Definition of the variables and Data sources

Primary Education	Average years of primary schooling for the population of age 15 and older taken from Barro and Lee (2010). First difference yields the required variable.
Secondary Education	Average years of secondary schooling for the population of age 15 and older taken from Barro and Lee (2010). First difference yields the required variable.
Physical Capital	Indicator of physical capital accumulation has been retrieved from Penn-World Tables 7.1. It is defined as investment Share of PPP Converted GDP Per Capita at 2005 constant prices.
Π_{5yt}	Average annual changes in the log values of consumer price inflation (π) in the period of 5 years before t, taken from the World Development Indicators (WDI, online data bank).
$VINF_{5yt}$	Inflation variability is calculated by 5-years standard deviation of inflation from quarterly observations taken from International Financial Statistics CD-ROM (IFS, 2011). Ten windows of 20 observations each (1971Q1-1975Q4) are generated and then inflation variability is calculated as VINF=log(1+sd(INF)).
GE_{5yt}	Average annual real per capita government expenditures on education (as percentage of real GDP) in the five year before t. This data set has been obtained from UNESCO online data source: http://www.uis.unesco.org/i_pages/IndPGNP.asp.
$DEMOC_{5yt}$	Indicator of democracy varies from -10 (highly autocratic) to 10 (highly democratic). Polity IV, source http://www.systemicpeace.org/polity/polity4.htm.
$Pop.Gr_{5yt}$	Average annual population growth data is retrieved from the World Development Indicators (WDI).
$Gov.Exp_{5yt}$	Average annual government expenditure as proportion of GDP data is obtained from the World Development Indicators (WDI).
$Fin. Dev_{5yt}$	Ratio of liquid liabilities (M3) to GDP is taken as an indicator of financial development.
$GDP.Gr_{5yt}$	The effect of GDP growth on the accumulation of physical and human capital accumulation is controlled by including the 5-years average GDP growth.

Chapter 4 Sectoral variability and the foundations of optimal inflation rate

1. Introduction

A plethora of empirical works tests the inflation–growth nonlinearity after the seminal paper of Fischer (1993). This literature employs different econometric techniques and concludes heterogeneous inflation thresholds for both developed and developing economies. Usually the inflation thresholds fall between 2-4 percent for the developed economies and between 8-18 percent for the emerging countries.[39] This is at odds with the fact that a majority of the central banks – especially in the emerging economies – are trying to keep their inflation rate well below these empirically advanced optimal thresholds. For instance, the inflation rate of West African Economic and Monetary Union (WAEMU) is recorded as 3.8% in 2011 (see IMF country report No. 12/59, March 2012). Conceivably, a leading factor behind this lack of coherence is that central banks around the world use the DSGE models whose prominent features include the introduction of real rigidities via monopolistically competitive firms and infrequent adjustments of wages and prices in the market (Ambler, 2008). In the presence of these rigidities, inflationary shocks cause dispersions in the product and labor markets. This state of the art New Keynesian technology analyzes the micro level consequences of inflation, and thereby the welfare effects of inflation turn out to be much larger than the ones proposed by the macro based models of inflation and GDP growth.

Billi and Kahn (2008) highlight these micro level effects where the authors argue, "*…the main channel through which inflation is costly in the New-Keynesian framework is through "relative-price distortions." As observed in the data, the prices of many goods and services tend to adjust infrequently even though the general price level is rising over time. Thus, under general price inflation, many prices do not fully reflect the relative costs of production. And, the higher the inflation rate, the greater the distortion caused by price stickiness. As a result, absent other factors of influence, such as the zero bound problem, zero inflation would appear optimal as it limits the distortions in relative prices due to inflation* (Billi and Kahn, 2008: p.20)".

[39] In Chapter 2 we present a survey of all of these studies and our own empirical findings for the developed and emerging economies. For the emerging economies, Khan and Senhadji (2001) suggest 11% inflation rate, Sarel (1996) identifies 8% and López-Villavicencio and Mignon (2011) find a further higher threshold level of 17.5%. All of these studies contend that the growth inhibiting effects of inflation start appearing after these levels. Our own results of Chapter 2 show 16.28% inflation rate for these economies.

Putting differently, in the representative agent's New Keynesian models, inflation is costly both because of its macro level effects (disruption in the overall macroeconomic environments) as well as its micro level effects (disruptions in firms' production decisions or individuals' labor-leisure choices). Constituting both these components together exacerbates the overall cost of inflation and thus formulates complete price stability an optimal choice for the policymakers. Nautz and Scharff (2012) argue that because of this collective cost, the behavior of central banks becomes asymmetric, for instance, while targeting an inflation rate of 2%, monetary authorities respond more strictly when the actual inflation rate reaches 3% than in a case of its reduction to 1% (see also Cover, 1992). This complements the monetarists' view where unexpected inflationary changes, irrespective of the actual level of inflation, tend to augment RPV because firms only take into account their own price changes and overlook the overall inflation rate (Lach and Tsidden, 1993; Apergis and Miller, 2004). As a result, they hire new workers in the short-run and fire them in the long-run when they realize the overall price changes. This hiring and firing defines a welfare cost of inflation.

In short, both monetarists and the New Keynesian models argue that the growth impeding effects of inflation mainly appear through price and output variability channels and these effects start well below the level of inflation where it starts harming the aggregate GDP growth. Keeping in view the importance of these sectoral shocks and their contribution to the long-run macroeconomic instability, the recent empirical research has started inquiring about the level of inflation which minimizes these distortions. Some country-specific studies examining this relationship include Fielding and Mizen (2008) for the U.S and Choi (2010) for Japan and the U.S. Caraballo and Efthimiadis (2012) analyze this relationship for three European economies; France, Spain and Germany. Interestingly, their study shows that a 2% optimal inflation target of the European Central Bank (ECB) is not optimal for all of the three member countries. The inflation rates which minimize RPV of the three member states not only differ substantially from the ECB targets but also among the sample economies. For Spain the optimal inflation rate is higher than the ECB target rate whereas for Germany and France they are lower than the ECB target. Nautz and Scharff (2012) test and confirm a nonlinear inflation–RPV relationship for a panel of 12 European Monetary Union (EMU) economies.

Our study expands this micro-based literature of the inflation–growth nonlinearity in several directions. First, we extend the research by Nautz and Scharff (2012) and test the functional form of the inflation–RPV relationship for 31 developed and emerging European economies. Further, our sub-sample analysis specifically examines this relationship for 13 emerging European economies. The objective here is to investigate whether the inflation–RPV nexus depends upon the country-specific macroeconomic developments such as the income level of an economy. Second, our study analyzes the role of different monetary policy regimes in the emerging European countries and tests whether the choice of a particular monetary policy regime determines its inflation–RPV relationship. In other words, the question being addressed becomes: does the adoption of a particular monetary policy regime – mainly inflation targeting or currency board systems in our selected sample – enables the country to absorb the effect of inflation changes on RPV or sectoral output growth variability? This can be tested in two ways; first, by observing the sign and significance of the exchange rate (ER) regime variable and, second, by introducing dummy variables for currency board and inflation targeting regimes. We analyze then the temporal evolution of relative price variability and output growth variability for the selected emerging economies. This is mainly motivated by the fact that our selected sample period includes the recent financial crisis episode during which the central banks of our selected emerging economies have kept their inflation rate under tight control. The question is how this choice of maintaining low inflation rate affected their price uncertainty.[40]

In fact, the main rationale of the central banks behind minimizing the RPV is the fact that the later is considered directly responsible for higher output growth variability and therefore lower growth. The literature takes this connection from the Lucas (1973)'s misperception theory where a high price variation directly affects the growth variability. This makes a one-to-one relation between RPV and output growth variability. However, this direct connection between RPV and output growth variability has been called into question by some studies. Parsley (1996), for example, maintains that although the inflation–RPV relationship is positive yet these effects are minor in magnitude and die out quickly. Similarly, Choi (2010) notices that this relationship, by no means, preserves its stability over time as it changes with the conduct of monetary policy or inflation regimes. This questioned the real effects of inflation on output growth. This fragile nature of the inflation–RPV relationship also motivated some authors e.g., Iscan and Osberg (1998) and Khan (2013) to directly test the relationship between inflation and output growth variability.

Iscan and Osberg take the case of Canada and find no robust evidence of a relationship between inflation and output growth variability over the period 1961:Q1 to 1995:Q4. By contrast, Khan (2013) supports a positive relationship between inflation and

[40]It is important to mention that these emerging European economies do not have lots of policy options for their monetary policies since by the joining of European Union or the Euro Area they are required to keep their inflation rate in line with the Euro Area economies.

output growth variability for Bulgaria. The author argues that in the presence of a currency board system, Bulgarian exchange rate remains fixed with the largest trading partners and all the fluctuations are directly transmitted to the domestic prices. This increases price and output volatility for this small open economy, resulting in a positive relationship between the two variables. The present study expands all of these country-specific studies for a panel of 25 developed and emerging European economies. The main spirit is to see that even if inflation affects the RPV in most of the previous studies, are these effects transmitted to sectoral output growth variability; as warned by the misperception theory. We test both linear and nonlinear relations between the two variables to determine the exact nature of this relationship. We also repeat the same analysis for a sub-sample of 9 emerging European economies.[41]

Consistent with the inflation–RPV relationship, here again, we analyze the role of monetary policy regimes – mainly inflation targeting or currency board systems in our selected sample – in appeasing or augmenting sectoral output growth variability. This question is important in the context of Taylor (1993)'s stability trade-off where a strict inflationary discipline can increase output growth variability. Although a huge amount of empirical works have been conducted to analyze the performance of different exchange rate regimes in terms of their macroeconomic stability and growth, yet this literature overlooks their ability to account for the output growth dispersion. The proponents of the opposing monetary policy regimes i.e. inflation targeting versus currency board regimes of our selected sample economies, make several claims about the performance of these regimes in controlling inflation and improving the macroeconomic performance. Our empirical work tests the relative strength of their claims. This is yet another way to test the Taylor's stability trade-off (see Blanchard et al. 2010).

To conclude all of the above discussion, this chapter answers the following question with regards to inflation growth nonlinearity. First, does the inflation–growth nonlinearity finds some support from the micro or sectoral level data? Second, are these sectoral level optimal inflation thresholds consistent with the overall inflation–growth nonlinearity results of the previous research? Third, if the lack of coherence exists, could it explain the divergence of views between the optimal inflation rates of the recent growth literature and the one targeted by different central banks around the world? Four, does the choice of a particular monetary policy regime matters for the performance of the emerging economies in terms of

[41] It is important to mention that due to the unavailability of data for some of the EU countries, we could not test this relationship for all 31 countries that have been used in the inflation–RPV analysis. Our sub-sample analysis of the emerging countries has also reduced from 13 to 9 emerging European economies.

their lower nominal and real uncertainty? Last, has the choice of the lower inflation rate during the recent financial crisis affected the macroeconomic performance of the emerging European economies? Or, do the crisis periods offer some different optimal inflation options than the normal times?

We find some interesting results concerning the effects of inflation on both RPV and output growth variability. On the inflation–RPV relationship, our results, based on the panel-fixed effect model and instrumental variable 2-SLS and GMM models, support a strong impact of inflation and its components e.g., expected and unexpected inflation on RPV. Second, a rolling regression analysis shows that price dispersion is minimized at annual inflation rate of 1.44%, both for the global sample as well as for the emerging markets' sub-sample. Third, in the inflation targeting regimes, the effects of inflation on RPV is appeased, compared with other monetary policy arrangements. Fourth, the country-specific analysis shows that the selected emerging economies experience a weakening effect of inflation on RPV; thanks to their integration with the EU countries. However, this relationship has again strengthened during the financial crisis periods because of low production and high uncertainty in the macroeconomic environment. Although the average inflation rates have been reduced in the emerging countries, as part of their agreement or as a pre-condition for the EU membership, the overall RPV has nevertheless increased during the on-going crisis periods.

On the inflation and output growth variability relationship, the empirical estimations confirm the importance of several possible connections between the two variables. Broadly speaking, the sign of both the actual and expected inflation rates is negative. Inflation dampens output growth variability, supporting the Taylor's view on a trade-off between real and nominal uncertainties. In the presence of supply shocks, complete price stability is associated with a higher variability of output across sectors. The unexpected component of inflation is ineffectual for bringing any significant changes in the output variability. Our results for the average sectoral output growth are interesting; the expected inflation rate represses sectoral growth whereas unexpected inflationary changes amplify it. This supports the Phillips-curve trade-off between unexpected inflation and average output growth. On the role of monetary policy regimes, the currency board countries are better able to deal with growth variability compared to the inflation targeting regimes. Last but not least, the nonlinear specifications show some regime based relationship between inflation and output growth variability. The later exhibits a U-shaped profile with respect to inflationary changes and the threshold inflation level is found to be 1.95% for both developed and emerging European economies.

The rest of the chapter is organized as follows. Section 2 presents some important theoretical and empirical studies on the effect of inflation on relative price dispersion and output growth variability. Section 3 presents the econometric approach to answer the above-mentioned questions. Section 4 describes the data set. Section 5 reports our findings of the inflation-relative price variability relationship. Section 6 discusses the results of the inflation and output growth variability nexus. The last section offers conclusions and some possible recommendations for the conduct of monetary policy and the optimal inflation rate.

2. Review of the literature

1.1. Inflation and relative price variability

1.1.1. Theoretical DSGE models and the inflation–RPV relationship

In the theoretical monetary policy literature optimal inflation rate is the one which minimizes relative price dispersion across sectors. For example, the New-Keynesian dynamic stochastic general equilibrium (DSGE) models that became a workhorse tool for monetary policy making around the world, explain potential role of relative prices in resource allocation (see Woodford, 2003). In these models, inflation is costly because it provokes relative price dispersion. Interestingly, the New-Keynesians economists argue that even a perfectly anticipated level of price dispersion is costly for firms (Ambler, 2008). More precisely, in these models, firms set their prices more than one period in advance based on future inflation rate. This signifies that the individual price level will be higher than average prices in the adjustment period while prior to readjustment period, prices will be lower than the average inflation rate. Differences in the readjustments time will cause price dispersion which increases with the level of inflation.

The quantitative impact of this channel – inflation effect on growth through relative price variability – has been tested by Ascari (2004) and Wolman (2001). Ascari (2004) tests this relationship in a standard New-Keynesian model using the true numerical values of the structural parameters for the U.S economy to estimate the steady state output growth. The study further assumes a Calvo-price setting environment and finds that steady state cost of a moderate inflation is quite high.[42] The adverse effects of inflation on the output growth start appearing at the moderate inflation rates while the overall growth becomes zero when the inflation rate goes beyond 15%. These growth effects are, albeit, very minute in the Taylor price setting technology: a price setting behavior where firms change their prices after a fix period of time. This systematic difference in the welfare cost of inflation reflects the fact that firms' reaction to overall inflation and the resulting price variability is the principal factor in determining the cost of inflation. Wolman (2001) also shows that the welfare cost of inflation increases in the New-Keynesian DSGE models when the distortions appearing from price dispersion are included in it. In fact, their simulation results suggest zero percent inflation rates as optimal policy choice.

While the theoretical New-Keynesian models have incorporated the effects of inflation on RPV, the contemporaneous empirical studies have tested the relevance of these mechanisms for various markets. The optimal rate of inflation calculated by this method differs from the actual inflation targets of developed economies. For example, when Caraballo and Efthimiadis (2012) incorporated this inflation–RPV channel in their analysis, they find that a 2% inflation rate, fixed by the European Central Bank (ECB) as its long-run policy objective, is higher than the optimal rate for some of the Euros area economies. Caraballo and Efthimiadis (2012) test the optimality of the ECB inflation targets for France, Germany and Spain and come up with the findings that this target is not optimal for any of the three Euro area economies. For France and Germany the optimal inflation rate is found too low i.e. 0.6% and 0.5% respectively and, for Spain it is 3% which is higher than the optimal ECB target band.

1.1.2. Alternative explanations of the inflation–RPV relationship

Starting from Mills (1927), a large theoretical and empirical literature (discussed below) has shown a positive impact of inflation on relative price dispersion. Inflation induced relative price variability has been considered non-neutral for real sectors' growth since it obstructs the signaling channels of price changes which are the most important source for efficient resource allocation. High inflation therefore results in a resource misallocation and exerts a huge welfare loss for an economy. The macroeconomic policy which aims at minimizing these welfare losses should therefore focus on the complete price stability. Any ambitious attempt by the central bank to get the short-run benefits of high production will have the long-run consequences in terms of low growth and high variability. The

[42]Calvo-price setting assumption is a standard price setting framework of the New-Keynesian models which states that in a given time period only a fraction of the firms adjust their prices. This heterogeneity in the price setting behavior by different firms translates into higher relative price variability after inflation.

policymakers are therefore forced to opt for a level of inflation which minimizes the sectoral price variability.

In the economic theory, resource misallocation and the resulting welfare cost of inflation have been explained through several mechanisms. These include the menu cost of price changes, incomplete information on both producers' and consumers' sides as well as price elasticity differences among firms – explaining heterogeneous response of different producers following an aggregate shock. All of these possibilities are theoretically argued and empirically investigated by a range of developed and emerging markets' studies. Here we present some frequently cited papers on each of these factors. It is important to mention at the outset that the ultimate outcome of all of these parallel theoretical views is a unique positive relationship between inflation and relative price variability.

Menu cost Models

Sheshinski and Weiss (1977) opine that anticipated price changes entail adjustment costs of changing price catalog that creates a wedge between an individual firm's price and the average inflation rate. In their model, a representative firm chooses a one-sided (S, s) pricing rule in inflation. Between these two limits nominal price is held constant and it is changed only when real price hits the lower boundary s. At time when nominal price hits this boundary, a readjustment in the nominal price is done in such a way that the readjusted real price becomes S. As the inflation rate increases, the difference between s and S widens. In addition to this, different fixed costs of price changes across firms will cause staggered price changes that can establish a positive relationship between inflation and RPV across firms. Rotemberg (1983) expanded this framework to a more general equilibrium setting where firms have to pay a fixed cost of price changes. This fixed cost of price changes forces firms to make changes in their prices at discrete intervals in a way that the loss of keeping constant prices is minimized during this interval. Rotemberg (1983) shows that with the assumption of a variable money growth, inflationary shocks will change the equilibrium path of prices and facilitate the adjustment mechanisms among firms.

Caplin and Leahy (1991) disintegrate two effects of price changes; namely, time effect that explains a change in prices coming from internal decision mechanism of firms, and a state effect that implies price changes resulting from exogenous variables e.g., due to money supply changes or inflation. Inflation induced state dependent changes in relative prices directly influence the division of aggregate demand among firms as well as their profits. All of these studies consider menu cost as a principal source of price variability in their models. Some further empirical support to the menu cost model has been advanced by Binette and Martel (2005) in a Markov regime-switching Phillips curve model. The authors test the validity of competing theories: a signal extraction model, an extension of signal extraction model and a menu cost model to explain the Canadian inflation–RPV relationship. Their results show that menu cost is the major factor behind a positive relationship between inflation and RPV.

Signal-extraction model

While the menu cost model explains a positive inflation–RPV connection due to some explicit factors, the signal-extraction model of Lucas (1973) is based on incomplete information on the part of individual producers. Here accelerating inflation erodes the information content of price changes and confounds distinction between real and nominal shocks. More precisely, inflation triggers nominal uncertainty and generates 'misperception' about the absolute and relative price changes. This complicates the distinction between aggregate and relative price shocks. Among the earlier studies Barro (1976) proposes a model where producers supply their goods in different markets with cross-market price differences for similar goods. At any given point in time, producers know about changes in the price structure of local market but are unaware of the overall state of economy. This information asymmetry leaves ground for high inflation to augment RPV and, through this channel, output growth. Any change in the level of inflation instigates the agents to respond by increasing their output.

The empirical work on the signal extraction model tests whether inflation uncertainty significantly influences RPV across sectors. This work includes Grier and Perry (1996) who test the relationship between these two variables using a GARCH-M model. Their results show a positive effect of inflation uncertainty on RPV for the U.S. Aarstol (1999) confirms these findings for the U.S using a monthly data of producer price index. However, the author shows that both the signal-extraction theory and menu cost models explain a part of the U.S inflation–RPV relationship. Furthermore, the study also shows asymmetry in these effects with positive inflationary shocks being more influential for explaining RPV than the negative shocks of same magnitude. The author conjectures that this asymmetry in the inflation uncertainty and RPV relationship is explained by the real world rigidities. Binette and Martel (2005) support these findings for Canada, though for core inflation rates only.

Extension of the signal extraction

The signal extraction model is extended by Hercowitz (1981) and Cukierman (1983). These authors include the role of price elasticity for explaining the sectoral inflation–RPV relationship. The studies assume product-specific price elasticity in market and therefore aggregate monetary shocks have heterogeneous effects on different firms' production. The transmission of aggregate monetary shock on individual firms' prices is more complete for less elastic goods than for the more elastic ones. This all yields a positive relationship between unexpected inflationary shocks and RPV while expected changes in it remain indifferent for determining RPV. Moreover, since it is the unexpected shock to money that matters for the price movements across firms, the magnitude of this shock becomes relevant for these changes.

Parks (1978) tests these views in a study that proposes a new measure of price variability based on the weighted standard deviation of individual price changes from their average. The RPV estimated from this method is then tested with the unexpected inflation for the U.S. The study empirically substantiates the extended signal-extraction model for the U.S during the period 1929 to 1975. Following Parks (1978), several studies confirmed the empirical evidence of this positive relationship between the unexpected inflation and RPV. Nautz and Scharff (2005) identify that the relative strength of expected versus unexpected inflation and their influence on the price variability depends upon country's previous experience with inflation, and thereby credibility of its central bank among the market participants. Their empirical analysis supported the role of unexpected inflation to explain the German RPV. As Bundesbank enjoys a high reputation for maintaining the price stability and successfully anchoring the long-run expected inflation at a lower level, unexpected changes in inflation remain the only matter of concern for the market participants. Nevertheless, the role of unexpected inflation was strong, validating the viewpoint of extended signal extraction in case of German RPV.

By contrast, for high-inflation countries like Israel, Lach and Tsidden (1992) show that it is the expected inflation rate that mainly explains RPV. The strong role of expected inflation is also found by Konieczny and Skrzypacz (2005) for Poland during its transition period from 1990 through 1996. The transition of Polish economy from a centrally planned to a market based economy contained a high macroeconomic uncertainty and therefore a high expected inflation that consequently increased RPV. A panel data study testing the relevance of expected versus unexpected inflation for RPV is Nautz and Scherff (2012) for the Euro area. The study uses panel transition regression model and offers two thresholds where these effects are significant. These thresholds occur of $\pi_t \leq 0.95\%$ and $\pi_t \geq 4.96\%$ inflation rates, respectively. In the moderate inflation regimes, the effects turn out to be insignificant.

Costly consumer search models

A fourth strand in the theoretical literature explains consumers' search cost as a principal factor behind this positive inflation–RPV relationship. Here, inflation discards the price information of consumers and augments the intra-market price variability. Stigler and Kindahl (1970) posit that in high inflation environments, consumer search is not sufficient to eliminate the intra-market price dispersion. Higher search cost and the resulting lower time allocated by consumers make a positive connection between inflation and RPV. In Ball and Romer (2003) lower information on part of consumers reduces price elasticity of goods which, incidentally, encourages firms to make frequent changes in inflation. In Ball and Romer, a major portion of cost of inflation in terms of RPV falls on consumers since producers can make frequent changes in their prices at a minor cost to keep up with the overall inflation rate. Their theoretical model assumes a long-run contract between consumers and producers to reach at these results.

The empirical work on the costly search models has been motivated by Fischer (1981). Fischer (1981, p. 391) conjectures, "*if excessive search is believed to be the mechanism through which monetary disturbances produce misallocations of resources, it would be desirable to collect time-series of the dispersion of prices of the same good.*" Domberger (1987), inspired by Fischer's remarks tested the relevance of this hypothesis for the U.K data from 1974 to 1984. The intra-market price variability is tested to see if consumers' lack of information is positively attached with inflation. The estimated results support this hypothesis for U.K. Parsley (1996) conducts a more comprehensive empirical investigation of this theory for the U.S intra-market price dispersion. The empirical results show a higher intra-city price movement in inflation. Nevertheless, the impulse response function shows that the effects are short lived and die out quickly. These results indicate very minor welfare implications of inflation through RPV channel.

1.1.3. *Some dissenting views to the positive inflation–RPV relationship*

The above-mentioned literature is a very brief summary of the empirical work that validates the positive inflation–RPV relationship. Various authors mention that this positive relationship is a stylized fact in the empirical literature. However, some dissenting views to this positive relationship have also been noted in the literature, indicating an adverse effect of inflation on RPV. The theoretical motivations of this unconventional view comes from Benabou and Gertner (1993) who argue that price dispersion decreases in high inflation since its cost increases for individuals. Agents are keen to get additional information about prices during inflation which consequently keeps the actual market prices close to the reservation price. Reinsdorf (1994) supports this view by finding a negative relationship between inflation and RPV for the U.S during the 1980s recession. The author also notes that a rapid obsolesce of consumers' information during inflation induces them to have updated information about price changes. This incidentally reduces RPV causing an adverse relationship between unexpected inflation and intra-market price variability (see also Fielding et al, 2011).

Silver and Ioannidis (2001) also show a negative inflation–RPV relationship for nine European countries, mainly for the unexpected inflationary changes. Nevertheless, the intensity of this negative relationship is country-specific and depends upon the macroeconomic environment of each economy. Fielding et al. (2011) find this relationship during recessions and inter-war periods for Canada. According to them, this represents the fact that in countries where financial sector is not well developed and consumers are severely credit constrained, price shocks in recessions seriously threaten their consumption and they start searching for cheaper prices. This all implies that during the crisis periods, price dispersion appeases with inflation. These results are particularly interesting for emerging economies as they states that by opting for supply-side measures, these economies can increase average prices and reduces their dispersion which will encourage firms to produce more in recessions.

1.1.4. Nonlinear relationship between inflation and Relative Price Variability

As mentioned elsewhere, relative price variability has often been considered as one of the main components of welfare cost of inflation. The proponents of a negative inflation rate have often based their arguments on the view that the unanticipated inflationary changes will lead to erroneous changes in relative prices and output growth resulting a misallocation of resources (Friedman, 1977). A positive and robust relationship between inflation and RPV of the previous empirical studies has further strengthened this view. If the objective of monetary policy is to minimize market distortions emanating from high inflation, the optimal monetary policy will be the one that minimizes RPV. Moreover, recent theoretical research shows that a slight positive inflation rate is required to minimize RPV. For example, when Schmitt-

Grohé and Uribe (2005) address this issue in a basic New-Keynesian model with the assumption of Calvo-price setting environment, the authors show that in an income tax regime, the Ramsey taxation rule calls for a slight positive inflation tax to minimize these market distortions (see also Choi, 2010).

The idea of a slight positive inflation rate for minimizing RPV has been supported by both consumer and producer theories focusing on the welfare cost of inflation. On the first front, recent monetary search models argue that the marginal impact of inflation on RPV depends upon how agents put search efforts for the optimal prices, following each price change. Moreover, this search effort varies with the level of inflation and a slight positive inflation rate maximizes the search efforts or minimizes the distortions related to the RPV (Head and Kumar, 2005). On the second front, Rotemberg (1996) posits that in a rigid price environment, marginal changes at firm level prices can fall short of overall inflation rate leading to lower markups, higher output and high social welfare at a moderate inflation rate. However, in high inflation periods, the adverse effects due to resource misallocation overcome its desirable effects on the allocative efficiency, establishing a negative connection between inflation and growth.

The theoretical findings of the nonlinear inflation–RPV relationship have also been empirically tested for some developed economies over the last few years. The empirical research supporting this nonlinearity includes the works by Fielding and Mizen (2008); Choi (2010); Caraballo and Efthimiadis (2012) and Nautz and Scharff (2012). Fielding and Mizen (2008) particularly explains this nonlinear relationship in the context of optimal monetary policy. To authors, in a monotonic inflation–RPV relationship, inflation acts as 'sand' in the wheels of an economy and the optimal inflation rate becomes zero. In contrast, in a non-monotonic inflation–RPV relationship, the optimality of a slight positive inflation rate to minimize RPV explains its 'grease' effects. The above-mentioned studies have tried to examine how this sequence of '*grease*' versus '*sand*' effects operate when the inflation rate moves from zero to high levels of inflation rates and the authors also estimated country-specific inflexion points for this non-monotonic inflation–RPV relationship.

Choi (2010) confirms a U-shaped profile of the inflation–RPV relationship for the U.S and Japan. Nevertheless, the study identifies that the relationship is not stable over time and estimated inflation parameters vary in different inflationary regimes and across different time periods. In the theoretical model, Choi assumes a modified Calvo-price setting mechanism with heterogeneity in price adjustment among different firms and shows that the stability of this U-shaped relationship depends upon the degree of price rigidity. As the degree of price stickiness is adversely related to inflation rate, RPV increases in high inflation environment. Caglayan and Filiztekin (2003) complement these findings for a wide range of inflationary periods in Turkey. The authors take data from Turkish Bazaars to support this regime dependence in the inflation–RPV relationship. Caraballo and Debus (2008) also support the regime dependence of inflationary effects on RPV. Nautz and Scharff (2012) is the only panel data study for 12 Euro area economies. Their empirical results, based on a panel threshold model identify strong effects of inflation on RPV both for very low ($\pi_t \leq 0.95\%$) and high ($\pi_t \geq 4.96\%$) annual inflation rates. Between these two regimes, inflation does not exert any significant impact on RPV.

1.2. Inflation and output growth variability: previous developments

A large amount of empirical literature has tested the adverse effects of inflation in terms of higher real output uncertainty in the spirit of misperception theory. All this literature has, however, tested a possible link between inflation and overall GDP variation and overlooked the micro level effects of inflation. As an illustration, Okun (1971) uses data of 17 OECD countries to see whether high-inflation countries observe a high and variable output growth. The correlation results of the study do not show any systematic link between inflation and output growth variability for most of the selected economies other than France and Italy. Similarly, Karanasos and Kim (2005) test the direct effect of inflation on output variability for Germany, Japan and the U.S in a bivariate GARCH model for a long sample period of 1957-2000. Their empirical results also find no evidence of a robust relationship between these two variables. Fountas et al. (2006) test the same relationship for the G-7 economies. Their output growth variability, taken from bivariate-GARCH model, is not linked with inflation for the U.S, France and Canada; positively (though weakly) linked for Japan and Italy; and, negatively linked for Germany and the U.K. Fountas et al. (2002) also show no inter-connection between inflation and output growth variability for Japan.

Keeping aside the Parsley's remarks (1996) that inflationary shocks do not exert any persistent and long-lasting effects on RPV, the validity of the misperception theory also requires a strong link between RPV and output growth uncertainty. The later is also not unanimously supported by the literature. Although a direct test of this relationship has not been conducted in the previous literature, a macroeconomic parallel to this, such as testing the effect of inflation uncertainty on output growth uncertainty, has been drawn in a large number of theoretical and empirical papers. For example, Taylor (1979) shows an inverse relationship between the two variables under the assumptions of nominal (wage and price) rigidities and rational expectations of agents. This implies a stability trade-off between inflation uncertainty and output growth uncertainty. Whenever an aggregate supply shock hits an economy, a downward rigidity of real wages generates larger fluctuations in output.

Fuhrer (1997) obtains the same variability trade-off in a structural monetary policy model. The solution to his model involves minimization of a loss function that contains variances of output and inflation as the arguments for optimal monetary policy. The results confirm a variability trade-off between these two variables (see also Clarida et al, 1999). Empirical relevance for this view comes from the study of Cecchetti and Krause (2001) using the data of 23 developed and developing economies. Study tests whether the economies which have reduced their inflation uncertainty had to face higher output variability. Their results of both inflation targeting and non-targeting regimes support the hypothesis of this trade-off relationship between the two volatilities. A counterview is held by Blanchard and Simon (2001) who confirm a positive impact of inflation volatility on output variability for the U.S. The study uses a long quarterly data set from 1952:Q1 to 2000:Q4 and shows that high inflation volatility is attached with high real growth variability and vice versa. Their robustness tests extend these results for the G-7 economies.

1.3. Exchange rate regimes and the relationship between inflation and real growth uncertainty

It is widely held view that adoption of a particular monetary policy regime, to some extent, determines the nature and sensitivity of inflation effects on both real and nominal uncertainties. Nevertheless, a direct comparison of different monetary policy regimes in terms of their efficiency to control RPV or output growth variability is hard to conduct due to data availability problems. The analysis of exchange rate regimes however provides a solution to this problem since the former are considered an important policy organ of different monetary regimes. A comparison of different exchange rate regimes enables us examining their performance to appease these fluctuations and to increase the average growth. As a matter of fact, both financial and product markets are quite closely connected at present and any particular exchange rate regime of a country can influence its performance in terms of real and nominal uncertainties as well as its capacity to absorb the external shocks. Further, as argued by Summers (2000), with a growing access to international capital markets, countries are expected to choose one among the bi-polar regimes e.g., pegged versus flexible systems. This makes it interesting to analyze the impact of adopting a particular exchange rate on the ability of an economy to curtail uncertainty and to increase average growth.

It is important to note that the efficiency of bi-polar exchange rate regimes is mainly important for developing economies since developed economies usually follow floating exchange rate systems. In fact, a favorable economic environment of the developed countries such as their high credibility, strong financial systems, sound macroeconomic performance, and lower public debt to GDP ratios allow them to exploit the benefits of complete floating regimes. However, the systematic difference in the ability of both exchange rate regimes in absorbing domestic or global shocks is very important for emerging countries that are more vulnerable to global shocks. A large number of papers have probed into the existence of any relationship between exchange rate regimes and macroeconomic stability with their opposing views on the efficiency and sustainability of both systems. Here we try to summarize their main arguments and some important empirical support on both sides.

On the pegged exchange rate arrangement, the main theoretical argument of the previous studies notes that this system appeases market uncertainty and stimulates investment. Since pegged exchange rate acts as a disciplining device, it allows policy makers to bring credibility during the times of accelerating inflation rates (Dornbusch, 2001). Following the implementation of pegs, inflation rate goes down in these regimes, which subsequently minimizes the interest rate or the cost of new investment. Moreover, as argued by Dornbusch, a lower uncertainty broadens the horizons of economic agents and facilitates their investment decisions (see also Rose, 2004; Thom and Walsh, 2002).

Nevertheless, the proposition that pegged exchange rates are better able to cope with uncertainty is far from being universally accepted either. A dissenting view comes from the fact that sustainability of a pegged exchange rate regime strongly depends upon a country's exposure to outside world. As an economy's exposure to outside world increases, the risk of speculative attacks also goes up, requiring more money to back the fixed regimes. Therefore, the credibility gains under fixed regimes become murky with increasing levels of trade and financial openness (Tornell and Velasco, 2000). Moreover, an opportunist regime can misuse these credibility gains by creating larger deficits which can result into a complete collapse of the system. Similarly, Edwards and Levy-Yeyati (2003) argue that the rigid exchange rate regimes poorly respond to terms of trade shocks and therefore experience lower average growth.

By contrast, studies favoring the flexible exchange rate regimes argue that this system offers an easy way to respond unfavorable shocks. For example, Milton Friedman

(1953) posits that one of the most important advantages of the flexible regimes is their smooth adjustment to shocks in the presence of real world rigidities. Since these shocks cause relative price variability across sectors, exchange rate movements can bring down the cost of these adjustments and enhance country's competitiveness. Moreover, a second argument favoring flexible regimes is their ability to deal with speculative attacks. In open capital markets, the risk of speculative attacks remains high under the pegged regimes. Flexible regimes provide a better policy option to tackle these attacks. Empirical support for this view comes from Broda (2001) who uses the data of 74 developing countries with heterogeneous exchange rate regimes and shows that the effect of terms of trade shocks on real GDP, real exchange rate and inflation is higher under fixed exchange rate regimes. On the other hand, flexible exchange rates are found more efficient in absorbing the effect of these fluctuations. Edwards and Levy-Yeyati (2003) expand the work of Broda and study the impact of these terms of trade shocks on output growth. The authors conclude that in the presence of wage rigidity, these terms of trade shocks translate into lower long-run growth.

Some further evidence on the link between exchange rate regime and macroeconomic performance has been reported by Ghosh et al. (1997) in a large panel of 140 countries working under nine different exchange rate regimes. The results complement Friedman's view that exchange rate flexibility lowers the output volatility and increases the average growth, though not to a large extent. On the other hand, nominal (inflation) uncertainty is higher in flexible regimes. This implies a kind of variability trade-off between real and nominal variables. Another argument that has been usually put forwarded by the proponents of flexible regimes is their capacity to control twin – banking and currency – crisis. This general perception has also been supported by the Asian crisis of 1990s when the pegged regimes of these countries proved more prone to crises (see also Husain et al., 2005).

While flexible regimes are generally assumed shock absorbers, flexibility by itself can trigger volatility in the emerging markets. It remains a stylized fact that real exchange rate volatility is higher in flexible regimes. In the emerging economies with underdeveloped financial markets and limited possibility of hedging, exchange rate flexibility can generate uncertainty, increase the transaction cost and fuel inflation in the economy. In short, flexibility does not come without its inherent problems of higher volatility in the developing economies. Nevertheless, for the developed economies these effects are not found significant in the literature (Rogoff, 1999). Aghion et al. (2009) argue that favorable effect of flexibility strictly depends upon the level of financial development of an economy. If the structure of financial markets is not well developed then flexibility can lead to an instability and hold back productivity growth.

A third possibility is the exchange rate neutrality which reflects that in the long-run exchange rate regimes do not exert any impact on both real and nominal variables. Baxter and Stockman (1989) is among the pioneer empirical works for both developed and developing economies which identifies a lack of robust link between exchange rate regimes and the variability of main macroeconomic variables such as output growth, consumption, government expenditures and trade. The authors posit that the macroeconomic conditions of an economy are usually long-term phenomena while exchange rate fluctuations appear at regular intervals. Flood and Rose (1995) theoretically test this idea in a sticky price model where they examine if fixing the exchange rate eliminates its volatility or transfers it to other macroeconomic variables. Their main findings do not suggest any volatility transfer to the other sectors. Obstfeld and Rogoff (1995) show no trade-off between exchange rate flexibility and trade volatility.

1.3.1. Currency Board versus Inflation Targeting systems: bipolar regimes

It can be drawn from the above discussion that the impact of inflation or its uncertainty on both RPV and sectoral output variability can be influenced by the adoption of particular exchange rate regime. Nevertheless, the empirical literature on the relationship between inflation and RPV or sectoral growth variability does not analyze the role of exchange regime in this nexus. This is because most of the existing studies test this nexus only for developed economies working under floating exchange rate regimes. The studies focusing on the emerging economies generally use a country-specific data and therefore do not present any direct comparison of the bipolar regimes. In the present case, we are dealing with a panel data that contains information on both currency board and inflation targeting regimes. These bipolar regimes follow their specific mechanisms for the conduct of monetary policy.

Inflation targeting is a recent phenomenon after its first adoption by the Reserve Bank of New Zealand in 1990. Since then a host of developed and emerging countries adopted this system due to its inherent benefits of transparency and accountability. Briefly, inflation targeting regimes make clear announcements about the level of inflation they are going to maintain. Hubbard (2005) highlights five elements of these regimes 1) public announcement of medium-term numerical targets for inflation; 2) an institutional commitment to price stability as a primary long-run goal of monetary policy; 3) an information-inclusive strategy, with a limited role for intermediate targets such as money growth; 4) increased transparency of monetary policy strategy through communication about the policymakers' objectives; and 5) increased accountability of the central banks for attaining its inflation targets.

A notable characteristic of the inflation targeting regimes is that in contrast with the pegged systems, here economy focuses mainly on domestic shocks and develops a rapid response to these shocks. Moreover, since the level of communication is high in this system, it reduces nominal uncertainty among agents and, to some extent, breaks the vicious circle from nominal to real uncertainty and, thus average output growth. Nevertheless, the critics argue that despite a lack of connection between monetary policy and the government's fiscal objectives, an unaccommodating fiscal policy can still result into large fiscal deficits and cause a breakdown of regime in the long-run.

By contrast, currency board systems also share some common characteristics for their money supply framework. First, under these monetary regimes, exchange rate is pegged to a foreign currency – the Euro in the case of our selected economies – and the CB is responsible to convert the national currency to its foreign counterparts upon demand. Second, money supply is backed by reserve assets, making this system a fractional form of gold standard. Third, the role of central bank as lender of last resort and its ability to change money supply is minimized in this system. Mainly, it is the CB that is responsible for money supply based on the availability of foreign currency reserves, and the discretionary authority of central bank to issue the currency remains limited.

To summarize the above discussion, the main difference between the two regimes is their explicit target about inflation and their specific exchange rate policies. While a currency board system is the outcome of high inflation in most of the cases, this system does not explicitly target any specific rate of inflation while an I.T regime, by contrast, does so explicitly. Inflation targeting regimes employ all of the orthodox monetary policy tools to achieve their objectives while the CB systems do not have these tools at their disposition. In the currency board systems money supply is backed (fully or partially) by the reserve money, whereas the inflation targeting regimes do not face this constraint. The role of central bank as lender of last resort is more prominent in the I.T regimes but absent (or at least minimized) in the CB regimes.

As our selected emerging sub-samples of the emerging European countries are open economies, they face frequent external shocks that can considerably influence their domestic inflation changes. As mentioned earlier, the central banks in these countries have two different monetary strategies to deal with these shocks. On the one hand, the IT countries absorb these shocks by allowing their exchange rate adjustments, while, on the other hand, in CB economies the shocks directly affect the domestic prices since the value of their money is held fixed with their largest trading partner. By adopting the CB regimes if external shocks are directly transmitted to domestic prices, the RPV should be higher in these regimes. On the other hand if the absence of domestic monetary policy substantially reduces the inflation expectations, the RPV can be lower in CB regimes as well.

3. Empirical Methodology

2.1. Empirical estimation of the inflation–RPV relationship

As our selected sample includes both developed and emerging European economies constituting their heterogeneous levels of development; a natural starting point is to estimate a fixed effects model in a panel setting to account for country-specific heterogeneity. The benchmark equation becomes:

$$RPV_{it} = \alpha_i + RPV_{it-1} + \beta\left|\pi_{it}\right| + \varepsilon_{it} \qquad (1)$$

Here α_i captures the country fixed effects. Equation (1) assumes a one-way relationship between inflation and RPV where the later is an endogenous variable and the aggregate inflation rate is exogenous. However, previous research mentions that both these variables can be affected by some common supply shocks making the error term in equation (1) correlated with the inflation rate. Jaramillo (1999) proposes a solution to this problem by eliminating energy sectors in RPV estimation. We use core inflation index to account for endogeneity issues or the effects of common supply shocks on both inflation and RPV. Moreover, equation (1) is also estimated by instrumental variable 2-SLS method to check the robustness of our fixed effects results. In our IV 2-SLS model, we use 12-months lag of inflation and previous period money market rates as the instruments of inflation. The relevance of money market rate for inflation has been explained by Nautz and Scharff (2005). It is important to mention that previous interest rate can serve as an independent variable in the RPV equation so its exogeneity from the error term can be questioned. Nevertheless, it is hard to find completely exogenous instruments and therefore we have to rely on the econometric tests for the exogeneity and the relevance of instruments. In the present case, the value of the Hansen tests signifies the exogeneity of our instruments.

In this simple formulation, the role of inflation expectations for augmenting RPV has been kept silent. However, the systematic differences in expected versus unexpected effects of inflation have been supported by theoretical as well as empirical research. As an illustration, the menu cost model of Rotemberg (1983) underscores the role of expected inflation whereas the misperception theory of Lucas (1973) highlights the role of unexpected inflation in changing RPV (see also Hercowitz, 1981). To test the relative importance of expected versus unexpected effects of inflation on RPV, we decompose inflation series into expected (π_{it}^{e}) and unexpected $(\pi_{it} - \pi_{it}^{e})$ components and get the following equation:

$$RPV_{it} = \alpha_i + RPV_{it-1} + \beta_1 \left|\pi_{it}^{e}\right| + \beta_2 \left|\pi_{it} - \pi_{it}^{e}\right| + \varepsilon_{it} \qquad (2)$$

The recent literature assumes asymmetry in the unexpected effects of inflation on RPV following the findings of Aarstol (1999) for the U.S. Caraballo and Debus (2008) also show asymmetries in the unexpected effects of inflation for Argentina, though valid only for stable inflationary periods. As most of our included sample economies exhibit low inflation rates during the selected sample period, we test for a possible asymmetry in the unexpected effects of inflation using the following specification:

$$RPV_{it} = \alpha_i + RPV_{it-1} + \beta_1 \left|\pi_{it}^{e}\right| + \beta_2 (\pi_{it} - \pi_{it}^{e})^{+} + \beta_3 \left|(\pi_{it} - \pi_{it}^{e})^{-}\right| + \varepsilon_{it} \qquad (3)$$

where $(\pi_{it} - \pi_{it}^{e})^{+} = (\pi_{it} - \pi_{it}^{e})$ if $(\pi_{it} - \pi_{it}^{e}) \geq 0$ and $(\pi_{it} - \pi_{it}^{e})^{-} = (\pi_{it} - \pi_{it}^{e})$ if $(\pi_{it} - \pi_{it}^{e}) \leq 0$ (zero otherwise).

In the next step, to test the influence of particular monetary policy regimes in the hypothesized inflation–RPV relationship, we introduce two dummy variables that take value one when a selected economies follow either inflation targeting or currency board regimes and zero otherwise. By incorporating these regime effects, equation (2) becomes:

$$RPV_{it} = \alpha_i + RPV_{it-1} + \beta_1 \left|\pi_{it}^{e}\right| + \beta_2 \left|\pi_{it} - \pi_{it}^{e}\right| + \beta_3 MPDummy_i + \varepsilon_{it} \qquad (4)$$

Here, i=1, 2 for inflation targeting countries and currency board economies, respectively. The previous research shows that relative price dispersion caused by inflation is not the same at different levels of the inflation rate since both consumers' search efforts and the producers' market power varies with the inflation (Head and Kumar, 2005). A slight positive inflation rate limits the market power of producers by increasing the search efforts of consumers. This mitigates RPV and increases the welfare gains at these small positive inflation rates. However, after some inflexion points, resource misallocation from inflation take away its welfare enhancing effects and RPV increases with inflation. Here we try to find the rate of inflation that minimizes RPV for both our full sample as well as for sub-sample. To test the possibility of a nonlinear relationship between inflation and RPV, we introduce an inflation squared term to analyze the effect of additional inflation. With this addition of inflation squared variable equation (2) takes the following form:

$$RPV_{it} = \alpha_i + RPV_{it-1} + \beta_1 \left|\pi_{it}^e\right| + \beta_2 (\pi_{it}^e)^2 + \beta_3 \left|\pi_{it} - \pi_{it}^e\right| + \varepsilon_{it} \qquad (5)$$

We expect significant values of both inflation parameters β_1 and β_2 with their opposing signs for the relevance of a nonlinear relationship between inflation and RPV. For robustness purposes, a rolling regression analysis is conducted in ascending order of the inflation rate variable. The behavior of the inflation rate variable explains its functional form.

2.2. Empirical estimation of inflation–output growth variability relationship

For our empirical estimation of the inflation and output growth variability relationship, we mainly follow Lucas, signal extraction model. Lucas (1973) formulates his model of supply and demand behavior. Production decisions are based on relative price changes only. Moreover, it is assumed that a change in output is a function of a change in relative prices.

$$\Delta q_{it} = F(\Delta p_{it}) \qquad (6)$$

Here Δ is the first difference operator, and q_{it} is the output that the firm chooses to produce in period *t* in industry *i* and p_{it} is relative price that the firm receives in industry *i* and period *t*. Following Lucas (1973), the quantity supplied by industry *i* in period *t* consist of trend output q_{it}^n and cyclical output q_{it}^c:

$$q_{it} = q_{it}^n + q_{it}^c \qquad (7)$$

The cyclical component of output can be further decomposed into the lagged value of the cyclical component of output q_{it}^c (persistence effect), plus a relative price effect- that is proportional to the deviation of relative price p_{it} from the mean price level $\overline{p}_t$ that firms in industry *i* receive. Hence, the output equation then becomes:

$$q_{it} = q_{it}^n + q_{it-1}^c + \theta(p_{it} - \overline{p}_t) \qquad (8)$$

Since relative prices are affected by some financial market variables, which in turn affect the output growth of a firm; we include the real interest rate to capture these effects. Another influential factor can be oil prices; they are expected to significantly affect the production in the energy-sensitive sectors. Bomberger and Makinen (1993) and Ball and Mankiw (1995) validate the importance of the oil price shocks. The effect of both these variables on price variability can be shown as:

$$Var_{it}(\Delta P) = b + \alpha(L)\pi_{it} + \eta(Oilp_{it}) + \theta^2 \mu(I.Rate_{it}) \qquad (9)$$

If Output growth variability is denoted as $Var_{it}(\Delta q) = v_{it}$ and $\rho\theta \operatorname{cov}(\Delta q^c_{it-1}, \Delta p_{it}) = \varepsilon_{it}$, then by substituting equation (5) into (4), we get our final equation as:[43]

$$V_{it} = c_i + \theta^2 V_{it-1} + \rho^2 \pi_{it} + \theta^2 \eta(Oilp_{it}) + \theta^2 \mu(I.Rate_{it}) + \varepsilon_{it} \qquad (10)$$

Estimation and specification tests

The above description can be summarized as:

$$V_{it} = \alpha_i + \rho_1 V_{it-1} + \alpha_2 \pi_{it} + g_1 X_{it} + \varepsilon_{it} \qquad (11)$$

Here X_{it} represents the exogenous variables. As discussed in the previous section, producers' decisions about future prices and production level can be influenced either by the menu cost changes (Rotemberg, 1983) or by their misperception about the overall price changes in the economy (Lucas, 1973). The econometric treatment of both these opposing possibilities varies since the menu cost effects are captured by expected inflation while the misperception theory is tested via unexpected inflation. Both these specifications are tested in this study by replacing the inflation variable of equation (11) with its expected and unexpected components respectively. For example, the expected inflation specification takes the following form:

$$V_{it} = \alpha_i + \rho_1 V_{it-1} + \alpha_2 \pi^e_{it} + g_1 X_{it} + \varepsilon_{it} \qquad (12)$$

Similarly the unexpected inflation equation – not shown here – replaces π^e_{it} with $(\pi_{it} - \pi^e_{it})$ in equation (12). Our next step estimation aims for investigating the direct relationship between inflation and average sectoral output growth. Here again, we regress the mean output growth across sectors against the expected and unexpected inflation rate in the consecutive specifications, along with the other exogenous variables of specification (11). The average output growth equation for the expected inflation rate becomes:

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[43]Here, for an individual country, sectoral output growth variability; V_t is calculated as $V_t = \sum_{i=1}^{n} \frac{(\Delta q_{it} - \Delta \bar{q}_{it-1})^2}{N-1}$ while N represents the number of selected sector (see Iscan and Osberg, 1998 for more details)

$$\Delta \bar{Y}_{it} = c_i + \rho_1 \Delta \bar{Y}_{it-1} + \alpha_2 \pi_{it}^e + g_1(X_{it}) + \varepsilon_{it} \tag{13}$$

As discussed in the previous section, to analyze the influence of bipolar monetary policy regimes (currency board versus inflation targeting systems) in the hypothesized inflation–output growth variability relationship, a dummy variable is introduced in equation (11) that assumes the value of one when a selected economy follows an inflation targeting or currency board regime and zero otherwise. By incorporating these regime dummies, equation (11) takes the following form:

$$V_{it} = \alpha_i + \rho_1 V_{it-1} + \alpha_2 \pi_{it} + g_1 X_{it} + \theta_i MPDummy + \varepsilon_{it} \tag{14}$$

Here, i=1, 2 for inflation targeting countries and currency board economies respectively.

2.2.1. Threshold effects in the inflation–output growth variability relationship

To identify the existence of nonlinearity in inflation and output growth variability relationship, we first make a preliminary test and add an interaction variable of inflation squared in equations (11) to examine the effect of high inflation rate on the average output growth and its variability. The objective is to test if, beyond certain thresholds, inflation becomes more or less important in influencing the dependent variable. For instance, equation (11) takes the following form:

$$V_{it} = c_i + \rho_1 V_{it-1} + \alpha_1 \pi_{it} + \alpha_2 \pi_{it}^2 + g_1 X_{it} + \varepsilon_{it} \tag{15}$$

The inclusion of this interaction term allows us estimating the marginal effects of inflation on output growth variability at different inflation rates. These marginal effects can be calculated by taking a partial derivative of ΔV_{it} with respect to π_{it}:

$$\frac{\partial(\Delta V_{it})}{\partial \pi_{it}} = \alpha_4 + 2\alpha_5 \pi_{it} \tag{16}$$

And the optimal inflation rate is:

$$\pi^* = -\alpha_4 / 2\alpha_5 .$$

PSTR Model Specification

To further probe into this nonlinear relationship and to investigate into the exact functional form of the relationship, we use a panel smooth transition regression (PSTR) model of

Gonzàlez, et al. (2005) and Fok et al. (2005). Most of the key characteristics of this model have been comprehensively discussed in Chapter 2. Let us suppose a simplest case of a PSTR with two extreme regimes and a single transition function to illustrate the inflation–output growth variability relationship:

$$V_{it} = \alpha_i + \rho_1 V_{it-1} + \beta_0' \pi_{it} + \beta_1' \pi_{it} \Gamma\left(q_{it}; \gamma, c\right) + \delta_0' z_{it} + \varepsilon_{it}. \qquad (17)$$

For $i = 1,...,N$ and $t = 1,...,T$, where N and T denote the cross-section and time dimensions of the panel, respectively. The dependent variable V_{it} is a scalar and denotes sectoral output growth variability, π_{it} is the inflation rate, z_{it} is a k-dimensional vector of control variables; discussed above. The parameter α_i captures individual fixed effects, and ε_{it} is the error term. The fact that our dependent variable is output growth variable in this case does not affect the key characteristics which have been detailed in the chapter 2. We can therefore avoid further description on it.

3. Data and estimation process

For our selected sample economies, the estimates of core inflation rate are provided by the Eurostat where Harmonized Index of Consumer Prices (HICP) inflation strips out food and energy prices – the prices that are particularly influenced by the supply shocks.[44] Deseasonalized inflation series are calculated from these indices using $\ln(P_{t+12} / P_t)$ the definition of inflation (see Silver and Ioannidis, 2001). To analyze the effect of monetary regimes on the emerging markets' inflation–RPV nexus, we included exchange rate regime variable based on the IMF de-facto ER regime classification.

RPV is calculated from a complete set of sub-categories of the Harmonized Index of Consumer Prices (HICP) provided by the Eurostat database. The data set contains 12 seasonally adjusted subcategories with their respective annual weights for our selected sample of 31 developed and emerging European economies.[45] The data set starts from 1996 though we used the series from 2000 to 2012 as the information before 2000 was not so credible for some of the Eastern European countries, given their transition from centrally planned economies to the market based systems. In fact, after the above-mentioned deseasonalization, our actual data set consists of 144 monthly values for all countries between

[44]The ECB (2005) explains how HICP inflation has diverged from overall inflation in the Euro area during the last few years. For example, when the overall inflation rate increased from 2 to 2.6% during 2005-06, the HICP inflation reduced from 2 to 1.6%. These types of deviations were noticed several times in the recent past.
[45]The details are reported in Appendix.

2001: M1- 2012:M12. Following Parks (1978), the RPV for country i in period t (RPV_{it}) is defined as square root of weighted sum of squared deviations of subcategory-inflation π_{ijt} around the average inflation rate for country i (π_{it}) such as:

$$RPV_{it} = \sqrt{\sum_{j=1}^{12} w_{ijt}(\pi_{ijt} - \pi_{it})^2}$$

where $\pi_{ijt} = \Delta \ln P_{ijt}$ and P_{ijt} is the price index of j-th subcategory in country i in period t. w_{ijt} stands for a country-specific weight of the j-th subcategory in the aggregate index so that $P_{it} = \sum_{j=1}^{12} w_{ijt} P_{ijt}$ gives the aggregate price level in the country i and the inflation rate π_{ijt} is $\Delta \ln P_{it}$.

The previous studies on this subject indicate that both magnitude and dimension of the effects of expected and unexpected inflationary shocks on the price and output decisions of firms can vary systematically. We follow the tradition of previous empirical studies and decompose the inflation rate into expected and unexpected components (see Silver and Ioannidis, 2001 and Konieczny and Skrzypacz, 2005). Following Aarstol (1999) and Fielding and Mizen (2008) the unexpected inflation is generated using a forecast equation of inflation in a country-specific GARCH model. The numbers of lags in the mean equation of the inflation rate have been selected based on the minimum values of Akaike's Information Criterion (AIC) and Hannan-Quinn Information Criterion (HQIC) tests. The expected inflation rate is one period ahead forecast from the mean equation of the GARCH model whereas unexpected inflation rate is the difference between actual and expected inflation rates. The interest rate has also been used as an instrument of inflation in our instrumental variables 2-SLS specifications following Nautz and Scharff (2005). Our interest rate variable is represented by a 3-month money market rate taken from the Eurostat and the IFS (for missing countries).

Similarly, to estimate output growth variability, deseasonalized values of both the monthly (2000:M1 to 2012:M12) and the quarterly (1998:Q1 to 2012:Q4) industrial production indices (IPI) for 25 developed and emerging European economies have been used. The selected data consists of 30 sectors, all ranked as two-digit industries according to the Eurostat classification (see Appendix for details). The data on all of these issues is retrieved from the Eurostat. For the cross-sectional output growth variability, first difference from the log values of IPI was taken and then the cross-sectional variance from this first difference yields growth variability across sectors. Inflation series are generated by log-differencing the consumer price index (CPI) data of the selected economies, taken from the Eurostat. The expected and unexpected inflation rate series are generated same as the ones in the above-mentioned RPV model. The exogenous variables include both the monthly and the quarterly observations on the real interest rate and oil prices. The data on the real exchange rate is taken from on-line data source of the Eurostat whereas oil prices are spot prices of crude oil in Dollars per Barrel.[46]

3.1. Descriptive Statistics

The descriptive statistics of the variables selected for the inflation–RPV analysis are shown in the Panel A of Table 4-1. The statistics show a high standard deviation of inflation for the global sample as well as for the sub-samples. Generally, the average inflation and RPV are lower in the global sample compared to all of the sub-samples. Interestingly, both mean inflation rate and its deviation are lower in the currency board economies compared with the inflation targeting monetary regimes. Anchoring the domestic currency with largest trading partners allows the Eastern European currency board regimes to lower their average inflation and RPV. This is also true for the real exchange rate, as its deviation is almost three times lower in the currency board regimes compared to the inflation targeting economies.

It also indicates that both these variables are positively correlated; as shown by several studies in the empirical research. The systematic difference of the inflation and relative price variability in the two monetary systems also motivates our sub-sample comparisons of inflation–RPV relationship between these polarized regimes. Our Fisher-type stationarity tests for the whole sample as well as for all sub-samples – not reported here – show that both inflation and relative price variability variables are stationary at their levels whereas the real exchange rate is stationary at first difference. Therefore, the empirical results take the first two variables at their level and exchange rate at its first difference. Finally the correlation tests between the two variables also show a very high correlation between inflation and RPV and a low correlation between inflation and output growth variability. It is important to mention that our correlation tests are based on within correlation (i.e. x(it) – x(i)) because our estimation is based on the country-fixed effects and therefore uses these variables in the transformed form.

[46]Data is taken from the U.S Energy Information Association
http://www.eia.gov/dnav/pet/pet_pri_spt_s1_m.htm

Panel A: Inflation and Relative Price Variability (2001: M1- 2012:M12)

	Global Sample			Emerging Countries			I.T Economies			C.B Economies		
	Inflation	RPV	I-Rate	Inflation	RPV	I-Rate	Inflation	RPV	I-Rate	Inflation	RPV	I-Rate
Mean	0.013	0.011		0.021	0.015		0.026	0.019	12.135	0.018	0.013	
Std. Dev	0.017	0.013		0.025	0.018		0.028	0.022	2.821	0.015	0.009	
Countries	31			13			5			4		
Correlations												
Inflation	1			1			1			1		
RPV	0.942	1		0.953	1		0.966	1		0.845	1	

Panel B: Inflation and Output Growth Variability (2000: M1- 2012:M12)

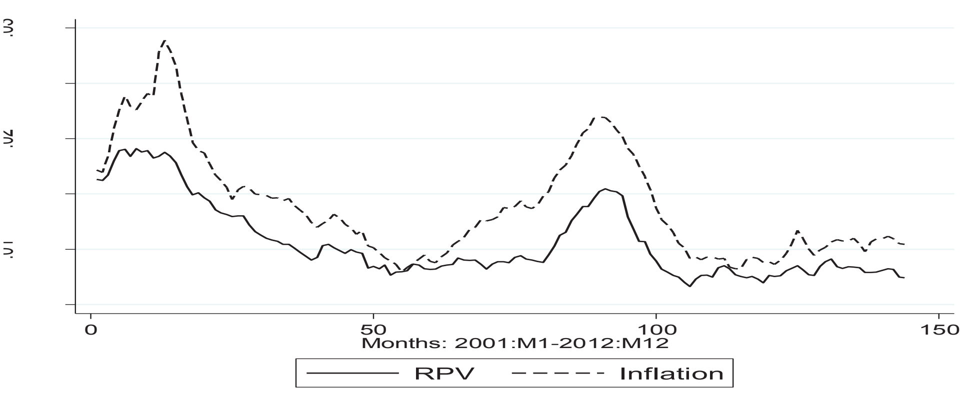
	Inflation	OGV	I-Rate	Inflation	OGV	I-Rate	Inflation	OGV	I-Rate	Inflation	OGV	I-Rate
Mean	0.037	0.012	96.85	0.061	0.017	97.63	0.045	0.010	98.24	0.043	0.023	105.07
Std. Dev	0.054	0.034	22.29	0.077	0.027	26.41	0.027	0.020	23.9	0.035	0.034	18.97
Countries	25			10			5			4		
Correlations												
Inflation	1			1			1			1		
OGV	-0.022	1		-0.035	1		0.024	1		-0.086	1	
I-Rate	0.784	-0.011	1	0.825	-0.008	1	0.912	0.068	1	0.379	-0.11	1

Panel B of Table 4-1 reports descriptive statistics of the variables used in the inflation and output growth variability analysis. Consistent with the nominal uncertainty shown above, the real (output growth) uncertainty is also higher in the emerging European economies compared with the developed countries. Comparing the inflation targeting and the currency board sub-samples, the inflation rate does not differ significantly between these two categories while the output growth variability does. In fact, the inflation targeting regimes outperform currency board systems in terms of curbing the sectoral output growth variability. A comparison of both these variables shows that even if the average inflation rate is slightly higher in the inflation targeting countries, it is attached with lower sectoral output variability. Although these descriptive statistics are not directly comparable with the previous section's values, the mean values of output growth variability and RPV (shown above) contain some important information regarding the two sub-samples. While output growth variability has been better controlled by the inflation targeting countries, RPV is lower in the currency board regimes. This show some sport of stability trade-offs for the emerging economies when they adopt any particular monetary policy regime.

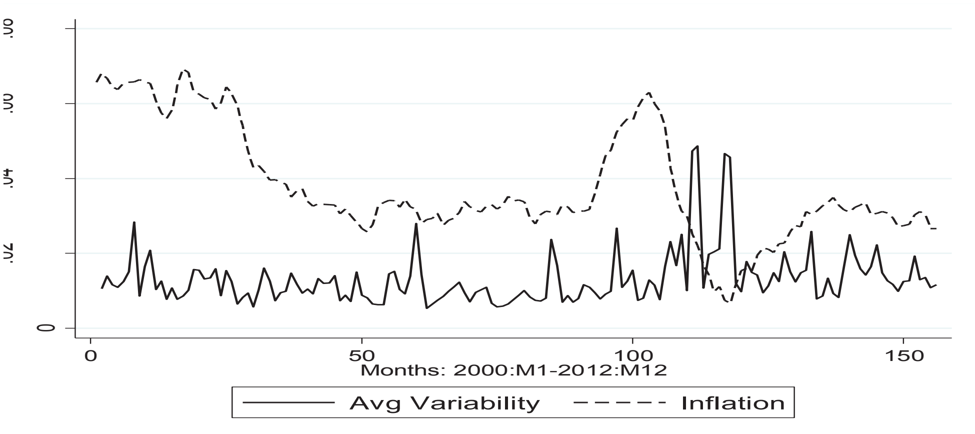
Figure 4.1 shows the evolution of inflation rate and all of the dependent variables over-time. Part 'a' shows a very strong correlation between inflation and relative price variability for the selected period. A high inflation rate is attached with a high dispersion of prices and vice versa. Part 'b' reports a negative impact of inflation on output growth variability for our selected panel. In the beginning when inflation is high, output growth variability is at its minimum. Similarly for the crisis periods, when output variability is at its peak, inflation is quite stable. Part 'c' reports a similar pattern for the average sectoral output growth. Here high inflationary periods of the sample are associated with low and unstable average output growth across sectors. This negative correlation can be clearly viewed from the entire sample periods when average inflation moves upwards, exceeding its previous values.

Figure 4-1 Descriptive Statistics: Evolution of variables over time

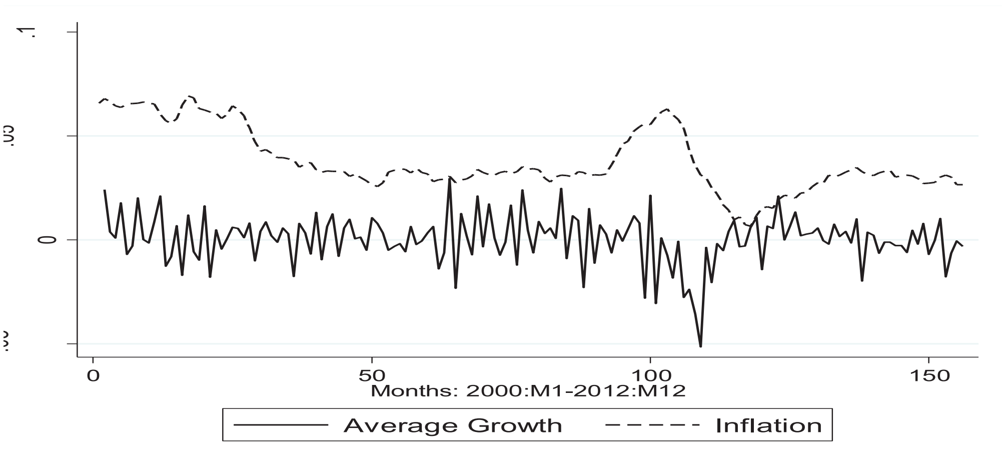
a : Evolution of monthly inflation and relative price variability over-time



b: Evolution of monthly inflation and output growth variability over-time



c: Evolution of monthly inflation and average output growth over-time



4. Inflation and Relative Price Variability: Results and discussion

Here we present our main results of the inflation–RPV relationship for the full sample and for the sub-samples. Table 4-2 contains the main findings of our linear model. The specification (1) shows a strong positive AR (1) process in the dependent variable that is also present in all of the other specifications of Table 4-2. The most important result is a positive impact of inflation on RPV which complements the large empirical literature on the subject. Indeed, price changes among firms become less synchronized in inflation, causing a higher sectoral deviation of prices from their average. However, since the previous research explains different mechanisms behind this positive relationship, our next specification tests the validity of these divergent views. The specification 2 decomposes inflation into its expected and unexpected components and tests the validity of menu cost and misperception theory, respectively. Both these variables are positive and significant, explaining the validity of these views for the inflation–RPV nexus.

Moreover, consistent with Nautz and Scharff (2005, 2012) the influence of unexpected inflationary changes on RPV is higher than that of the expected inflation rate. Nautz and Scharff (2012) find these results for the Western European economies where the inflation rate is quite stable over their sample period. Our results also include emerging European economies where the inflation rate is relatively more volatile. However, given that all of these countries are part of European Union (except Turkey), their monetary policy strictly follows the discipline of Euro zone countries. Their political objectives of becoming the Euro area or the European Union membership (in case of Turkey) force them to keep their inflation expectations lower.[47] The monetary search model of Head and Kumar (2005) explains the role of expected inflation rate in influencing RPV.

Lach and Tsidden (1992), also discuss the role of expected inflation in the monetary policy decisions of central banks. A complementary support comes from the menu cost models where expected inflation triggers a substantial part of the intra-market relative price variability (see Head and Kumar, 2005; Nautz and Scharff, 2012). In the next step, we further separate the effects of positive unexpected inflationary shocks from the negative ones. Here we identify an asymmetry in the effects of inflation since positive unexpected inflationary

[47]Konieczny and Skrzypach (2005) advanced a strong effect of expected inflation for Poland during the transition period of the Polish economy. As inflation expectations were higher in Poland during its transition from centralize to a market based system, the effect of expected inflation was twice stronger than the unexpected one.

shocks exacerbate RPV while the negative unexpected inflationary shocks appease it. These results support the findings of Silver and Ioannidis (2001) for the nine European economies.

Table 4-1 Dependent Variable: Relative Price Variability (Full Sample)

VARIABLES	(1) F.E	(2) F.E	(3) F.E	(4) 2-SLS	(5) GMM	(6) F.E
RPV_{t-1}	0.751***	0.900***	0.911***	0.851***	0.753***	0.896***
	(0.022)	(0.031)	(0.019)	(0.014)	(0.058)	(0.039)
Core Inflation	0.178***					
	(0.020)					
Expected Inflation		0.054**	0.043***	0.071***	0.159***	0.052**
		(0.025)	(0.016)	(0.009)	(0.043)	(0.023)
Unexpected Inflation		0.255**		0.066	0.202**	0.252**
		(0.113)		(0.049)	(0.090)	(0.120)
Positive Unexp. Inf.			0.467***			
			(0.074)			
Negative Unexp. Inf.			-0.355***			
			(0.026)			
Inflation Squared						0.028
						(0.070)
Constant‡	0.007	-0.008	0.014***		0.006	-0.003
	(0.008)	(0.012)	(0.004)		(0.012)	(0.023)
Observations	4,296	4,271	4,271	3,808	4,271	4,271
R-squared	0.980	0.976	0.987	0.971		0.976
Hansen p-value				0.524	0.173	
Number of Countries	31	31	31	31	31	31

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1.To reduce leading zeros, we multiply by 100 the estimated coefficients and the standard errors on the variables marked by ‡. Inflation is instrumented by 12 months lags values of inflation and interest rate.

That said the relation between inflation and RPV can be influenced by some common supply shocks which jointly determine both these variables. This can establish a relation between inflation and the error-term rendering our OLS estimates biased and inconsistent. To address these concerns, our next two specifications test the robustness of our previous results by using both IV-2SLS model and system-GMM for expected inflation rates. In both these models, expected inflation is instrumented by 12 months lag values of interest rate and inflation. The estimated results of both these models complement our previous fixed effects findings with the unexpected inflationary shocks again appear more relevant for explaining RPV than the expected changes.

The last specification focuses on nonlinearity between inflation and RPV. Here our results do not support nonlinearity as the coefficient of inflation squared term turns out to be insignificant, though with a negative sign. Therefore, the results do not support any structural break in this relationship. This contradicts with the recent findings of Choi (2010) and Nautz and Scharff (2012) where the inflation–RPV nexus is nonlinear and RPV enhancing effects of inflation appear only when inflation reaches certain thresholds. In fact, the PSTR model specification of Nautz and Scharff (2012) identifies three inflation regimes with the effects of inflation being positive and significant in both the extreme regimes and insignificant in the middle regime. The above-mentioned functional form can however only deal with the second order nonlinearity with a single structural break. To address this issue and to identify the existence of multiple structural breaks, we used a constant window rolling regression analysis with initial window size of 500 observations.[48] The subsequent regressions include one additional observation until the highest value of the inflation rate. The results are shown in Figure 4-2:[49]

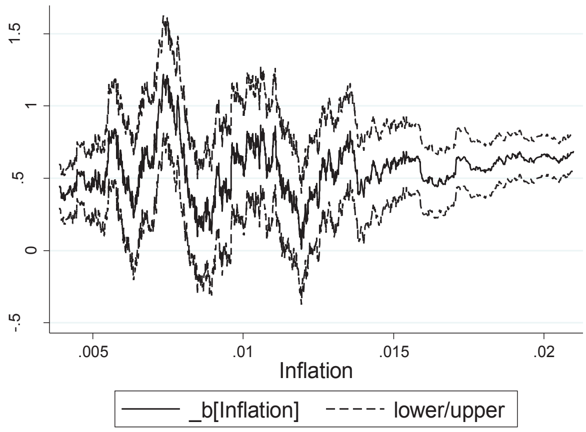
As can be viewed from Figure 4-2, the inflation effect remains positive for all ranges of the inflation rate. However, the intensity of this relationship is different when inflation moves from lower to higher zones of the inflation rate. For both lower and higher levels of the inflation rate, its coefficients are positive and significantly different from zero. The magnitude of inflation coefficients is lowest when the monthly inflation rate is 0.012. It gives the annual inflation rate of 1.44 percent. This complements the findings of Nautz and Scharff (2012) that the inflation coefficient becomes insignificantly different from zero at its slight positive rates and remains high in both lower and upper levels of the inflation rate. In fact, as can be viewed from the graph, the inflation coefficients are insignificant twice before this inflation value. Nevertheless, the mere insignificance of coefficients at 95 percent confidence interval does not provide any useful guidance about the nonlinearity; as argued by Yilmazkuday (2011) when the author (p. 290) stresses, " *….the significance may not be an indisputable guidance, because with a high number of observations in a panel framework and a large number of regressions, the significance at conventional levels may imply 5 or 10 percent of type-1 errors (rejecting the null when it should be maintained). At the same time, failure to meet conventional significance levels does not imply the certainty that the null is true (type-2 error)*". Keeping in view this argument, RPV is minimized when the monthly inflation rate is 0.012 percent in our case.

[48]For robustness checks, we also changed the window size and found the similar results. As we are dealing with a large number of monthly observations, the evolution of coefficients can nevertheless be more clearly observed when the initial window size is relatively large.

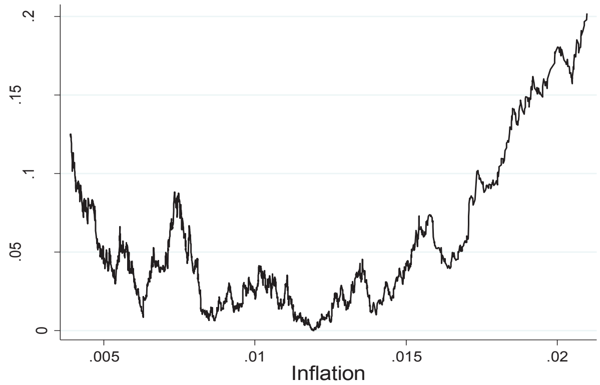
[49]We also tested this nonlinearity by using a panel smooth transition regression model. However, our data set did not pass the nonlinearity tests and therefore we did not proceed with this method. Our RATS code and the results of F-test and LM-test are available upon request from the author.

Figure 4-2 Inflation- RPV relationship at 95% confidence interval (b) Adjusted R2

a: Inflation coefficients



b: Adjusted R^2



These results provide an overall picture of the relationship for both the developed and the emerging European economies. Nevertheless, as mentioned elsewhere, some fundamental differences between emerging and developed economies for their price determination mechanisms and labor market conditions have also been acknowledged by the economic literature. Table 4-4 repeats our analysis for the above listed emerging European economies.[50] As shown by the results, both the nature and intensity of relationship are same for the emerging economies' sub-sample. Despite the fact that the overall macroeconomic developments of these economies are considerably different from the Western European members, the new member states are enjoying a close integration with the Western counterparts which forces them to follow a strict monetary policy discipline. This brings convergence in the RPV response to inflationary changes of both sub-samples; as shown by the specifications 1-3 of Table 4-4.

Some interesting differences among these emerging economies are their monetary policy arrangements which, to a large extent, determine their exchange rate movements. Our sample includes a range of exchange rate regimes from completely fixed currency board economies to fully flexible inflation-target and non-target countries. Here we aim to analyze the role of exchange rate flexibility in determining the effects of inflation on RPV. For comparative purposes, we analyze two bi-polar regimes, namely, inflation targeting versus currency board systems. The specification 4 includes a dummy variable that takes value 'one' for the inflation target regimes and 'zero' otherwise. The results show that inflation targeting

[50]The other sub-sample of developed economies of the Western Europe has been studied by Nautz and Scharff (2012) over the period of 1996-2006. Their results are consistent with our findings of Table 2, indicating a positive and nonlinear inflation–RPV relationship.

arrangement ensures a lower sectoral RPV for these countries compared with the other emerging market economies. As the inflation targeting regimes allow a higher transparency and stability of the exchange rate, RPV diminishes under these systems. Exchange rates realignments absorb the shocks of price changes in tradable goods' and the intra-market RPV remains lower than in the fixed regimes (Fielding and Mizen, 2000). Parsley (1996) shows that exchange rate realignments are the most important factors behind reducing RPV in the U.S (see also Goldfajn and Valdes, 1999). Following the same line of argument, the reverse is true for the currency board economies as in the specification 5 when the pegged exchange rate variable appears with a positive sign, indicating a higher RPV in these regimes compared with the other systems.

For robustness purposes, we include a de facto exchange rate regime classification variable – taken from the IMF database – and examine how it influences RPV in the selected economies. The IMF data set classifies the regimes from 1 to 14; denoting a fully pegged system to a completely flexible regime, respectively. To incorporate these monetary policy arrangement differences and to analyze the role of exchange rate flexibility in appeasing the inflation–RPV relationship, we include an additional variable exchange rate regime in the specification (6). Here the exchange rate variable turns out to be insignificant with a positive sign. Rests of the results retain their signs and significance. The nonlinear effects of inflation on RPV are tested in the specification 7. The results complement our previous findings for the full sample data set as the coefficients of high inflation is negative but insignificant.

Table 4-2 Dependent Variable: Relative Price Variability (Emerging Economies)

VARIABLES	(1) F.E	(2) F.E	(3) 2-SLS	(4) F.E	(5) F.E	(6) F.E	(7) F.E
RPV_{t-1}	0.733***	0.897***	0.838***	0.845***	0.896***	0.897***	0.898***
	(0.033)	(0.041)	(0.019)	(0.028)	(0.041)	(0.041)	(0.050)
Core Inflation	0.193***						
	(0.029)						
Expected Inflation		0.057	0.075***	0.075**	0.058	0.057	0.058*
		(0.036)	(0.013)	(0.028)	(0.036)	(0.036)	(0.032)
Unexpected Inflation		0.277*	0.011	0.128	0.277*	0.278*	0.278*
		(0.147)	(0.064)	(0.083)	(0.147)	(0.147)	(0.156)
IT Dummy				-0.015***			
				(0.000)			
CB Dummy‡					0.025**		
					(0.0001)		
Exchange Rate‡						0.095	
						(0.025)	
Inflation Squared							-0.010
							(0.081)
Constant‡	-0.0001	-0.021		0.601***	-0.029*	-0.021	-0.023
	(0.005)	(0.017)		(0.021)	(0.015)	(0.017)	(0.038)
Observations	1,781	1,762	1,606	1,762	1,762	1,762	1,762
R-squared	0.985	0.982	0.974	0.986	0.982	0.982	0.982
Hansen p-value			0.307				
Number of Countries	13	13	13	13	13	13	13

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. To reduce leading zeros, we multiply by 100 the estimated coefficients and the standard errors on the variables marked by ‡.

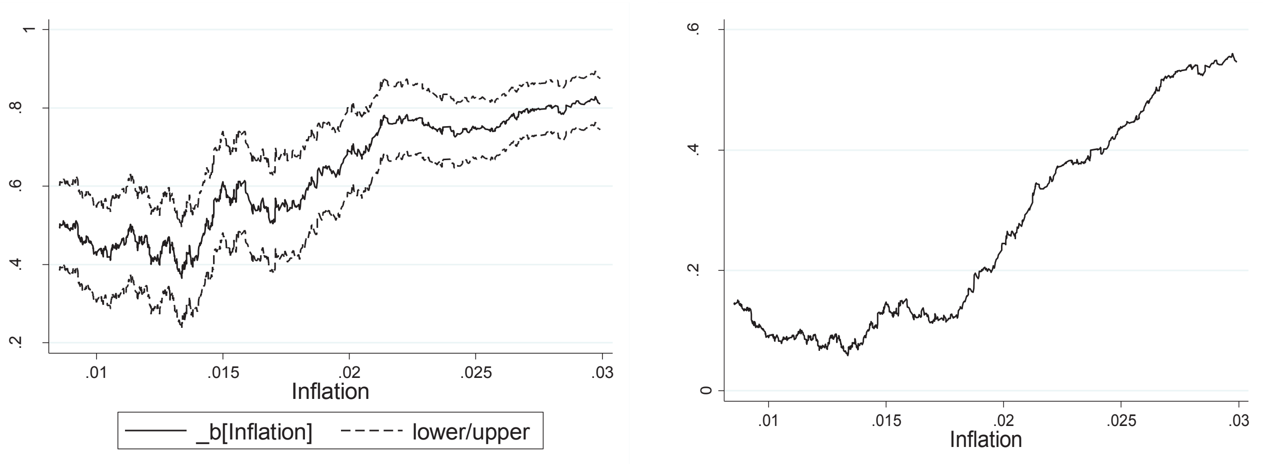
To get some clearer picture we conduct a rolling regression analysis with the same 500 observations per window and obtain a U-shaped profile of the inflation–RPV relationship. The level of inflation which minimizes the RPV also remains same with the global sample; approximately 0.013 percent inflation rate. These results are shown in Figure 4-3 below. These findings are different from our optimal inflation rate for the upper middle-income countries, found in Chapter 2 (Table 2-4).[51] The optimal inflation rate for the overall GDP growth was found about 4.91 percent for the upper middle-income countries. This is clearly higher than the preferences of the central banks in these economies. These micro-based results of the optimal inflation rate that minimize RPV are consistent with the theoretical predictions of the state of the art DSGE models. As DSGE modeling framework analyzes the effects of inflation from a micro perspective, the growth inhibiting effects of

[51]We are comparing these results with the Upper middle-income-countries of Chapter 1 because most of the selected economies of this sub-sample fall in the upper-middle income category according to the World Bank classification.

inflation start at considerably lower rates than the one suggested by standard models – empirically tested in Chapter 2. It is important to mention that due to data problem, here we are unable to compare the micro and macro threshold estimates for the lower middle-income and low-income countries which were pooled together in Table 2-5 of Chapter 2. The micro based threshold should be alarmingly different than the one reported there since we had 16.28 percent threshold inflation rate based on the PSTR model (see also López-Villavicencio and Mignon, 2011; Kremer et al., 2013 for similar thresholds).

Figure 4-3 Inflation- RPV relationship at 95% confidence interval (b) Adjusted R2

a: Inflation coefficients **b:** Adjusted R^2



4.1. The EU Integration versus the Financial Crisis effects on the Emerging markets' RPV

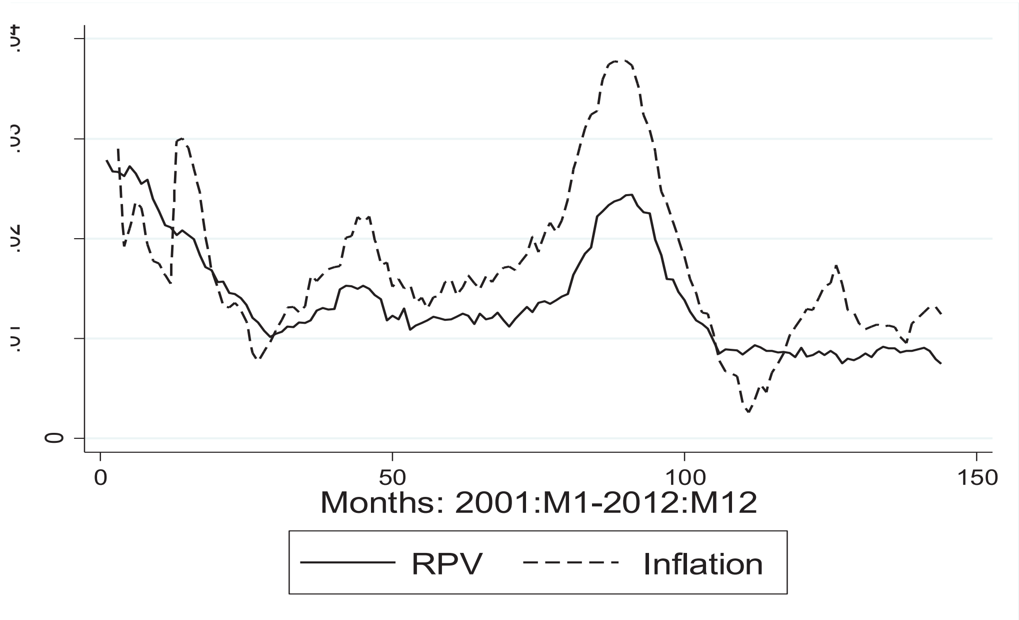
The search-cost model of Head and Kumar (2005) reports a nonlinear relationship between inflation and RPV. The authors argue that at a mild level of inflation, upward changes in it motivate buyers to search for lower prices which limit the RPV. However, when inflation exceeds certain threshold levels, the real value of fiat money held by consumers erodes, forcing them to buy more in the current period and causing a positive link between inflation and RPV. This makes a V-shaped relationship between inflation and RPV with a positive inflation rate being an optimal choice for minimizing the RPV (see also Choi, 2010).

Recently, Becker and Nautz (2012) argue that with higher degrees of market integration this V-shaped relationship disappears and cost of inflation in terms of RPV goes down. In strongly integrated markets, the number of buyers observing market prices increases which further encourages the search activity following each price change and the V-shaped inflation–RPV relationship flattens. In other words, for a given magnitude of change in the inflation rate, the stronger the market integration the weaker the RPV response to this inflation change. The empirical findings of Becker and Nautz (2012) for the EU countries state that with a rapid integration of new member states in the EU zone, price dispersion of the same product across these markets has become less responsive to inflationary shocks. However, the authors get these results for the inter-markets RPV of same product and do not address the integration effects on intra-market sectoral RPV. We want to extend their analysis for a cross-sectional variability in the new member states. Precisely, we want to see whether the inflation–RPV relationship has undergone any systematic change over time. We expect a weak inflation–RPV relationship over time for the selected economies.

Nevertheless, this integration of the member states and the consequent reduction in RPV can be strongly influenced by the advent of financial crisis. The financial crisis has adversely affected the global industrial production and therefore RPV is expected to be higher over the crisis period. Theoretically, a weakening output demand could force firms to make quick price changes in order to retain their market share and this could increase RPV in recession. Rapid price changes can also mitigates consumers' search effort and increase RPV. On the other hand, there exist some studies e.g., Reinsdorf (1994) and Fielding et al. (2011) supporting a negative effect of crisis on RPV based on the very same search cost model. To this view, consumers' search effort increases during the turbulent times and therefore RPV diminishes. Fielding et al. (2011) report this relationship for recessions and the inter-war periods for Canada. Our main task is to analyze whether the process of EU membership has reduced RPV of the new member economies. Second, if this effect holds then whether it has been lessened or accelerated by the recent financial crisis.

To conduct this analysis, we selected eight emerging markets economies, namely, Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Romania and Poland. As a preliminary test, Figure 4-4 presents evolution of average inflation and relative price variability for these economies over the selected time period. As can be viewed from Figure 4-4, both inflation and RPV are higher in the beginning of the sample period. The average value of both these variables is approximately 0.03 in 2001 and it decreases to the level of 0.01 in 2012:M12. Nevertheless, both variables have faced a huge increase in the beginning of financial crisis. Since 2009, the average inflation rate has fluctuated more than the average RPV in these countries, although both variables converged in the very last sample periods. Briefly, the figure gives some support to both opposing views of Becker and Nautz (2012) versus Riensdorf (1994) hypothesis – as explained above.

Figure 4-4 Evolution of inflation and RPV in the selected emerging countries over-time



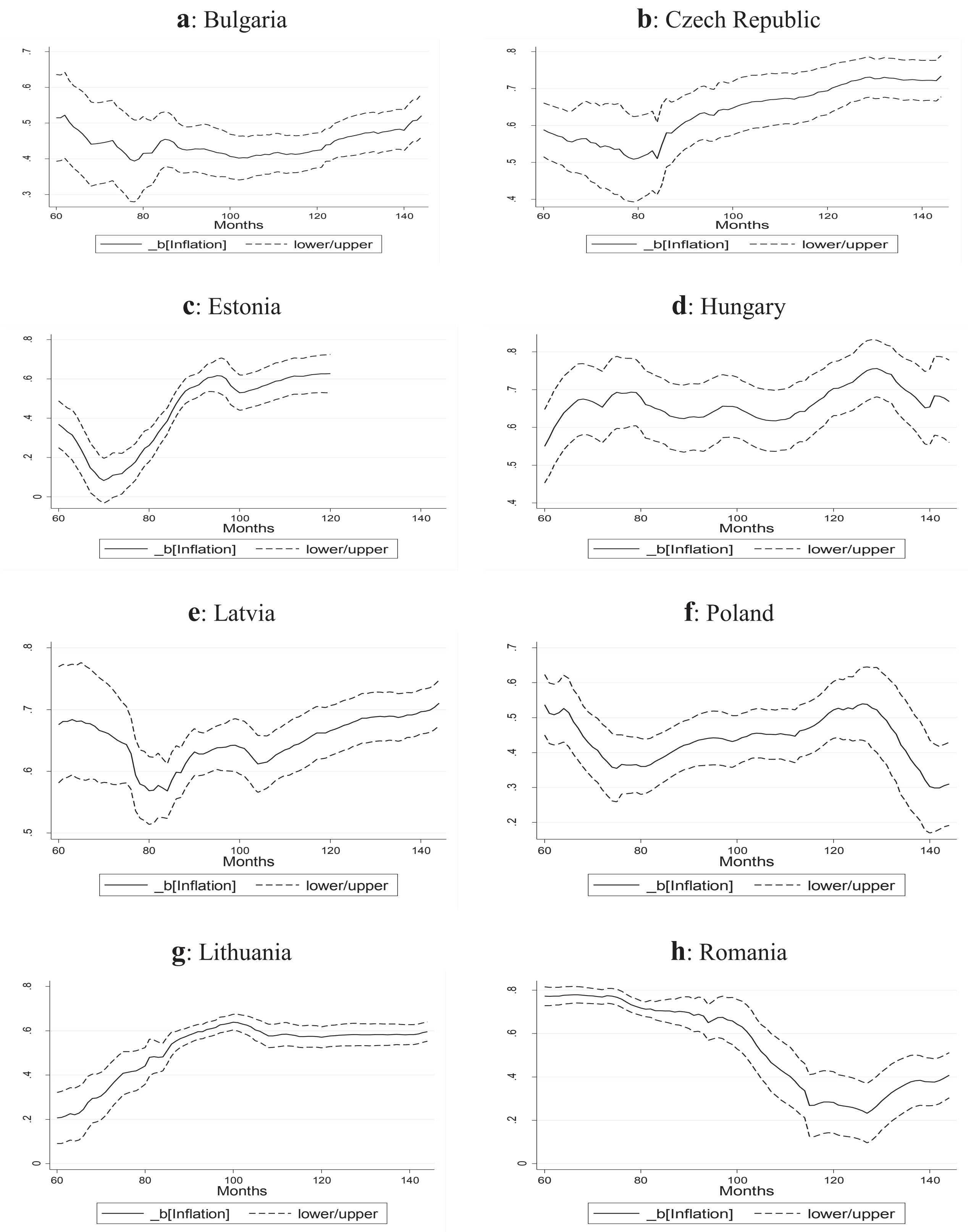
To precisely analyze the time and country-specific effects of both these external events, we run some rolling regression models on the individual country series and examine how the coefficients of inflation behave before and after the ongoing financial crisis for the emerging EU member states. A priori, we are expecting a decreasing magnitude of inflation coefficients over time for the new member states in spirit of Becker and Nautz (2012)'s convergence effect.[52] Nevertheless, during the crisis, RPV can go either way depending upon the consumers' search efforts. To test the presence of all of these effects, we select a time based rolling regression model for each country where the behavior of inflation coefficients is analyzed over time. Our initial window size is 60 monthly observations, and we use a moving window method to keep the same degree of freedom for all coefficients. The rolling based estimates are shown in Figure 4-5.

Our results generally support the convergence hypothesis of Becker and Nautz for the initial regressions until the advent of crisis periods and then the crisis effect dominates, causing a higher RPV. As our window size is sixty monthly observations, the first coefficient corresponds to the value of inflation in December, 2005. The sequential coefficients add one

[52]Our particular focus on the emerging markets is motivated by the findings of Becker and Nautz (2012) that for the developed European economies this effect does not hold since their markets are already well integrated and the price dispersion among these markets has been brought at lower levels. Our rolling regression results for these markets complement their views. The results are available from the authors upon request.

month period for each regression until the end of 144 data points (or December, 2012). In Figure 4-5, the left side columns show the currency board countries while the right side columns contain the inflation targeting regimes. In the beginning, the inflation coefficients become smaller in magnitude over time. However, when the crisis starts in 2008, the value of inflation coefficients increase in size beating each time their previous values and the curve showing behavior of these coefficients becomes positively sloped. This happens for almost all countries, excluding Lithuania and Hungary. Nevertheless, the point of inflexion is not same for all of the selected economies. For example, in Estonia RPV starts taking-off since the start of financial crisis while in Romania its effects appear very late. Putting otherwise, in Romania it is the integration effect that appeases RPV until the middle of ongoing crisis period and then the crisis effect prevails making this RPV higher for the subsequent periods.

Figure 4-5 Rolling 5-years Estimates of Inflation with 95% Confidence Intervals



5. Inflation and Output Growth Variability: Results and discussion

For our empirical investigation of the relationship between inflation and output growth variability, the estimation is based on a fixed effect model in panel setting. Table 4-5 shows the effect of inflation and both of its components, namely, expected and unexpected inflation on output growth variability that has been explained in equation (11) of our model. In all of the specifications, output growth variability contains a strong autoregressive effect which is significant and positive everywhere. With regards to our main variable of interest, inflation, its sign is negative, supporting the view that higher inflation dampens output variation across sectors. This strengthens the concerns raised by Parsley (1996) that the real effects of sectoral relative price variability are minor. In fact, it rather speaks the opposite by supporting the structuralists' point of view that the marginal changes in inflation from its small positive rates lessen output growth variability and exert a positive impact on the average growth.

The fact that our selected economies consist of relatively low and stable inflationary regimes, price changes in these economies are perceived real by the agents and any upward movement in prices incites the producers for more capacity utilization of their firms. This all ends up with lower growth variability and a high sectoral production in the selected economies. With respect to the exogenous variables, oil price changes are positive but not significant in influencing output growth variability across sectors. Interest rate changes, nevertheless, play a significant role to exacerbate the sectoral output growth variability. As a high interest rate retards the investment decisions of the potential projects and generates resource misallocation, sectoral output fluctuations increase with it.

In the next two specifications, effects of inflation is divided into expected and unexpected segments and the results show that it is the expected inflation rate that plays a pivotal role in reducing sectoral output fluctuation of the selected economies. The effects of unexpected inflation are insignificant – though appear with a negative – in reducing the output fluctuations. The positive sign of oil price variable in the specification 2 highlights the importance of international supply-side shocks on the production of these oil importing industrialized economies. The last two specifications (4 and 5) analyze the direct effects of inflation on the average sectoral output growth. For brevity, here we do not show the positive and significant effects of inflation on the average growth, we only present the influence of expected and unexpected inflation rates. As can be seen from the results, the unexpected inflationary changes enhance sectoral output growth while the expected changes are not responded by the producers. Combining both the average growth and growth variability, our findings clearly support the structuralists' view about the real effects of inflation.

Table 4-3 Dependent Variable: Output Growth- its Variability (Full Sample)

VARIABLES	(1) Variability	(2) Variability	(3) Variability	(4) Growth	(5) Growth
Variability$_{t-1}$	0.438***	0.438***	0.438***		
	(0.023)	(0.023)	(0.023)		
Growth$_{t-1}$				-0.394***	-0.390***
				(0.022)	(0.023)
Inflation	-0.026*				
	(0.014)				
Expected Inflation		-0.020*		-0.116**	
		(0.010)		(0.051)	
Unexp. Inflation			-0.101		0.265***
			(0.062)		(0.092)
Exchange Rate$_{t-12}$‡	0.014	0.014	0.012		
	(0.013)	(0.013)	(0.013)		
Interest Rate	-0.002***	-0.002**	-0.002***		
	(0.001)	(0.001)	(0.001)		
Oil Prices$_{t-1}$‡				-0.021***	-0.024***
				(0.005)	(0.004)
Constant	0.008***	0.008***	0.007***	0.004**	-0.0001
	(0.000)	(0.000)	(0.000)	(0.002)	(0.0003)
Observations	3,287	3,287	3,287	3,383	3,383
R-squared	0.193	0.193	0.193	0.162	0.156
Number of id	24	24	24	24	24

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1. To reduce leading zeros, we multiply by 100 the estimated coefficients and the standard errors on the variables marked by ‡.

The result of an adverse inflation and output growth variability relationship indirectly implies a positive effect of inflation on the average output growth. Keynes (1936) discusses that fluctuations represent the riskiness of the investment projects and entrepreneurs take them into account while estimating the returns on their investment. Thus larger output fluctuations represent higher perceived riskiness of investment projects which consequently lowers investment and output growth. Our findings offer some empirical foundations to this view by showing that a mild inflation rate is optimal since it limits growth variability and enhances average growth. Indeed, as argued by the structuralists, in the presence of real market distortions, a slight positive inflation rate is optimal since an inflation target of zero or below is more costly in terms of output loss during recessions (Akerlof et al., 1996; Blanchard et al., 2010). A slight positive inflation rate is optimal since the expected inflation rate attached with this level minimizes output growth variability. Moreover, the unexpected changes in inflation within this range enhance the average output growth without inflicting any significant damage on sectoral output growth variability.

These results depict an overall relationship between inflation and the real sectors output growth or variability for all of the selected developed and emerging countries. Nevertheless, the systematic differences between developed and emerging economies in terms of their existing inflation rates or labor market conditions can play a decisive role in altering the nature of relationship; reported in Table 4-5.[53] Moreover, as mentioned earlier, monetary policy credibility of an emerging economy heavily depends upon the underlying institutional framework of that country. For instance, while prices of tradable goods are more stable in the pegged exchange rate regimes, the domestic monetary policy tools, which assure stability in the presence of external supply shocks, are absent in these economies. Further, some less frequent but large exchange rate devaluations have also been observed in these economies, making these systems vulnerable to the speculative shocks.

Table 4-6 reports the inflation–output growth variability relationship for the selected emerging economies and investigates a regime effect by regressing equation 14 of the model with separate dummies for the currency board and inflation targeting economies. The overall results do not systematically differ from our previous findings. This shows the robustness of our earlier inflation–output growth variability relationship with respect to income levels or the levels of development in a country. Regarding the role of monetary regimes in assuring output stability, our results (shown in the specification 4 of Table 4-6) favor the currency board systems in terms of their influence for reducing sectoral output fluctuations. On the other hand, specification 5 shows that the adoption of an inflation targeting regime does not bring any additional stability for the selected IT countries.

[53]It is important to mention that, in our case, the inflation rate between the developed and the emerging EU economies does not differ as most of the selected emerging economies are either part of the EU or expected to join the club in the next few years and are obliged to follow a strict monetary discipline as part of the EU membership requirement. The exception includes Turkey with a stable inflation targeting monetary regime since 2006. The emerging economies with some higher inflation rates and unstable macroeconomic environment can be a more potential laboratory to check the robustness of our findings.

Table 4-4 Dependent Variable: Output Growth Variability (Emerging Countries)

VARIABLES	(1) Variability	(2) Variability	(3) Variability	(4) Variability	(5) Variability
Variability$_{t-1}$	0.375***	0.375***	0.377***	0.371***	0.375***
	(0.049)	(0.049)	(0.047)	(0.047)	(0.050)
Variability$_{t-6}$	-0.014	-0.013		-0.020	-0.013
	(0.050)	(0.050)		(0.055)	(0.050)
Inflation	-0.024*			-0.025*	-0.021
	(0.013)			(0.013)	(0.014)
Expected Inflation		-0.023*			
		(0.012)			
Unexp. Inflation			-0.070		
			(0.058)		
Dummy CB				-0.012***	
				(0.002)	
Dummy IT					0.001
					(0.002)
Oil Prices‡	-0.016*	-0.017*	-0.014	-0.017*	-0.017*
	(0.008)	(0.008)	(0.008)	(0.008)	(0.008)
Interest Rate	-0.001***	-0.001***	0.000	-0.001***	-0.001***
	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)
Constant	0.012***	0.012***	0.010***	0.017***	0.011***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)
Observations	1,336	1,336	1,351	1,336	1,336
R-squared	0.148	0.148	0.143	0.151	0.148
Number of id	10	10	10	10	10

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1. To reduce leading zeros, we multiply by 100 the estimated coefficients and the standard errors on the variables marked by ‡.

Our results so far are based on the monthly data of the selected economies. However, the empirical growth research usually prefers a low frequency data because of its stability properties and its irrelevance with the business cycle fluctuations. To check the robustness of our results with respect to data frequency, we use quarterly data of the selected economies following Iscan and Isberg (1998). Unfortunately we cannot afford the luxury of further lower data frequency since doing that will cause a degree of freedom problem for most of our selected economies. Our main findings for both the developed and the emerging economies are shown in Table 4-7. The overall results portray the same picture of effects of inflation on output growth and its variability; illustrating the robustness of this relationship with respect to the data frequency. For conciseness, we only show the effects of expected and unexpected inflation on output growth and its variability. On the whole, a slight positive inflation rate is helpful in controlling the output fluctuations across sectors whereas the unexpected changes in inflation under this slight positive inflation rate are growth enhancing. A frequently cited paper of Dotsey and Sarte (2000) favor a variable monetary policy for higher capital formation and output growth.

Table 4-5 Dependent Variable: Output Growth- its Variability (Quarterly Data)

	Full Sample				Emerging Economies	
	(1)	(2)	(3)	(4)	(5)	(6)
VARIABLES	Variability	Variability	Growth	Growth	Variability	Variability
$Variability_{t-1}$	0.212***	0.057**			0.202***	0.199***
	(0.028)	(0.021)			(0.047)	(0.052)
$Growth_{t-1}$			0.288***	0.278***		
			(0.055)	(0.026)		
Exp. $Inflation_{t-1}$	-0.804***		-0.111		-0.353***	
	(0.229)		(0.197)		(0.117)	
Unexp. Inflation		0.128		0.388***		-0.072
		(0.176)		(0.128)		(0.076)
Exchange Rate	-0.016	-0.029	-0.028	-0.028**	0.013	0.007
	(0.018)	(0.025)	(0.016)	(0.012)	(0.008)	(0.009)
Interest rate	0.001***	0.047**	-0.001	-0.001**	0.001**	0.001‡
	(0.000)	(0.018)	(0.000)	(0.000)	(0.000)	(0.007)
Constant	0.031*	0.042	0.029*	0.029**	0.001	0.004
	(0.018)	(0.025)	(0.017)	(0.012)	(0.008)	(0.009)
Observations	1,225	1,237	1,254	1,254	437	438
R-squared	0.058	0.014	0.105	0.112	0.066	0.049
Number of Countries	24	24	24	24	9	9

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1. To reduce leading zeros, we multiply by 100 the estimated coefficients and the standard errors on the variables marked by ‡.

5.1. Threshold effects in the inflation–output growth variability relationship

The overall positive relationship shown in the previous tables assumes a linear functional form of this relationship. Here we question this functional form of the previous estimations. To this end, we apply a PSTR model. As the PSTR model requires some preliminary tests to determine nonlinearity and to decide about the number of possible regimes, our first stage results test whether the response of output growth variability changes when inflation moves from lower to higher levels of the inflation rate. This implies the testing of the null-hypothesis of linearity in the transition variable q_{it} (i.g., inflation) in equation 17 against the nonlinear model. The test results are presented in Table 4-8. The p-values of LM and F-tests reject the linearity hypothesis in favor of the nonlinearity at 10% level of significance for the full sample as well as for the emerging markets' sub-sample.

Nevertheless, the hypothesis of higher order nonlinearity has been rejected in both cases. This allows us to estimate the nonlinear effects of inflation on output growth variability using the PSTR framework.

Table 4-6 LM and F-tests of linearity (p-values)

	Full Sample		Emerging Economies	
	m=1	m=2	m=1	m=2
LM	0.086*	0.22	0.076*	0.21
F	0.087*	0.23	0.077*	0.21

Notes: (1) LM and F are the Lagrange multiplier and F tests for linearity; (2) H0: linear model, H1: PSTR model. Parameter 'm' shows the order of nonlinearity in the model.

Our main results are presented in Table 4-9. We start these nonlinear analyses by first estimating equation 15 with country fixed effects. The inclusion of inflation squared variable helps examining several important aspects of the inflation and output growth variability relationship. First, the opposing signs on both inflation and inflation squared variables evidence the nonlinearity in this relationship. Second, the exact sign of the inflation squared parameter informs us about the curvature of this relationship. A positive sign of this parameter implies a U-shaped relationship; as can be noticed from the specification 1 of Table 4-9. Further, we can also estimate the point where variability appeasing effects of inflation turns into variability aggravating effects by using equation 16 of the model. The moderate level of inflation mitigates sectoral output variability while the high inflation rate exacerbates these fluctuations.

Nevertheless, the fixed effect model is not our preferred specification as it does not allow estimating the time and country-specific elasticity of output growth variability with respect to changes in inflation; as mentioned earlier. To incorporate all of these effects, the specification 2 revisits the same relationship using a PSTR model. As shown by the results, the value of the location parameter c is 0.163 indicating a monthly inflation threshold which is same as the one from the panel fixed effect model. This gives us the annual inflation rate as $\pi^* = 1.96\%$. Moreover, as discussed by López-Villavicencio and Mignon (2011), the values of inflation and transition function parameters are hard to interpret at their extreme points. The coefficients of these variables are hence generally viewed on the basis of their signs. We can also estimate the time varying and country-specific elasticity of output growth variability with respect to the inflation rates, as discussed by Colletaz and Hurlin (2006).

Table 4-7 Dependent Variable: Output Growth Variability, Fixed Effects and PSTR models

	Full Sample		Emerging Economies	
	(1) F.E	(2) PSTR	(3) F.E	(4) PSTR
$Variability_{t-1}$	0.429***	0.091***	0.354***	0.115***
	(0.031)	(0.016)	(0.054)	(0.026)
Inflation	-0.047*	-0.081**	-0.052*	-0.077**
	(0.024)	(0.032)	(0.028)	(0.029)
Inflation Squared	0.111*		0.119*	
	(0.061)		(0.065)	
$Inflation*\Gamma(q_{it};\gamma,c)$		0.069**		0.064**
		(0.033)		(0.029)
Constant	0.008***		0.013***	
	(0.0006)		(0.002)	
Transition Parameters				
C		0.163		0.164
γ		79.56		79.07
LM_F		0.005		0.001
Observations	3,790	3,740	1480	1460
R-squared	0.18	0.011	0.13	0.018
No. of Countries	25	25	10	10

Robust standard errors in parentheses: *** p<0.01, ** p<0.05, * p<0.1

Further, the value of slope parameter is high in the transition function ($\gamma = 79.56$), indicating an abrupt change of regime from low to high inflation rates. Thus the inflation rate shows two extreme regimes with rough transition between these two regimes to characterize the inflation–output growth variability relationship. The last two specifications of Table 4-9 illustrate the same PSTR and F.E results for the emerging markets' sub-sample. The overall results are consistent with the global sample both in terms of the nature of the inflation–output growth variability relationship and also concerning the particular inflexion points of the inflation rate. Due to the prudent macroeconomic policies of these countries, the inflation expectations are kept low and the responsiveness of output growth variability to expected changes in the inflation rate has been harmonized in the region.

6. Conclusions

The recent inflation–growth literature has persistently verified a nonlinear relationship between these two variables. This literature uses macro based models and finds the optimal inflation rate as the one where it starts inhibiting the overall economic activity – represented by the per-capita GDP growth. The optimal inflation rate in this literature has shown to have strong income dependence. For the developed economies it starts appeasing growth beyond a very low level of the inflation rate whereas for the emerging economies it does not hamper growth until the inflation rates of 15-20 percent. Central banks in the emerging market economies do not seem convinced by this rationale of the empirical research. The main reason is that the policy makers use the New-Keynesian models in the formation of inflation targets. The New-Keynesian literature acknowledges the relevance of supply shocks along with the real world rigidities in labor and product markets. The optimal inflation rate in these models is the one that minimizes relative price dispersion following the shocks (Wolman, 2001).

The optimal inflation rate found by this criterion is well below the one observed by the macro based models. Nautz and Scharff (2012) opine that the effects of inflation on relative price variability explain an important channel through which it impedes the overall economic growth. As price changes contain some signals for producers in regards to their resource allocation, the higher RPV after certain inflation thresholds lowers the information content of price changes and causes misallocation of resources. This dynamic response of RPV to inflation changes has strong implications for the conduct of monetary policy. The policy makers would certainly be interested in maintaining the inflation rate at a level where it minimizes RPV. Moreover, a direct inflation–RPV relationship also provides some empirical foundations to the overall inflation–growth nonlinearity found in the last two decades.

This section analyzes the inflation–RPV relationship for a panel of 31 advanced and emerging European countries. The overall results complement the previous findings by indicating a robust positive relationship between the two variables. The rolling regression analysis shows that the overall relationship becomes weak at the annual inflation rate of 1.44%, notably for both the global sample as well as for the sub-sample. Regarding the role of exchange rate regimes, our results show that the adoption of a particular exchange rate regime definitely influences the inflation–RPV relationship of that country. In the present case, the inflation targeting regimes are found more efficient than the currency board and the other monetary regimes of the emerging European countries, as opting for the former regimes lowers their sectoral RPV. On the role of market integration to decrease RPV of the member countries, our results show that a closer integration of the EU member countries is systematically lowering relative price dispersion of the new-member states due to lower search cost for the optimal prices. Nevertheless, these beneficial effects of the EU integration have disappeared in the recent financial crisis since RPV has increased for all of the new member states despite their tight control over prices. Fielding and Mizen (2000) argue that in recessionary periods, market share of different firms goes down, forcing them to make quick changes in their prices and RPV increases despite the overall stability of inflation rate.

In the next step, we directly tested the relationship between inflation and output growth variability to address the concerns raised by Parsley (1996) and Choi (2010). The authors doubt the welfare cost of inflation appearing through the inflation and RPV channels for two reasons; first, because this relationship is fragile and dies out quickly (Parsley, 1996) and second it also remains unstable over time (Choi, 2010). The fragile nature of this relationship has already motivated some researchers to test the direct nexus between inflation and output growth variability and their results strengthen the Parlsey's view on the welfare consequences of inflation. To illustrate, Iscan and Osberg (1998) do not find a robust relationship between inflation and output growth variability. Our empirical analysis expands the Iscan and Osberg (1998)'s work and we check whether the U-shaped profile of inflation–RPV implies a similar U-shaped relationship between inflation and sectoral output growth variability. The role of monetary policy regimes to minimize output growth variability is also analyzed. Besides, the average output growth is also tested for the presence of a Phillips curve relationship.

Our empirical results show a significant role of inflation for explaining output growth variability and the average output growth across sectors. The empirical results also uncover several important dimensions of this relationship. First, both the overall inflation rate and the expected changes in inflation appease output growth variability and fuel the average output growth, supporting the Taylor's view on the variability trade-off between real and nominal variables. For the open economies that face nominal rigidities and observe supply shocks, the mild inflation rate enables the system to absorb external supply shocks, and output growth variability is appeased by a slightly positive inflation rate. By contrast, complete price stability comes with a high output growth variability across sectors, as mentioned by Taylor (1979). On the average output growth effects of inflation, expected inflationary changes are not important for growth whereas the unexpected shocks enhance the sectoral production, supporting the Phillips curve argument of the inflation–growth relationship in the short-run. On the role of particular exchange rate regimes, our results favor the currency board systems in assuring stability and reducing cross-sectional fluctuations of output growth.

More importantly, our results of the fixed-effect and PSTR models show that the effects of inflation are nonlinear on output growth variability with the optimal annual inflation threshold at $\pi^* = 1.96\%$. Below this level, inflation reduces output growth variability and increases the average output growth. This inflation threshold is consistent with the actual inflation targets of the ECB and the other central banks in most of the selected economies. Within our global sample, the threshold estimates do not differ between the developed and emerging economies. As most of the European economies are either the member of Euro area or the future candidates to join this club, their inter-market price dispersion is declining (Becker and Nautz, 2012). It is important to note that all of these new member states have to follow a strict monetary discipline and they also share some other economic and political similarities. All this keeps our sub-sample inflation threshold of the new member states consistent with the global results of the developed and emerging European economies.

On the whole, the joint analysis of the effects of inflation on nominal and real uncertainties lead us to understand the logic behind the actual inflation targets of central banks in both developed and emerging countries. The results for the emerging economies' sub-sample need special attention of the policy makers of these countries. Although fighting inflation became a general trend in the central banks of both developed and emerging economies, high inflation can still be observed in several developing economies. This attitudinal slackness in curbing high inflation can be explained by several factors in the developing economies. The important reasons include a lack of central bank independence, strong history of high inflation, weak fiscal systems and the Balassa-Samuelson effect, etc. Besides all these, one prominent factor is the previous macro based estimates of the inflation threshold which show that the inflation rate below 17 percent is not growth inhibiting. Our results raise some serious questions on this view and contain a very strong 'anti-inflationary' message for the conduct of monetary policy in emerging economies. These results show that despite the institutional differences between developed and emerging economies, the optimal inflation rate is more or less same in the two groups. For our selected sub-sample of the emerging European economies, these results are easily understandable because these countries enjoy a strong coordination with the developed economies and therefore their monetary policy actions need convergence with the western European countries.

Second, although inflation exacerbates relative price variability across sectors, its adverse welfare effects in terms of labor market's hiring and firing cost – described by the misperception theory – are not supported by our empirical results since the direct effects of inflation on output growth variability are negative. This helps understanding the rationale behind the policy makers' use of New-Keynesian models and not the Lucas (1973) type signal extraction model. Indeed, in the presence of real world rigidities along with the unexpected supply shocks and incomplete indexation by the private contracts as well as the use of various debt instruments, the optimal inflation rate is slightly above zero (Ambler, 2008). Even if RPV is positive below this optimal inflation rate, it does not exert a huge welfare cost (or perhaps not as alarming as shown by the misperception theory) because it motivates consumers to put more search efforts for better prices which inhibits price dispersion of inflation until the inflexion point of this nonlinear relationship (Head and Kumar, 2005).

Third, concerning the role of monetary or exchange rate regimes for the emerging economies, a huge number of recent studies discuss the role of monetary policy regimes in assuring stability and reducing fluctuations for these countries. The question that has been raised frequently in the literature is whether an active monetary policy assures more stability or a passive stance of monetary policy makers. Our results provide dissimilar answers for nominal and real uncertainty variables. Relative price variability is higher in the inflation targeting regimes while output growth variability has been better tackled by the currency board systems. Intuitively, in the selected small open currency board systems as the exchange rate is anchored with the largest trading partners, the effects of exchange rate fluctuations on investment and trade are avoided by these systems. This stabilizes their output growth variability in the well integrated European Union market. However, the higher variability of relative prices in the currency board systems certainly exerts its effects on the consumer welfare since the external price shocks are not absorbed by the exchange rate realignments and are directly transferred to the consumers in terms of volatile prices (Bailliu et al., 2003).

The overall results of both these sections share some very strong links with theoretical discussion of Chapter 1 where we present the optimal inflation rate propositions by the Friedman rule versus the New Keynesian theory. Although the Friedman rule and the misperception theory have been persistently supported by the results of several recent theoretical and empirical papers, their impact in the policymaking circles is very limited or has rather been replaced by the New Keynesian models. In the presence of supply shocks and real world rigidities, a moderate inflation rate adopted by the central banks provides them a 'policy space' for responding these shocks (Blanchard, 2010). Nevertheless, this policy space certainly not supposed to cross the level where high inflation volatility, fundamentally attached with accelerating inflation rates, starts obstructing the useful signals of price mechanism.

Appendix

Inflation and Relative Price Variability (2001:M1-2012:M12)

Countries	Among the selected 31 countries we have 18 developed economies namely Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherland, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom. Then we have 13 emerging countries that can be mainly categorized into three sub-groups based on their monetary policy regimes. These subgroups include Czech Republic, Hungary, Poland, Romania and Turkey that follow inflation targeting system; Bulgaria, Latvia, Estonia (until 2011) and Lithuania with Currency Board systems and Croatia, Cyprus, Slovakia and Slovenia being the third sub-group with their country-specific monetary policies.
HICP Categories	The HICP subcategories are food and nonalcoholic beverages; alcoholic beverages, tobacco and narcotics; clothing and footwear; housing, water, electricity, gas and other fuels; furnishings, household equipment and routine maintenance of the house; health; transport; communication; recreation and culture; education; restaurants and hotels; miscellaneous goods and services.
Inflation and Output Growth Variability (2000:M1-2012:M12)	
Countries	The selected sample composed of 15 developed economies; Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherland, Norway, Spain, Sweden, Portugal, U.K and 10 emerging countries that include Czech Republic, Hungary, Poland, Romania and Turkey that follow inflation targeting system; Bulgaria, Latvia, Estonia (until 2011) and Lithuania with Currency Board systems and Croatia, being the third sub-group with their country-specific monetary policies.
IPI Categories	Selected industries include Mining of coal and lignite, Extraction of crude petroleum and natural gas, Mining of metal ores, Other mining and quarrying, Mining support service activities, Manufacture of food products, Manufacture of beverages, Manufacture of tobacco products, Manufacture of textiles, Manufacture of wearing apparel, Manufacture of leather and related products, Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials, Manufacture of paper and paper products, Printing and reproduction of recorded media, Manufacture of coke and refined petroleum products, Manufacture of chemicals and chemical products, Manufacture of basic pharmaceutical products and pharmaceutical preparations, Manufacture of rubber and plastic products, Manufacture of other non-metallic mineral products, Manufacture of basic metals, Manufacture of fabricated metal products, except machinery and equipment, Manufacture of computer, electronic and optical products, Manufacture of electrical equipment, Manufacture of machinery and equipment n.e.c., Manufacture of motor vehicles, trailers and semi-trailers, Manufacture of other transport equipment, Manufacture of furniture, Other manufacturing, Repair and installation of machinery and equipment, Electricity, gas, steam and air conditioning supply.

General Conclusion

The economic policies which are designed for the objectives of high growth and welfare essentially require stability in the economic environment. Macroeconomic stability is composed of several elements such as sustainable fiscal policy, competitive and predictable exchange rates and favorable balance of payments, among others. The low and credible inflation rate also remains the focal point of this stability oriented policy. Unstable macroeconomic environment characterized by high and volatile inflation rates describes a potential threat for the long-run growth and stability. Accelerating inflation rates cause rapid changes in the interest rate and other financial markets' variables and pose some potential threats to the credibility and performance of domestic financial institutions. All this undermines the efficient resource allocation in an economy. Indeed, the list of damages provoked by inflation is long and includes its influence on decisions of agents regarding their labor-leisure choices and more importantly, their choices for work and human capital accumulation.

The collective effect of all of these inflation induced disruptions on the long-run output growth is quite large and makes this subject an important avenue for the academic research. All this motivated a large work, particularly from the beginning of the 20th century to date. Nevertheless, the question of the exact nature of the relationship between inflation and output growth and the magnitude of inflation effects at its various levels is still open for further discussion. Several factors explain why economist could not develop a consensus on these fundamental questions of the effects of inflation. First, money plays several roles in today's world which includes its role as medium of exchange, store of value, input in the production process and source of revenue for government budget requirements. The influence of money on all of these dimensions is different and sometimes completely in opposition. The net effect of an increase in inflation is therefore only relevant for the particular dimension under consideration. Second, inflation–growth relationship depends upon country-specific characteristics. The nature of relationship and its degree of sensitivity are therefore influenced by differences in the degrees of economic development of various countries. This all implies a country-specific and time-specific structural break in the inflation–growth relationship. Lastly, the inflation–growth relationship also exerts strong duration dependence; a short-run relationship can be completely different from a long-run nexus between the two variables.

In a nutshell, despite the key importance of an appropriate money supply for the long-run growth, the economic theory could not precisely guide policy makers concerning the optimization of its supply along with the question of how this optimal inflation rate changes when an economy moves from a low-income country to an industrialized state. This lack of consensus invited the empirical experimentation to determine the exact nature of this relationship. However, the empirical literature has also shown limited success due to the fact that this work basically tests the same theoretical reasoning; a lack of consensus in the later brings diverse results in the former. Further, the empirical works until recent past contained some serious econometric limitations such as the exact determination of functional form of the inflation–growth relationship, heterogeneity of the economic conditions among countries and in the same country over time, reverse causality, among others. Among these main econometric issues, the first limitation regarding the exact functional form of this relationship has been partially addressed following the seminal attempt of Fischer (1993) that indicates a nonlinear relationship between the two variables. Most of the subsequent studies nonetheless did not properly take into account this nonlinearity.

The present study addresses some fundamental empirical deficiencies of the nonlinear inflation–growth relationship. In the first step, we provide time and country-specific estimates of the nonlinear inflation–growth relationship using a large sample of developed and emerging economies. We also identify the role of some main macroeconomic developments in conditioning the intensity of the inflation effects on the output growth. Our second step analysis highlights the channels through which inflation influences the output growth and explains the role of human and physical capital accumulation in the inflation–growth nexus. In spirit of a large theoretical literature testing the Tobin and reverse-Tobin effects of inflation, we argue that inflation actually affects the factors realignment and their accumulation, and this nexus explains its nonlinear effects on growth. On this side, the role of financial development of a country is especially important in determining the Tobin and reverse-Tobin effect on physical and human capital accumulation. We also focus on the mismatch between macro based empirical models and micro based theoretical DSGE models that are workhorse of the monetary policy analysis in the recent decades. We argue that the empirical nonlinear relationship between inflation and growth should be particularly viewed from the micro perspective. The optimal rate of inflation is the one which minimizes the real and nominal disruptions across sectors. We estimate the effects of inflation on relative price variability and output growth variability. Lastly, we explain the role of monetary policy regimes of emerging economies in determining all of these connections.

On the nonlinear relationship between inflation and output growth, our results, reported in Chapter 2, complement previous research on the subject and we show that the inflation–growth relationship exerts certain thresholds. Our threshold estimates are different for developed and emerging economies and the optimal inflation rates declines with the level of development of an economy. Precisely, our threshold estimates, based on the panel smooth transition regression model, support 3.01 percent inflation rate for the global sample of developed and emerging economies; 3.89 percent for the advanced economies; 4.91 percent for the upper middle-income economies and 16.28 percent for the emerging economies. These findings are also supported by our fixed effects and IV-2SLS models. A moderate inflation rate greases the wheels of an economy whereas a high inflation rate throws sand and obstructs the efficient resource allocation. A higher optimal inflation rate for the emerging economies can be explained by the Balassa-Samuelson effect and a high degree of inflation tolerance in these economies compared with their developed counterparts.

The next important result is the role of macroeconomic conditions in determining the sensitivity of inflation effects at its particular levels. Our results validate the relevance of these channels and substantiate the fact that the inflation–growth relationship varies between two countries working at different levels of the macroeconomic developments. For instance, an economy with a higher level of capital accumulation, the adverse effects of inflation is partially moderated by Tobin type effects that stimulate capital accumulation by lowering real interest rate. Similar conclusions hold for the other conditional variables such as the degree of trade openness and ratio of government expenditures to GDP. Effectively, the specific features of the macroeconomic environment of a certain country determine both its optimal level of inflation and its welfare cost, once inflation crosses certain thresholds. Here again, the sub-sample analyses provide a more clear picture of the conditional variables' influence. The Tobin effect of inflation that modifies the intensity of adverse inflation effects is particularly relevant for the emerging markets' sub-sample. As the actual interest rate is high in these economies, reducing the real interest rate through inflation makes capital accumulation more attractive and partially offsets the negative effects of inflation. Conversely, a high level of government expenditures exacerbates the adverse effects of inflation on growth for the emerging and upper-middle economies but not in the advanced economies where the use of these expenses is more efficient.

Our results in Chapter 3 mainly explain the nonlinear inflation–growth relationship by the effects of inflation on human and physical capital accumulation. Our estimated results are based on the data set of 105 developed and developing economies over the 5-year periods of

1971-2010. These results are based on fixed effects and IV-2SLS models and the nonlinearity is tested using a rolling regression technique. The benchmark linear models support a negative effect of inflation for physical capital accumulation and a positive effect for human capital. The nonlinear specifications, however, show that both these effects are valid only for high inflation regimes. A movement from complete stability to high inflation rates entails Tobin effects at low inflation rates and reverse-Tobin effects at the higher rates. Conversely, for human capital accumulation the effects are negative for low inflation ranges and positive for high-inflation episodes. Given that all of the major theoretical links between inflation and output growth appear through capital accumulation, these results have some strong implications for the inflation–growth nonlinearity.

Comparing these results with the ones obtained in Chapter 2 clarifies that the *grease* effects of inflation are due to Tobin effects on physical capital at moderate inflation rates. The *sand* effects follow them when inflation enters into its higher levels. The positive effects of high-inflation episodes on human capital accumulation that are also maintained by the previous research (Helene and Pozzi, 2007) explain why inflation is less harmful when it enters in its extremely higher zones (see Levine and Zervos, 1993). Decreasing real wages force agents to leave labor markets for human capital accumulation. Our inflexion points for physical and human capital accumulation are 8.17 percent and 15.64 percent respectively. Precisely, the effects of a moderate inflation rate $(\pi < 8.17\%)$ are positive only for physical capital. Similarly, for a high inflation rate $(\pi > 15.64\%)$ the effects are positive for human capital accumulation. In middle inflation ranges $(8.17\% < \pi < 15.64\%)$ the effects are strongly negative for both types of capital accumulation. We also study the role of financial development as an interaction variable for the effects of inflation on both human and physical capital accumulation. Our results of the interaction variables show that Tobin effects are significant only in economies that contain some well-developed financial systems. Indeed, strong financial systems channelize the funding for physical and human capital accumulation when real interest rate and real wages observe a downward shift in inflation.

Last but not least, the findings presented in Chapter 4 correspond to the effects of inflation on sectoral relative price variability and output growth variability of developed and emerging European economies. The relationship between inflation and RPV is estimated using the monthly data of 31 European economies over the period of 2000:M1 to 2012:M12. Consistent with previous findings, our results based on the fixed effects and IV-2SLS models show a positive effect of inflation – and both its expected and unexpected components – on RPV. Interestingly, we support a slight positive inflation rate (0.013 percent monthly) to minimize RPV. This strengthens the New-Keynesian view on the optimal inflation rate. The DSGE models favor a slight positive inflation rate to avoid zero interest bound and to absorb the effects of shocks in the presence of price and wage rigidities. Among the emerging market economies, inflation targeting regimes have been found more efficient than the rest of monetary systems in terms of their efficiency for minimizing the RPV. However, both I.T and non-I.T regimes have faced a higher RPV during the recent crisis years despite their low level of inflation in these times.

The results for inflation and sectoral output growth variability are based on monthly (2000:M1 to 2012:M12) and quarterly (1998:Q1 to 2012:Q4) data sets of 25 developed and emerging European economies. The linear effects of inflation on sectoral output growth variability are negative while the nonlinear results, which are estimated using a PSTR model, show a U-shaped behavior of growth variability. The strong response of output growth variability shows that the effects of inflation on RPV are therefore transmitted to sectoral growth fluctuations. We also tested the effect of expected and unexpected inflation on the average output growth across sectors. The results show a negative effect of the former and a positive effect of the later, consistent with the Phillips curve theory. Interestingly, our comparison of the inflation targeting and the currency board regimes shows that the later have been more efficient for their control over output growth variability. Comparing these results with the inflation–RPV relationship shows that, on the one hand, inflation targeting regimes are more successful in the reducing RPV whereas, on the other hand, currency board regimes have shown more efficiency in lessening the output fluctuations. All this implies that the performance of a particular regime depends upon the nature of shocks faced by the economy. Countries which are more prone to external supply shocks need a flexible exchange rate regime such as inflation the targeting regimes of emerging EU economies. By contrast, countries which are more vulnerable to domestic shocks can better avoid the use of their monetary policy discretions by fixing their currency with the credible trade partners.

The overall results of this thesis have some strong relevance for the existing literature on this topic. We test the comparative strength of the monetarists and New-Keynesian views on the optimal inflation rate. Our findings from macro- and micro-based data sets do not support the optimality of complete price stability, let alone the negative inflation rate propositions of Friedman and his followers. The monetarists opine that in a country with a strong credibility of a low inflation rate, price and wage rigidities cease to exist. The optimal inflation in this situation can therefore be lowered down to a level of complete stability without incurring significant welfare losses of this deflation. Our empirical results however do not support this view since, even for the developed economies with strong reputation of low inflation rate, we find that a slight positive inflation rate is an optimal choice. The risk of a zero nominal interest bound is not only a theoretical possibility but also a practical phenomenon faced by the Japanese economy during its 1990s recession. A Taylor's type stability trade-off between nominal and real uncertainties supports the case of a moderate inflation rate against complete stability. This view has been increasingly accepted in the recent theoretical research which shows a nonlinear long-run Phillips curve (see Graham and Snower, 2008 and references therein).

Although the nonlinear relationship is not an unforeseen finding in the recent literature, our results still preserve their newness for the conduct of monetary policy. As shown by our findings in Chapters 2 and 3, both optimal inflation rates and marginal cost of inflation beyond these thresholds depend upon macroeconomic developments. For instance, the distortionary effects of marginal inflation changes are not same for the closed economies compared to their open counterparts. The sensitivity of inflation effects is much elevated for the latter group compared with the former. This explains how the heterogeneity among countries brings systematic differences for their effects of inflation. This can also hold true for a same country over different periods of time. As a matter of fact, countries' political and financial institutions exhibit continuous changes because of their domestic developments as well as their international commitments. In these circumstances, monetary policy actions that aim for findings the optimal choice between the *grease* and *sand* zones of the inflation rate require a continuous analysis of the macroeconomic environment. The exact magnitude of the welfare effects of money supply changes can only be observed in a broader horizon.

Our analysis in Chapter 3 also shows that changes in the money supply influences the factors' realignment and their intensity in the production process. To be more exact, the response of human and physical capital accumulation to inflation changes is heterogeneous, not only in terms of its magnitude but also in terms of the dimension of these effects. If a particular monetary policy decision favors one type of capital accumulation at a certain inflation rate, the same may not hold true for the other factor. This implies that monetary policy actions have not only a strong impact on short-run resource allocation of a country but also on its long-run factors' accumulation. This also shows that the net welfare effects of any particular changes in inflation rate will depend upon the factors' endowments of a country and production technologies used by it. Certainly, these results do not support an inflationist policy for any type of capital accumulation because even if high inflation rate exerts a positive effect on the accumulation of a particular production factor, its negative effects through the factors' reallocation and other sources should definitely be a matter of concern for the policy makers. What we can safely claim is that all theoretically advanced effects of inflation on agents' reallocation of assets and time have a strong empirical relevance at different levels of the inflation rate. It also rejects the super-neutrality of money advanced by Sidrauski (1967) and others.

Our findings in Chapter 4 justify the anti-inflationary stance of the monetary policy makers around the world. The results for the emerging economies' sub-sample need special attention of the policy makers. In the emerging markets, central banks are less strict in dealing with inflation when it goes beyond their expectations. Several factors explain this behavior including the lack of central bank independence, weak fiscal systems and the Balassa-Samuelson effect. This behavior is also justified by the previous macro based estimates of the inflation threshold which show that the inflation rate below 17 percent is harmless for these countries. Our results do not support this view and constitute a very strong recommendation for the conduct of monetary policy in emerging economies. Despite the structural differences between developed and emerging economies, the level of inflation beyond which it starts augmenting the dispersion of sectoral prices and output growth is similar for the two groups. This implies that the monetary policy options available for the developing countries are not so different from those of the advanced economies. This is especially true for the countries that have strong political and economic links with the developed economies such as our selected sample of the emerging European markets. As labor and products markets are closely connected among the EU member states, the monetary policy actions also need to be harmonized between the member states, irrespective of their level of economic development.

Like every research project, this thesis has certain limitations that are left for consideration in future research. First, in the second chapter we discussed the role of some macroeconomic conditions to explain the sensitivity of the inflation–growth relationship. Although our selection of the conditional variables includes the most important growth covariates yet it misses the role of some important factors for this nexus. In fact, previous research on economic growth has included a wide range of covariates for explaining the differences in GDP growth of various economies (see e.g., Barro 1991; Mankiw et al, 1992). The role of political and financial market variables deserve special attention for explaining the differences in the sensitivity of inflation effects for various countries. Second, our results in Chapter 3 are based on the measures of human and physical capital accumulation that contain some computational deficiencies. As discussed elsewhere, it is hard to get precise estimates of these variables. Physical capital accumulation observes depreciation, the estimates of which are always based on approximation. Similarly, human capital accumulation has no single computational criteria. Some more precise estimates of both these variables can better reveal the story behind inflation–growth nonlinearity.

Third, the estimated results of Chapter 4 could also be extended in several directions. These results do not show large differences in the threshold estimates between the developed and emerging economies. However, it is important to note that our analysis has mainly focused on the upper-middle-income countries and high income economies of the EU. This issue is nevertheless more important for the lower-middle-income and low-income economies where the macro based inflation threshold estimates give a double digit inflation rate as the optimal policy choice. Our limitation is again driven by the data availability. Further, our results concerning the relevance of monetary regimes in the inflation–RPV relationship have shown some interesting differences between these two regimes. Some more refined analysis of the monetary policy regimes in all of these economies can be an interesting contribution to the literature on the monetary policy regimes and macroeconomic stability. For instance, in different monetary policy regimes the response of RPV to inflation and other nominal and real shocks can be estimated by using the Vector Autoregressive (VAR) type models.

Clark and Stephen (2010) identify the role of monetary policy in responding the supply shocks for U.S. To probe into the responsiveness of monetary policy to supply shocks they test whether a shock to energy prices affects the federal fund rate. Their assumption is that a passive monetary policy amplifies the effect of a shock on real output. In the present case, we have different monetary policy regimes from the active monetary policy arrangements of inflation targeting economies to relatively less responsive currency boards. A possible extension would be to see if the effect of an inflationary shock on RPV differs with respect to the monetary policy regimes. Similar extensions are valid for inflation and sectoral output growth variability relationship. Lastly, some country-specific threshold estimates will be helpful in analyzing whether the common monetary policy is equally optimal for all of the member states of the European Union in terms of reducing their real growth uncertainty. The results of Caraballo and Efthimiadis (2012) show that the optimal inflation rate for the member states depend upon their production structure – it is high for economies that are relatively backward on the growth frontier. This result has some interesting policy implications for the new-member states of the EU countries as well as for the existing members of the Euro club.

Conclusion Générale

La stabilité de l'environnement économique est une condition nécessaire à l'atteinte des objectifs majeurs des politiques macro-économiques, que sont la croissance économique et le bien-être social. La stabilité macroéconomique prend en compte plusieurs éléments tels que la soutenabilité de la politique budgétaire, la compétitivité des taux de change, la stabilité de la balance des paiements, etc. La maîtrise de l'inflation est également un point essentiel d'un environnement économique stable. En effet, l'instabilité de l'environnement macroéconomique peut être caractérisée par des taux d'inflation élevés et volatiles, qui compromettent les prévisions à long terme. Une hausse des taux d'inflation provoque des changements rapides dans les taux d'intérêt et constitue une menace potentielle pour la crédibilité et la performance des institutions financières, compromettant par conséquent, la répartition efficace des ressources dans l'économie. Au nombre des effets négatifs de l'inflation, on peut citer l'influence sur les décisions des agents en ce qui concerne leurs choix entre travail et loisirs, surtout, leurs choix pour entre le travail et l'accumulation de capital humain.

Les effets adverses de l'inflation sur le bien-être social et la croissance économique ont fait l'objet de nombreux travaux scientifiques, en particulier à partir du début du XXème siècle. Toutefois, la question de la nature exacte de la relation entre l'inflation et la croissance économique, de même que celle relative à l'ampleur des effets de l'inflation à ses différents niveaux restent toujours d'actualité. Plusieurs raisons justifient l'absence de consensus entre les économistes sur les effets d'une inflation modérée. D'abord rappelons que la monnaie joue plusieurs rôles de nos jours à savoir : un moyen d'échange, une réserve de valeur, un intrant dans la production, une source de revenus pour les besoins budgétaires des gouvernements, etc. L'influence de la monnaie sur l'ensemble de ces dimensions est différente et contradictoire. Un autre facteur à l'origine de l'absence de consensus est le fait que la relation inflation - croissance dépend de caractéristiques propres à chaque pays. La nature de la relation et de son degré de sensibilité varient selon le niveau de développement économique des pays. Cela implique des ruptures structurelles et un moment précis propres à chaque pays dans la relation inflation - croissance. Enfin, la relation inflation - croissance varie également suivant que l'on est à court terme ou à long terme.

En bref, malgré l'importance d'une masse monétaire appropriée pour la croissance à long terme, la théorie économique fournit peu d'indications aux décideurs sur la façon d'optimiser cette offre et comment le niveau optimal d'inflation peut se définir suivant le niveau de développement du pays. Cette absence d'orientation claire, conduit à la réalisation d'études empiriques afin de déterminer la nature exacte de la relation selon les différentes configurations. Cependant, la littérature empirique a également révélé ses limite, puisque basée sur les mêmes fondements théoriques. En outre, les travaux empiriques jusqu'à un passé récent utilisent des techniques économétriques baisées pour estimer la relation entre l'inflation – croissance, et tiennent pas compte de l'hétérogénéité de l'environnement économique des pays et des variations de ce contexte dans le temps selon les pays. Par exemple, Fischer (1993) remarque cette limite, en spécifiant une forme non linéaire entre la croissance et l'inflation. Par la suite, de nombreuses études prendront en compte cette non-linéarité.

La présente thèse s'inscrit dans cette perspective en étudiant la relation entre l'inflation et la croissance à travers un modèle qui prend en considération la non-linéarité. Dans un premier temps, les estimations de la non-linéarité tenant compte de spécificités individuelles et temporelles ont été réalisées sur un large échantillon de pays aussi bien développés, qu'en développement. Nous mettons également en évidence l'incidence de certaines variables macroéconomiques dans la relation non linéaire entre l'inflation et la croissance économique. Dans un second temps, nous étudions les canaux par lesquels l'inflation affecte la croissance économique et mettons en évidence le rôle de l'accumulation de capital humain et physique dans le lien inflation - croissance. S'inscrivant dans le même ordre d'idées que la littérature théorique de l'effet Tobin et l'effet inverse de Tobin, nous montrons que l'inflation affecte la dynamique des facteurs, et par conséquent justifierait la relation non linéaire avec la croissance économique. De ce point de vue, le rôle du développement financier d'un pays est particulièrement important dans la détermination de l'effet Tobin ou son inverse dans l'accumulation de capital physique et humain. Nous mettons également l'accent sur l'inadéquation entre les modèles empiriques et les modèles théoriques à fondements microéconomique tels que les DSGE qui ont été très utilisés dans l'analyse de la politique monétaire au cours des dernières décennies. Nous montrons que la relation non linéaire empirique entre l'inflation et la croissance devrait être notamment perçue dans une perspective microéconomique. Le taux d'inflation optimal est celui qui minimise les variabilités réelles et nominales dans tous les secteurs. Nous estimons les effets de l'inflation sur la variabilité des prix relatifs et la variabilité de la croissance de la production. Enfin, nous analysons le rôle des régimes de politique monétaire des économies émergentes dans la détermination de l'ensemble de ces interactions.

En ce qui concerne la relation non linéaire entre la croissance de l'inflation et le taux de croissance économique, nos résultats, présentés dans le chapitre 2, corroborent ceux des recherches antérieures qui mettent en évidence l'existence d'effets de seuils dans la relation entre inflation et croissance. Nos seuils estimés à partir de la méthodologie des panels à transition lisse sont différents suivant le niveau de développement des pays. Par exemple, nos résultats suggèrent que le seuil d'inflation est de 3,01 % pour l'échantillon global des économies développées et émergentes; 3,89 % pour les économies avancées, 4,91 % pour les pays à revenu intermédiaire, et 16,28 % pour les pays à revenu inférieur. Ces résultats sont également confirmés à travers des estimations de modèles à effets fixes et les modèles IV-2SLS. Le taux d'inflation modérée « graisse les rouages » de l'économie alors que les taux d'inflation élevé ont des effets négatifs sur la croissance contribuant aussi à une inefficacité dans l'allocation des ressources. Un taux d'inflation plus élevé optimal pour les économies émergentes est justifiée par l'existence d'un fort effet Balassa-Samuelson et un degré de tolérance de l'inflation dans ces pays relativement plus élevé par rapport aux pays développés.

Un autre résultat important que nous avons obtenu est relatif au rôle des conditions macro-économiques dans la détermination de la sensibilité de la croissance par rapport aux effets de l'inflation. Nos résultats valident la pertinence des canaux indirects et permet de justifier le fait que la relation inflation - croissance varie en fonction des conditions macroéconomiques des pays. Par exemple, les effets négatifs de l'inflation sont partiellement atténués dans une économie qui dispose d'un niveau élevé d'accumulation du capital grâce aux effets de type Tobin qui stimule l'accumulation de capitale en abaissant le taux d'intérêt réel. Des résultats semblables ont été obtenus en ce qui concerne les autres variables conditionnelles telles que le degré d'ouverture commerciale et le ratio des dépenses publiques au PIB. En effet, les caractéristiques de l'environnement macro-économique des pays déterminent à la fois leur niveau optimal d'inflation et les coûts sociaux, une fois ce seuil optimal dépassé. Là encore, l'échantillon étudié fourni des résultats probant sur l'influence des contextes macroéconomiques dans la relation entre l'inflation et la croissance. L'effet Tobin qui réduit l'intensité de l'effet adverse de l'inflation est particulièrement pertinent pour le sous-échantillon des pays émergents. Comme le taux d'intérêt réel est élevé dans ces économies, la réduction du taux d'intérêt réel à travers l'inflation modérée entraîne une accumulation du capital, à tour compense partiellement les effets négatifs de l'inflation. A l'inverse, un niveau élevé de dépenses publiques exacerbe les effets négatifs de l'inflation sur la croissance pour les économies émergentes, mais pas dans les économies avancées où l'utilisation de ces dépenses est plus efficace.

Les résultats du chapitre 3 mettent principalement en évidence la relation non linéaire entre l'inflation et la croissance par le biais de l'accumulation de capital humain et physique. Nos résultats estimés sont basés sur un panel de 105 pays développés et en développement au cours des périodes de 1971 à 2010. Les données sont prises sur une périodicité quinquennale. La démarche méthodologique est essentiellement basée sur les modèles à effets fixes, les modèles IV - 2SLS et la non-linéarité est testée à l'aide de la technique des régressions récursives (*rolling regressions*). Les modèles linéaires de référence soutiennent un effet négatif de l'inflation pour l'accumulation de capital physique et un effet positif sur le capital humain. Les spécifications non linéaires, cependant, montrent que ces deux effets ne sont valables que pour les régimes élevés d'inflation. Un mouvement de la stabilité complète à taux d'inflation élevé entraîne des effets Tobin pour de faibles taux d'inflation et un effet de Tobin inversé pour des niveaux d'inflation élevés. Inversement, pour l'accumulation de capital humain, les effets sont négatifs pour de faibles niveaux d'inflation et positifs pour les périodes de forte inflation. Étant donné que tous ces liens théoriques entre inflation et croissance se réalisent à travers l'accumulation de capital, ces résultats ont des implications fortes pour la non-linéarité de l'inflation et la croissance.

La comparaisons de ces résultats à ceux obtenus dans le chapitre 2 suggère que les gains liés à l'inflation sont dus à des effets Tobin sur le capital physique pour des taux d'inflation modérés. Les effets défavorables apparaissent lorsque l'économie enregistre des épisodes de fortes inflations. Les effets positifs des fortes inflations sur l'accumulation de capital humain, qui ont été également mis en évidence par les travaux précédents (Hélène et Pozzi, 2007) expliquent en partie les conséquences négatives modérées lorsque l'économie traverse des périodes de fortes inflations (voir Levine et Zervos, 1993). La baisse des salaires réels obligent les agents à quitter le marché du travail pour accumuler du capital humain. Nos points d'inflexion pour l'accumulation de capital physique et humain sont respectivement de 8,17% et 15,64%. Plus précisément, les effets de l'inflation modérée ($\pi < 8{,}17\%$) sont positifs seulement sur l'accumulation du capital physique. De même pour des niveaux élevés d'inflation ($\pi > 15{,}64\%$), les effets positifs se réalisent sur l'accumulation de capital humain. Pour des niveaux d'inflation modérés, c'est-à-dire situés entre les deux valeurs extrêmes précédentes, l'impact négatif est significatif aussi bien sur l'accumulation du capital physique, que sur l'accumulation du capital humain. Nous étudions également le rôle du développement financier comme variable d'interaction pour les effets de l'inflation sur l'accumulation de capital humain et l'accumulation du capital physique. Nos résultats suggèrent que l'effet Tobin n'est significatif que dans les économies disposant d'un secteur financier développé. En effet, les systèmes financiers développés ont la capacité de canaliser les financements vers l'accumulation du capital physique et humain lorsque le taux d'intérêt réel et les salaires réels enregistrent une tendance à la baisse compte tenu de l'inflation.

Enfin, les résultats du chapitre 4 mettent en perspective les effets de l'inflation sur la variabilité relative des prix et la variabilité de la croissance de la production dans les économies développées et émergentes. La relation entre l'inflation et la variabilité des prix est estimée en utilisant les données mensuelles de 31 pays européens sur la période de 2000: M1 à 2012: M12. Conformément aux résultats précédents, nos résultats basés sur les effets fixes et les modèles IV - 2SLS montrent un effet positif de l'inflation sur la variabilité des prix. En effet, nous obtenons un faible taux d'inflation (0,013% par mois) susceptible de minimiser la variabilité des prix. Ce résultat renforce la vision néo-keynésienne sur le taux d'inflation optimal. En effet, les modèles DSGE sont favorables à une légère inflation positive pour éviter intérêt nul lié et permettre d'absorber les effets des chocs compte tenu de la rigidité des prix et des salaires. Parmi les économies de marché émergentes, les régimes de ciblage de l'inflation se sont révélés plus efficaces que les systèmes monétaires en termes de contrôle pour réduire la variabilité des prix. Toutefois, les régimes de ciblage d'inflation et les autres régimes ont enregistré de fortes variabilités des prix au cours des récentes années de crise en dépit de leur faible niveau de l'inflation au cours de ces périodes.

Les résultats en ce qui concerne l'inflation et la variabilité sectorielle de la production sont basés sur des données mensuelles (2000: M1 à 2012: M12) et trimestrielle (1998: Q1 à 2012: Q4). L'échantillon est constitué de 25 développés et émergents d'Europe. Les effets linéaires de l'inflation sur la variabilité sectorielle de la production sont négatifs alors que les résultats non linéaires, qui sont estimés à l'aide d'un modèle PSTR, montrent une relation en forme de U. La forte réaction de la variabilité de la production montre que les effets de l'inflation sur la variabilité des prix ont entraîné des fluctuations sectorielles de la production. Nous avons également testé la relation entre l'inflation anticipée et non anticipée et la croissance moyenne de la production sectorielle. Les résultats montrent un effet négatif de l'inflation attendue, contre un effet positif de l'inflation non anticipée, en accord avec la théorie de la courbe de Phillips. Plus intéressant encore, nos comparaisons entre les régimes de type ciblage d'inflation et ceux de type caisse d'émission (*currency board)* suggèrent que les seconds ont été mieux capables de réduire la variabilité de la production. En comparant ces résultats avec la relation inflation – RPV, nous concluons d'une part que, les régimes de ciblage d'inflation sont plus capables de réduire la variabilité des prix, tandis que, d'autre part, les régimes de type caisse d'émission (currency board) ont montré une plus grande efficacité dans la réduction des fluctuations de la production. Tout cela implique que la performance d'un régime particulier dépend de la nature des chocs auxquels l'économie domestique est confrontée. Les économies qui sont plus vulnérables aux chocs externes d'offre ont besoin d'un régime de taux de change flexible tels que les régimes de ciblage d'inflation des économies émergentes de l'UE. En revanche, les pays qui sont plus vulnérables aux chocs internes peuvent mieux éviter l'utilisation de leur pouvoir discrétionnaire de la politique monétaire en fixant leur monnaie avec les partenaires commerciaux crédibles.

Nos résultats, basés sur une approche macroéconomique et microéconomique ne supportent pas l'optimalité de la stabilité complète des prix, du moins encore les effets globalement négatifs de l'inflation prônés par Friedman et ses disciples. Les monétaristes estiment que dans une économie avec une forte crédibilité des taux d'inflation faible, les prix et les salaires cessent d'être rigides. L'inflation optimale dans cet environnement peut donc être abaissée à un niveau de stabilité complète sans le risque d’atteindre la borne à zéro du taux d’intérêt cette déflation n'entraîne des coûts sociaux importants. Nos résultats empiriques ne supportent pas ce point de vue puisque, même pour les pays développés avec du taux d'inflation bas, nous trouvons qu'un faiblement taux d'inflation reste optimal. Le risque des obligations à taux zéro n'est pas seulement une hypothèse théorique, mais aussi un phénomène pratique vécu par l'économie japonaise au cours de la récession des années 1990. Un arbitrage de stabilité à la Taylor entre l'incertitude nominale et réelle montre la supériorité d’une situation où le taux d'inflation est modéré plutôt qu’une situation de stabilité complète. Ce point de vue a été largement admis dans la littérature théorique récente qui montre que la courbe de Phillips est non linéaire à long terme (voir Graham et Snower, 2008 entre autres).

Bien que la relation non linéaire ne soit pas un résultat inattendu, nos résultats conservent tout leur intérêt pour la conduite de la politique monétaire. Comme le montre nos résultats dans les chapitres 2 et 3, le taux d'inflation optimal et le coût marginal de l'inflation au-delà de ces seuils dépendent les évolutions macroéconomiques des économies. Par exemple, les effets distorsifs des changements d'inflation ne sont pas de même pour les économies fermées et les économies ouvertes. La sensibilité par rapport à l'inflation est plus forte dans les économies ouvertes. C'est ce qui explique aussi entre autre, comment l'hétérogénéité entre pays apporte des différences systématiques en ce concerne les effets de l'inflation. Cela peut aussi être vrai pour le même pays sur des périodes de temps différentes. Dans ces conditions, les mesures de politique monétaire visant à déterminer un niveau optimal d'inflation situé les zones d'effets favorables et défavorables nécessitent une analyse continue de l'environnement macroéconomique. L'ampleur exacte des effets de bien-être à la suite des modifications de la masse monétaire ne peut être observée que sur un horizon plus large.

Notre analyse dans le chapitre 3 montre également que les changements dans l'offre de monnaie influencent le réalignement des facteurs et de leur intensité dans le processus de production. Plus précisément, la réponse de l'accumulation de capital humain et physique à l'évolution de l'inflation est hétérogène, non seulement dans son ampleur, mais aussi en ce qui concerne le sens de ces effets. Si une décision de politique monétaire favorise notamment un type d'accumulation du capital à un taux d'inflation donné, cela pourrait ne pas être vrai pour l'autre facteur. Cela implique que les actions de politique monétaire ont non seulement un impact fort sur l'allocation des ressources à court terme, mais aussi sur l'accumulation des facteurs à long terme. Cela montre aussi que les effets nets sur le bien-être d'une variation du taux d'inflation dépendra des dotations technologiques de chaque pays et aussi du degré d'utilisation de chaque facteur dans le processus de production. Certes, les résultats ne soutiennent pas une politique inflationniste pour tout type d'accumulation du capital. Certes, les résultats ne soutiennent pas une politique inflationniste quel que soit le type d'accumulation du capital étant donné que, même si une forte inflation exerce des effets positifs sur l'accumulation d'un facteur de production particulier, ses effets négatifs (notamment la réallocation des facteurs) devraient certainement être un sujet de préoccupation pour les décideurs politiques. Ce que nous pouvons affirmer de façon certaine, c'est que les effets théoriques de l'inflation sur la réallocation des actifs des agents restent pertinents sur le plan empirique. L'hypothèse de super- neutralité de la monnaie avancée par Sidrauski (1967) et les autres se trouve également rejetée.

Nos résultats dans le chapitre 4 justifient la position anti-inflationniste des responsables de la politique monétaire dans le monde entier. Les résultats pour le sous-échantillon des économies émergentes nécessitent une attention particulière. Dans les marchés émergents, les banques centrales sont moins rigoureuses sur le traitement de l'inflation quand cette dernière dépasse les valeurs espérées. Plusieurs facteurs expliquent ce comportement, y compris le manque d'indépendance de la banque centrale, les systèmes fiscaux faibles et l'existence de l'effet Balassa-Samuelson, entre autres. Ce comportement est également justifié par les estimations macroéconomiques précédentes du seuil de l'inflation, qui montrent que le taux d'inflation en dessous de 17 % n'est pas néfaste pour ces pays. Nos résultats ne confirment pas ce point de vue et constituent une recommandation forte pour la conduite de la politique monétaire dans les économies émergentes. Malgré les différences structurelles entre les pays développés et émergents, le niveau de l'inflation au-delà duquel la dispersion sectorielle des prix et la croissance de la production commencent à augmenter est le même dans les deux groupes. Cela implique que les options de politique monétaire disponibles pour les pays en développement ne sont pas si différentes de celles des économies avancées. Cela est particulièrement vrai pour les pays qui ont une forte coordination avec les pays développés tels que notre échantillon de marchés européens émergents. Comme les marchés du travail et des biens et services sont étroitement liés entre les États membres de l'UE, les mesures de politique monétaire doivent être aussi harmonisées entre les pays membres, indépendamment de leur niveau de développement économique.

Comme tous les projets de recherche, cette thèse présente certaines limites qui pourront être prises en compte dans les recherches futures. Tout d'abord, dans le deuxième chapitre, nous avons discuté du rôle de certaines conditions macroéconomiques pour expliquer la sensibilité de la relation entre l'inflation et la croissance. Bien que notre sélection de variables conditionnelles comprendre les déterminants les plus importants de la croissance, il manque toutefois certains facteurs dans ce lien. En fait, la recherche précédente sur la croissance économique a inclus un large ensemble de variables pour expliquer les différences dans la croissance du PIB de différents pays (voir, par exemple, Barro, 1991; Mankiw et al., 1992). Le rôle des variables politiques et financières méritent une attention particulière dans l'explication des différences de sensibilité des effets de l'inflation dans les différents pays. Deuxièmement, nos résultats dans le chapitre 3 sont basés sur les mesures de l'accumulation du capital physique et humain qui contiennent erreur de mesure. Comme nous l'avons d'ailleurs souligné, il est difficile d'obtenir des estimations précises pour ces variables. L'accumulation de capital physique connait une dépréciation dont les estimations sont basées sur l'approximation. Similairement, l'accumulation de capital humain n'a pas de critères comptables singuliers. Certaines estimations plus précises de ces deux variables peuvent mieux révéler l'histoire derrière la non-linéarité de la relation entre l'inflation et la croissance.

Troisièmement, les résultats estimés au chapitre 4 peuvent également faire l'objet de plusieurs prolongements. Ces résultats ne montrent pas une grande différence dans les estimations de seuil entre les pays développés et les économies émergentes. Cependant, il est important de noter que notre analyse a porté principalement sur les pays à revenu moyen-supérieur et les économies de l'UE à revenu élevé. Ce problème est toutefois plus important pour les pays à revenu moyen-inférieur et à revenu faible où les estimations de seuils de l'inflation obtenus à partir des modèles macroéconomiques donnent des taux d'inflation relativement élevés. Aussi, la disponibilité des données sur longues périodes peut être aussi évoquée comme une limite du travail. En outre, nos résultats concernant la pertinence des régimes monétaires dans la relation entre l'inflation et la variabilité des prix ont montré des différences intéressantes entre ces deux régimes. Une analyse approfondie des régimes de politique monétaire dans l'ensemble de ces économies peut être une contribution intéressante à la littérature sur les régimes de politique monétaire et la stabilité macroéconomique. Par exemple, dans les différents régimes de politique monétaire de la réponse de la variabilité des prix à l'inflation et d'autres chocs nominaux et réels peut être estimée en utilisant une modélisation VAR (Vector Autoregressive).

Une autre extension possible serait de voir si l'effet d'un choc inflationniste sur la variabilité des prix diffère selon les régimes de politique monétaire. Ainsi Clark et Stephen (2010) soulignent le rôle de la politique monétaire en réponse aux chocs d'offre pour l'économie américaine. Pour examiner la réactivité de la politique monétaire aux chocs d'offre, ils testent si un choc de prix de l'énergie influence le taux des fonds fédéraux. Leur hypothèse est que la politique monétaire passive amplifie l'effet d'un choc sur la production réelle. Dans le cas présent, nous avons différents régimes de politique monétaire, qui vont des régimes de politique monétaire de ciblage de l'inflation aux régimes plus rigides de type caisse d'émission. Des prolongements semblables sont possibles pour la relation entre l'inflation et la variabilité sectorielle de la production. Enfin, certaines estimations de seuils spécifiques à chaque pays seront utiles pour analyser si la politique monétaire commune est également optimale pour tous les États membres en matière de réduction des incertitudes de la croissance. Les résultats de Caraballo et Efthimiadis (2012) montrent que le taux d'inflation optimal pour les États membres dépend de la structure de chaque État membre et il est grand pour les économies qui sont relativement éloignées de la frontière de la croissance. Ce résultat a des implications intéressantes pour les nouveaux États - membres des pays de l'UE ainsi que pour les actuels membres du club euro.

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Muhammad KHAN

Les effets de l'inflation sur la croissance et sur ses déterminants macroéconomiques

Résumé:
La présente thèse analyse l'impact de l'inflation sur la croissance économique et ses différents déterminants. Dans un premier temps, notre étude s'intéresse à deux aspects de la relation entre l'inflation et la croissance économique. Ainsi, nous examinons tout d'abord la non-linéarité du lien entre l'inflation et la croissance économique et identifions plusieurs seuils pour l'échantillon global ainsi que pour les différents sous-échantillons définis selon le niveau du revenu. Ensuite, nous procédons à l'identification de certaines caractéristiques macroéconomiques au niveau des pays qui influencent cette non-linéarité. Nos résultats empiriques corroborent les deux éléments d'analyse précédents et montrent que la non-linéarité de la relation entre l'inflation et la croissance dépend de l'ouverture commerciale du pays, de son accumulation de capital et du niveau de ses dépenses publiques **(chapitre 2)**. Puis, dans un second temps, nous nous intéressons à l'explication de la non-linéarité de la relation entre l'inflation et la croissance en testant l'effet Tobin de l'inflation sur le capital physique et sur l'effet de substitution entre le travail et l'éducation pour le capital humain. Nous montrons que l'impact positif des taux d'inflation modérés résulte de l'effet Tobin sur le capital physique, tandis que la réduction de l'impact de l'accélération de l'inflation provient d'une meilleure accumulation du capital humain. Nous confirmons tous ces effets et mettons en évidence le rôle du développement financier pour l'ensemble de ces mécanismes **(chapitre 3)**. Enfin, nous abordons la question du manque de cohérence entre la vision macroéconomique fondée sur la détermination d'un seuil optimal d'inflation et les préférences réelles des banques centrales à travers le monde. Nous remarquons que les banques centrales utilisent des modèles microéconomiques néo-keynésiens qui définissent le taux d'inflation optimal comme celui minimisant les dispersions dans les marchés des produits et des facteurs de production. Nous testons alors l'effet de l'inflation sur la variabilité des prix relatifs et de la croissance ; nos résultats montrent que seul un faible taux d'inflation positif réduit ces incertitudes et cela quel que soit le niveau de revenu du pays. Concernant les pays émergents de notre échantillon, le choix du régime de politique monétaire affecte également cette variabilité **(chapitre 4)**.
Mots clés: Inflation, Croissance Economique, Capitale physique, Capital humain, Variabilité des prix relative, Variabilité de taux de croissance, Modelé PSTR.

The effects of inflation on economic growth and on its macroeconomic determinants

Abstract:
This thesis is concerned with the effects of inflation on output growth and on its determinants. In the first step, our study analyzes two aspects of the inflation–growth relationship. First, it examines the nonlinearity of the relationship between inflation and output growth and identifies several thresholds for the global sample and for various income-specific sub-samples. Secondly, it identifies some country-based macroeconomic features that influence this nonlinearity. Our empirical results substantiate both views and validate the fact that the inflation–growth nonlinearity is sensitive to a country's trade openness capital accumulation, and government expenditures (**chapter 2**). After that, we explain this inflation–growth nonlinearity by testing a Tobin effect of inflation on physical capital and a substitution effect – from work to education – for human capital. We find that the positive effects of moderate inflation rate are due to the Tobin effect on physical capital whereas a weak negative effect of high inflation rate stems from a better human capital accumulation. We identify a strong role of well developed financial systems in all these mechanisms (**chapter 3**). Lastly, we address a lack of coherence between the macro based optimal inflation thresholds for output growth and the actual preferences of central banks around the world. We notice that central banks use micro based New-Keynesian models and their optimal inflation rate is the one that minimizes dispersions in factors and product markets. We test the effect of inflation on relative price variability and output growth variability and, for all income groups, the results support a slight positive inflation rate to minimize these uncertainties. For our selected emerging economies, monetary policy regimes also affect these dispersions (**chapter 4**).
Keywords : Inflation, Output Growth, Physical Capital, Human Capital, Relative Price variability, Output Growth Variability, PSTR Model

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