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THÈSE DE DOCTORAT

Stabilité financière et coordination des
politiques économiques

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GREDEG-CNRS

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du grade de docteur en Sciences Economiques
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Stabilité financière et coordination des politiques économiques

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Résumé

Cette thèse propose une analyse du triangle politique monétaire – politique prudentielle – prise de risque. En ce sens, cette thèse vise à étudier les effets de la politique monétaire sur la prise de risque des banques. Elle cherche également à déterminer les conditions de coordination des politiques monétaires et prudentielles nécessaires pour assurer la stabilité du secteur bancaire et la solvabilité des institutions financières. Au niveau macro-économique, nous évaluons l'impact de cette coordination sur le crédit domestique et le coût attendu de la faillite bancaire. Dans le premier chapitre, nous proposons une revue de la littérature de l'analyse théorique et empirique du canal de la prise de risque ainsi que de la question de la coordination de la politique monétaire et de la politique prudentielle. Cette revue de la littérature permet de montrer que les effets de la politique monétaire sur le risque bancaire ne sont pas univoques, remettant en question la connaissance que l'on a du canal de la prise de risque. De même, ce chapitre permet d'indiquer que les modalités de coordination des politiques monétaires et prudentielles sont multiples. Le deuxième chapitre propose une étude empirique originale du canal de la prise de risque de la politique monétaire. Nous développons un modèle de panel à effet de seuil qui permet de montrer que la politique monétaire a des effets différents selon le "régime monétaire" dans lequel celle-ci est menée. Ainsi, une baisse des taux d'intérêt engendre une prise de risque de la part des banques si la politique monétaire est considérée comme souple (taux d'intérêt en-dessous du taux issu de la règle de Taylor). Inversement, lorsque la politique monétaire est considérée comme plus stricte (taux d'intérêt au-dessus du la règle de Taylor) une baisse des taux d'intérêt réduit la prise de risque de la part des banques. Le troisième chapitre s'intéresse à l'impact de la politique monétaire sur le risque bancaire selon la nature de la politique prudentielle. A l'aide d'un modèle d'équilibre partiel, nous déterminons les conditions sous lesquelles la politique monétaire, en présence d'un ratio de capital réglementaire sensible au risque, conduirait à une prise de risque des banques. Les résultats montrent que les effets de la politique monétaire sur le risque bancaire ne sont pas indépendants de la nature de la politique microprudentielle. Par ailleurs, les objectifs de stabilité financière et de réduction du coût de la faillite bancaire, pris en compte conjointement, permettent d'identifier des situations dans lesquelles le couplage d'une politique macroprudentielle à une politique microprudentielle s'avère nécessaire. Toutefois, l'intervention du macroprudentiel, qui se fait aux dépens du financement de l'économie, n'est pas toujours efficace pour limiter les coûts de la faillite bancaire.

Mots clés : Politique prudentielle; Politique monétaire; Canal de prise de risque; Modèle de panel à effets de seuil; Modélisation en équilibre partiel.

Abstract

This thesis proposes an analysis of the triangle formed by monetary policy, prudential policy and bank's risk-taking. Accordingly, this thesis aims to study the effects of monetary policy on banks' risk-taking and to determine the conditions for monetary and prudential policy coordination in order to ensure the stability of the banking sector and the solvency of financial institutions. At the macroeconomic level, we also assess the impact of this coordination on domestic credit and on the expected cost of bank failure. The first chapter reviews the literature on theoretical and empirical analysis of the risk-taking channel, and the analysis of the issue of monetary policy coordination with prudential policy. This literature review reveals that the effects of monetary policy on bank risk-taking are not one-sided, calling into question our knowledge of the monetary risk-taking channel. Similarly, this chapter suggests that the nature of monetary and prudential policy coordination is not unique. The second chapter is devoted to an original empirical study on the risk-taking channel of monetary policy. Using a panel threshold model, we show that monetary policy has different effects depending on the "monetary regime" in which monetary policy is conducted. Thus, a fall in interest rates leads to more risk-taking if monetary policy is considered loose (interest rate below the Taylor rule rate). Conversely, when monetary policy is considered as restrictive (interest rate above Taylor's rule rate), a decrease in interest rate reduces banks risk level. The third chapter examines the impact of monetary policy on bank's risk according to the nature of prudential policy. Using a partial equilibrium model, we determine conditions under which monetary policy, in presence of a risk sensitive capital requirement ratio, would lead the bank to take more risk. The results show that the effects of monetary policy on banking risk are not independent of the nature of microprudential policy. The objectives of financial stability and reduction of the cost of a bank failure, taken together, makes it possible to identify situations in which it is necessary to complement the microprudential tool with a macroprudential one. However, macroprudential intervention, which comes at the expense of financing the economy, is not always effective in limiting the costs of bank failure.

Keywords: Prudential policy; Monetary policy; Risk-taking channel; Panel threshold model; Partial equilibrium modelling.

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To my Parents

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INTRODUCTION GENERALE

Au lendemain de la crise financière de 2008, les systèmes bancaires ont connu deux changements majeurs. D'une part, les banques centrales des économies développées ont mis en oeuvre des politiques monétaires tant conventionnelles que non conventionnelles. Elles ont fixé les taux d'intérêt à des niveaux très bas, ont même parfois opté pour des taux d'intérêt négatifs et ont acheté des actifs financiers à grande échelle. D'autre part, les autorités de régulation ont renforcé la réglementation bancaire (réglementation microprudentielle) et ont mis en place de nouveaux outils comme la politique macroprudentielle. Leurs objectifs étaient doubles : sauvegarder et renforcer la stabilité du système bancaire ; stimuler la croissance économique. Alors que le second objectif semble avoir été atteint, la réalisation du premier objectif reste en suspend car la période de taux d'intérêt bas semble avoir des effets néfastes sur le comportement des banques et la stabilité financière.

D'une part, des taux d'intérêt bas réduisent le coût de refinancement des banques, ce qui joue positivement sur leurs bénéfices. D'autre part, une longue période de taux d'intérêt monétaire très bas ou négatifs réduit la marge d'intérêt des banques. Ce mécanisme joue négativement sur leurs bénéfices.

Par conséquent, d'un point de vue théorique, une période prolongée de taux d'intérêt bas peut exacerber la prise de risque des banques afin d'augmenter leurs profits (Rajan, 2005 ; Jimenez et al., 2008 ; Gambacorta, 2009 ; Altunbas et al. 2010). La prise de risque peut être comprise comme une action ou une décision des banques qui induit une plus grande volatilité des actifs et déprécie la solidité des banques. L'impact d'un taux d'intérêt bas sur la prise de risque est double.

Premièrement, un taux d'intérêt bas modifie *ex-ante* les incitations des agents économiques à prendre des risques (Borio et Zhu, 2012 ; Dell'Araccia et Marquez, 2013). Les mécanismes à l'oeuvre sont simple et sont fondés sur ce que Rajan (2005) décrit comme le « paradigme de la recherche du rendement ». La recherche de rendement dans un environnement de taux d'intérêt bas augmente la demande d'actifs risqués. La demande massive de ces actifs pousse leur prix à la hausse, réduisant ainsi les primes de risque qui leur sont attachées et envoyant un « faux » signal sur leur qualité réelle. Ce mécanisme est auto-entretenu puisque la baisse générale des rendements, combinée à l'illusion d'une baisse des niveaux de risque, augmente l'incitation à prendre des risques. Le système financier devient donc plus fragile, car les actifs détenus par les agents financiers (banques, fonds de pension, investisseurs privés) sont généralement plus risqués.

Deuxièmement, il assouplit *ex-post* les contraintes de financement des agents, ce qui augmente leur niveau d'endettement global (Bernanke et Blinder, 1988 ; Bernanke et Gertler, 1989).

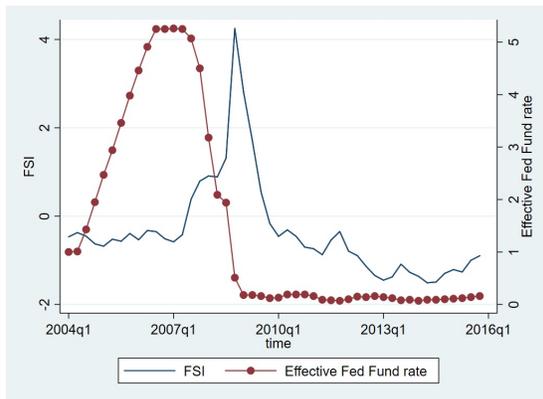
Une politique de taux d'intérêt bas réduit le coût du capital et facilite la substitution des fonds propres aux dépôts, ce qui encourage les banques à accorder des prêts. Une telle politique se traduit également par une valorisation importante des actifs (bulles immobilières ou financières) et une appréciation de la richesse des agents, leur conférant ainsi une plus grande solvabilité (en raison d'une valeur plus élevée de leurs garanties). Le niveau d'endettement (c'est-à-dire le rapport entre les actifs et les capitaux propres) augmente, ce qui accroît la vulnérabilité des bilans en cas de chocs macroéconomiques négatifs. En définitive, la politique monétaire peut modifier la composition des bilans des agents privés et des banques : à l'actif, en augmentant le poids des titres risqués, au passif, en augmentant l'effet de levier, ce qui affaiblit la stabilité du système financier dans son ensemble.

Ainsi, la prise de risque peut se caractériser par une réduction des fonds propres exigés (même si les banques se conforment à la réglementation), une dégradation du ratio de levier, des prêts excessifs ou un assouplissement des conditions d'octroi de crédit, une détérioration de la qualité des prêts accordés et une diminution de la liquidité de la banque. Le comportement de prise de risque des banques est un facteur majeur qui pourrait nuire à la stabilité financière, entraînant une diminution de la stabilité financière. Cette dernière peut se définir au sens large comme la capacité du système financier à fournir de manière cohérente les services d'intermédiation de crédit et de paiement qui sont nécessaires pour que l'économie réelle puisse poursuivre sa croissance (Rosengren, 2011).¹

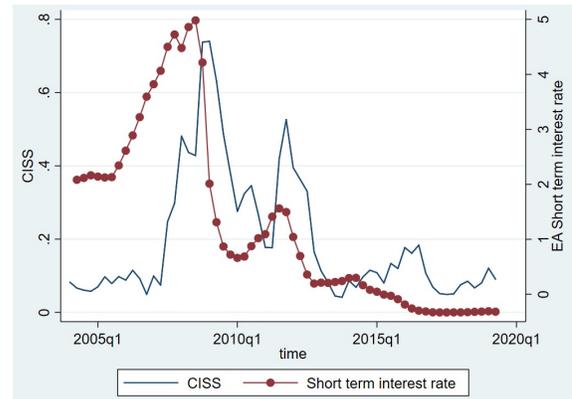
Cependant, la prédiction suivant laquelle la stabilité financière se détériorerait ne semble pas se réaliser puisque le système apparaît stable. Deux indices, visant à évaluer la stabilité du système financier, sont généralement utilisés : l'indice de stress financier (FSI) et à l'indice composite de stress systémique (CISS), utilisés respectivement aux États-Unis et dans la zone euro. Le FSI mesure le degré de stress financier sur les marchés et est construit à partir de 18 séries de données hebdomadaires : sept séries de taux d'intérêt, six écarts de rendement et cinq autres indicateurs. Le CISS est un outil alternatif à l'ISF et comprend 15 mesures de stress financier, principalement basées sur les marchés financiers, réparties en cinq catégories, à savoir le secteur des intermédiaires financiers, les marchés monétaires, les marchés des actions, les marchés obligataires et les marchés des changes. Comme le montrent les Figures 1a et 1b, alors que les taux d'intérêts sont bas, depuis 2010, les systèmes financiers semblent solides.

¹Rosengren E. (2011), "Defining financial stability, and some policy implications of applying the definition", Keynote remarks at the Stanford Finance Forum, Graduate School of Business, *in* Kashyap et al. (2014), « Deux principes pour la réglementation macroprudentielle », *Revue de la Stabilité Financière*, avril 2014.

(a) Taux d'intérêt et FSI aux États-Unis



(b) Taux d'intérêt et CISS dans la zone Euro



Source: Les graphes ont été réalisés grâce aux données collectées sur les sites de FRED et de la BCE

Figure 1: Aperçu des taux d'intérêt et des indices de stress financiers aux USA et en zone Euro

On peut alors imaginer que les politiques prudentielles ont joué efficacement leur rôle et neutralisé la source d'instabilité financière induite par des taux d'intérêt excessivement bas. En augmentant les fonds propres des banques, le renforcement des exigences de fonds propres requis par la nouvelle réglementation de Bâle III augmente la contribution aux pertes des actionnaires, ce qui fait que la majeure partie du coût lié à la prise de risques excessifs serait supportée par ces derniers. Par conséquent, en atténuant les incitations des banques à prendre des risques, la politique prudentielle devrait compenser les effets négatifs d'une politique monétaire accommodante (Gertler et Karadi, 2011).

Néanmoins, deux problèmes apparaissent immédiatement. Le premier est que l'impact de la politique prudentielle peut être limitée par la nature de la politique monétaire (Agur et Demertzis, 2012). Par exemple, l'exigence de fonds propres est moins stricte en période de croissance économique favorisée par une politique de taux d'intérêt bas. Le second est que la politique prudentielle peut également affecter l'économie réelle et peut entrer en conflit avec les objectifs de la politique monétaire. Ainsi, l'augmentation des exigences en fonds propres (approche microprudentielle), l'introduction d'un effet de levier maximal ou d'un volant de fonds propres contracyclique (approche macroprudentielle) peuvent limiter le volume de crédit, accroître les contraintes de financement et avoir un impact sur l'activité économique et sur le niveau d'inflation. Par conséquent, la politique monétaire et la politique prudentielle peuvent interagir. Ces interactions soulèvent la question de la coordination des deux politiques pour un résultat satisfaisant pour les sphères économique et financière.

Objectif et structure de la thèse

L'objectif de cette thèse est donc d'étudier le triptyque politique monétaire - politique prudentielle - risque bancaire afin de déterminer les conditions de renforcement de la stabilité financière et de préservation de l'économie de pertes sévères en cas de crise. Plus précisément, notre contribution est double.

D'un point de vue empirique, nous essayons d'identifier un éventuel effet non-linéaire dans le canal de la prise de risque des banques. La littérature empirique existante analyse le canal de prise de risque à l'aide de modèles linéaires et établit un effet univoque de la politique monétaire sur le risque bancaire. Cependant, les changements de taux d'intérêt affectent à la fois l'actif et le passif des bilans bancaires. En ce sens, la politique monétaire a un impact à la fois sur les revenus et les coûts des banques. Les approches linéaires peuvent ne pas tenir compte de ces deux effets. Nous nous demandons donc si l'impact de la politique monétaire sur le risque de la banque est univoque ou s'il dépend du poids relatif de ces effets.

D'un point de vue théorique, nous analysons si l'effet de la politique monétaire sur le risque des banques dépend de la sévérité de la politique prudentielle et explorons l'impact de la prise de risque sur le coût attendu des faillites bancaires. La mise en œuvre d'une politique microprudentielle affecte le passif des banques par le biais de la quantité et du coût du capital. Par conséquent, la politique microprudentielle peut modifier la manière dont la politique monétaire affecte le comportement de prise de risque des banques. De plus, l'ampleur différente des crises passées nous incite à nous interroger sur le lien entre la stabilité financière et le coût d'une crise bancaire. On peut se demander si une plus grande instabilité financière est nécessairement liée à un coût plus élevé d'une crise bancaire. Alors que la politique prudentielle vise à limiter la prise de risque et le coût de la crise, la remise en cause de la relation entre la prise de risque des banques, la stabilité financière et le coût de ces crises appelle à revoir l'analyse de la coordination des politiques monétaire et prudentielle.

Nous prévoyons d'organiser la thèse en trois chapitres étroitement liés.

Dans le premier chapitre, nous faisons une revue de la littérature des études théoriques sur les conditions d'émergence d'un canal de la prise de risque selon la nature de la politique monétaire et ses liens avec la politique prudentielle. L'identification d'un tel canal est au cœur de la question d'un éventuel arbitrage entre les différents objectifs de politique économique et donc de leur coordination. De nombreuses études empiriques ont déjà identifié l'existence d'un canal de la prise de risque et confirment l'effet de taux d'intérêt bas sur l'appétit des

banques pour le risque.² Plus les taux d'intérêt sont bas, plus les banques prennent des risques. Néanmoins, il semble qu'il n'y ait pas de consensus parmi les travaux théoriques sur la question. D'une part, l'assouplissement monétaire stimule l'appétit des banques pour le risque par différents canaux : le canal du bilan (de la banque et des emprunteurs) (Bernanke et Gertler, 1989 ; Rajan, 2005) et le canal de la liquidité (Diamond et Rajan, 2006). D'autre part, d'autres études montrent que l'assouplissement monétaire peut être bénéfique pour les banques et limiterait leur prise de risque. La baisse des taux d'intérêt réduit les coûts d'opportunité et de refinancement de la banque, et augmente la valeur de franchise de la banque (Smith, 2002 ; Agur et Demertzis, 2012 ; Korinek et Simsek, 2016). En ce sens, les banques sont encouragées à réduire leur risque suite à la baisse des taux d'intérêt. On peut toutefois citer Dell'Ariccia et al. (2014) qui contrastent les effets de la politique monétaire sur le risque bancaire. Ils montrent que les effets d'une politique de taux d'intérêt bas seront différents selon que les banques peuvent ou non ajuster leur niveau de capital. Par ailleurs, De Nicolò et al (2010) mettent en évidence deux forces opposées qui jouent un rôle dans le canal de la prise de risque : l'effet de recherche du rendement et l'effet de transfert du risque. Alors que le premier effet entraîne une plus grande prise de risque suite à la baisse des taux d'intérêt, le second effet produit le résultat inverse. La baisse des taux entraîne une diminution du coût des engagements de la banque. Dès lors, afin de s'assurer le maximum de profit en cas de succès de ses investissements, cette dernière est encouragée à investir dans des actifs moins risqués et donc à prendre moins de risques. En résumé, on peut imaginer que l'impact de la politique monétaire sur le risque bancaire est non linéaire et dépend de certains facteurs qui se doivent d'être identifiés.

En outre, la littérature existante prouve que, même si les politiques monétaires et prudentielles doivent se concentrer sur leurs objectifs respectifs et être menées par deux institutions distinctes ou non, elles interfèrent inévitablement. C'est pourquoi elles devraient être coordonnées. Bien que ce point de vue soit maintenant largement partagé, les effets positifs de l'assouplissement de la politique monétaire ou les effets négatifs de la contraction monétaire sur le comportement de prise de risque de la banque sont ignorés. Dans les modèles théoriques, l'assouplissement de la politique monétaire est considéré comme un facteur de prise de risque de la banque et une menace pour la stabilité financière. De plus, les implications de la politique monétaire en termes de stabilité financière et de coût attendu de la résolution des crises en présence d'une politique prudentielle restent posées.

Dans le deuxième chapitre, nous approfondissons l'analyse empirique sur le canal de prise de

²pour une synthèse des études empiriques, voir Gambacorta (2009).

risque en identifiant l'existence d'effets de seuil dans l'impact de la politique monétaire sur l'incitation à la prise de risque des banques. Nous avons souligné que le canal de la prise de risque mobilise des canaux traditionnels de transmission de la politique monétaire tels que le canal de la richesse ou du crédit. Néanmoins, les résultats contradictoires de la littérature existante, tels que relevés dans le chapitre 1, motivent notre détermination à reconsidérer le lien entre la politique monétaire et le risque bancaire. Les effets de l'assouplissement monétaire, tant en termes de pertes de marge que de réduction de coût de refinancement, ne sauraient être exclusifs. Nous pensons que l'impact final de la politique monétaire sur le risque bancaire résulte de l'interaction de ces deux effets. En outre, il existe des règles, comme la règle de Taylor, qui régissent le processus de fixation des taux d'intérêt. Il arrive cependant que les autorités monétaires s'écartent de ces règles. Il est donc possible que l'intensité des deux effets soit différente en fonction de la position de l'économie dans le cycle monétaire (position relative du taux d'intérêt monétaire par rapport à la règle de Taylor). En ce sens, l'impact de la politique monétaire sur le risque de la banque peut ne pas être indépendant de la position de l'économie dans le cycle monétaire (déviations de la règle de Taylor). Ainsi, alors que Ioannidou et al. (2007) montrent que la politique monétaire accommodante en Bolivie pousse les banques à accorder des prêts à risque, Gambacorta (2009) et Altunbas et al. (2010) montrent que le risque bancaire augmente en présence d'un assouplissement de la politique monétaire et que cet effet est amplifié pour les écarts de taux monétaires inférieurs au taux de la règle de Taylor. Ce dernier résultat suppose un impact linéaire des chocs monétaires sur le risque bancaire, quelle que soit l'importance de l'écart par rapport à la règle de Taylor. C'est ce point que nous proposons d'approfondir en identifiant s'il existe un seuil au-dessus duquel les effets de la politique monétaire sur le risque bancaire changent. Pour ce faire, nous choisissons un modèle de panel non dynamique à effets de seuil tel que développé par Hansen (1999). Dans notre spécification, la variable seuil est la différence entre les taux monétaires et les taux de la règle de Taylor (1993 ; 1999). Les résultats mettent en évidence un seuil dans l'écart du taux d'intérêt monétaire à celui issu de la règle de Taylor à partir duquel l'effet d'une variation du taux monétaire sur le risque de la banque s'inverse.

Le troisième chapitre a pour objectif de proposer une modélisation de la coordination des politiques monétaire et prudentielle. Nous proposons d'étudier ce policy-mix dans un modèle d'équilibre partiel. Sur la base des conclusions des chapitres 1 et 2, il est légitime de se demander si l'effet de la politique monétaire sur le risque bancaire doit être analysé indépendamment de l'intensité de la politique prudentielle. Nous proposons de compléter la littérature existante en examinant la transmission de la politique monétaire au comportement de prise de risque des banques en présence d'un capital réglementaire sensible au risque. En outre, il a été démontré que la prise de risque des banques a été le principal facteur de

la crise financière, ce qui a conduit à la mise en œuvre d'une politique macroprudentielle. Conformément à Bâle III, selon lequel le régulateur vise à limiter la fréquence et l'ampleur des crises, nous tenons également compte du coût de la défaillance des banques dans notre analyse. Par conséquent, nous évaluons l'impact de la politique monétaire sur le coût attendu de la résolution d'une crise et examinons les conditions sous lesquelles la politique prudentielle peut être efficace pour réduire ce coût attendu. En ce sens, la contribution de ce chapitre est d'analyser l'incidence de la combinaison de la politique monétaire et de la politique prudentielle en termes de stabilité financière et de coût social attendu des faillites bancaires. Nous constatons que l'impact d'une variation des taux d'intérêt sur le risque de la banque est non linéaire et dépend de la sensibilité au risque du ratio d'exigence de fonds propres par rapport à la sensibilité au risque des revenus d'intermédiation de la banque. De même, l'effet de la politique monétaire sur le coût social de la faillite des banques n'est pas uniforme. Étant donné que l'assouplissement monétaire peut entraîner ou non une prise de risque de la part de la banque, il peut également être suivi d'une augmentation ou d'une diminution du coût attendu de la résolution de la crise. Ainsi, nous mettons en évidence des situations dans lesquelles il est inutile de coupler un outil macroprudentiel à un outil microprudentiel. En résumé, une meilleure évaluation de la situation en termes de prise de risque est primordiale pour une meilleure coordination des actions des autorités monétaires et prudentielles.

GENERAL INTRODUCTION

In the aftermath of the 2008 financial crisis, two major changes impacted banking systems. On the one hand, central banks of developed economies have implemented both conventional and unconventional monetary measures. They set interest rates at very low levels, sometimes even opt for negative interest rates and bought financial assets on a massive scale. On the other hand, regulatory authorities increased the weight of the banking regulation (microprudential regulation) and implemented new tools as macroprudential policy. Their objectives were twofold: to rescue and strengthen the banking system; to stimulate economic growth. Whereas the second objective seems to have been achieved, the first is still in question since period of low interest rate seems to have deleterious impacts on banks' behaviour and financial stability.

On the one hand, low interest rate reduce the refinancing cost of banks which plays positively on their profits. On the other hand, long period of very low or negative monetary interest rate depress banks' interest margin. This mechanism plays negatively on their profits.

Consequently, from a theoretical point of view, extended period of low interest rate may exacerbate banks risk-taking in order to increase profits (Rajan, 2005; Jimenez et al., 2008; Gambacorta, 2009; Altunbas et al. 2010). Risk-taking can be understood as an action or a decision of banks that induces higher asset volatility and depreciates banks soundness. The impact of low interest rate on risk-taking is twofold.

First, it modifies *ex-ante* banks' incentives to take risks (Borio and Zhu, 2012; Dell'Ariccia and Marquez, 2013). The mechanisms at work are simple and based on what Rajan (2005) describes as the "paradigm of the search for yield". The search for yield in a low interest rate environment increases demand for risky assets. The massive demand of these assets pushes up their price, thus reducing the risk premiums attached to them and sending a "fake" signal on their actual quality. This mechanism is self-sustaining since the general decline in returns, combined with the illusion of falling risk levels, increases the incentive to take risks. The financial system is thus becoming more fragile, as the assets held by financial agents (banks, pension funds, private investors) are generally riskier.

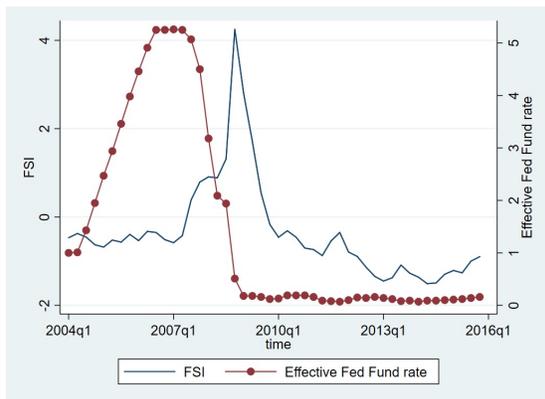
Second, it relaxes *ex-post* the funding constraints on agents, thereby increasing their overall debt levels (Bernanke and Blinder, 1988; Bernanke and Gertler, 1989). A low interest rate policy reduces the cost of capital and facilitates the substitution of equity for deposits, thus encouraging banks to grant loans. Such a policy also results in a significant valuation of assets (e.g. real estate or financial bubbles) and an appreciation of the wealth of agents. Then, agents benefit from greater creditworthiness (due to a higher value of their collateral). The level of leverage (i.e. the ratio between asset and equity) increases, exacerbating the

vulnerability of balance sheets to macroeconomic shocks. Ultimately, monetary policy can change the composition of private agents' and banks' balance sheets: on the assets side by increasing the weight of risky securities, on the liabilities side by increasing leverage, weakening the stability of the whole financial system.

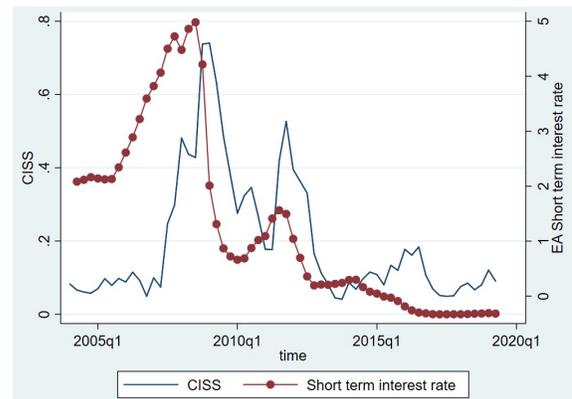
Thus, risk-taking can induce reduced capital requirements (even if the banks comply with the regulation), degradation of leverage ratios, excessive lending or softening of credit standards, deterioration of loan quality, and decreased liquidity. Banks' risk-taking behaviour is then a major factor that can deter financial stability that is broadly defined as *“the ability of the financial system to consistently supply the credit intermediation and payment services that are needed in the real economy if it is to continue on its growth path”* (Rosengreen, 2011).³

However, this prediction seems to be yet unfulfilled since the financial system appears stable. Two indexes are widely used to assess the stability of the financial system: the financial stress index (FSI) and the Composite Index of Systemic Stress (CISS) respectively used in the USA and in the euro area. The FSI measures the degree of financial stress in the markets and is constructed from 18 weekly data series: seven interest rate series, six yield spreads and five other indicators. The CISS is an alternative tool to the FSI and includes 15 mostly market-based financial stress measures equally split into five categories, namely the financial intermediaries sector, money markets, equity markets, bond markets and foreign exchange markets. As depicted in figures 2a and 2b, while the monetary interest rates are low, from 2010, the financial systems appear solid.

(a) Interest rate and Financial stress index in USA



(b) Short term interest rate and CISS in the euro area



Source: Data for the graphs are collected on the FRED and on the ECB websites

Figure 2: Overview of interest rate and financial stress index in USA and Euro area

³Rosengreen E. (2011), *Opcit.*

It is then possible to imagine that prudential policies have efficiently play their role and counter the source of financial instability induce by excessive low interest rate. By increasing banks' equity, higher capital requirement required by the new regulation of Basel III increases the shareholders' "*skin in the game*", making them to bear most of the cost associated to excessive risk-taking. Consequently, by mitigating banks' risk-taking incentives, prudential policy should offset the negative effects of an accommodative monetary policy (Gertler and Karadi, 2011).

Nevertheless, two problems appear immediately. The first one is that prudential policy can be constrained by the nature of monetary policy (Agur and Demertzis, 2012). For example, bank capital standards are less stringent in times of economic growth fostered by a low interest rate policy. The second one is that prudential policy can also affect the real economy and may conflict with monetary policy objectives. Thus, the increase in constraints on bank capital (microprudential approach), the introduction of maximum leverage or a counter-cyclical capital buffer (macroprudential approach) can limit the volume of credit, increase financing constraints and have an impact on the economic activity and on the level of inflation. Therefore, monetary policy and microprudential policy may interact. These interactions raise the question of the coordination of the two policies for a satisfying outcome for the economic and the financial spheres.

Objective and structure of the thesis

The objective of this thesis is to study the "eternal triangle" between monetary policy, prudential policy and bank's risk in order to determine the conditions for strengthening financial stability and preserving the economy from severe losses in the event of a crisis. Specifically, our contribution are twofold.

From the empirical point of view, we try to identify a possible non-linearity effect in the banks' risk-taking channel. The existing empirical literature analyses the risk-taking channel using linear models and establishes a unidirectional effect of monetary policy on bank's risk. However, change in interest rate affects both the asset side and the liabilities side of banks balance sheets. In this sense, monetary policy impacts both banks revenues and costs. The linear approaches may fail in accounting for these two effects. We thus ask if the impact of monetary policy on bank's risk is unique or may depends on the bargaining power of these effects.

From the theoretical point of view, we analyse whether the effect of monetary policy on bank's risk depend on the strength of the prudential policy and explore the impact of risk taking

to the expected cost of bankruptcy. The implementation of microprudential policy affects the liabilities side of banks through the cost of capital. Therefore, microprudential policy may change the way that monetary policy affects bank's risk-taking behaviour. Moreover, the different magnitude of past crisis questions the link between financial stability and the cost of a bank crisis. We can ask if higher financial instability is necessarily related to higher cost of a crisis. Whereas prudential policy aims to limit risk-taking and the cost of crisis, questioning the relation between bank's risk-taking, financial stability and cost of crisis calls for revisiting the analysis of the coordination of monetary and prudential policy.

We plan to organize the thesis into three chapters closely related.

In the first chapter, we make a literature review of theoretical studies on the conditions for the emergence of a monetary policy risk channel and its links with prudential policy. The identification of such a channel is at the heart of the question of a possible trade-off between the different economic policy objectives and therefore their coordination. Many empirical studies have already identified the existence of such a channel and confirm the negative effect of low interest rate on bank's risk-taking appetite.⁴ The lower the interest rate, the more the banks take risk. Nevertheless, it appears that there is not a consensus among theoretical works on this issue. On the one hand, monetary easing whets banks' risk appetite through various channels: the (bank's and the borrowers') balance sheet channel (Bernanke and Gertler, 1989; Rajan, 2005) and the liquidity channel (Diamond and Rajan, 2006). On the other hand, other studies show that monetary easing can be beneficial for banks and would limit their risk-taking. The interest rate cut reduces the bank's opportunity costs and refinancing costs and increases its franchise value (Smith, 2002; Agur and Demertzis, 2012; Korinek and Simsek, 2016). In this sense, banks are encouraged to reduce their risk following a decrease in interest rate. However, Dell'Ariccia et al. (2014) contrast the effects of monetary policy on bank's risk. They show that the effects of a low interest rate policy will be different depending on whether banks can adjust or not their capital level. De Nicolò et al (2010) highlight two opposing forces that play a role in the risk-taking channel: the search for yield effect and the risk transfer effect. While the first effect results in a greater risk taking following the fall in interest rates, the second effect produces the opposite result. The decrease in interest rate leads to a decrease in the cost of the bank's liabilities. Then, the bank, in order to capture the maximum gains from the success of its investments, is encouraged to invest in less risky assets and therefore to take less risk. In a nutshell, we can imagine that the impact of monetary policy on bank's risk is non-linear and depends on some

⁴For a synthesis of the empirical studies, see Gambacorta (2009).

factors that need to be identified.

In addition, the existing literature proves that, even if monetary and prudential policy should focus on its respective objective and be conducted by two separated institution or not, they inevitably interfere and should be coordinated. Even if this point of view is now widely shared, there is no room for the positive effects of monetary policy easing or for negative effects of monetary policy contraction on the bank's risk-taking behaviour. Monetary policy easing in theoretical models is considered as a factor of bank's risk-taking and a threat to financial stability. The question of the impact of monetary policy on the financial stability and the expected cost of crisis resolution in presence of prudential policy is still left opened.

In the second chapter, we deepens the empirical analysis on the risk-taking channel by identifying the existence of threshold effects of the impact of monetary policy on banks' risk-taking incentives. We pointed out that the risk-taking channel mobilizes other traditional monetary policy transmission channels such as the wealth or credit channel. Nevertheless, the opposing results of existing literature, as enlightened in chapter 1, motivate our determination to reconsider the link between monetary policy and banking risk. The effects of monetary easing in terms of both margin losses and lower refinancing cost are not exclusive. We believe that the final impact of monetary policy on banks risk results from the interaction of these two effects. Moreover, there are rules, such as the well-known Taylor rule, that govern the process of interest rate setting. However, it happens that monetary authorities deviate from those rules. Therefore, it is possible that the intensity of the two effects may be different according to the position in the monetary cycle (relative position of monetary interest rate with regard to the Taylor rule). In this sense, the impact of monetary policy on bank's risk may not be independent from the monetary stance (deviation from the Taylor rule). Hence, while Ioannidou et al. (2007) show that accommodative monetary policy in Bolivia pushes banks to grant risky loans, Gambacorta (2009) and Altunbas et al. (2010) show that banking risk increases in the presence of a relaxation of monetary policy and that this effect is amplified for deviations of monetary rates below the Taylor rule rate. The latter result assumes a linear impact of monetary shocks on bank risk regardless of the size of the deviation from the Taylor rule. This is the point that we propose to further explore by identifying whether there is a threshold above which the effects of monetary policy on bank risk change. To do this, we choose a non-dynamic Panel Thresholds Model inked on Hansen's (1999) model. In our specification, the threshold variable is the difference between monetary rates and rates from the Taylor rule (1993; 1999). The chapter provides evidence of a threshold in the deviation of the interest rate from the Taylor rule based interest rate from which the effect of policy rate on bank's risk reverses.

The third chapter is based on a theoretical modelling. We propose to study policy-mix (between prudential and monetary policy) in a partial equilibrium model that is close to models on banking regulation (Dell’Ariccia and Marquez (2006), Kara (2016) and Agur and Demertzis (2019)). Based on the concluding remarks in chapter one and chapter two, it is legitimate to ask whether the effect of monetary policy on bank’s risk should be analysed independently from the strength of the prudential policy. We intend to fill the gap in the existing literature by examining the transmission channel of monetary policy to banks risk behaviour in presence of a risk sensitive capital requirement ratio. Moreover, it has been shown that banks’ risk-taking was the main factor of the financial crisis, leading to the implementation of macroprudential policy. In line with the Basel III, according to which the regulator aims at limiting the frequency and the magnitude of crisis, we also account for the cost of bank failure in our analysis. Therefore, we also assess the impact of monetary policy on the expected cost of the resolution of a crisis and examine conditions under which prudential policy may be effective in reducing the expected cost of crisis resolution. In this sense, the contribution of this chapter is to analyse the incidence of combination of monetary and prudential policy in terms of financial stability and expected social cost of bankruptcy. We find that the impact of monetary rate on bank’s risk is non-linear and depends on the risk sensitivity of the capital requirement ratio in regard to the risk sensitivity of the bank’s intermediation revenue. Similarly, the effect of monetary policy on the social cost of bank failure is not unique. Since monetary easing can lead either to more or lower risk-taking, it can also be followed by an increase or a decrease in the expected cost of crisis resolution. Then, we evidence situations where combining microprudential tool with macroprudential tool is unnecessary. In a nutshell, monetary and prudential authorities should better assess the situation before coordinating their actions.

Chapter 1

MONETARY POLICY, PRUDENTIAL POLICY AND BANK'S RISK-TAKING: A LITERATURE REVIEW

The 2008 financial crisis highlighted the excessive risk-taking of financial agents and its negative impact on the financial stability. Risk-taking can be defined as any action or decision that creates or increases risk. Referring to the banking system, it could translate into easing of credit conditions or the reduction of the control effort by the bank (Dell’Ariccia et al., 2010). There two notions when referring to financial stability: the robustness of the financial system to external shocks and the resilience to internal shocks (stemming from the system) (Galati and Moessner, 2013). However, we will retain the definition provided by Rosengreen (2011)⁵ and define the financial stability as: *“the ability of the system to provide uninterrupted credit intermediation and payment services that are necessary for the real economy to continue to grow”*.

Backed by the fairly serene climate in the financial markets, financial agents have increased their tolerance threshold to risk and their reliance on the robustness of the financial system. Galati and Moessner (2013) pointed out that the exaggerated reliance in the self-adjustment ability of the financial system drove the underestimation of the explosion of credit and asset prices (particularly in the real estate sector) that resulted in the accumulation of asset stocks and leverage. The pre-crisis macroeconomic conditions seem to have changed the determinants of agents’ risk behaviour, perception and risk tolerance (Borio and Zhu, 2012). In fact, pre-crisis macroeconomic environment was characterized by sustained economic growth, booming real estate and financial markets. Such a favourable climate had already been seen as conducive to the emergence of crises.⁶ However, a potential important factor of bank’s risk-taking may be monetary policy, which proved to be accommodative. The main focus of the analysis in this chapter is on the potential influence of monetary policy on the risk-taking behaviour of banks.

Nevertheless, the authorities have hardly remained insensitive to the crisis and the costs it has entailed. With a view to limiting the recurrence and costs of crises, the authorities have taken measures to strengthen banking supervision. The microprudential policy was complement with a macroprudential view. However, aiming at mitigating bank’s risk-taking and fostering financial stability, prudential policy inevitably interferes with monetary policy. That is, the problem of their coordination is raised and remain an area of improvement. On the one hand, monetary policy is often used to “mop after the crisis”. In the event of a crisis, monetary policy ensures liquidity to financial institutions by lowering interest rate. This strategy aims at preventing the spread and amplification of the crisis (Freixas, 2010). On

⁵Rosengreen E. (2011), *Opcit.*

⁶According to Minsky, stability is destabilizing since it is in times of calm that crises are initiated.

the other hand, if monetary policy aims to promote the economic growth, its action may be hampered by a severe prudential policy. Severe prudential measures such as stringent capital requirement could lead to a credit crunch, thus strangling investment and growth (Galati and Moessner, 2013, European Central Bank (ECB), 2013). Prudential policy can therefore offset the expected effect of a monetary policy of lowering rates.

As a result, it is therefore necessary to address the issue of monetary and prudential policy coordination. But first of all, better coordination requires a better understanding of the impact of prudential and monetary policy on the bank's risk-taking behaviour. In this chapter, we intend to provide an overview of the literature on the prudential policy-monetary policy-banking risk triangle. This review of the literature will enable us to identify areas for reflection in order to complement existing work on the impact of monetary policy on banking risk and on the question of the coordination of monetary and prudential policy.

To achieve this objective, we propose to organize this chapter as follows. First, we present the prudential instruments aimed at disciplining banks and ensuring the stability of the system. Then, we present the potential effects of monetary policy on the bank's risk-taking behaviour. At the end of this second point, we make proposals for further analysis in order to better understand the link between monetary policy and bank's risk-taking. In a last point, we examine how the two policies interact and provide ideas to complement the existing literature.

1 Prudential policy

Banks are considered as important agents for the economy. They fulfill specific roles:

- Smoothing consumption: Diamond and Dybvig (1983) show that banks smooth consumption since their liabilities provide insurance against shock that could face consumer. In case of sudden consumption needs, consumers can withdraw a fraction of their deposits from the bank.
- Information production: Information is generally costly and gives rise to the "*reliability problem*" (difficulty to prove that the information produced is valuable) and to the "*appropriability problem*" (risk that the information may be sold in a chain: purchasers of the information can sell or share the information with others without necessarily diminishing its usefulness to themselves) (see Hirshleifer (1971)). As shown by Leland and Pyle (1997), these problems can be solved by financial intermediaries who issue securities and use the proceeds to invest in a portfolio of securities about which they

are privately informed. In this sense, it can be concluded that the existence of financial intermediaries is rooted in the production of information about potential investments (Campbell and Kracaw, 1980).

- **Monitoring:** Due to information asymmetry, depositors and investors should have confidence on the use of their funds. So, banks exist to monitor borrowers (Diamond, 1984). In fact, only monitoring could ensure that borrowers have enough incentive to honor their promises. However, we should distinguish the “*post monitoring*” from the “*ante monitoring*”. In the former type, monitoring takes place only after the borrower repays the lender (see Townsend (1979) for more details). In the latter type, monitoring takes place before the borrower’s repayment (Diamond, 1984). Since monitoring is costly, it is efficient for depositors and investors to delegate monitoring to banks.
- **Providing liquidity:** as argued by Acharya and Mora (2015) “banks have a natural advantage in providing liquidity to businesses through credit lines and other commitments established during normal time”. So banks are considered as key agents in refinancing the economy.

However they are prone to some risks which require some actions to be taken in view of maintaining their soundness. In fact, due to information asymmetry and moral hazard, banks could be likely to behave such as to maximize their private profit at the expense of depositors and other creditors. The bank’s risk-taking behaviour can translate into search for yield (investing in riskier projects), granting loans to risky borrowers, reducing the monitoring effort, etc. Hence, the banking sector has proven to be the more prone to threats to stability than other sectors of the economy. As stated by Gorton and Winton (2002) “*banks and panics are inherently intertwined*” (p. 64). At any time, depositors can be likely to withdraw all their deposit, to such an extent that banks suspend convertibility. It is then necessary to introduce and to develop prudential measures that aim at fostering individual bank’s soundness, mitigating the occurrence and the magnitude of crisis, and at protecting depositors.

Before presenting prudential tools and their transmission in the real economy, let’s analyse the potential threats to financial stability.

1.1 Sources of threats to financial stability

The threats to financial stability stem from two distinct sources according to which side of the bank’s balance sheet is concerned. The instability stemming from the liability side refers

to the bank runs and contagion (systematic crisis). The instability related to the asset side of the bank balance sheet deals mainly with (excessive) risk-taking.

1.1.1 *Bank run and contagion*

Banks are principal agents of financial intermediation, but they face asymmetric information and uncertainty. While their role as information producers provide banks with economies of scale, they face a risk of runs by achieving their role as maturity transformers. In fact, the deposit contract allow depositors to withdraw cash when needed. If depositors loose confidence in their bank, depositors precipate to their bank in order to withdraw their funds, what is qualified as a run. To satisfy the massive withdraw the bank sell its liquid assets. If the withdraws persist the bank may become insolvent since it may not have enough liquid assets to sell in order to satisfy all depositors.

A model of bank run is developed by Diamond and Dybvig (1983). Their model is a two periods model where banks maximize the utility of depositors (inter-temporal consumption) through a deposit contract. They show that under certain conditions all depositors withdraw their funds prematurely and the bank collapses (bad equilibrium). The bank run, here, is irrational since it is simply the fear of being the last one to withdraw that lead depositors to withdraw. However, a bank run can be rational when it is an information-based run. In this case, bank runs occur in response to changes in fundamentals. For example, if depositors anticipates that bank will face a liquidity shock that will shrink its probability to meet its commitments, depositors could suddenly withdraw their funds. We find such an explanation in Jacklin and Bhattacharya (1988). These authors show that if the expected utility from withdrawing prematurely exceeds the expected utility from waiting and receiving the consumption profile initially designed for them, depositors withdraw their funds prematurely and a run occurs. Chari and Jagannathan (1988) make the two type of bank runs coexist. They distinguish between informed and uninformed depositors. In some situations, individuals may withdraw for other reasons than a concern about the bank insolvency. If uninformed individuals observe an important line of depositors before the bank, they may fear a banks insolvency problem. Then, uninformed individuals will be misled and will precipitate a run on the bank. The growing withdraws scale may also lead informed individuals to run to bank because of real concern about the bank insolvency. Thus, the run is both irrational and information-based since early observable withdraw could simply be for consumption and not an indicator of negative signal on the bank solvency, leading to irracionale run. Then, later, the irracionale run induces a ratioanle one. Therefore, bank runs could result from either coordination failure among depositors or anticipation of bank

unsoundness or both. However, banks run should be distinguished from banking panic. As stated by Gorton and Winton (2002) “...if the depositors of a single bank suddenly demand cash in exchange for their deposits, this is not system-wide event. It may be called a “run,” but it is not a banking panic” (p.65). Furthermore, Wicker (1996) define banking panic as “...an exogenous shock whose origins can be found in any sudden unanticipated revision of expectations of deposit loss accomplished by an attempt to substitute currency for checkable deposits, a situation usually described as a run on the banks. A general loss of depositor confidence distinguishes a banking panic from other episodes of bank failures. A transfer of deposits from weak to strong banks during a bank run without any change in the public’s preference for currency does not qualify.” (p. 17).

Moreover, Schoenmaker (1996) argues that banks are prone to spillover effects that take the form of contagious runs or domino effects. While the former refers to the propagation of a run from a single bank to other banks, the second depicts the propagation of difficulties faced by a single bank to other banks through the interbank market and the payment system. The two effects can occur jointly or independently. The structure of the banking network determines the velocity of the propagation of shocks and the magnitude of the contagion.

1.1.2 *Excessive risk-taking*

The second source of financial instability stems from the asset side of the bank’s balance sheet, and deals with excessive risk-taking. We can define excessive risk-taking as the loan origination towards risky firms (“firms with a large share of their loans and not improving over time”) as presented by Altavilla et al. (2020). This excessive risk-taking is rooted in the agency problem which proves to be more severe in the banking sector. In fact, banks face agency problems: between depositors and bank managers, between bank managers and borrowers, and between bank managers and shareholders. As evidence by Jensen and Meckling (1976) manager acting on behalf of shareholders may act to maximize the utility of the latter. In this sense, the bank’s manager has strong incentives to engage in risky projects which yield high return in case of success but with low probability of success. In case of success shareholders will enjoy higher net profit, i.e. the profit after having repaid depositors. And in the event of failure, shareholders will only suffer a part of the loss since the loss is shared with depositors. This is the result of the limited liability that benefit banks and translates into risk-shifting. Risk-shifting can be defined as the transfer of the risk to an other party. Increasing the asset risk of its portfolio, banks transfer this risk to depositors who bear are considered as “final risk bearer”. Besides the risk-shifting, there is also a looting (Boyd and Hakenes, 2014). Looting consist for the bank’s manager to convert bank assets

to its personal benefit. In other words, the bank's manager can make investment such as to maximize its private profit instead of maximizing the shareholders' revenue.

Moreover, the excessive risk-taking is exacerbated by the "risk shifting" through the "gambling for resurrection" by ailing banks. The underlying idea is that an ailing bank may willingly take on large risks even if these risks are associated with low expected returns in the event of a crisis and that its equity depleted. Given that bank will fail anyway, the bank will gamble to survive. In this sense, risk-shifting is a mean to ensure higher private benefit rather than an end to itself (Akerlof and Romer, 1993). Moreover, the gambling for resurrection can translate into the willingness of a failing bank to retain troubled assets in its portfolio (Diamond and Rajan, 2011). The underlying idea is that troubled assets will pay handsomely in good future states of the world, and will be evicted from the market in bad states.

In sum, it is clear that agency problems are at the root of the bank's risk behaviour, as long as it can shift losses to depositors. While the bank has the capacity to monitor (its assets), it may also have incentive to reduce its monitoring efforts.

In fact, there is an optimal monitoring effort that maximizes the bank's profit. Banks invest in a project that yields, in case of success, a certain return with a probability that depends on the bank's monitoring effort. Although the probability that the bank's projects succeed may be higher under higher monitoring effort, the bank may be reluctant to have a maximum monitoring effort. Given that monitoring is costly for the bank, the bank tend to reduce its monitor effort in order to maximize its expected profit. In the same vein, any factor that tend to reduce the bank's profit may lead the bank to reduce its monitoring effort. In this sense, the more the deposits level the lower the bank's monitoring effort (Holmstrom and Tirole, 1997). In fact, raising deposits leads the benefit of higher monitoring effort to be shared between the banks and depositors. For this reason banks tend to decrease their monitoring effort. Moreover, if the bank choose its monitoring effort after the deposit rate has been set, the bank will choose a lower monitoring effort.

The bank's excessive risk-taking can be amplified by many other factors such as the opacity and the long maturity of bank's asset, moral hazard, the deposit insurance and the wide dispersion of bank's funds providers.

In a nutshell, banks are likely to behave in undesirable way in order to maximize their own profit while generating some threats to the financial stability. To prevent the economy from theses threats, authorities have implemented banking supervision and set prudential tools.

In the following subsection we will develop these prudential tools.

1.2 The transmission and effectiveness of prudential tools

The preceding threats to the financial stability due to perverse bank's behaviour have induced the implementation and the reinforcement of prudential policy. The latter includes microprudential and macroprudential policies, and aims at preventing banks to take more risk and at fostering financial stability. There are a several prudential tools and each of them transmits to the real economy through different channels. To better understand the transmission channels of prudential it appears important to present the different prudential tools.

1.2.1 *The prudential tools*

As presented in the preceding subsection, banks are prone to idiosyncratic risk but to systemic risk as well. As a result, the regulator in order to prevent threats to financial stability should disentangle idiosyncratic risk, which stems from specific problems in individual banks from systemic risk, which jeopardize the financial system as a whole due to interconnection between banks.

There is a set of tools the regulator can use to reach its objective of financial stability. These tools are used to alleviate the endogenous risk as well as the systemic risk. The endogenous risk originates in the bank's financial activity. This risk can translate into exchange rate risk, the borrowers default risk, etc. Moreover, this risk is mostly related to the moral hazard problem stemming from the bank capital structure which is exacerbated by the deposit insurance. Due to the public safety nets, banks shift the credit risk to depositors (risk-shifting effect). Mitigating this idiosyncratic risk is the main objective of microprudential regulation.

However, financial stability is not guaranteed by the only microprudential policy since solving individual bank moral hazard problem do not suffice to tackle systemic risk.

The systemic risk originates in the interconnection of financial institutions (Cartapanis, 2011). Banks reciprocally hold assets of each of them (interbank loans for example) and are subject to the risk related to difficulties faced by the other partner or other partners. This risk is driven by the bank interconnection and the asset market. In the event of difficulties, an institution that responds by selling a large part of its assets, causes the price of these assets to decrease, thus putting all the other institutions holding these assets into illiquidity and

insolvency concerns.

The macroprudential policy complements the microprudential policy in that way since macroprudential tools target systemic risk. In this sense, following Borio (2003), we can feature each side of the prudential policy as presented in Table 1.1.

Table 1.1: Macroprudential approach versus Microprudential approach

	Macroprudential approach	Microprudential approach
Proximate objective	Limit financial system-wide distress	Limit distress of individual institutions
Ultimate objective	Avoid output (GDP) losses	Consumer (investor/depositor) protection
Model of risk	(in part) endogenous	exogenous
Correlations and common exposures across institutions	Important	Irrelevant
Calibration of prudential controls	In terms of system-wide distress; Top-down	In terms of risks of individual institutions; Bottom-up

Source: Borio (2003)

However prudential tools can be separated in 3 main groups. The first one are related to capital. The second one is related to liquidity. And the third category focuses on the credit. We will present successively microprudential and macroprudential tools.

1.2.1.a *Common tools for micro and macro prudential policy*

As previously said, microprudential tools are set to at alleviate idiosyncratic risk. They aims at disciplining individual bank in order to protect depositor. In this sense, some requirements in terms of capital requirement, leverage ratio and liquidity have been established. However, some of these tools also deals with macroprudential policy and aims at ensuring financial stability of the whole system.

- **The capital requirement** which is essentially a microprudential tool and is the amount of capital a bank should have as required by the regulator (here the banking supervisor).

The capital requirement, usually expressed as equity as a percentage of risk-weighted assets, is the first pillar of prudential regulation. It was introduced in Basel I and focuses on the quality of banks' capital to ensure the resilience of individual financial institutions (microprudential view of regulation). The Basel I agreements focuses on requiring banks to build regulatory capital of at least 8% of risk-weighted assets. The objective here is to avoid the idiosyncratic risk induced by bank insolvency. This capital requirement aims at strengthening the ability

of banks to cope with unexpected losses. However, this threshold of 8% has no economic basis. As Girod (2011) points out, this threshold was taken from the only observation that banks that had a capital provision below this threshold had experienced difficulties during previous crises. The Basel I regulatory capital also refers to the so-called capital ratio or Cooke ratio:

$$\frac{\text{Capital requirement}}{\text{Total risk-weighted assets}} > 8\%$$

The underlying idea is that the bank's assets, adjusted to the risk, may not be larger than 12.5 (1/0.08) time the capital provision. The regulator has then determined different classes of risk. But, this classification is not free of bias. It triggers banks to take more risk within a same class of risk. For a given class of risk, a bank is likely to choose the riskier assets. This shed light on insensitivity to the risk of the Basel I capital requirement. This leads Figuet (2013) to assert that there is a sub-optimal allocation of capital since capital adequacy do not reflect the risk profile. This is why the Basel II agreements aims at addressing the shortcomings of the Cooke ratio.

In regards to the first pillar, Basel II maintain the same definition of regulatory capital (Tier 1, Tier 2), but modifies the weight of risk of different assets. In fact, Basel II agreements increase the sensitivity of the capital requirement to the risk of the bank's assets. In addition to credit and markets risks, the operational risk is introduced. In this sense, there is a direct and strong connection between bank's capital and the risk of its assets. Moreover, Three methods for determining regulatory capital are proposed: the standard approach (Basel I with risk class following the ratings received from rating agencies), the internal rating approach (IRB) and the advanced internal rating approach (advanced IRB). The credit risk is determined through three elements: the exposure at default (EAD), the loss given default (LGD) and the probability of default (PD). In the IRB approach, each bank use their internal rating systems to determine the PD, while the EAD and LGD are given by the regulator. Following the advanced IRB approach, the bank determines all these elements itself, i.e. they use their internal estimates of risk parameters such as PD, LGD and EAD.

But, Basel II is not free of limits. The first limit results from the cost of implementing the IRB approach that induces competitive distortions in the banking system (Lannoo, 2001). Small banks may not be able to implement this approach and should remain under the standard approach which is less beneficial than the IRB approach (reduction in capital holding). Then, there are a competitive disadvantage for small banks (Hakenes and Schnabel, 2011). Another shortcoming that we can note is the way the counterparty risk is estimated. On the one hand, the credit risk is considered exogenous, whereas it is related to assets volatility which stem

from the interaction between financial agents. The assessment of the credit risk is then biased leading to a sub-optimal capital provision, threatening the resilience of the whole system in the event of negative shock. On the other hand, the assumption of normal distribution of return triggers an under-estimation of losses in the tails of the distribution. The last limit that we can formulate against Basel II is its procyclicality. Like the Cooke ratio, the McDonough ratio is procyclical. The determination of credit risk rely on the probability of default of the borrower. Since this probability is positively correlated to the economic cycle, it increases during recession and so does the capital requirement. Therefore, banks have to shrink their credit supply for them to not have to increase their capital provision. The credit crunch exacerbate the recession. There is then a self-fuelfiling mechanism leading to a financial amplification. The McDonough ratio is then binding at the bottom of the cycle, and relax at the top of the cycle.

The 2008 financial crisis has moreover revealed major imbalances between loss rates on certain asset classes and weightings assigned to them in the calculation of capital requirements. It is the case for certain sovereign risks that are not subject to a capital charge as highlighted by Pollin (2012). To deal with these shortcomings, Basel III introduces a leverage ratio which does not depends on the assets risk.

- **The leverage ratio** which could be understood as the ratio of bank capital over total asset and measures the amount of protection provided to the bank by its equity. The higher this ratio, the more protection there is.

Basel III has introduced a leverage ratio that sets a limit on the amount of assets (on-balance sheet, but also partly off-balance sheet) that are not risk-weighted as a proportion of equity. This ratio is also an instrument of macroprudential regulation since it allows to manage the total credit volume in the economy. More importantly, it may be another way to reduce the moral hazard that encourages risk-taking. In fact, the higher the required amount of equity capital, the more likely shareholders are to assume large losses and the more the incentive to take risks is reduced (Blum, 2008).

The 2008 financial crisis highlighted the necessity to control the bank's leverage since the latter was a key factor of the crisis. Banks were forced to improve their leverage (by selling assets) at the beginning of the crisis , inducing a downward pressure on asset prices. Banks faced severe losses that translated into capital losses and credit crunch (Basel Committee, 2010), amplifying the crisis. From its conception, the leverage ratio aims at supporting the risk based capital requirement. Its calculation is based on the quarterly average of monthly leverage. A minimum of Tier 1 leverage ratio of 3% was set on the period 1st January 2013

to 1st January 2017. This minimum implies that a bank with a capital of 1 euro can finance a maximum of 33.33 euros ($1/0.03$) assets.

- **The liquidity ratios:** The liquidity logic was omitted from the pre-crisis prudential analysis. In the aftermath of the crisis, Basel III introduced two ratios (the *liquidity coverage ratio* and the *net stable funding ratio*) to ensure bank's liquidity.

The liquidity ratios are both microprudential and macroprudential instruments. First, they aim at preventing individual from liquidity risk and mitigating accumulation of excessive debt. Second, they address the cross-sectional dimension of systemic risk due to the banks interlinkage stemming from the interbank market. These ratios can be seen as a way to deal with maturity matching issue (Lim et al., 2011). In fact, financing long term assets with short term resources (mainly deposits and short-term borrowings), banks play a major role in the financing of the economy. But, this maturity mismatch could lead them to severe liquidity problems. According to the banking regulation, the liquidity (of an asset) stands for the capacity of an asset to be sold without impacting the general price level (see also Borio and Zhu, 2003). The liquidity requirements imply that banks possess liquid assets that can help them to meet their commitments if needed. This definition should be distinguished from the market view of the liquidity which refers to the capacity of the market to match supply and demand in the short time without creating volatility. But according to Pollin (2012), liquidity remains a vague notion and is difficult to measure. The regulation should lead to a change in the composition of both liabilities and assets.

To ensure a certain liquidity, a bank should comply with two liquidity ratios which have distinct but complementary goals.

On the one hand, we have the *liquidity coverage ratio* (LCR) which focuses on a short term time horizon. It is composed of two constraints related to *high quality liquid assets* (henceforth, HQLA), i.e. assets that can be transformed into cash to meet cash outflows for a 30 day period (Basel Committee, 2013), capital inflows and outflows. To be considered as HQLA, an asset must have low risk and volatility, be easier to assess, be less correlated to asset risk, etc. Moreover, the consultative document of Basel III stipulates that the LCR aims at favoring the short term resilience of bank (regarding their liquidity risk), ensuring banks sufficient HQLA to stand a crisis over 30 days. According to Pollin (2012), a way for banks to comply with this constraint is to increase the maturity of the liability side.

On the other hand, the second ratio, the *net stable funding ratio* (NSFR), establishes the principle of balancing the bank's budget: long-term resources must cover long-term

commitments. According to Pollin (2012), this ratio ensures the consistency between liabilities and the liquidity of assets. The Basel Committee (Basel III, 2014) sets the minimum NSFR requirement at 100%. The NSFR is the ratio of the amount of available stable funding to the amount of required stable funding

$$\frac{\text{Available amount of stable funding}}{\text{Required amount of stable funding}} \geq 100\%$$

The available stable funding relies mainly on the sources of funding. In fact, the Basel III consultation paper asserts that “*The amount of available stable funding (ASF) is measured based on the broad characteristics of the relative stability of an institution’s funding sources, including the contractual maturity of its liabilities and the differences in the propensity of different types of funding providers to withdraw their funding*”.⁷

In a nutshell, although the main focus of microprudential policy is to safeguard individual banks from idiosyncratic risks and prevent them from taking too much risk, the resurgence of crisis has evidenced that the stability of individual banks alone is not enough to ensure the stability of the financial system as a whole. This is the reason why policy-makers have developed a complementary approach to microprudential supervision, a macroprudential policy. The latter shares some common tools (the leverage ratio, the liquidity ratios) with the microprudential policy. However, there are specific tools are devoted to the macroprudential policy.

1.2.1.b *The specific macroprudential tools*

Macroprudential policy has been designed to address the failures of microprudential policy. For instance, macroprudential policy account for the interconnections between individual financial institutions, as well as the financial sector’s feedback loops with the real economy, including the costs of systemic risk in terms of output losses. Generally, expansionary phases of the credit and business cycles are periods where risk is endogenously generated. In fact, in the upside of the cycle, the perception of the risk by financial institutions lowers, and financial institutions are likely to not internalize the adverse externalities which their increased risk-taking behaviour may cause to the entire economy. The main benefit of macroprudential supervision lies in the fact that it internalizes those externalities. Moreover, macro-prudential policies have a preventive role aimed at avoiding the excessive build-up of systemic risk over

⁷For more details on the categorization and coefficients of available stable funding (Available Stable Funding, ASF) see Basel Committee(2014).

time, which in practice may also give these policies a macroeconomic stabilization dimension. For example, it is likely that macroprudential policy will be eased stance during downturns and tightened during upturns. In this sense, macroprudential policy also embeds a counter-cyclical component.

The different improvements introduced by macroprudential policy are related to the capital requirements, and the credit supply.

- **The counter-cyclical capital requirement** which addresses the procyclicality problem of the existing capital requirement and is composed of a counter-cyclical capital buffer and a capital conservation buffer.

The objectives and the constitution logic of counter-cyclical capital buffer and the capital conservation buffer are similar. However, the counter-cyclical capital buffer provisioning depends on the credit growth. In case of excessive credit growth, the regulator could require the provision of an additional capital to curb the credit growth and to prevent systemic risk. The counter-cyclical capital buffer account for the macroeconomic environment of banks. This capital buffer is counter-cyclical since its allows banks to absorb negative shock while limiting the importance of credit crunch, and at the top of the cycle its allows to slow the credit growth. The implementation of such additional capital provisioning belongs to the national regulator, knowing that the provision can be up to 2.5% of risk-weighted assets depending on the assessment of the regulator of the credit growth and the underlying systemic risk (Basel Committee, 2010).

The capital conservation buffer is a capital provision (in addition to the minimum capital requirement) during a period of absence of stress in order to absorb probable future losses (Basel Committee, 2010). This means that a capital conservation buffer is automatically set up during good times to prevent regulatory capital from being affected during a crisis. It aims at strengthening the capacity of individual banks to absorb losses.

The additional capital provisioning (capital conservation buffer and counter-cyclical capital buffer) produces an increase of the capital requirement as described in Table 1.2 .

Table 1.2: Calibration of the Capital Framework (Basel III)

Capital requirements and buffers (in %)			
	Common Equity Tier1	Tier 1 Capital	Total capital
Minimum	4.5	6	8.0
Conservation buffer	2.5		
Minimum plus conservation buffer	7.0	8.5	10.5
Countercyclical buffer range	0–2.5		

Source: Basel Committee(2010)

It is obvious that the Tier 1 ratio increase to 9.5% in case of a conservation buffer coupled with a countercyclical buffer set at its maximum (2.5%).

With Basel III, the regulator possess another measure related to bank capital: the dividend restriction. In fact, the regulator can restrict dividend payments in view of strengthening bank capitalization. Retains earnings allow bank to easily build up conservation and countercyclical buffers. Moreover, it avoid banks to send a bad signal on market since external refinancing could be interpreted as a financial distress by investors (Giese et al.,2013). Furthermore, this measure may increase the bank’s incentive to monitor since it increases the bank’s stake in the game.

- **Caps on the debt-to-income ratio (*DTI*) and the loan-to-value (*LTV*)** wich are measures related to the credit supply and aim to control for credit risk. *LTV* and *DTI* caps may reduce the borrower’s probability of default, by imposing borrowing constraints.

As noted by Cartapanis (2011), the credit risk is a main factor that fuel the risk of a systemic crisis. The credit boom mainly results from excessive risk-taking, increasing the probability of default of the counterparty (*PD*) and the losses given default (*LGD*). The regulator implemented two tools aiming both at counteracting the credit boom and at matching credit supply to the quality of credit demand. These tools refer to the *loan-to-value ratio* and the *debt-to-income ratio*. These two ratios limit the bank’s exposure to risk. They require banks to only partially finance projects. The *debt-to-income ratio* requires the bank to appreciate the capacity of a borrower to support the credit charges given its revenue. While the *loan-to-value ratio* requires the bank to limit its exposure in case of a mortgage loan. It oblige

banks to grant credit up to a fraction of the collateral. The higher the *loan-to-value ratio* the higher the counterparty credit risk. The *loan-to-value ratio* is determined as follow:

$$\text{Loan-to-value ratio} = \frac{\text{Mortgage amount}}{\text{Appraised value of the property}}$$

Hence, if the LTV is set to 75%, it would be impossible for a bank to grant a loan to someone who is taking 90,000 euros mortgage to purchase a home appraised at 100,000 euros. The bank's exposure would be 90% which is higher than the LTV limit.

According to Oh (2013), the LTV ratio is an efficient macroprudential tool since it alleviates housing bubble. It allows the regulator to reach two simultaneous goals: reduce bubble frequency and strengthen the financial stability by limiting credit boom during good times. This tool also allows to control household leverage and to avoid housing delinquency. Setting a binding ceiling on the LTV ratio prevents banks over-investments and limits banks' losses in case of default of the borrower. The LTV ratio is also good at smoothing cycles since it limits credit supply and hike in collateral price in good times while reducing the depth of the crisis and the fall of collateral in bad times.

At this stage, it should be noted that macroprudential policy is the set of measures aiming to ensure the stability of the financial system as a whole. To achieve this, the regulation provide the planner with many tools that can be combined or used in isolation. These tools focus mainly on the systemic risk and address it in its cross-sectional (interconnection between banks) and time dimension (counter-cyclical measures).

However, micro and macro approaches of prudential regulation can be complementary, but conflicting as well. The complementarity between the two approaches of banking supervision stems from the fact that macroprudential measures are often blunter than microprudential ones. Counter-cyclical macroprudential measures are softened uniformly across all banks during downturns, leading to undesirable results. For instance, unhealthy banks may be keep alive due to such policy easing and discourage lending on the interbank market. Microprudential policies can alleviate such undesired effects. Moreover, macroprudential policy may fail in ensuring a sound financial system because of collective moral hazard (see Fahri and Tirole, 2012). For instance, if financial institutions anticipate that requirements will be softened in the downturn, they will have ex ante incentives to collectively take more risk. According to individual bank risk, microprudential requirements on banks can be tightened, then banks would be discouraged to take on too much in isolation. In this sense, microprudential policy can mitigate collective risk.

The macroprudential goals may conflict with microprudential ones. We can imagine that, in a boom, as individual banks seem to be sound, bank supervisors may consider regulatory requirements tightening unnecessary, while procyclicality and aggregate risk-taking concerns may lead macroprudential authorities to tighten prudential instruments. Conversely, in a downturn, seeking to mitigate the impact on the economy, the macroprudential authorities could wish to release buffers, while bank supervisors may prefer that institutions preserve as much capital as possible so as to better absorb their losses (BIS, 2018).

Moreover, for the prudential policy to be effective, the transmission channel of its tools should be known and controlled. In the following development, we will give an overview of different channels through which prudential policy could transmit to real economy.

1.2.2 The transmission channel of prudential tools to the economy

The macroprudential tools essentially aim at limiting the rise of endogenous risk. In this subsection, we examine how a prudential shock (loosening or strengthening constraints) helps to ensure the resilience and the stability of the financial system.

While many studies have examined the transmission channels of monetary policy, very few have focused on those of macroprudential policy.

The regulator may use the anticipation channel to drive the financial agents behaviour. This channel (the anticipation channel) is an important channel through which macroprudential instruments operate (New Zealand Central Bank Report, 2013). Based on Lucas' rational expectations theory that individuals take decisions based on available information, since they are able to anticipate the consequences of economic policies, it is therefore possible for the regulator to obtain from financial actors the desired behaviour. Through the sent policy signal, the regulator may align the behaviour of financial agents (mechanism qualified of "moral suasion"). Thus, the regulator by disclosing the information on the evaluation of systemic risk, manages to persuade financial institutions to modify their behaviour and to act in the desired direction. The credibility of macroprudential tools, however, remains the bedrock of effective moral suasion. The deployment of macroprudential tools provides a stronger signal than the mere declarations of the regulator (actions are better than words).

The different channels identified in this report are based on three tools based respectively on regulatory capital, liquidity and the asset market (asset prices). In the following development, we provide a description of the transmission mechanism of these tools.

The strengthening of the regulatory capital composition requirements, by increasing the

share of common stocks and reserves, leads banks to increase their long-term resources and deposits, but to shrink the amount of their assets (known as “credit crunch”). As a result, the capital buffer increases. The reaction of banks leads to a revaluation of the credit, with a negative impact on both the demand and supply of credit. The regulatory capital requirement affects agents’ expectations, thus mitigating risk and reinforcing the resilience of the financial system. In fact, following the reinforcement of the capital constraint, households anticipate a rise in the cost of credit. Then, credit growth slows down. The drop in credit demand implies obviously a fall in the supply of credit, and thus ensures a better resilience to the system.

The same transmission mechanism could be also found when the countercyclical capital requirement is tightened. The only difference is that this measure results in a better ability of banks to absorb losses. The resilience of the system is therefore ensured if banks choose to improve their capacity to absorb losses either by increasing their capital or by lowering their credit activity.

Increasing the core funding ratio, countercyclical capital buffer (or for a specific sector) requirements help to smooth financial cycle. Banks could issue equity or retain earnings.

Compared to the strengthening of the countercyclical capital buffer, the increase of a sectoral countercyclical capital buffer appears more effective since the ability of banks to raise external funds reduce considerably. Banks do not have to fund a sector declared as risky by the regulator, and thus, they do not have to raise funds.

If the increase in the preceding requirements (core funding ratio and counter-cyclical buffer) spreads in the banking circuit (change in banking behaviour) and in the credit market, the implementation of a threshold on the Loan-To-Value ratio (LTV) impacts directly the agents’ expectations, as well as the credit market. Households change their behaviour of credit demand with respect to the perceived signal on the LTV ratio. If it turns out that the next LTV cap would reduce their debt capacity, then households will increase their demand for credit. Which leads to perverse behaviour. Indeed, the tightening of the restrictions on the LTV ratio leads to a fall in the demand for credit, and thus a fall in asset price (because households buy less). Moreover, the increase in the LTV ratio leads to the reinforcement of the collateral requirements (value of collateral required higher than before), and therefore a decrease in the loss (for the banks) in case of default [Loss Given Default (LGD)] (Central Bank of New Zealand, 2013).

In addition, macroprudential policy can spread in the economic and financial sphere through

other channels such as the allocation channel and the signal channel (Giese et al., 2013) .

The allocation channel can be considered as the channel of capital. Indeed, it consists for the regulator to address financial agents' constraints and motivations through the regulatory capital requirement. In the event of a credit boom, the rise in the counter-cyclical buffer limits the credit bubble and strengthens the resilience of the financial system. On the other hand, during a recession, the decline in the counter-cyclical buffer helps support credit supply, safeguard market confidence, and foster growth. This channel is close to the channel of anticipations as previously discussed.

The signal channel reflects the role that have information provided by macroprudential authorities. The regulator allows a better decision-making of the financial actors, by the disclosure the signals on the costs and profits of the alternative actions. Banks that are judged to be weakly capitalized should use the information contained in clear and objective standards to recapitalize. Indeed, the presentation of clear standards allows banks to assess their capitalization and take the necessary measures to comply with the requirements.

In sum, prudential tool transmit to the economy through differents channels. However, the facility with which they transmit to the economy will determine their use and effectiveness.

1.2.3 The use and effectiveness of prudential tools on the economy

We have shown in the preceding development that prudential tools are diverse and transmit to real economy through different channels. Therefore, it appears that their effectiveness in ensuring financial stability also differs. While most studies describe macroprudential policies, Cerutti et al. (2017) focus on which policies are actually used across a large set of countries. These authors also analyse which policies are most effective in reducing procyclicality in financial markets and associated systemic risks. They find that macroprudential policies are used more frequently in emerging economies, with foreign exchange related policies. And, borrower-oriented macroprudential tools (such as caps on loan to value (LTV) and debt to income (DTI) ratios) are used relatively more in advanced countries. In regards to the effectiveness of macroprudential policies, Cerutti et al. (2017) find that limits on LTVs and DTIs, and financial institutions-based policies (such as limits on leverage and dynamic provisioning) appear to be especially effective in alleviating growth rates in credit and house prices.

Macroprudential policies appear effective in ensuring some stability at some extend. For instance, Lim et al. (2011) show that the procyclicality of credit and leverage is reduced

by prudential tools such as LTV and DTI limits, reserve requirements and ceiling on credit growth. Capital inflows in emerging markets is reduced by the use of reserve requirements when there is floating exchange rates (IMF, 2013c). IMF (2013c) also evidences that macroprudential tools negatively impact house price appreciation rates and credit growth. Moreover, macroprudential policy limits the risk that a bust occurs and the shock that could hit the real economy due to financial turmoil (Dell’Ariccia et al., 2012). Studying the effects of macroprudential tools on diverse economies since 2000, Zhang and Zoli (2014) find that these tools are effective to varying degrees, with most effect for LTV caps and measures aiming at limiting credit growth, capital flows and house price growth. Cerutti et al. (2015) find the same results, more precisely for the LTV tool. Furthermore, dynamic provisioning appears effective in smoothing downturns and ensuring credit availability during recession. Bruno et al. (2015) evidence that macroprudential policies are more successful when they complement monetary policy by reinforcing monetary tightening than when they act in opposite directions.

However, prudential regulation presents some limits since some agents remain unregulated. As enlightened by Levy-Garboua and Maarek (2014), the preventive side of macroprudential policy is inefficient since some activities are out of its scope, such as shadow banking. These financial agents are important as they can impact the financial system by spreading the risk to the banking system. Other sectors such as insurance and pension funds also escape. As Dirks et al. (2014) say, these two financial actors have important balance sheets and could be sources of instability for the financial system. That is, they deserves more attention for the regulator.

In addition, numerous studies show that more stringent regulations could lead to a rise in the cost of capital and to a credit crunch (Jeanne and Korinek, 2013; 2014; Pollin, 2012; Levy-Garboua and Maarek, 2014; European Central Bank, 2013). As these authors show, a strict capital requirement drives poorly capitalized banks to search for funding in financial markets. However, according to the pecking order theory developed by Mayer and Majluf (1984), market funding remains the last resort for any organization. This type of funding sends a bad signal to the market, and leads to mistrust of investors and to higher risk premium. This translates into an increase in the bank’s funding cost. To avoid such a cost, banks are more inclined to reduce their assets. This inevitably leads to credit rationing. In a study, the European Central Bank (2013) highlights the risk of an infernal spiral in which a restrictive regulation plunges corporate and the economy. Restrictive capital requirement leads to a credit crunch, higher funding cost and disinvestment. There is a slow down of economic growth. Corporate face more difficulties, leading to an increase in the risk perception. The

increasing risk perception leads to an increase in the funding cost, deepening the credit crunch.

But the impact of the regulations differs according to the types of asset, customers and financial institution. In fact, Pollin (2012) show that the effects of macroprudential regulation will differ according to the maturity and risk of each asset, the characteristics of the investments, the sensitivity of the borrowers to the interest rate, the type of the borrower (household or corporate) and the quality of the financial institution (well capitalized or not).

However, prudential policy is not the only policy that affect the bank's risk-taking behaviour. Monetary policy appears to have an important role in driving banks behaviour. The next section will deal with the link between monetary policy and the bank's risk.

2 Monetary policy and bank's risk: the bank's risk-taking channel of monetary policy

The risk-taking channel of monetary policy refers to "*the notion that interest rate policy affects the quality and not just the quantity of bank credit*" (Dell'Ariccia et al., 2016). Some authors like Altunbas et al. (2010) mainly focus on the effects of low interest rates on the behaviour of financial agents, and in particular their risk aversion, when referring to this notion. Said differently this channel refers to any change in perception and tolerance of risk by agents (Borio and Zhu, 2012). It acts through the balance sheet and the liquidity channels.

Monetary policy mainly transmits to the financial system through 3 main channels (Basel, 2011):

- The borrower's balance sheet channel which refers to how the monetary policy impact the credit supply via changes in the borrowers' creditworthiness;
- The bank's balance sheet channel or the bank lending channel that deals with changes in the credit supply stemming from the impact of monetary policy on the bank's liabilities and assets ;
- The Liquidity channel which focuses on the impact of the policy on the banks' ability to provide liquidity on markets.

The magnitude of the first two channels are exacerbated by the "financial amplification" mechanism: the deterioration of credit conditions amplifies any negative shock to the economy

(Bernanke and Gertler 1989, Bernanke et al. 1996). During a recession, financial position of companies weakens, raising refinancing costs. The credit supply and the production drop and finally damaging enterprises' financial capabilities. The same analysis hold in the opposite direction. In the upside of the cycle, financial position of companies fosters and then financing costs decline. At the same time, the supply of credit and production rise and consequently support the financial capabilities of economic agents.

The liquidity channel addresses the role of converters of maturity played by banks. In their intermediation activities, banks transform short-term deposits into long-term (credit) assets. Consequently, a market negative shocks following a monetary policy, banks may face illiquidity issues since their long-term commitments would constraint their ability to honour short term ones.

In order to better understand the relationship between monetary policy and bank's risk-taking, we present successively theoretical developments and some empirical works carried out so far.

2.1 Theoretical evidences of the risk-taking channel

In this subsection we aim at presenting the theoretical literature explaining the mechanisms through which monetary policy may affect bank's risk-taking behaviour. As stated previously, theses mechanisms act through the borrower's and bank's balance sheets and the bank liquidity.

2.1.1 *The balance sheet channel*

Monetary policy affects both lenders and borrowers risk tolerance and perception through changes in their respective balance sheets.

2.1.1.a *The borrower balance sheet channel*

The borrower's balance sheet channel has been highlighted in Bernanke and Gertler (1989) and in Kiyotaki and Moore (1997). Disruptions arise from the information asymmetry between lenders and borrowers as lenders (banks) are unable to assess borrowers' risk and solvency, in order to control their investment and to fully observe the repayment of loans.

This channel plays its full role because of the external financing costs faced by the borrowers (Myers and Majluf, 1984; Bernanke and Gertler, 1989). From their inability to fully observe

borrowers' solvability, lenders charge on them a risk premium (agency premium) or high collateral requirements. On the other hand, borrowers might increase their bet (share in the financing of his project) to signal their implication in the project and the wise use of the loaned funds. The greater the borrowers' investment in the project, the lower the agency problems and the agency premium (Bernanke and Gertler, 1989).

From what precedes, we infer that any shock affecting borrower's wealth will modify its financing costs and its volume of debt (Basel, 2011). An expansionary monetary policy leads to an upgrading of assets as a result of hike in prices. This improves the borrowers net wealth, and reduces agency problems and financing costs decrease. For the same amount of assets used as collateral, borrowers access a larger amount of financing. As the overall borrowers solvability ("fictitiously") improved, the supply of credit increases and financing costs reduce (Bernanke and Gertler, 1989).

Importantly highlighted by the same authors, restrictive monetary policy modifies the financial position of the borrowers in two direct ways. On one hand, the rise in interest rates leads to an increase in interest charges on outstanding loans, driving a reduction in the net cash flow of borrowers, and a reduction of their solvency. On the other hand, the rise in interest rates leads to falling prices and a deterioration in assets value. This is followed by a tightening of financial constraints (due to the loss of collateral value) and deleveraging. This mechanism refers to what Bernanke and Gertler (1989) describe as debt-deflation. Following an unexpected fall in prices, access to credit for borrowers would fade or suddenly harden. This would negatively modify the supply and demand of credit and would lead to a fall in prices, the mechanism repeating itself in a loop. As Blot et al. (2015) point out, an infernal spiral of deleveraging develops, price instability and financial instability starts. This mechanism of debt deflation reveals the threats of monetary policy for financial stability.

If monetary policy have direct actions on borrower's financial position, it may also indirectly modify the of borrowers (firms) creditworthiness. A monetary contraction depletes households as the value of their assets is revised downwards. Concomitantly, the rise in monetary rates increases real interest rates and induces a rise in households' savings that in turn reduces their consumption. All of this contribute to lower corporate revenues while their expenses are almost stable. Business profits deteriorated as financial position do so (Bernanke and Gertler, 1989).

Moreover, according to Gilchrist and Leavhy (2002) the balance sheet channel can be considered as the "channel of wealth". An accommodative monetary policy changes preferences of agents between holding liquidity or investing. The decrease of monetary rate

reduces the profitability of holding liquidity and causes households to withdraw and increase their consumption and investment. In turn, the rise in demand for assets induces inflation (bubble formation) while the revaluation of assets leads to a misperception (underestimation) of probability of default (Borio and Zhu, 2012). This implies an increase of investment in risky assets that would not be financed without this inflation.

Lastly, the "financial acceleration" comes from endogenous changes in agency costs between lenders and borrowers. By this mechanism, Bernanke and Gertler (1989) highlight the role of the net wealth of borrowers in the propagation of shocks to the economy (see figure 1.1) which can amplify the risk-taking behaviour. During recession the devaluation of assets leads to a tightening of financing constraints, hampering investments and further depreciating assets. The risk perception of banks grows up and is reflected in higher credit rate, leading to adverse selection. The investors with safer projects will be penalized because they consider that the interest rate is too high for their level of risk. As a result, they will exit the market, leaving only riskier investors. Finally, banks face only riskier projects while trying to screen among borrowers. On the contrary, in a period of economic expansion, the assets value increases leading to favourable financial condition and boosting investment. Due to these conditions, the risk perception and tolerance decrease (Borio and Zhu, 2012). Even riskier borrowers access credit market and at cheaper price.

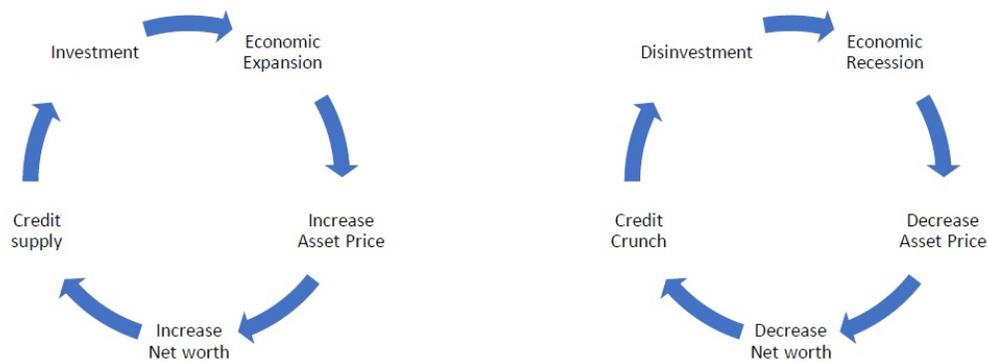


Figure 1.1: Financial accelerator process during economic expansion (left) and recession (right)

If monetary policy changes the wealth of borrowers, it can also impact the wealth of lenders, namely banks.

2.1.1.b *The bank's balance sheet channel*

Monetary policy is transmitted through banks' balance sheets via two sub-channels: the credit channel and the bank capital channel. We then note the existence of three effects facilitating this transmission: asset substitution, the pro-cyclicality of the bank leverage and the search for yields (Bernanke et al., 1996; De Nicolo et al., 2010; Adrian et Shin, 2009; Rajan, 2005).

Substitution of assets plays on the asset side of the bank's balance sheet. It implies that following a decline in the monetary interest rate, the return of banks risk-free assets decline. Banks substitute risky assets to risk-free assets until the returns of the two types of assets equalise. De Nicolo et al. (2010) emphasize the necessary hypothesis of bank's limited liability, bank's neutrality or non-aversion to risk for this effect to reveal. In fact, if banks are risk averse, it can be possible that the substitution effect (substitution of risky assets to risk-free assets) does not take place.

This asset substitution effect is reinforced by what Rajan (2005) describes as "search for yield". Unlike the substitution effect, the search for yields acts on the liabilities side of the banks' balance sheet. Rajan (2005) explains that the fall in the interest rate makes it difficult for the bank to meet its obligations to its creditors. The decrease in the monetary rate drives the decrease of the lending rate, while the deposit rate remains almost constant. This makes banks less profitable. Facing the decline in profitability, banks would rather invest in highly risky/ highly profitable assets in order to maximize profitability and ensure depositors' remuneration.

Besides the substitution and search for yields effects which imply change in the quality of originated loans, there is also a volume effect. This effect has its roots in bank leverage. As suggested by Adrian and Shin (2009), a positive monetary shock (lower interest rate) improves the wealth of banks, whose leverage exceeds the regulatory leverage ratio. Thus, banks can increase their assets in order to reduce the level of their leverage to that of the regulatory. Conversely, a negative monetary shock (rising interest rates) results in a depreciation of banks' wealth, and constraints banks to reduce their assets to meet regulatory requirements. The positive feedback between the banking leverage and the level of risky assets held by the bank when the bank has limited liability has been highlighted by Agur and Demertzis (2012). Limited liability allows the bank to repay savers only to the level of the bank capital. A high leverage would allow the bank to pocket maximum gain in case of success and to be covered (i.e. to lose only their stake) in case of failure. Thus, the higher the bank leverage the more attractive are risky profiles. Conversely, when the leverage is low, bank's capital is

more important and encourages cautious investment choices. This analysis is consistent with the risk-shifting effect (see De Nicolo et al., 2010). Heavily indebted banks would invest in risky assets. In case of success, it gives them a greater private benefit while savers bear the most important part of the risk in case of failure. However, the same analysis holds in the context of a monetary contraction. A rise in the monetary rate raises the cost of liability which, in turn, raises the funding cost and obliges banks to hold less debt (deposits) and to reduce their leverage. Since the relationship between leverage and risk-taking incentives is positive, banks will be reluctant to take risk.

Furthermore, as credit conditions loosen, "bad" borrowers access the credit market, increasing the number of new projects to be financed. Under competition pressures, banks are likely to finance as many projects as possible to cover a larger market share. This means that the negative effects of an expansionary monetary policy on the credit conditions are amplified by banking competition. If the capital structure is set exogenously, a fall in interest rates entails highly capitalized banks to take more risk, while the opposite effect occurs for high-levered banks (lower risk) (Dell'Ariccia et al., 2014).

Finally, there is a "Greenspan put" effect involving the effects of monetary policy on the risk taking of agents via expectations (De Nicolo et al., 2010). These authors establish that if agents anticipate a decline in interest rates in the event of difficulties in the future, then they will take more risk today. This means that a high interest rate would be associated with greater risk taking.

If monetary policy impact bank's lending activity, it may also affect the bank's liquidity.

2.1.2 *The liquidity channel*

Liquidity can be defined as the ability of the bank to meet its current commitments without affecting daily operations or financial conditions.

The liquidity channel is identified by Diamond and Rajan (2006) as a rather close version of the bank lending channel. In their activity, banks do not only do maturity conversion, but also conversion of liquidity. They use liquid deposits to finance illiquid assets. Banks are therefore subject to a risk of illiquidity if savers decide to simultaneously withdraw their funds. That could be the case if the demand for money by economic agents (for transaction purposes) is greater than the supply of money. Thus, monetary policy is an important element that affect the capacity of banks to finance the economy and exposes them to illiquidity risk. An expansionist monetary policy aims to satisfy a demand for money and to maintain satisfying

liquidity conditions on the markets. Relying on liquidity conditions, banks tend to finance long-term projects, while their liabilities (the deposits) have a short-term horizon. Therefore, this has a negative effect on the soundness of the financial system since banks may become insolvent in case of a massive withdrawal of deposits. In other words, monetary easing threatens the financial stability of the whole system by stealth because, following a negative monetary shock, banks would face illiquidity issues. In absence of loose monetary policy, and in order to finance long-term projects, banks would have to raise interest rates on deposits in order to avoid massive withdrawals.

The liquidity channel differs from the bank lending channel, which is based on three assumptions that are not considered by Diamond and Rajan (2006). These authors note that expansionist open market operations increase liquidity and reduce the real value of the interest charges that banks must pay. This allows banks to finance more long-term projects. Through the liquidity channel, we understand that an expansionary monetary policy would lead banks to take risky position by ensuring them a fictitious liquidity. The number of financed long-term projects will increase as long as interest rate are low. As soon as rates rise, the bank will face higher refinancing costs (higher deposits remuneration). Hence, the bank may become more and more illiquid, as long-term assets will only provide liquidity in a distant horizon. In other words, monetary easing increase the risk that banks face insolvency problems in the event of monetary contraction.

However, the preceding transmission mechanisms of monetary policy (balance sheet and the liquidity channels) are described for conventional monetary policy. It is then necessary to understand how monetary policy affect bank's risk-taking behaviour during unconventional periods.

2.1.3 The monetary risk-taking channel under unconventional monetary policy

Monetary policy is considered as unconventional when exceptional measures are introduced in response to the inability to the standard nominal interest rate to play its role. Unconventional measures deals with negative interest rate, credit easing (purchasing private assets), forward guidance (public communication about the future monetary policy stance), helicopter money (permanent increase in the money supply) and negative interest rates (nominal interest rates below zero).

Demiralp et al. (2019), studying the banks reaction to unconventional monetary policy in the Euro area, analyse the different channels in presence of negative interest rate. First, negative

interest rate may impact the interest rate channel.⁸ The negative interest environment triggers some heterogeneity in the banking system as it prevents mostly deposit-funded banks from fully adjusting their funding costs. In fact, when the zero lower bound (ZLB) is crossed, interest rate on deposit cannot be further adjusted, inducing a change in the standard transmission mechanism. The resulting contraction of profit margins may impair the standard interest rate channel because banks that mostly rely on deposits, for profitability reasons, might start raising interest rates charged on loans instead of lowering them in response to a policy easing to protect their profit margins (Demiralp et al., 2019).

Second, while some authors consider that the bank lending channel is ineffective or is broken down in negative interest territory (see Borio and Gambacorta, 2017; Eggertsson et al., 2017), Demiralp et al. (2019) argue that this channel is strengthened instead for two main reasons. On the one hand, negative interest policy is assimilated to a charges on reserves that may incentivize banks to extend more loans in an effort to reduce their reserve holdings. On the other hand, due to the ZLB on deposit rates, there is a decrease in the opportunity cost of holding retail deposits and an increase in the demand for deposits. Then, banks may issue more loans in response to this increased deposit funding.

Finally, according to Demiralp et al. (2019), the risk-taking channel, developing through risk perception and risk tolerance (see Adrian and Shin, 2009; Borio and Zhu, 2012) and the “*search-for-yield*” effect (Rajan, 2005) may be amplified in the negative interest rate environment.

In a nutshell, according to the theory of the monetary risk-taking channel, there are three channels through which monetary policy can affect bank risk-taking behaviour. However, the impact of conventional and unconventional monetary policy impact the bank’s risk-taking behaviour differently. Furthermore, other factors influencing bank risk-taking exist and are of considerable importance, namely: the banking competition, the manager compensation structure, the habits formation, the agent expectations (or policy communication). For example, the conjunction of low monetary rates and high competition pressure may exacerbate the search for yields. In order to compensate for the loss of competitiveness (due to lower profits), the bank is more prone to invest in riskier assets. In addition, Campbell and Cochrane (1999) focusing on the risk premium, note that monetary easing boosts the economic activity and consumption, making agent more tolerant to risk during periods of

⁸According to the standard interest rate channel, a change in the policy rate is transmitted to deposit and loan rates through the banking system.

expansion. Finally, a transparent monetary policy (easier to be anticipated by agents), would enhance the optimism of agents, reduce uncertainty in markets and lead to greater risk taking. If agents expect that monetary policy would be soften in the event of economic turmoil, agents would be prone to take more risk today. What the authors called the "insurance effect".

After reviewing some of the theoretical supports to the monetary risk-taking channel, it is interesting to have an overview of the empirical studies assessing this channel.

2.2 Empirical studies on the monetary risk-taking channel

While the theoretical works on the risk-taking channel have been elaborated decades before, it is only recently that empirical studies on the subject are emerging. Part of these empirical works is summarized in this section and deal with the balance sheet channel, the ex-ante and ex-post bank's risk. The ex-ante bank's risk refers to the risk taken when granting loans, i.e. the credit quality at the loan origination. We refers to ex-post risk, the risk that materializes after the loan origination, i.e. the risk (and/or the change of risk) of outstanding loans.

2.2.1 *Empirical studies on the balance sheet channel of monetary policy*

In order to understand how the bank lending channel of monetary policy work, Kashyap and Stein (2000) conduct a quarterly survey on about 1 million banks over the period 1976q1-1993q2. So, they intend to test if the impact of monetary policy on lending behaviour differ among banks in regard to the liquidity of their balance sheets, where liquidity is measured by the securities to assets ratio. In other word, they try to test differences in banks' response to monetary shocks. Bank variables are the volume of loans (total loans including commercial and industrial loans) and the strength of the balance sheet (securities + federal funds sold / total assets ratio). A high value of this ratio implies a good coverage of the bank against any shock affecting its credit activity. Three monetary policy measures are adopted. The first is the Boschen-Mills index (1995). This index allows to categorize the monthly monetary rate into five categories: "highly expansive", "moderately expansive", "neutral", "moderately restrictive", and "highly restrictive" depending on the target of the monetary policy (inflation vs. unemployment). The second measure is the Fed interest rate, following Bernanke and Blinder (1992). The third measure of monetary policy adopted by Kashyap and Stein (2000) is the flexible autoregressive vector model (VAR) of Bernanke and Mihov (1998), which makes it possible to calculate an indicator of the monetary policy stance (and to estimate high frequency monetary shocks). A two-step regression is used to estimate the share of the balance sheet strength in the change in credit volume (isolating mass effects). Then, a regression of the coefficients associated with the strength of the balance sheet on the

monetary variables makes it possible to estimate the impact of the monetary policy on the balance sheet. The results of their analysis show that small banks are more sensitive to monetary shocks, especially banks with low liquidity. In addition, banks whose debtors are highly sensitive to monetary shocks hold very little liquid assets.

The behaviour of banks loan portfolio components (business loans, mortgages, and household loans) in the event of monetary and non-monetary shocks (productivity shocks) has been examined by Den Haan et al. (2007). Their analysis, over the period 1977q1-2004q2, reveal two non-monetary shocks: structural productivity shocks and shocks on inventory. Using VAR models, they show that, following a monetary contraction, mortgages and households loans decline considerably, while the response of credit to enterprises is positive. This could be explained by an increase in the demand of credit of enterprises in order to finance the increase of the inventory. The rise in inventory is the result of a lower households' consumption level due to their impoverishment following a monetary contraction. Companies then see their inventories increase and must contract more debts in order to finance this increase in stocks. Moreover, taking the balance sheet channel into account, the monetary contraction would have a stronger effect on the balance sheet of consumers. This would encourage banks to reduce credit to households in favour of corporate credit. Also, the rigidity of rates on loans granted to households would reduce bank margins following the rise in monetary rates. Another argument according to Den Haan et al. (2007) is that a monetary contraction amplifies the volatility (measured by the duration) of long-term assets. To reduce the interest rate risk on long-term assets, banks would sell their long-term assets, which would increase the premium on these assets (and lower the price of long-term assets) and reduce the supply of mortgages. The monetary contraction is also reflected in a decline in profits and thus in the amount of banks' equity. To comply with the regulatory constraints and to compensate for the loss of profits, banks would reallocate their funds to assets with shorter maturity (and thus reduction of mortgage) and a flexible rate (reduction in loans to households).

Other empirical studies exist and evidence an impact of monetary policy on the bank's balance sheet. For instance, Lown and Morgan (2006) find that credit conditions harden following a monetary contraction. But this relationship is not statically significant. Maddaloni et al. (2008) establish a positive relationship between monetary expansion and credit conditions easing. This relationship is reinforced by a prolonged period of monetary easing. The easing of credit conditions by the bank implies an easier access to bank credit for risky borrowers. There is then a weakening of the bank stability.

If monetary policy affect the bank's portfolio composition, this may result from a change in

the ex ante period of the bank's decision making, i.e. before and at the loan origination. The following section deals with this aspect.

2.2.2 The link between monetary policy and the ex-ante bank's risk

De Nicolo et al. (2010) analyse quarterly US bank data from 1997-2008 to assess the impact of monetary shocks on banks' ex-ante risk-taking. Credit quality (associated with borrowers' ex-ante risk) is measured by the average internal risk ratings assigned to loans by the bank (risk rate) and the average relative credit spreads (difference between the lending rate and the effective Fed rate). The effective Fed rate is a volume-weighted average of rates on trades arranged by major brokers and calculated daily by the Federal Reserve Bank of New York using data provided by the brokers). The econometric analysis is carried out using the regression (by the ordinary least squares, OLS) of the bank risk (aggregate of the average internal risk ratings and the average relative credit spreads) on Fed interest rate, controlling for bank capital, macroeconomic performance and expectations of future economic conditions. Controlling for macroeconomic performance makes it possible to neutralize the part of bank risk arising from the degradation of the macroeconomic conditions. The underlying idea is that in a period of recession, bank risk is high because all the assets have become riskier and therefore this do not reflect a willingness of the bank to take more risk. So, the authors can finely capture the banks risk-taking behaviour. The results of this analysis highlight a negative relationship between Fed real rates and bank risk-taking. A decrease of interest rate leads to an increase in the ex-ante risk of banks assets. But this impact of monetary policy on asset risk is less pronounced for less-capitalized banks. Moreover, the relationship between GDP and risk is negative, implying an increase in ex-ante credit risk when GDP falls. Equivalent results are obtained when De Nicolo et al. (2010) capture bank's risk through the ratio of risk-weighted assets to total assets. Using the OLS, De Nicolo et al. (2010) attempt to assess the effect of interest rate and bank leverage shocks on overall banking risk, while controlling for macroeconomic variables and economic expectations. They find a negative relationship between the Fed real rate and the ratio of risk-weighted assets to total assets. A decline in interest rates results in an increase in bank risk, but less for less-capitalized banks.

While the assessment of impact of changes in short-term interest rate on the credit volume has been the main point of most studies, Jimenez et al. (2008) study the impacts of change in short-term interest rate on banks' appetite for credit risk. Precisely, these authors seek to find how Euro overnight interest rates affect the riskiness of loans. We can formulate their main research questions as follows: do low short-interest rate whet bank risk appetite? And has the increases of short-term interest contributed to the financial crisis? To conduct their analysis

Jimenez et al. (2008) use the credit register of the *Banco de España* that contains loan conditions and performance variables. Thanks to within borrower comparison models and duration analyses, they investigate whether short-term interest rates prior to loan origination influence credit risk-taking by banks. They find that low interest rates lead to an increase in credit supply and a high probability of allocating more credit to risky borrowers. They also find a positive (short-term) relationship between interest rates and bank portfolio risk. This means that the interest rate cut reduces the default risk of borrowers, as it reduces their interest expenses. This improves their repayment capabilities and reduces their probability of default as well as that of the bank. However, if interest rates are low for a prolonged period the banks are likely to take more risk. A prolonged period of rate cut would whet the banks appetite to the risk and lead to the search for yield. This would then amplify bank risk over the long run.

In general, monetary policy easing is considered as a key factor leading banks to take more ex ante risk. However, its impact appears to be dependent on bank's characteristics such as the bank's capitalization. Moreover, monetary policy may also have effect on the bank's ex-post risk, i.e. on the risk of outstanding loans.

2.2.3 The link between monetary policy and the ex-post bank's risk

In order to study the relationship between short-term interest rate and ex-post banking risk, Altunbas et al. (2010) perform a regression on quarterly data from European and American banks over a period from 1998 to 2008. Their sample comes from the Bloomberg database.

The dependent variable related to risk-taking is measured by the variation of the Expected Default Frequency (EDF) which is the probability of bankruptcy of a bank over a given period. Data on the EDF are provided by Moody's KMV. In order to extract the individual risk of each bank (idiosyncratic risk), the authors carry out a risk analysis according to the Capital Assets Pricing Model (determination of the specific risk β of each bank) and following the model of Campbell et al. (2001) (decomposition of stock market movements into total market volatility, banking sector and individual banks).

Monetary policy is captured by two variables:

- The change in the 3-month interbank rate (and not the central bank's credit rate) to capture the effect of monetary policy on the risk of existing loans
- The interest rate gap to:

- The rate determined according to the Taylor rule (with smoothing of the rates and with identical weights for the countries) identified as the Taylor gap (TGAP)
- The natural interest rate (generally considered as the anticipated marginal productivity of the capital)

Following theoretical studies, Altunbas et al. (2010) assume that the country in which interest rates were lower than the rate derived from the Taylor rule and the natural rate have experienced an increase in the risk of their banks. The advantage of introducing the interbank rate and the money rate gap to a benchmark (Taylor rule or natural rate) is that it allows to disentangle the two effects of the monetary easing on bank risk. On the one hand, a decline in interest rates implies lower interest expense on floating rate loans and an increase in assets price (as a result of lower interest rates). On the other hand, the fall in rates below the benchmark would lead to the search for yield as identified by Rajan (2005). In order to address the endogeneity bias due to the interaction between monetary policy and macroeconomic variables, the authors perform regression analysis using the Generalized Method of Moments (GMM).

The regression analysis allows to observe:

- A positive effect of the monetary rate (ΔMP) on bank risk: the fall in short-term rates leads to a revaluation of the asset portfolio, and therefore a decrease in the EDF of existing loans.
- A negative effect of the Taylor gap: the more the interest rates are below the benchmark (negative variation of TGAP) the riskier is the banking system, highlighting the existence of the risk-taking channel.
- A negative effect of nominal GDP, meaning that economic growth improves the net present value of projects. The improved quality of projects reduces their default risk and that of the bank.

Since the real estate market was designated as the root cause of the recent financial crisis, Altunbas et al. (2010) also examine the impact of the real estate on the bank's risk. They evidence a negative relationship between housing prices and banking risk in countries that did not experience a bubble, and positive relation for in countries experiencing the boom and bust of the housing market. This means that when the rise in housing prices is determined by the fundamentals (and not by a speculative mechanism), bank risk decrease since debtors get richer.

Moreover, they evidence that some specific banks characteristics play a key role in build-up of vulnerabilities. For instance, it has been shown that the impact of credit growth on the bank's risk is non-linear (U-shaped). Hence, banks with a credit growth rate below or above the average credit growth rate in the sample have a higher level of risk than the others. Moreover, the analysis shows that liquid and well-capitalized banks are considered to be less risky than others by the market. The impact of bank's size on bank's risk is blurring. According to Altunbas et al. (2010) there is a negative relationship between size and bank risk for banks that did not experience the crisis. This relationship turns positive for banks that experienced the crisis, thus blurring the real relationship between bank size and risk taking.

In a nutshell, Altunbas et al. (2010) evidence two important elements:

- There is an amplification of the effect of monetary policy on risk-taking due to low interest rate (interest rate below the natural rate or the rate implied by a Taylor rule) and to the length of the period of low interest rate.
- The prudential regulation may help in mitigating the bank risk since there is identified a negative relationship between the severity of regulation and the banks risk. Banks in countries with stringent regulation have a moderate level of risk relative to those in countries with flexible regulation.

A similar analysis has been held by Gambacorta (2009). However, its objective is to assess the impact of pre-crisis characteristics on the fragility of banks during the crisis. The key monetary policy variable is the number of consecutive quarters for which the interest rate is below the benchmark (natural rate and Taylor rule rate) during the six years preceding the 2008 crisis. The study has been conducted on 600 American and European banks. The control variables are observed from 2001q2 to 2007q2, while the controlled variable (variation in the expected default frequency, ΔEDF) is observed from 2007q2 to 2008q4. The results of the analysis prove a positive relationship between the number of consecutive quarters of low rates (i.e. monetary interest rate below the rate implied by the Taylor rule) and the weakening of banks soundness (increase in EDF). Similarly, credit expansion above the banking sector average, rising house prices, securitization, and the relaxation of prudential rules before the crisis have weakened banks soundness. However, liquidity ratio, GDP growth and the capital ratio strengthen banking stability.

Despite the relevance of the works of Altunbas et al. (2010) and Gambacorta (2009), some reservations remain. Their studies identify changes in banks' risk as a result of changes

in monetary policies. But the identification of banks' behaviour remains unclear since the results of their econometric analysis could suffer from misinterpretation. We can wonder whether the increase (decrease) of the dependent variable (variation in the expected default frequency, ΔEDF) reflect a rise in the bank's risk.

For example, let's suppose Table 1.3.

Table 1.3: Illustration of risk-taking measure following Altunbas et al. (2010)

Banks	Periods	EDF (level)	$\Delta EDF_{i,t}$	Interpretation of derivative of $\Delta EDF_{i,t}$
B1	T1	25	/	/
	T2	20	-5	/
	T3	22	-2	+3
	T4	21	-1	+1
B2	T1	20	/	/
	T2	24	+4	/
	T3	26	+2	-2
	T4	27	+1	-1

As we can see, Bank 1 become safer (EDF decreases) and Bank 2 become riskier (EDF increases). However, considering the change of EDF (ΔEDF) as the dependent variable leads to an interpretation different from that of Altunbas et al (2010) and Gambacorta (2009). An increase in ΔEDF doesn't mean that the bank's risk increase, but that the decrease (increase) of EDF is lowering (growing). In other word, it means that the speed of growth (of decrease) of EDF is slowing down (is increasing). Hence, the negative relationship between, on the one hand, monetary interest rate, the Taylor gap, and the dependent variable (ΔEDF), on the other hand, would mean that a decrease of interest rate or low interest rate is related to a slowdown of the speed of decrease of EDF or a growth of the speed of increase of EDF. That is, low interest rate would lead to more risk-taking, but could mitigate risk-taking as well.

An other shortfall of the analysis of Altunbas et al. (2010) is the risk-taking identification strategy. The increase of EDF could be a result of the fall in interest rates due to the search for yield by banks or just a consequence of the changes in the composition of the portfolios offered to them. In other words, is the change in the EDF of the bank due to the nature of the bank? In this case, we will speak of risk taking, because the latter is driven by the supply of credit. Or is the rise in EDF due to the quality of demand faced by banks? In this case, risk-taking is induced by the demand for credit, and bank risk-taking can't be properly

considered. We can find a solution to the distinction between risk stemming from banks and that stemming from borrowers in Ioannidou et al. (2007).

While most studies focus on the impact of monetary policy on the volume of bank credit, Ioannidou et al. (2007) study the impact of monetary policy on Bolivian bank's risk-taking using a different approach. The risk-taking channel of monetary policy is not analysed only on the quantity of new loans but also on their price. This study seeks to examine how short-term interest rate shocks affect banks' appetite for risk. A strong point of their analysis is that the analysis of the impact of monetary policy (the Fed rate) on the risk-taking of Bolivian banks makes monetary policy exogenous. Indeed, the strong indexation of the monetary policy of Bolivia on the rate of the Fed makes it possible to make the monetary shocks (resulting from the changes in the rates of the Fed) exogenous to the Bolivian economy. Risk-taking is successively measured by: ex-post performance of loans, time to default, internal credit rating at origination, loan maturity and collateral use. The period of the analysis extends from 1998 to 2003, and monthly information on borrowers (location, industry, number of relationships, total bank debt, etc.), contracts (date of signature, amount, maturity, type and value of the collateral, interest rate, rating, etc.), on the characteristics of banks (capital ratio, non-performing loans, size, liquid assets, etc.) are collected. In a duration model, the time to default is considered as a dynamic measure of risk. For each period, the probability that the loan will default conditional on surviving until this period is calculated. In other words, the time to defaults refers, for example, to the probability of a borrower failing in 2003, knowing that he was never in default until 2003. Ioannidou et al. (2007) also define the default risk as the deterioration of the rating of a loan (when the bank downgrade it to the lowest grade category). Thus, it is possible to estimate the impact of monetary policy (measured by the monthly average of the Fed nominal rate) on the probability of default of the bank's assets. In order to carry out their analysis, the authors take into account the internal credit rating and the previous non-performance of borrowers (ex-ante measures of risk taking). The effect of credit demand of risky borrowers on loans is purged by considering the effects of monetary policy on the interest rate charged on risky loans relative to the interest rate charged on risk-free loans. To differentiate between the monetary conditions prevailing the month prior the loan origination and that prevailing during the life of the loan, the default rate of new loans and that of outstanding loans are regressed on the monetary conditions.

Their results establish a negative relationship between the change in the Fed rate before loans origination and the default rate of new loans. This means that a monetary easing leads banks to grant new loans to riskier agents. Furthermore, the authors find a positive

relationship between the Fed rate during the life of the credits and the default rate of the outstanding credits. This can be explained by the fact that the fall in Fed rate results in a decrease of interest expenses of borrowers leading to a lower default risk of the bank. These results are consistent with those of Jimenez et al. (2008) indicating that the decrease in the monetary interest rates improves the repayment capacity of the bank's debtors and reduces their probability of default. However, low rates over an extended period increase the default rate of loans, indicating a greater risk-taking of the bank. Ioannidou et al. (2007) also evidence that banks with sufficient liquid assets are more likely to take more risks because they face no liquidity constraints.

An other aspect of the bank's risk-taking behaviour that is analysed by Ioannidou et al. (2007) is the determinants of risk pricing. Since it is established that banks are likely to take more risk when monetary conditions are softened, we can wonder whether it is the borrowers or the banks themselves that are at the origin of this risk-taking. The underlying idea when focusing on risk-pricing, is that if banks are not the source of risk-taking, then they correctly measure the risk and adjust their lending conditions. To do this, a Neutral Hazard Rate is calculated at the median value of the Fed rates in the month prior the loan origination. The default rate is then determined for each current value of the Fed rate. The difference between this default rate and the neutral hazard rate makes it possible to have the change in the default rate ($\Delta NeutralHazardrate$). This change captures the change in the default rate due to the deviation of the monetary rates from its median value (the interest rate corresponding to the neutral hazard rate). A positive change corresponds to a high default rate resulting from an expansionary monetary policy. The regression of the bank's lending rates on the neutral default rate and the change in the default rate makes it possible to determine whether banks' appetite for risk increases with falling interest rates so that they lend more to risky borrowers (indicating a lending conditions softening). The authors observe that interest rate charged on borrowers increases less than the risk of the borrower. This means that the increase in risk stems from the credit offer (banks) and not from the credit demand (borrowers). Banks do not properly calculate the price of the risk and/or do not integrate it into the lending rates.

In a nutshell, according to the risk-taking channel, it is clear that monetary policy drives the risk-taking behaviour of banks. It has been proven that low interest rate may not only lead banks to grant loans to risky borrowers, but also to narrow the interest rate spread between safe and risky assets.

However, if low interest rate may depress bank's margin, they can also have beneficial effects. Low interest rate trigger low refinancing costs, and, then appear as a support to bank's profit. In addition, low interest rate reduce the bank's opportunity cost (cost of hoarding liquidity) and, therefore, its risk incentive (Smith, 2002). In fact, since holding cash become cheaper, the bank is no more under pressure to invest rapidly. In this sense, the bank may take more time to well assess the risk profile of projects before financing them. Moreover, higher interest rate may also induce more risk-taking (Gan, 2004; Merrouche and Nier, 2010). Higher interest rate may reduce the bank's franchise value and trigger risk-taking (Gan, 2004). In addition, higher interest rate may flatten the yield curve and lead banks to take more risk in order to maintain profits (Merrouche and Nier, 2010). While numerous studies link monetary softening to a credit boom and financial fragility, Agénor and Da Silva (2011) find that the same results still hold in the event of higher interest rate. According to Agénor and Da Silva (2011), in a middle-economy, an increase in the monetary interest rate to alleviate inflationary pressure, translates into capital inflow and a credit boom.

Furthermore, it could happen that rates no longer play the role assigned to them. Brunnermeier and Koby (2016, p.1) establish the existence of a reversal interest rate, which they define as "*the rate at which accommodative monetary policy "reverses" its intended effect and becomes contractionary for lending. It occurs when recapitalization gain from the duration mismatch are offset by decreases in net interest margins, lowering banks net worth and tightening its capital constraint*". In other words, monetary easing can lead banks to reduce their risk since their capital constraints become more binding.

It is then noticeable that there is no consensus on the effect of monetary policy on bank's risk-taking behaviour. There is a disappointment in regard of the impact of monetary policy shock on the financial stability. While a monetary softening and tightening can trigger financial imbalances via the search for yield or the credit crunch and economic downturn, they can also improve financial stability through balance sheet effect or by limiting the risk-taking behaviour of financial agents. In fact, low interest rate by depleting the bank's revenue can lead the bank to take more risk. At the same time, low interest rate may increase the bank's franchise value leading to cautious behaviour os the bank. Conversely, higher interest rate may increase the bank's revenue and refrain its risk-taking behaviour. However, higher interest rate is also related to higher refinancing cost, thus reducing bank's profit and may lead to more risk-taking.

Due to divergence of the results of these study, we can deepen the analysis of the risk-taking channel of monetary policy in view of better assess the relationship between monetary policy

and financial stability (or the bank's risk-taking behaviour).

2.3 Deepening the analysis of the monetary risk-taking channel

From what precedes, we can assert that the relationship between monetary policy and bank's risk-taking remains ambiguous. In fact, if it is established that the interest rate cut may induce a risk-taking by the banks through the search for yield, this result would not be systematic. Indeed, banks do not suffer only from profit losses due to the fall in interest rates, but they also benefit from the reduction in refinancing costs at the same time (De Nicola et al., 2010; Santos, 2014; Dell'Ariccia et al., 2014; Lamers et al., 2016). We can then imagine that the positive and negative effects of monetary policy on bank's risk are not exclusive. In other words, these effects co-exist and interact. The final behaviour of the banks would result from the balance of these opposite effects. In this sense a monetary easing could lead either to an increase in the bank's risk if the search for yield prevails, or to a bank's cautious behaviour in the opposite. In other words, the behaviour of bank will depend on the gain or loss the bank undergoes due to lower interest rates. Thus, there would be non linearity in the risk-taking channel of monetary policy because the impact on bank's lending operations counteract the impact on financing cost.

The contribution to the literature on the bank's risk-taking channel of monetary policy will be devoted to chapter 2 of this thesis. We can imagine that the positive and negative effects of monetary policy on the bank's risk may be stronger than each other depending on the prevailing monetary stance. We can consider the monetary stance as the position of the monetary interest rate from a benchmark (following Altunbas et al., 2010). Using a non linear econometric model may help in dealing with that issue.

At the end of this section, we can say that banks are important economic agents but are exposed to various risks, which requires a supervision of their activity. It is in this sense that prudential regulation (micro and macro) has been thought out and is being improved. This regulation, through its tools, impacts not only the risk-taking behaviour of banks but also acts on macroeconomic variables. However, while risk-taking by banks seems to be inherent to their activity, the fact remains that their risk-taking behaviour is also dictated by monetary policy. It is therefore inevitable that monetary policy and prudential policy will interact in both the financial and economic spheres. This raises the problem of their coordination. This point will be the subject of the following section.

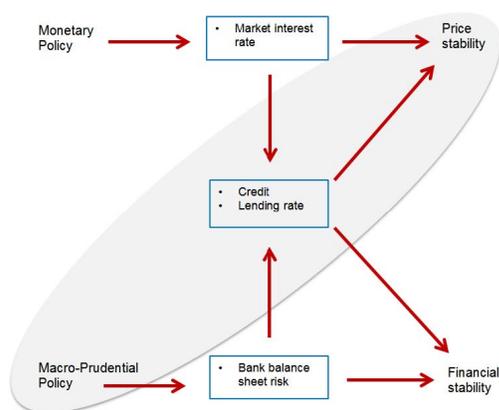
3 Prudential and monetary policy

As we have already said, even if prudential regulation and monetary policy seem independent since they have distinct objectives and tools, they very often interact. Sometimes they complements each other and sometimes they conflict. Indeed, on the one hand, De Boissieu (2011)⁹ argues that central banks fulfilled their role as lender of last resort during the 2008 crisis by applying unconventional monetary policies justified by the impossibility of negative interest rates (the zero lower bound of interest rate). Hence, the significant role of monetary policy in resolving crises is enlightened. The injection of liquidity in the economy supports the banking system and prevent the global financial system from collapsing. However, Borio and Zhu (2012) argue that too accommodative monetary policy (low interest rates) improves investor wealth and could lead to a spike in borrowing. In this sense, the quantitative easing may result in that financial agents hold risky assets. Lowering interest rate induces the financing of assets that should not have been financed without this rate cut. Thus, there is a risk of jeopardizing the financial system. On the other hand, a severe prudential policy could have a negative impact on monetary policy makers' actions. Imposing restrictions such as capital requirement could lead to a credit crunch and could slow economic growth (Galati and Moessner, 2013, European Central Bank (ECB), 2013). Prudential policy can therefore offset the expected effect of a monetary policy. As the objective of prudential policy is to alleviate risk-taking, there is obvious that it interacts with monetary policy. Figures 1.2 gives a bird's eye on how each policy impact the other's objective.

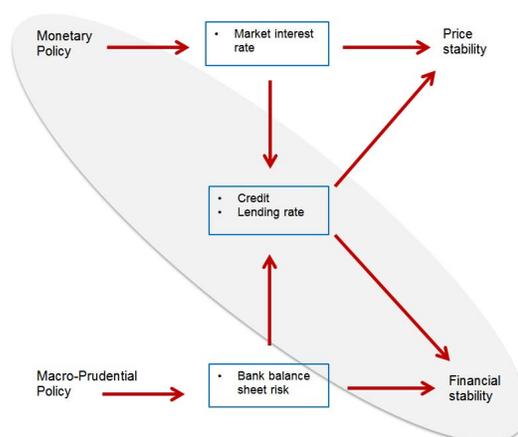
It is therefore common to find the question about the substitutability or complementarity of macroprudential policy and monetary policy (Cartapanis, 2011, Portes, 2014, Antipa and Matheron, 2014). The interactions between the two policies open the debate on three main points: the use of monetary policy for financial stability purposes, the number of institutions in charge of these policies (the both policies to an unique institution's control or separated institutions), and how to coordinate them. We will tackle successively the three points in this section.

⁹De Boissieu C. (2011), Introduction au rapport du CAE, p.7, in BETBEZE J-P., BORDES C., COUPPEY-SOUBEYRAN J. et PLIHON D. (2011), « Banques centrales et stabilité financière », rapport du Conseil d'Analyse Economique, 2011, 344 p.

(a) Impact of (macro-) prudential policy on price stability



(b) Impact of monetary policy on financial stability



Source: New Zealand Central Bank Report (2014)

Figure 1.2: Overlapping effects of monetary and prudential policy

3.1 On the use of Monetary policy for financial stability purposes

The separation between monetary policy and prudential policy almost relies on the Tinbergen principle. According to this principle, a tool must be used for a precise objective and must not be coupled with an other one for more efficiency. Antipa and Matheron (2014) note that interest rate changes, responding to inflationary pressure, should not affect prudential decisions. Conversely, depending on the evolution of systemic risk, prudential measures can be implemented or phased out without affecting monetary authorities' decisions when setting interest rate. For these authors, prudential and monetary policy are very different according to their tools and objectives.

With respect to the instruments used, it is important to note that both policies use tools that are fully independent. On the one hand, monetary policy acts mainly through interest rate. By setting the level of interest rates, monetary policy plays on agents' incentives and expectations, smoothing economic cycles. In recession, an interest rate cut supports bank's and businesses' funding, making capital cheaper. That is, it supports investment and fights against the economic slowdown. On the other hand, during period of expansion, in order to avoid bubble in the asset market, a restrictive monetary policy is necessary. Rising interest rate raise the cost of capital, make investments less attractive, and thus slow down the pace of growth and stabilize asset prices (slow down asset prices growth).

On the other hand, prudential policy relies mainly on regulatory capital and supervisory control. A tightening of the regulation in good times helps to limit the risk-taking. As

the paradox of tranquility stipulates, it is in tranquil times that the crisis (or instability) arise because it is during this period that the agents' risk-taking is greater since they underestimate the risk. The tightening of the constraints thus makes it possible to ensure the resilience of the financial system. Conversely, during a downturn period, the regulator tends to dampen the shock by softening the stress. This translates into maintaining the levels of credit and investment.

Moreover, the “clean” view supports the idea that monetary policy should not be used for financial stability purposes. Monetary policy should address credit boom only if its impacts inflation pressures. Prudential policies (micro- and macro-prudential policy) must be used to stabilize the financial system. According to this point of view, monetary policy would serve only to “clean up” after a crash. It is useless to use monetary policy for financial stability reasons since it has limited spill-over effects on credit and risk-taking. Hence, monetary instrument is blunt if used for financial stability.

Cecchetti (2009) deepens the analysis and presents both policies as substitutes. According to him, the more we use monetary policy with a goal of stabilization, the less we need to resort to macroprudential policy. It shows that interest rate can influence not only the economic sphere but also the financial sphere as well. In this sense, interest rate would help fighting against bubbles (asset and credit bubble), and would limit the agents' risk-taking behaviours. Therefore, monetary policy would have an objective of financial stability, the same objective of the macroprudential policy. It would therefore be useless to resort to macroprudential policy for the same purpose.

Another argument that supports this point of view is that economic growth, which is one of the main monetary policy objective, can be a source of instability in the financial system (Portes, 2014). The announcement of the stabilization of the macroeconomic sphere could trigger overconfidence of economic agents, and would incentivize the latter to take more risk, thus aggravating the vulnerability of the financial system to shock. Moreover, according to Portes (2014), following Svensson (2014), financial stability can not be ensured by monetary policy insofar as a restrictive monetary policy is inferior to macroprudential policy in limiting of bank excessive leverage (banks' ability to raise large funds from a limited amount of capital). A restrictive monetary policy that aims at stabilizing inflation could mitigate bank leverage. But, it would jeopardize the economy if inflation is low because it would triggers deflation. As a result, macro-prudential policy remains the optimal policy to address bank leverage.

Levieuge (2018) points that the non-synchronization of real and financial cycles leads to a

conflict of objectives, as shown in Table 1.4. In this case, there is a cost, in terms of inflation, for the central bank to have a financial stability objective. However, in institutional context, the monetary authorities give priority to the objective of price stability, leading to financial instability.

Table 1.4: Monetary policy stance according to real and financial cycles

		Financial cycle	
		Upside	Downside
Real cycle	Upside	Tightening	Conflict of objectives
	Downside	Conflict of objectives	Loosening

Source: Levieuge (2018)

As depicted in Table 1.4, when real and financial cycles are synchronized it is possible for the central bank to ensure both price and financial stability with its single instrument, the interest rate. But, when the two cycles are not synchronized (Upside/Downside or Downside/Upside), a conflict between objectives of price and financial stability appears. For example, when the financial cycle is upside while real cycle is downside, the central bank face a trade-off. Given that its main objective is price stability, it is obvious that central bank will loose its monetary policy (decrease interest rate) to rearm inflation. Such situation (low interest rate) will fuel the overheating of the financial system, increasing the risk appetite of financial agents and leading to financial instability.

Gertler and Karadi (2011) present macroprudential policy as more effective (than monetary policy) for financial stability purpose. They argue that macroprudential policy is more effective than monetary policy in an environment where bank capital is the main factor for risk-taking and level of credit. In this case, a monetary policy aiming at curbing the trend (leaning against the wind) has only a limited impact.

Although it has been proven that monetary policy has important impact on financial stability, the question of the number of institutions in charge of monetary and prudential policies remains.

3.2 The question of the authority in charge of the two policies

The institutional set-up for reaching price stability, on the one hand, and financial stability, on the other hand, leads to opposing positions among academics and politicians. On the one side, there is a point of view that asserts that central banks are able to conduct monetary and prudential policies. On the other side, some concerns are expressed as a counter-argument to the first point of view.

The arguments in favour of the designation of central banks as the institution in charge of monetary and prudential policy rely on their expertise on macroeconomic issues (Blanchard et al., 2010) . In fact, central banks are ideally qualified to monitor macroeconomic developments and, in several countries, they already regulate banks. This is the case, for example, in the European Union, where the ECB is the sole institution in charge of both policies.

Moreover, albeit the coordination between agencies involved in the resolution and the banking supervision appears as a solution to the dissociation of the central bank from the supervision in theory, this distinction causes some difficulties. It was the case with the coordination of the actions of various agencies involved (the Bank of England, the Financial Service Authority and the UK Treasury) in the rescue of the Northern Rock in 2007. The low process of rescuing causes important damages to the UK banking system, and to banking sectors around the world. Hence, the difficulties in deploying post-crisis monitoring measures with many agencies involved highlight the need for the conduct of monetary and prudential policies by the same institution. Coordinating the actions of two separate agencies in the crisis resolution phase has proven to be very difficult.

Furthermore, the key role of central banks as lenders of last resort requires central banks to be involved in banking regulation. Central banks should know more about ailing banks before rescue them. We can imagine that it is socially optimal to provide central banks (lenders of last resort) with supervision objective for the authorities to first realize the importance of a solvency issue before engaging large bailout. This point of view is driven by the Bagehot's guidance which advocates that resolution measures should be directed towards illiquid institutions and not towards insolvent ones.¹⁰ The overall idea can be summarized in the following statement of Kashyap (2010): *"As the lender of last resort, you are never sure who is going to come through the door and ask for a date. When you meet your date on a Friday night and your date is AIG, the question at hand is whether you'd like to know something about them before you have to pay \$85 billion to buy them dinner. If we mandate that the Fed is not involved in supervision then we make hasty, uninformed decisions inevitable when it is called upon as a lender of last resort."*

Similarly, centralizing macroprudential responsibilities within the central bank would allow better consideration of the potential implications of monetary policy decisions on leverage

¹⁰The Bagehot's guidance prescribe a set of principles for successful lender-of-last-resort operations. These principles were described in Walter Bagehot's Lombard Street, published in 1873.

and risk-taking. In fact, the main underlying idea is that since prudential policy (at least in its macro side) inevitably overlaps with the monetary policy's objectives, macroprudential policy could be carried out by the central bank. And the macroprudential policy can be coordinated with the microprudential policy held by a banking supervisor.

In contrast, if we follow the modified Jackson Hole consensus view, there is no need for prudential and monetary policies to be brought under one roof since there is sufficient information sharing among the monetary and banking supervision authorities.

Moreover, setting central banks as the single authority in charge of monetary and prudential policy may entail risk of misjudgements (Cartapanis, 2011). The behaviour of central banks would shift in favour of inflation to the detriment of the stability of the financial system. A separation of the two policies is therefore a *sine qua non* condition for achieving both objectives: financial stability on the one hand, and price stability and growth on the other hand. Furthermore, Leveuge (2018), questioning the ability of monetary policy in ensuring financial stability, find that central banks often face a trade-off between price stability and financial stability. This trade-off stems from the fact that the real and financial cycles are often out of phase. As a result, central banks' behaviour is biased towards price stability at the expense of financial stability. An incorrect assessment of the financial context would lead to an inappropriate action of the central bank, at the risk of undermining its credibility, especially since its action also affects its main objective of price stability.

The concerns about the involvement of central banks in financial stability are important. We do have reason to believe that the central bank's involvement in financial stability may undermine the credibility of its pursuit of price stability at least for two reasons. On the one side, it requires a stronger involvement in distributional policies (Brunnermeier and Sannikov, 2013)¹¹ and in quasi-fiscal operations (Pill, 2013)¹². The independence of the central bank may be undermined and central bank may be put under political pressures. Moreover, delegating the objective of financial stability to the central bank may create time-inconsistency problems to monetary policy. For example, in order to ensure long-term price stability, the central bank may be obliged to provide more liquidity than appropriate if inherent problems of over-indebtedness resulting from a financial crisis are not resolved.

¹¹Monetary policy can work if it redistributes wealth in such a way that dampens the amplification effects. For instance, lowering short-term interest rate can increase the value of long-term bonds, thus stabilizing banks' balance sheets. Purchasing specific assets held by a sector with impaired balance sheets softens amplification for that sector.

¹²Central banks have access to fiscal resources (seignorage) that might be used to deal with solvency issues

Cecchetti (2016, p.3) calls for a clear separation between institutions in charge of each policies and argues that: *“Each policy authority continues to have a distinct job. Monetary policy tools are ill-suited to manage financial stability risks, so central bankers should retain their focus on price stability. Prudential policy-makers have the tools that are particularly ill-suited for stabilization. They should retain their focus on financial stability, except in the most extreme circumstances”*.

In a nutshell, the optimal institutional set-up may prevent central banks from biased decisions and ensure them a clear independence. Even if many institutional set-ups may exist, the fact that financial stability and price stability are largely overlapping makes it is difficult to separate both objectives and the instruments to achieve those objectives. In this sense, there is a need for coordination of monetary and prudential policies.

3.3 Coordination of monetary and prudential policy

If monetary policy and prudential have different objectives, the last financial crisis changes the mindset that they should be set separately. Indeed, the coordination of the two policies seems to be desired and would be the optimal strategy as supported by the “lean” view. This point of view arises from the incapacity of prudential policy to rein in financial system instability and the costs of the resolution of the crisis. According to the lean view, monetary policy should actively address credit booms for financial stability and avoiding such costs in the aftermath of a crisis. A monetary policy that leans against credit booms insures price stability in the long-run and creates lower costs for the economy compared to costs associated with the aftermath of a crisis.

As several studies show, the coordination of the two policies leads to an optimal solution in the search for stability of both the financial system and the economic sphere.

In its inflation targeting, monetary policy promotes macroeconomic stability and thereby the stability of the financial system as well (Portes, 2014). Indeed, for this author, if monetary policy perfectly targets inflation, then the underlying macroeconomic stability is reflected in that of the financial system insofar as the authorities control the fundamentals and easily succeed in smooth the cycles. This author pushes the analysis further and concludes on a complementary between the two policies. Relying on Stein (2014), Portes (2014) argues that monetary policy is a complementary tool to prudential policy. The latter observes that monetary policy, through the setting of interest rates, would limit the leverage (for high interest rates) even for financial agents who still escape the prudential policy (e.g. shadow banking).

Cecchetti (2009) deepens the analysis and presents both policies as substitutes: the more we use monetary policy with a goal of stabilization, the less we need to resort to macroprudential policy. In fact, as already stated interest rate can influence not only the economic sphere but also the financial sphere. In this sense, interest rate would help fighting against bubbles (asset and credit bubble), and would limit the agents' risk-taking behaviours. Therefore, monetary policy would have an objective of financial stability, the same objective of the macroprudential policy. It would therefore be useless to resort to macroprudential policy for the same purpose. Conversely, the increased use of macroprudential policy rules out any need for monetary policy, as stability is already assured.

Working on the question of the link between the two policies, the 2012 background paper of IMF (henceforth IMF (2012)) establishes that macroprudential policy tools would affect the components of aggregate demand (real estate, credit, etc.). For example, macroprudential policy can influence real estate spending through the LTV or DTI ratio, sustainable goods expenditure and investment by enhancing credit constraint. A relaxation of the constraints imposed by these tools would allow a higher consumption and a strong investment. And conversely when the constraints are tightening.

The need to jointly conduct macroprudential policy and monetary policy is crucial for the system as a whole since these two policies inevitably interact. Based on econometric studies establishing the negative relationship between interest rates and risk taking of financial agents (described as a macroprudential paradigm: the higher the interest rate, the lower the risk taking of private agents), Cartapanis (2011) notes that a joint conduct of macroprudential and monetary policy is therefore necessary to ensure the effectiveness of the tools of each of them. In the same vein, Antipa and Matheron (2014) find that macroprudential policy is complementary to monetary policy. For these authors, macroprudential policy would support the real economy because it would limit disinvestment (and thereby the decline in production) in times of crisis.

According to the European Central Bank (2013), macroprudential policy allows to align agents' incentives in counter-cyclical way, to deal with the specificity of each country and to reduce the risk-taking induced by a loose monetary policy as well. While monetary policy would encourage private agents to take risks, macroprudential policy by introducing constraints (on capital and credit) would help to resolve imbalances induced by such a monetary policy. It is therefore important that monetary and prudential policy be coordinated.

Furthermore, monetary policy is often used as resolution measure in the event of a crisis.

Then, if agents expect a bailout during crisis, they have incentives to take more risk. Prudential policy can therefore be used to mitigate the ex-ante risk-taking of agents and prevent the economy from severe crisis (Jeanne and Korinek, 2013). Thus, there is a need for coordination of the two policies that act at specific periods (ex ante for macroprudential policy, and ex post for monetary policy).

Macroprudential policy and monetary policy prove complementary in that price stability and system stability reinforce mutually (ECB, 2013). This report presents financial stability as a factor facilitating the Central Bank’s pursuit of its mission (price stability). But price stability alone does not ensure financial stability. It must be combined with a macroprudential policy. As the European Central Bank (2013) explains, price stability is a precondition for financial stability, but, alone, is insufficient. Moreover, while macroprudential policy aims at smoothing out economic fluctuations, it must be complemented by other policies (such as monetary policy) to boost the economy in a downward phase. This is consistent with Kawata et al. (2013). These authors show that separated policies are not at all desirable and a coordination between monetary and prudential policy is a necessity for the promotion of economic growth and financial stability.

In a nutshell, the coordination of monetary and macroprudential policy can be summarized through a game theory. An interesting work that well depicts the payoffs of each policy is that of Agur (2018). This author study the coordination of both policy among equilibria where each policy tends to minimize its coordination cost. Based on the Prisoner’s Dilemma and the optimal outcome of the prisoners, Agur (2018) establishes the payoffs of each policy with two Nash equilibria (see Table 1.5). Monetary policy seek to reach a high outcome in terms of stable inflation while macroprudential policy a high outcome in terms of financial stability.

Table 1.5: Payoffs of monetary and macroprudential authorities in relation to their play

	Loose Macroprudential	Tight Macroprudential
Loose Monetary policy	Low, Low	High, Medium
Tight Monetary policy	Medium, High	Low, Low

Source: Agur (2018)

Given Table 1.5, the two policy should act in opposite direction to get greater pay-off. When monetary policy is loosened, macroprudential policy must be tightened for better outcome for both policies. Conversely, when monetary policy is tightened then macroprudential policy should be relaxed for both policies to have better outcome. But, as stated by Agur (2018),

since the game has two Nash equilibria, the authorities disagree which of these is better. In this sense, when the two policies act separately (without coordination) there are risks to fall in sub-optimal equilibrium with worse outcomes for both policies.

3.4 Deepening the analysis of the coordination of monetary and prudential policy

The preceding development has largely shown that monetary and prudential policies interact and could be sources of economic support or instability. The interaction of both policies and the question of their coordination has deserved attention in the recent banking literature. Partial equilibrium models as well as DGSE models prove the optimal outcome of using prudential tools to counteract negative effects of monetary policy on financial stability (Jeanne and Korinek, 2013; Quint and Rabanal, 2014; Brzoza-Brzezina et al., 2013).

Although the existing literature on the banking regulation examines the interaction between monetary and prudential policies, there is no room for the positive effects of monetary policy easing or for negative effects of monetary policy contraction on the bank's risk-taking behaviour. The monetary policy easing is addressed merely as a threat to financial stability. Moreover, the combination of micro- and macro-prudential tools in the same framework has deserved only little attention. We propose to complement the existing literature by showing that the form or nature of the coordination between monetary policy and prudential policy is not clear-cut. In particular, we will show that the structure of microprudential regulation will determine the risk-taking behaviour of banks following a restrictive or expansionary monetary policy. In the same way, we will show that the effect (and therefore the effectiveness) of prudential policy will be conditioned by the nature of the effect of monetary policy on the bank's risk-taking behaviour.

We can then formulate some questions: which calibration of microprudential tools is well suited to address the bank's risk-taking driven by a change in monetary policy? Is a unique calibration of the microprudential policy appropriated for any change in monetary policy? Which combination of monetary and prudential measures are socially desirable? In other words, should the supervisor always respond to monetary easing by tightening its standards?

Chapter 3 is devoted to the analysis of the coordination of monetary and prudential policy and tackles most of these questions.

Conclusion

It is important to note that the financial stability results from the attitude of financial institutions towards risk. Their risk-taking behaviour is mainly driven by monetary policy and is sometimes the root cause of threats against financial stability. The latter can be defined as a decline in the robustness or resilience of the financial system. The robustness of the system refers to the system's ability to resist negative shocks. The system is said to be resilient in relation to its capacity *"to adapt in response to both short-term shocks and long-term changes in economic, social, and ecological conditions while continuing to fulfil its functions in serving the real economy"* (Berry et al., 2015, p.10).

However, the impact of monetary policy on bank's risk-taking appears to be ambiguous. On the one side, monetary policy easing implies profit losses that may wet bank's risk appetite. On the other side, lower interest rate induce lower refinancing cost that can refrain the incentives of banks to take risk. Although the effect of monetary policy on bank's risk has been largely analysed, the potential positive effects of accommodative monetary policy on banks' risk has been neglected. In order to complement the existing literature, we intend, in chapter 2, to deepen empirical analysis of the risk-taking channel using a non-linear approach. This non-linear analysis may help to simultaneously account for positive and negative effect of monetary policy on bank's risk.

Nevertheless, in order to mitigate bank's risk-taking behaviour and prevent crisis, policy makers have set prudential tools. Albeit, prudential policy objectives seem to be independent from monetary policy, it appears that the two policies interact. On the one hand, if prudential constraints are binding, the expected beneficial effect of monetary tools could fade. On the other hand, a too loose monetary policy could lead banks to take more risk, refraining the effectiveness of prudential tools. Albeit the coordination of the two policies is obvious, the question of how to coordinate them appears crucial. One of the key points is the independence of the institution in charge of the prudential policy. On this point, two major streams of thought oppose each other. A clear separation between monetary and prudential authorities is advocated on one side, and a single institution in charge of the two policies is desired on the other. The defenders of the former stream of thought rely on the risk for the central bank's behaviour to be biased towards price stability and to be no more independent. The proponents of the second stream highlight the Central banks expertise and the complementary between price stability and financial stability.

However, whether monetary and prudential authorities should be separated or not, monetary

and prudential policy must be coordinated. Macroeconomic and financial stability can be reached only if policies are optimally coordinated. While the coordination of both policies has been largely analysed, there are still rooms for improvement. Further works would be needed for better analysis of the question of the coordination of monetary and prudential policy, and is the objective of chapter 3.

Chapter 2

A NON-LINEAR APPROACH OF THE RELATIONSHIP BETWEEN MONETARY POLICY AND BANK'S RISK-TAKING

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The adequate adjustment of prudential measures to ensure financial stability is of paramount importance given its implications in terms of macroeconomic stability. However, as discussed in the previous chapter, the risk-taking behaviour of banks, which threatens financial stability, has been largely attributed to monetary policy being considered too accommodative. However, theoretical and empirical work on the risk-taking channel of monetary policy has revealed mitigated results. On the one hand, low interest rates would lead to a narrowing of the interest margin and profit losses, leading banks to take more risk in order to restore their profitability (Rajan, 2005; Adrian and Shin, 2009; Ioannidou et al., 2007; Jimenez et al., 2008; Gambacorta, 2009; Dell’Ariccia et al., 2010; Altunbas et al., 2010). On the other hand, low rates also lead to an increase in banks’ residual value and lower financing costs, which would reduce banks’ incentives to take more risk (Kane, 1989; Smith, 2002; Gan, 2004; Agénor and Da Silva, 2011; Agur and Demertzis, 2012; Korinek and Simsek, 2016; Brunnermeier and Koby, 2016).

This lack of consensus is a major issue in terms of economic policy, especially in a context where the regulator is seeking to reform banking regulation in the wake of the latest financial crisis.

We are therefore likely to assume that the effects of monetary policy on the risk-taking behaviour of banks, although opposing, are by no means mutually exclusive. The two effects would act at the same time, with different intensities depending on the position in the monetary cycle. In this chapter, we seek to provide an empirical analysis of the monetary risk-taking channel to support this view. To do so, we aim to further analyse the hot topic of the risk-taking channel of monetary policy, investigating the non-linearity in this relationship. The panel threshold model developed by Hansen (1999) appears appropriate since it allows linear and non-linear relations to be tested in the same regression. In other words, this model should allow us to identify different marginal effects of monetary shocks on banks’ risk behaviour using a threshold variable.

In testing this relationship between monetary policy and bank’s risk, we face two major challenges associated to measuring banks’ risk-taking behaviour and the monetary policy stance. The choice of a good measure of risk-taking behaviour is not obvious. Altunbas et al. (2010) and Gambacorta (2009) use the change in the Expected Default Frequency (ΔEDF) to proxy for bank risk-taking behaviour. This variable is derived from Moody’s KMV and measures the probability that a firm will default over a given time period. According to Moody’s KMV, a default occurs when the market value of the assets falls below the liabilities payable. So, the EDF can be considered as a forward-looking indicator of credit risk.

In this chapter, we adopt a backward-looking approach of bank’s risk measure and use the Z-score¹³ as a proxy for bank risk. The Z-score or its log is used commonly to measure banks’ financial soundness or insolvency (Roy, 1952; Boyd et al. 2006; Lepetit et al. 2008; Lepetit and Strobel, 2013; Delis et al., 2014; Lepetit and Strobel, 2015). The lower the bank’s Z-score the higher its risk of insolvency.

The second issue is the assessment of the monetary policy stance. Since then, monetary policy has never been conducted *ex nihilo*. Central banks have adopted monetary rules in order to better steer their actions. One of the most widely used monetary rules is known as the "Taylor rule".¹⁴ We follow Altunbas et al. (2010) and assess the monetary policy stance by looking at the deviation of monetary rates from the rates provided by this Taylor rule, deviation referred to as the “Taylor gap”. The Taylor gap is used as our threshold variable. We understand a negative Taylor gap as an accommodative monetary policy, and a positive Taylor gap as a restrictive monetary policy.

Using quarterly data for 194 US banks from 1998q1 to 2015q4 (72 quarters), we evidence a threshold value in the Taylor gap (i.e. the deviation of the monetary rate from the Taylor rule) from which the effects of the monetary rate on the bank’s risk-taking behaviour reverse. The results show that when the monetary interest rate is far below the Taylor rule, a decrease in the interest rate has a negative effect on the bank’s soundness. This can translate into more risk-taking behaviour following an interest rate cut. However, this effect turns positive for lower negative deviations or for positive deviations from the Taylor rule, meaning that monetary easing will foster bank soundness when the monetary rate is close to or greater than the Taylor rule.

Our results allow for some recommendations about monetary and prudential policies. In light of our findings, monetary policy authorities should take account of the monetary rate regime (positive or negative deviation of the interest rate from the Taylor rule) when setting their monetary policy. Moreover, our findings call on prudential authorities to be more vigilant to the (monetary) cycle in which change in interest rate occurs since it could have different

¹³Z-score = $\frac{car+roa}{\sigma_{roa}}$ where *roa* is profits after tax/total assets, *car* is equity capital/total assets and σ_{roa} is the standard deviation of *roa*. The underlying idea of the Z-score is that since bank is supposed to become insolvent when its current losses exhaust capital, $car + roa \leq 0$, we can easily estimate the likelihood of insolvency by assuming that this likelihood refers to the probability that $roa \leq -car$ (or $car < L$), with *car* the bank’s capital to asset ratio, *roa* its return on asset ratio (Lepetit and Strobel, 2015), and *L* its losses.

¹⁴The Taylor rule rate is estimated following Taylor (1993) Following Taylor (1993): $i = r + \pi + 0.5(\pi - \pi^*) + 0.5y$ where *r* is the natural interest rate (set at 2%), π^* is the inflation target set at 2% and *y* is the output gap. As quarterly data have short frequency and do not allow to smooth fluctuation in price level, Taylor (1993) suggest that π should be estimated as the moving average of the inflation on the 4 last quarters.

impact on financial stability.

The chapter is organized as follows. The non-linear econometric model that we adopt is presented in section 1. Section 2 describes the data and presents the risk-taking measure used in our work. Section 3 deals with the econometric analysis and presents the results of linear models. The results of the non-linear analysis and the robustness tests are provided in section 4.

1 Non-linear econometric analysis: an overview

Econometrics has mainly used linear model to explain phenomena. However, these linear models have proven to have certain limitations in providing explanations for certain phenomena. Therefore, another form of econometric modelling has emerged and has spread quite widely in all areas of research. These new models, which tend to take into account non-linearities in certain mechanisms, are worth a brief presentation of their interest. In addition, we will present the threshold effects model that we have chosen for our analysis.

1.1 The scope of non-linear model in econometrics

In econometrics, both non-linearity and non-stationary have been considered as dominant properties. These properties have been taken into account in the various fields of scientific research. Indeed, in economics, many empirical studies have shown that ARMA-type linear models often fail to capture the dynamics of a particular economic process for two main reasons: the presence of asymmetry in the data and structural changes that trigger temporal instability in relationships between variables.

Applied econometrics is totally modified by the need to take into account non-linearity and more particularly regime changes. Colletaz and Hurlin (2007) compare this evolution to the gradual passage in micro-economics from the Walrassian framework (assimilated to linear econometric modelling) to non-linear models that focus on the multiple forms of imperfect competition. Among the multitude of means that have been explored to model non-linearity, the regime change models have proven to be one that well economically explain non-linearity. Originally initiated by Tong (1978) and Tong and Lim (1980), regime change models possess properties allowing an economic series to have a different dynamic according to the regimes or states of the world.

However, regime change can be of two distinct natures. The regime change can be either deterministic (i.e. occurring at a date known in advance) or stochastic. The application by

Franses and Van Dijk (2000) on the equity market is well suited to illustrate the deterministic regime change model. Empirically, the pick in the activity on a financial market at the end of the week (“weekend effects”) can be taken into account in the econometric analysis. In contrast, in models with stochastic regime changes, the date when the transition occurs is unknown and is determined ex-post using a transition variable. For example, dynamics of the GDP growth rate can be analysed through a stochastic regime change model. For instance, Beaudry and Koop (1993) use these models and specify differently the dynamics of the GDP growth rate depending on whether the current GDP is above or below its latest maximum. Periods when GDP is above or below certain endogenously determined thresholds are therefore considered as distinct regimes. In other words, the level of GDP is the economic variable that determines the change in regimes and divides the data into subgroups. In this thesis, we will focus on models with stochastic regime changes.

Nevertheless, the definition of the transition mechanism between the different regimes is the main challenge in models with stochastic. Whether this transition mechanism depends on observable transition variable or not set a clear distinction between markovian regimes (unobservable transition variable) and the threshold models (observable transition variable). In markovian models, the transition mechanism is based on an unobservable state variable that is supposed to follow a Markov chain. Therefore, at each time period, there is a certain probability of belonging to a given regime. In contrast, in threshold models, the transition mechanism is then carried out at using an observable transition variable, a threshold and a transition function. The main difficulty of this type of model is therefore the choice of the observable transition variable, but there are statistical methods, such as linearity tests, to guide the researcher in his choice. Two transition mechanisms are then possible, depending on the form of the transition function used. Indeed, it is possible to consider either an indicator function or a continuous and bounded function. The former induces a brutal transition as the transition from one regime to another can take place in one period. More precisely, with an indicator function the transition is obtained by comparing the transition variable to a threshold, if the latter becomes higher or lower than this threshold, the transition is done instantly. In the second form of transition function (a continuous and bounded function), the transition is bounded between 0 and 1 and allow a smooth transition between extreme regimes (see Chan and Tong, 1987). Smooth transition models have the advantage of containing a continuum of regimes. Belonging to a regime then depends on the transition function and the distance between the threshold and the transition variable.

It is therefore important to say that the set of regime change models discussed so far has brought some novelties in the empirical literature. For example, it is now possible to model

asymmetries such as distinct dynamics in the upward and downward phases using their different regimes. Moreover, the temporal stability of the coefficients over time can be questioned. However, unlike the break-up model, the transition from one regime to another is neither dated nor definitive, as it is determined endogenously based on a threshold. The contributions of regime change models extend into the short- and medium-term forecasting of macroeconomic and financial series. As Colletaz and Hurlin (2007) point out, if forecasts are considered from confidence intervals or in the form of density, then threshold models can be used to account for asymmetry around one-time forecasts, which was not possible from a linear model. Furthermore, the use of threshold models also enrich the debate relating to the treatment of non-stationarity. The existence of several regimes in a the same model allows a process to be generally stationary. In other words, not all regimes are necessarily have a unit root in their autoregressive polynomial, and not all do not need to be stationary. In econometric (time series and panel data), this question of non-stationarity versus non-linearity is also important, given that these two concepts can be confused after a conventional stationarity test.

It appears then that non-linear econometric models have the merit of simultaneously examining the potential different effects of an exogenous variable on a dependent variable. Therefore, the importance of the use of a non-linear model to support our assumptions deserves that we present the specific econometric model we retain for our analysis, namely the non-dynamic panel threshold model.

1.2 Looking for threshold effects in the monetary risk-taking channel: a non-dynamic panel threshold model

Threshold models are largely used in economics. For instance, threshold model has been used to prove that cross-country growth models with multiple equilibria can exhibit threshold effects (Durlauf and Johnson,1995). In addition, Khan and Senhadji (2001) evidence the existence of threshold effects in the relationship between inflation and growth. However, we can deplore the fact that such approach is not used effectively in the analysis of the impact of monetary policy on the bank's risk.

We seek to fill this gap and explore non-linearity through a threshold analysis using Hansen's methods (1999), i.e. the non-dynamic panel threshold model. This threshold model is described in the following subsection.

1.2.1 Framework and set-up

In this section, we describe the general econometric framework developed by Hansen (1999) that supports our empirical work. Following Hansen (1999), let us consider a panel dataset $\{y_{it}, q_{it}, x_{it} : 1 \leq i \leq n, 1 \leq t \leq T\}$. In this specification y_{it} is a scalar representing the dependent variable of interest; q_{it} is a scalar representing the threshold variable; x_{it} is a k vector of all control variables included in the regression. Individual and time subscripts are, respectively, i and t . In the general setting of the model, the threshold variable can potentially be the same as the dependent variable ('self-threshold', Tong 1990) or an exogenous/endogenous variable. Typically, the threshold model can be rewritten as follow:

$$y_{i,t} = \mu_i + \lambda_1 x_{i,t} I(q_{i,t} \leq \gamma) + \lambda_2 x_{i,t} I(q_{i,t} > \gamma) + \varepsilon_{i,t} \quad (2.1)$$

This is a compact form. Intuitively it can be written as two regressions:

$$\begin{cases} y_{i,t} = \mu_i + \lambda_1 x_{i,t} + \varepsilon_{i,t} & \text{if } q_{i,t} \leq \gamma \\ y_{i,t} = \mu_i + \lambda_2 x_{i,t} + \varepsilon_{i,t} & \text{if } q_{i,t} > \gamma \end{cases}$$

In this expression, the sample is divided into two regimes distinguished by different regression slopes λ_1 and λ_2 ; $I(\cdot)$ is the indicator function that defines the sample splitting. The term μ_i is a permanent but unobserved fixed effect. It captures cross-sectional unobserved heterogeneity due to differences in technology between individual and all other determinants of the variability in y_{it} not already controlled in x_{it} . There are several reasons why at this point we assume the presence of fixed effect. First, the econometric of the threshold panel that we are using is valid only under the assumption of fixed effect. Second, we argue that the fixed effect is more plausible than the random effect as the latter implies a zero correlation ($Cov(x_{it}, \mu_i) = 0$) between the unobserved effect μ_i , the variable in the right-hand side. Altunbas et al. (2010) and many other researchers have empirically shown that bank risk-taking behaviour is affected by several factors such as bank competition, technology, power bargaining between manager, shareholder and stakeholders, monetary policy expectations. Since we do not capture these factors, they can be viewed as being included in the unobserved fixed effect. The idiosyncratic errors of the model are denoted by ε_{it} with the usual assumption that they are independent and identically distributed normal. This is a simple specification form for the case of one single threshold. Equation 2.1 can easily be extended to allow for the presence of two, three or multiple thresholds. In case of m thresholds, the model will have $(m + 1)$ regimes or regression functions or regime dependent slopes.

To identify the regression slope, Hansen (1999) assumes that both x_{it} and q_{it} must be time variant. This constraint is not excessively restrictive. In fact, the inclusion of the fixed effect μ_i already accounts for all time invariant factors that could possibly explain the variability in the dependent variable. Also, technically all the time invariant variables are dropped after the within-transformation commonly used to eliminate the fixed effect. The panel threshold framework developed by Hansen (1999) does not apply to a dynamic panel. Our right-hand side variable will not include the initial level of Z-score. Seo and Shin (2010) address this gap by adapting the GMM estimation techniques for a dynamic panel estimation to the threshold panel regression methods advanced by Hansen (2000) and Caner and Hansen (2004).

Furthermore, the most important limitation of Hansen’s model is that all regressors and the threshold variable are required to be exogenous. Thus, there is a gap in the theoretical literature when the threshold variable q_{it} is endogenous and/or there are some endogenous variables among the covariates x_{it} . Caner and Hansen (2004) propose an attempt to consider endogenous regressors but only for cross-sectional data. The authors propose a modified version of the method in Hansen (1999) which is two steps least square (henceforth 2SLS) -like method that estimates a first step equation for the endogenous variable and their fitted values in the threshold regression. Kourtellos et al. (2007) also address the issue of endogenous threshold variable for cross-sectional data. Wang and Lin (2010) extend the results and propose a two-stage bias correction method to estimate the parameters of panel threshold model with endogenous threshold variables across different specifications. Seo and Shin (2014) also examine the same issue for dynamic threshold panel.

1.2.2 *Estimation*

Based on the assumption discussed above, Hansen (1999) suggests a concentrated least square estimation of the endogenous threshold γ after the elimination of individual effect μ_i as usual. This estimation consists of the minimization of the sum of squared error function:

$$\hat{\gamma} = \underbrace{\operatorname{argmin}}_{\gamma} S_1(\hat{\gamma}) = \hat{\varepsilon}_{it}(\hat{\gamma})' * \hat{\varepsilon}_{it}(\hat{\gamma})$$

The implementation of this minimization problem and the estimation of the parameters follow a grid search approach as described in the steps below:

1. Eliminate the smallest and the largest η % values on the threshold variable q_{it} and search for the optimal value of γ among the remaining values.

2. Estimate for each of the remaining values the regression after removing individual effect. The value of γ which yields the smallest sum of squared errors (SSE) is the optimal threshold.
3. With the $\hat{\gamma}$, split the data and use OLS to estimate regression parameters.

Empirically, the number of regressions to be performed in the grid search can rise exponentially with the sample size, making the estimation computationally costly. Instead of searching over the entire values of the threshold variable, a commonly-used short-cut that yields approximately an identical result, is to loop over specific quantiles between the η % and $(1 - \eta)$ % quantiles. For convenience, Hansen (1999, 2000) suggests that it might be desirable to impose some restrictions on the threshold variable in order to obtain a minimum percentage of observation (τ %) in each regime.

1.2.3 *Testing and inference*

After the estimation of the endogenous threshold $\hat{\gamma}$, it is necessary to test whether or not the threshold effect is significant. The null hypothesis of this test is written as $H_0: \lambda_1 = \lambda_2$. Hansen (1999) shows that the statistic for this test is:

$$LR_0(\gamma) = \frac{(S_0 - S_1(\hat{\gamma}))}{\hat{\sigma}^2}$$

$$\text{With } \hat{\sigma} = \frac{1}{(n(T-1))} S_1(\hat{\gamma})$$

Since the distribution of this test statistic under the null hypothesis is not a classic distribution, the suggestion would be to construct the p-value of this test using bootstrap procedure. The bootstrap p-values are asymptotically valid. Due to the panel nature of the data, special attention is needed in drawing up the bootstrap sample. As suggested in Hansen (1999, 2000) the easiest approach is to treat all the explanatory variables as constant and the countries as clusters. The regression residuals under the null hypothesis are used as the empirical distribution for bootstrapping. Once the bootstrapped sample is drawn randomly with replacement, the bootstrapped dependent variable is generated under the null hypothesis with the sampled residuals and holding the other covariates and the threshold variables constant. The bootstrapped likelihood ratios are computed by repeating this procedure several times. The bootstrapped p-value of the test of threshold effect is then computed as the percentage of draws for which the simulated statistic exceeds the actual.

The confidence intervals for γ is formed with the no rejection region of the test $H_0 : \gamma_0 = \gamma_1$

using the likelihood ratio test:

$$LR_1(\gamma) = \frac{(S_1 - S_1(\hat{\gamma}))}{\hat{\sigma}^2}$$

Hansen (1999, 2000) proposes an asymptotic distribution to the threshold parameter, showing that under the null hypothesis, the test statistics $LR_1(\gamma)$ converge to a random variable ξ with distribution:

$$P(\xi \leq x) = (1 - \exp(-\frac{x^2}{2}))^2$$

The asymptotic p-value for the significance of the threshold estimated is:

$$P_n = 1 - (1 - \exp(-\frac{LR_1(\gamma_0)^2}{2}))^2$$

The associated no rejection region can be graphically represented by drawing a flat line at

$$c(\alpha) = -\log(1 - \sqrt{1 - \alpha}),$$

with $(1 - \alpha)$ the desired confidence level. It corresponds to the values of the likelihood that lie beneath the flat line. The slopes λ_1 and λ_2 have asymptotic normal distribution provided that the errors are normally *iid*. This can be used for inference. The other regression slopes are unaffected and the usual normal asymptotic distribution can be applied for inference. The framework described above could be extended to two, three and multiple thresholds. Determination of the number of thresholds could be done by following a sequential approach of testing one threshold against none; two thresholds against one; and so on. It might also be acceptable to arbitrarily set an upper limit to the maximum number of thresholds to be explored. The upper limit is suggested by the number of dips in the graph of the likelihood ratio for the first threshold.

To test for non-linearity in the impact of monetary on bank's risk, we apply the non-dynamic panel threshold model on American banks data. The descriptive analysis of our sample and data are the purpose of the next section.

2 Data and bank’s risk indicators

2.1 Banks data and monetary variable

We use quarterly data on 194 American banks from Bloomberg over the period 1998q1 to 2015q4. This large period allows us to better assess the change in bank risk taking behaviour as it encompasses at the same time periods of economic expansion and of economic downturn, and periods of high and low interest rate.¹⁵ Our sample is composed of heterogeneous banks regarding their size (assets), efficiency, quality of assets and liquidity.

2.1.1 *Banks size and leverage*

Here, we try to classify banks regarding their size and leverage ratio. While the bank’s size is measured by the amount of its total asset, the bank’s leverage allows to measure the bank’s capitalization as the ratio of bank capital over total asset.

First, we categorize banks in our sample with respect to the bank size. The annual Community Reinvestment Act (CRA) asset-size threshold adjustments for small and intermediate small institutions defines a small bank or institution as “a bank or savings association that, as of December 31 of either of the prior two calendar years, had assets of less than \$1.252 billion”.¹⁶ Following this definition, and given that there is no precised threshold for medium and large banks, we consider as “small”, banks whose assets is at most equal to \$1.252 billion. “Medium banks” have an amount of assets in the range of \$1.252 billion and \$50 billion. Banks whose assets exceed \$50 billion are considered as “large”.

Table 2.1: Repartition of bank size (in average) over the whole period

Bank size	Frequency	Percent	Cum.
Small	68	35.05	35.05
Medium	114	58.76	93.81
Large	12	6.19	100.00
Total	194	100	

Table 2.1 represents banks repartition following their average size over the whole period. Considering their average assets, we have 68 banks that are considered as small banks,

¹⁵The notions of high and low interest rate will be discussed latter in the subsection related to monetary policy variable.

¹⁶see <https://www.ffiec.gov/cra/pdf/AssetThreshold2019.pdf> for more details. We use threshold applied in 2018.

representing 35% of the sample, and 12 banks could be considered as large banks since they have in average assets greater than \$50 billion.

However, the banks size did not remain constant and has proven to evolve over the period of our analysis. At the begin of the period (1998q1), the sample is composed by 68 small banks, 114 banks of medium size and 12 large banks (see Table 2.2). And, at the end of the period (2015q4), the distribution seems similar (see Table 2.3), but we note an increase of banks size as banks tend to become much larger.

Table 2.2: Repartition of bank size at the beginning of the period

Bank size	Frequency	Percent	Cum.
Small	68	35.05	35.05
Medium	114	58.76	93.81
Large	12	6.19	100.00
Total	194	100	

Table 2.3: Repartition of bank size at the end of the period

Bank size	Frequency	Percent	Cum.
Small	46	23.71	23.71
Medium	133	68.56	92.27
Large	15	7.73	100.00
Total	194	100	

Next let's turn to the bank capitalization, we refer to the leverage ratio as recommended by the US banking regulatory authority. In contrast to the Basel III leverage ratio that was fixed to at least 3%, the US regulatory authority imposed all the US banking organizations and intermediate holding companies a minimum of 4% leverage ratio and to the insured depository institution a minimum of 5% leverage ratio.¹⁷ The US leverage ratio is defined as the capital divided by the bank on-balance sheet exposure measure (total assets). In other words, US leverage ratio don't account for off-balance sheet as the Basel III leverage ratio does. Although, the minimum requirement started in the middle of 2000s, we examine whether banks were already well capitalized or not. For this purpose, we consider as "high levered" banks that have less than 4% of equity to assets ratio, "moderately levered" banks that have equity to assets ratio between 4% and 8% and "low levered" banks whose equity to assets ratio is at least 8%.

Most of banks of our sample (170 banks) appear to be well-capitalized since they have an

¹⁷for details, visit <https://www.structuredfinanceinsights.com/resources-28.html>

average leverage ratio over the period at least equal to 8%. No bank in our sample can be considered as high levered.

Table 2.4: Repartition of bank average leverage over the whole period

Average leverage	Frequency	Percent	Cum.
High levered	0	0.00	0.00
Moderately levered	24	12.37	12.37
Low levered	170	87.63	100.00
Total	194	100	

Table 2.5: Repartition of bank average size and average leverage over the whole of the period

Banks size	Banks leverage			Total
	High levered	Moderately levered	Low levered	
Small	0	12	56	68
Medium	0	11	103	114
Large	0	1	11	12
Total	0	24	170	194

The cross-analysis of banks' size and leverage is given in Table 2.5. This table shows that every bank size group is mainly low levered. Contrary to what we could have expected, even small banks are low levered. In fact about 82% (56 over 68) of small banks are low levered.

The two variables are summarized in Table 2.6 and shows that our sample is composed of heterogeneous banks based on their size (amount of assets) and their capitalization.

Table 2.6: Repartition of bank size (in million dollar) and capitalization

Variables	Obs.	Mean	Std. Dev.	Min	Max
Total assets	13,968	35,675.78	213,032.4	12.813	2,577,148
Leverage (%)	13,968	9.8056	3.19624	0.0585	62.96462

All the banks have an amount of assets which varies from \$12 million to \$2,577 billion. Thus, there are small, medium and large banks in our sample, with an average amount of assets of about \$35 billion. Looking at their capitalization, banks seem to be well-capitalized (or low levered) with an average leverage ratio of 9.8% which is more than the regulatory requirement. This suggest that in average banks do fully comply with the regulatory requirement and appear to be less levered as required by the regulator. But, the leverage ratio varies across banks, from 0.05% to 63%.

After this description of banks in terms of their size and leverage, an insight into their risk profile deserves special attention.

2.1.2 *Banks risk variable*

The bank risk variable is our dependent variable and is of primary interest. Indeed, the risk measurement must be as appropriate as possible in order to provide robustness to the analytical results. The literature is overwhelmingly full of multiple risk proxies as we saw in the previous chapter: the change in the Expected Default Frequency (Gambacorta, 2009; Altunbas et al., 2010) or the softening of the credit standards (Iaonnidou et al., 2007; Maddaloni et al., 2008; Jimenez et al., 2008). There are several other measures of bank risk-taking such as credit rating at origination as used by Black and Hazelwood (2012), the Basel capital requirement, i.e. the risk-weighted Tier 1 capital ratio, or a measure of asset quality such as the ratio of Non-performing loans over total assets.

Albeit, these measures of risk are relevant most of them seem to partially proxy risk-taking since they focus only on some components of the bank's risk and neglect others. We then look for a global banks' risk-taking indicator. Thus, we opt for the Z-score which is a measure of bank risk that is easily available and computable.

We use the traditional Z-score to proxy for bank risk, using actual car and roa , and standard deviation of roa estimated on the entire sample following Hesse and Cihak (2007) and Niu (2012):

$$Z\text{-score} = \frac{car_t + roa_t}{\sigma_{roa}}$$

where $roa = \frac{\text{profits after tax}}{\text{total assets}}$, car is equity to total assets ratio and σ_{roa} is the standard deviation of roa on the entire sample.

The Bank's Z-score is then an ex-post risk measure. The idea underlying the Z-score is that since a bank is supposed to become insolvent if its current losses exhaust its capital, i.e. $car + roa \leq 0$, we can estimate the likelihood of insolvency by assuming that the likelihood refers to the probability that $roa \leq -car$ (or $car < L$), where car is the bank's capital to asset ratio, roa is the bank's return on asset ratio, and L is the bank's losses (Lepetit and Strobel, 2015). The Z-score or its log is used widely to measure bank financial soundness or bank insolvency (Roy, 1952; Boyd et al. 2006; Lepetit et al 2008; Lepetit et Strobel, 2013; Delis et al., 2014; Lepetit et Strobel, 2015) and is inversely related to the probability the bank will become insolvent. The lower the bank's Z-score, the higher the risk of insolvency.

This (traditional) calculation of the Z-score has some limits. On the one hand, Delis et al. (2014) note that using the entire sample to calculate σ_{roa} does not reflect short-term fluctuation of bank risk. Certain method of calculating the Z-score have been applied to deal

with this issue:

- using actual *car* and *roa*, and standard deviation of *roa* estimated over a rolling window of 5 periods (Chortareas et al., 2012);
- using actual *car* and *roa*, and instantaneous standard deviation of *roa* ($roa_t - \mu_{roa}$), where μ_{roa} is the average *roa* estimated on the entire sample (Boyd et al., 2006);
- using the means of *car* and *roa*, and the standard deviation of *roa*, all estimated over a rolling window of 4 or 8 periods (Boyd et al., 2006; De Haan and Poghosyan, 2012; Anolli et al., 2014);
- using actual *car* and estimating the mean and standard deviation of *roa* over a rolling window of 4 or 5 periods (Yeyati and Micco, 2007; Anginer et al., 2014).

However, the time frame used to estimate σ_{roa} (and mean *roa*) is important. Delis et al. (2014) note that if a long-time frame is used, the risk will increase earlier, but the magnitude of the risk will be smaller. For example, if the period is reduced to eight quarters, the risk will increase later and will be a larger increase. It is easily understood that the assumption about the number of periods to include to construct the variance component will affect the results significantly.

On the other hand, the Z-score is computed assuming that *roa* is normally distributed. Unfortunately, this assumption is rarely validated. *roa* is skewed and has excess kurtosis, which can lead to misestimation of the bank's default probability. To deal with this issue, some authors use the logarithm of the traditional Z-score (Demirgüç-Kunt et al., 2008; Leaven and Levine, 2009; Lepetit and Strobel, 2015). Also, Lapteacru (2016) proposes a more flexible distribution function to make the Z-score consistent and preserve its original concept of risk.

Despite these drawbacks to the Z-score (the under- or over-estimation bias in the default probability due to the non-normality of the distribution of *roa*), and regardless of the "true" distribution of *roa*, the Z-score is a good proxy for bank risk since a decreasing Z-score translates to increasing bank fragility. In fact, a decreasing Z-score could stem from, on the one hand, a decrease either in the bank's capitalization, or in the bank's assets return profitability or both, on the other hand, from an increase in the volatility of returns on the bank's assets. In addition, we can rely on the Z-score since our aim is to assess the impact of monetary shock on banks risk behaviour, not to provide a better estimate of banks default probability.

Since bank risk is appreciated only when it materializes, bank risk-taking behaviour cannot be assessed at time. Therefore, the Z-score can be used to account for banks risk behaviour through their capitalization, profitability and asset volatility. We would expect the bank's risk behaviour to affect its level of capitalization, profitability and asset volatility, since the bank's financial decisions are related to capital structure and investment projects. Another advantage of the Z-score is that it is less data demanding and is easy to calculate since it requires only accounting data.

The identification strategy applied in this work is as follows: the risk-taking channel would suggest that bank risk increases (Z-score decreases) with a decrease in the Fed effective rate, and this mechanism is amplified by an accommodative monetary policy, that is, when the Taylor gaps are negative.

Now let's turn to our sample and observe how solvent are banks in regard to their Z-score.

Looking at bank probability of insolvency, we get a Z-score that varies between -4.69 and 20.97, with an average value at 3.07. The median value of the Z-score is 2.53, which is below the sample average. This means that more banks remain in average below the sample average Z-score. As a result we can conclude that most of banks are riskier (relatively to banks of the sample) as showed in Table 2.7 .

Table 2.7: Summary of Z-score and distance to mean Z

Variables	Obs.	Mean	Median	Std. Dev.	Min	Max
Z-score	13,968	3.073438	2.531094	2.894928	-4.691803	20.96824

As Figure 2.1 shows, the Z-score depicts quite well the American banking system and the different shocks it incurred. The American banking sector was in average sound from 1998 to 2006 with some shocks hitting the financial system during the 2001 dot-com bubble, the systemic crisis following the 2001 terrorist attack. Even if the banks solvency weakens during the financial crisis (2007-2009), it begin to recover the year after. However, the Z-score level of the pre-crisis period was not yet reached.

Looking at the distribution of the sample Z-score, we find that banks' Z-score are quite normally distributed, but this distribution is left skewed and has excess kurtosis as depicted in Figure 2.2.

This left skewed distribution and the excess kurtosis could be explained by the criticism of the *roa* as being skewed and having excess kurtosis. To deal with this issue, some authors

Figure 2.1: Average banks Z-score over the period

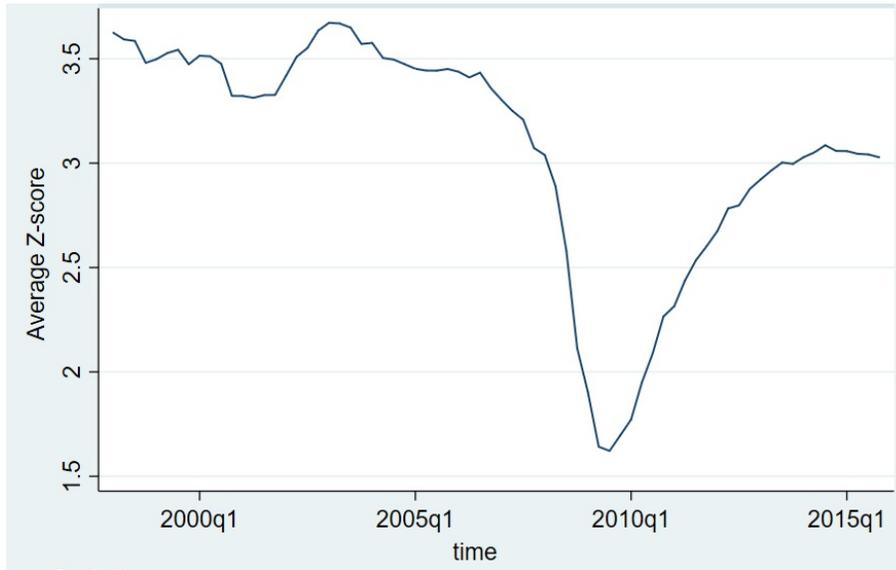
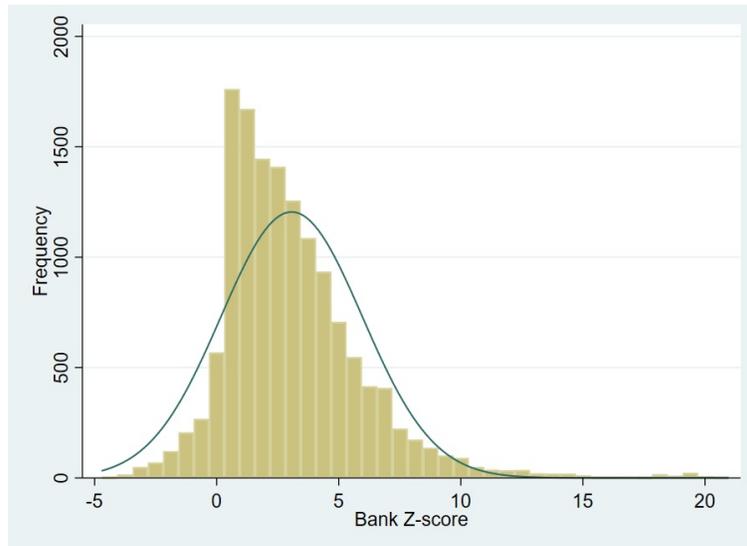


Figure 2.2: (Normal) distribution of Z-scores



propose to use the log of the Z-score rather than the Z-score. However, due to negative value in the Z-score, it is impossible to apply such treatment. Then, we use the Z-core as it is.

Having an insight on the bank's Z-score, let's turn to the second variable of interest in our study, namely the monetary policy variable.

2.1.3 The monetary policy variable and the monetary stance

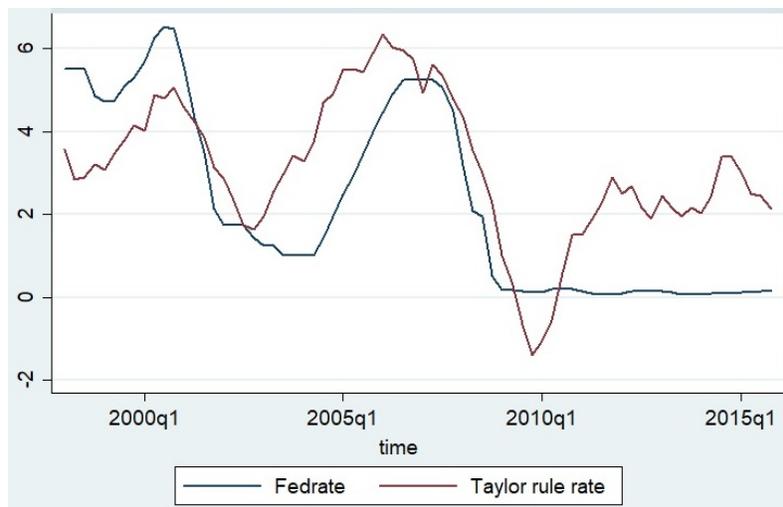
The monetary variable is another variable of interest since it will be used to assess the impact of monetary policy on bank's risk. As we have already stated, monetary policy is conducted by central banks following rules. We can therefore appreciate the monetary stance in terms of the position of nominal interest rate regard to interest rate provided by the Taylor rule. We estimate the deviation of the monetary policy from the Taylor rule based interest rate (henceforth the Taylor gap) and assess the Taylor gap computing the Taylor rate following Taylor (1993) :

$$i = r + \pi + 0.5(\pi - \pi^*) + 0.5y$$

where r is the natural interest rate (set at 2%), π^* is the inflation target set at 2% and y is the output gap. As quarterly data have short frequency and don't allow to smooth fluctuation in price level, Taylor (1993) suggest that π should be estimated as the moving average of the inflation on the 4 last quarters.

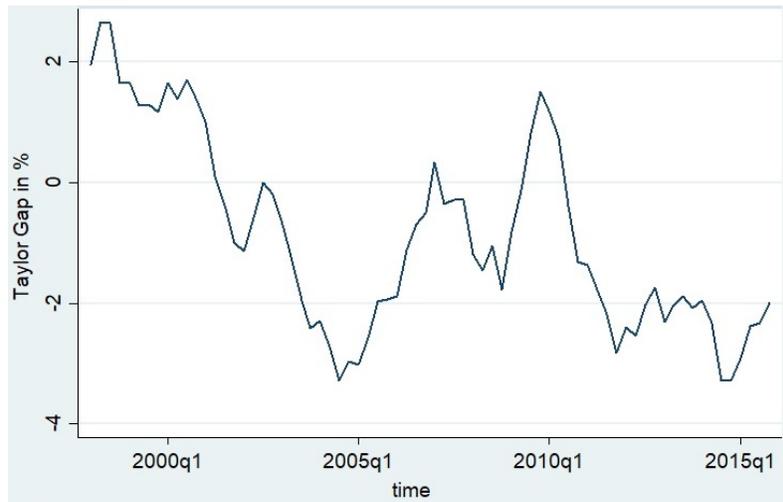
A negative Taylor gap refers to monetary interest rate being lower than the Taylor rule based interest rate, and the monetary policy is considered as accommodative. Conversely, positive Taylor gap refers to monetary interest rate being higher than the Taylor rule based interest rate, and the monetary policy is considered as restrictive. The Figures 2.3 and 2.4 show the relative position of Fed effective and the Taylor rule based interest rate, and the Taylor gap.

Figure 2.3: Fed real interest rate and Taylor rule-based interest rate⁽¹⁾



(1) The Taylor-rule rate is estimated following Taylor (1993): $i = r + \pi + 0.5(\pi - \pi^*) + 0.5y$ where π is the moving average of the inflation on the 4 last quarters and y is the output gap. And π^* is the inflation target set at 2%

Figure 2.4: Taylor gap⁽²⁾



(2) The Taylor gap is the difference between Fed interest rate and the Taylor-rule rate following Taylor (1993). Negative value indicates accommodative monetary policy.

As we can realize in Figure 2.4, the "monetary cycle" is composed of periods of restrictive and accommodative monetary policy. At the beginning of the period, monetary policy appears to be restrictive. But, it tends to be more accommodative over time, reaching its lowest point by the end of 2004. Although interest rate were brought up prior the crisis, the financial crisis has constrained the Fed to maintain interest rate lower than required. And in the aftermath of the crisis, monetary policy appears to be accommodative, maybe as a support to the recovery of the banking system.

After this brief presentation of banks characteristics and "monetary cycle", we propose to analyse how banks behave over the time.

2.2 Examining the bank's Z-score evolution

To better examine the banks risk regarding their position compared to the mean Z , we try to identify different regimes in the monetary policy.

According to the different stances of monetary policy as highlighted before, and taking the crisis period into account, we split the sample periods in 4 sub-periods, for us to better assess bank risk within and between each sub-periods. The first sub-period is a high interest rate pre-crisis period (1998q1 to 2001q2, henceforth sub-period 1). The second sub-period is a low interest pre-crisis period (2001q3 to 2006q4, henceforth sub-period 2). The third sub-period refers to the crisis period (2007q1 to 2008q4, henceforth sub-period 3). And the last sub-period is the post-crisis period featured by low interest rate coupled with unconventional

monetary policy (2009q1 to 2012q4, henceforth sub-period 4). Despite the fact that these sub-periods are of unequal length, they will be useful to examine the behaviour of the Z-score within and between sub-periods. In each sub-period, we distinguish between banks that have a Z-score above or below the sample mean \bar{Z} (positive or negative relative risk).

We define the relative risk profile of a bank as the average deviation from the sample average Z-score over each sub-period. Thus, we have:

Relative risk profile= Average distance to the sample average Z over the sub-period

Let's denote the relative risk profile RRP. Then, we can write that

$$RRP = \frac{1}{t} \sum_{t=1}^t (Z - \bar{Z})$$

where t is the number of quarter in each sub-period, $\bar{Z} = \frac{1}{NT} \sum_{i=1}^N \sum_{t=1}^T Z_{i,t}$, N and T are the sample size and the sub-period length.

Table 2.8 gives an insight of the distribution of individual banks' Z-score within each sub-period.

Table 2.8: Summary of individual average Z-scores in different sub-periods

Sub-periods	Frequency	Mean	Std. Dev.	Min	Max
1998q1-2001q2	194	3.4845	2.67634	-1.35298	17.3151
2001q3-2006q4	194	3.49128	2.76821	-0.87497	19.4516
2007q1-2008q4	194	2.93182	2.79059	-0.79147	19.0349
2009q1-2015q4	194	2.58	2.8161	-1.0096	19.0054

It is noticeable from Table 2.8 that banks' soundness, in general, was strong during the pre-crisis sub-periods. Although the banks' soundness deters during the crisis (the sample average Z-score fall from 3.49 to 2.93), it seems to further deteriorate in the aftermath of the crisis (the sample average Z-score fall from 2.93 to 2.58). In addition, the volatility of the Z-score tends to increase. However, this increase in the volatility of the Z distribution is driven by an increase in the upper values of banks' Z-score. We can then split the sample in two categories in each sub-period: the "riskier banks", i.e. banks that individual average Z-score is below the sample average Z-score, and "safer banks", i.e. banks whose individual average Z-score is above the sample average Z-score.

Tables 2.9 and 2.10 give an overview of the distribution of banks according to their relative risk profile within each sub-period.

Table 2.9: Summary of average distance to sample average Z-score in different sub-periods for safer banks

Dist. to mean Z	Frequency	Mean	Std. Dev.	Min	Max
1998q1-2001q2	87	2.223567	2.350116	0.0161796	13.83053
2001q3-2006q4	80	2.473308	2.607874	0.0093906	15.96035
2007q1-2008q4	77	2.526187	2.793876	0.0325739	16.10311
2009q1-2015q4	82	2.422039	2.738179	0.0108843	16.42535

Table 2.10: Summary of average distance to sample average Z-score in different sub-periods for riskier banks

Dist. to mean Z	Frequency	Mean	Std. Dev.	Min	Max
1998q1-2001q2	107	-1.807947	1.096899	-4.837499	-0.0221648
2001q3-2006q4	114	-1.735654	0.9815837	-4.366251	-0.0039058
2007q1-2008q4	117	-1.662533	0.9047282	-3.723292	-0.0389383
2009q1-2015q4	112	-1.773278	0.9006234	-3.589661	-0.0017509

For "safer banks", whose individual average Z-score are above the sub-period sample average Z-score, we observe that their distance to the sample Z-score remains, in average, constant (around 2.4) while the standard deviation tends to gradually increases. This suggests that within each period "safer banks" are in average at the same distance from the sub-period sample average Z-score. But the risk profile of these banks tends to diverge resulting in an upward movement in their dispersion across sub-periods. The opposite observation can be made for banks that seem riskier than the average of the sample. In each period, the average distance of "riskier banks" to the sub-period sample average Z-score remains also quite constant (around -1.7). However, the distribution of banks appear to be more concentrated (low standard deviation) and to concentrate even more over time as showed by the decrease in their dispersion across sub-periods. This could suppose that the situation of "riskier banks" tend to converge compared to the "safer" ones.

Looking carefully at the change in the relative risk across periods, we note that in average the

relative risk of banks above the sample mean Z-score remains quite stable in all sub-periods, but degrades of about 4% after the crisis. At the opposite, the average relative risk of banks below the sample mean Z-score ameliorates in average of 4% between the first two sub-periods, then degrades of 6% after the crisis. This significant difference in the degradation of the soundness of the 2 groups of banks lead to an interrogation on the bank risk-taking behaviour. Is the risk-taking behaviour the same for all banks? Are there key variables that can better explain the difference in the degree of soundness degradation? What is the real impact of low interest rates on bank risk-taking? In other words, should we be scared of the long period of low interest that last since 2009? And, should we be scared of the unconventional monetary policy introduced since 2009?

2.2.1 *Evolution of banks' soundness across sub-period*

Seeking to assess the bank behaviour in different sub-periods and distinct groups (following their position to the sample mean Z), we analyse the banks relative risk (average distance to the sample average Z-score) and its change (change in the distance to sample average Z-score) across sub-periods. For each of the 4 sub-periods, we obtain the distribution provided in Table 2.11 to Table 2.14.

Table 2.11: Distribution of banks given the relative risk and its change from 1998q1 to 2001q2

Average relative position	Average change in the relative Position		Total
	Positive	Negative	
Positive	27	60	87
Negative	36	71	107
Total	63	131	194

Table 2.12: Distribution of banks given the relative risk and its change from 2001q3 to 2006q4

Average relative position	Average change in the relative Position		Total
	Positive	Negative	
Positive	40	40	80
Negative	57	57	114
Total	97	97	194

Table 2.13: Distribution of banks given the relative risk and its change from 2007q1 to 2008q4

Average relative position	Average change in the relative Position		Total
	Positive	Negative	
Positive	29	48	77
Negative	31	86	117
Total	60	134	194

Table 2.14: Distribution of banks given the relative risk and its change from 2009q1 to 2015q4

Average relative position	Average change in the relative Position		Total
	Positive	Negative	
Positive	61	21	82
Negative	102	10	112
Total	163	31	194

We observe that on the 87 banks that are considered as “safer” over the sub-period 1998q1-2001q2, only 27 banks have experimented an increase in their relative solvency. 60 banks have seen their relative solvency decreased, notwithstanding they remains “safer” than the others. More important, we can see that more banks experienced a decrease in their solvency during the pre-crisis and crisis periods, while the opposite occur in the post-crisis period. This suppose that the solvency of the overall banking system tend to deteriorate before and during the crisis. And in the aftermath of the crisis (2009q1-2015q4), banks tend to behave cautiously so as to repair their balance sheet and solvency, leading to more banks with a positive change in their relative position in the distribution.

We then focus our analysis on two main opposite groups of banks: banks with both positive relative risk and positive change in the relative risk (henceforth “positive banks”), and banks with relative risk and its change both negative (henceforth “negative banks”).

In the pre-crisis period (sub-periods 1 and 2), we have 27 and 40 “positive banks”, 71 and 57 “negative banks”. We observe that the number of “positive banks” (of “negative banks”) remains stable (increase by 1/2) in the crisis period. This could mean that riskier banks were more affected by the crisis than safer one. Another explanation could be that riskier banks do take more riskier positions in the pre-crisis featured by lower interest rate. And, in the event of the crisis, their riskiness materializes leading to a decrease of their solvency. The post-crisis period (sub-periods 4) is featured by an average recovery of banks. The number of “positive banks” double and that of “negative banks” decrease by 87.5%. Moreover, even if more banks are below the sample mean in the post-crisis period, their positions tend to ameliorate in general over the sub-period.

After having examining the how the bank’s soundness evolve according the different monetary stance, we propose to have an insight on a specific factor contributing to threat the bank’s soundness, namely the credit lending.

2.2.2 *Overview on the banks' lending activity across sub-period*

The financial crisis has proven the bank's leverage to be also a key factor amplifying the crisis. In fact, the bank's leverage is related to more credit lending or less capital, threatening the bank's soundness. This is the reason why the banking regulation through Basel III introduce a leverage ratio.

We try to assess banks' behaviour across sub-period regarding their lending activity. For this purpose, we distinguish between banks with excessive lending growth (or excessive credit expansion) and those with lower lending growth relative to the sample average. The bank's excessive lending growth is appreciated based on the deviation of bank's lending growth from the average lending growth on the same period. We consider a bank as having excessive lending growth when its lending growth is higher than the average sample. Tables 2.15 to 2.18 give us an overview of the credit expansion of different group of banks (banks size) across the 4 sub-periods.

Table 2.15: Repartition of bank average size and average credit expansion from 1998q1 to 2001q2

Banks size	Banks excessive lending growth		Total
	No	Yes	
Small	54	14	68
Medium	73	41	114
Large	9	3	12
Total	136	58	194

Table 2.16: Repartition of bank average size and average credit expansion from 2001q3 to 2006q4

Banks size	Banks excessive lending growth		Total
	No	Yes	
Small	44	24	68
Medium	57	57	114
Large	5	7	12
Total	106	88	194

Table 2.17: Repartition of bank average size and average credit expansion from 2007q1 to 2008q4

Banks size	Banks excessive lending growth		Total
	No	Yes	
Small	39	29	68
Medium	61	53	114
Large	8	4	12
Total	108	86	194

Table 2.18: Repartition of bank average size and average credit expansion from 2009q1 to 2015q4

Banks size	Banks excessive lending growth		Total
	No	Yes	
Small	45	23	68
Medium	50	64	114
Large	11	1	12
Total	106	88	194

According to these tables (Tables 2.15 to 2.18), we can say that the proportion of small and medium banks experiencing excessive lending growth increases over time. In fact, the proportion of small banks with excessive lending growth grows up from 20.6% (14 over 68 in sub-period 1) to 35.3% (24 over 68 in sub-period 2) and to 42.6% (29 over 68 during the crisis period), before decreasing to 33.8% (23 over 68) in the aftermath of the crisis. In fact, the number of banks with excessive lending growth increase across sub-periods for small and medium banks. However, large banks may have stable and/or decreasing lending growth over time leading to a decrease of number of banks with excessive lending growth. An explanation could be that large banks tend to realize large investment with low frequency resulting in a decreasing (or stable) lending growth. At the opposite, small banks may support high opportunity cost, i.e. the cost of hoarding liquidity since they highly rely on deposits and short-term funding. Then, they could be led to grant more credit than other banks to increase their returns and profit.

Moreover, it has been shown that excessive lending do increase bank's fragility. In fact, Altunbas et al. (2010) empirically prove that bank's expected default frequency increase with credit expansion. They also find that there is a quadratic relation between bank's risk and credit expansion, meaning that banks that lend more or less than the other banks are more risky. To check if this finding still holds with our data, we identify in each sub-periods banks that appear in average more risky (first quartile of the distribution of average Z -score

in each sub-period) and those that are consider less risky (last quartile of the distribution of average Z -score in each sub-period). Tables 2.19 to 2.21 match banks' risk profile and its previous average credit expansion. Each table is related to each identified sub-period. We lag the average credit expansion since the risk profile (average individual bank's Z-score) is an ex-post risk measure, i.e. the risk is measured once it materializes, and so it depends on banks behaviour the previous period.

Table 2.19: Repartition of bank average risk and previous average credit expansion before the crisis (2001q3 - 2006q4)

Banks risk	Banks previous excessive lending growth		Total
	No	Yes	
More risky	29	19	48
Less risky	35	13	48
Total	64	32	96

Table 2.20: Repartition of bank average risk and previous average credit expansion during the crisis (2007q1 - 2008q4)

Banks risk	Banks previous excessive lending growth		Total
	No	Yes	
More risky	17	31	48
Less risky	34	15	49
Total	51	46	97

Table 2.21: Repartition of bank average risk and previous average credit expansion after the crisis (2009q1 - 2015q4)

Banks risk	Banks previous excessive lending growth		Total
	No	Yes	
More risky	33	16	49
Less risky	26	22	48
Total	59	38	97

It appears that about 65% (31 banks over 48) of banks that were riskier during the crisis had an excessive lending activity during the pre-crisis period (see Table 2.20). This relation can be explained by the aggressive price strategy and granting new risky loans. The prevailing low interest rate environment could have led banks to such strategies for searching for yield. This observation bolster the results of Altunbas et al. (2010) and confirm the potential negative effect of credit expansion on bank's fragility.

After this large overview of the bank's soundness and its relation with the bank's credit

expansion, next let's turn to the econometric analysis that may help to better assess and explain the monetary policy risk-taking channel.

3 Empirical model and results of linear specifications

In our analysis, we regress Z-score on monetary, macroeconomic and banks specific variables, using the panel threshold model developed by Hansen (non-dynamic panel, 1999) to identify the existence of structural changes in the impact of monetary policy on banks risk-taking behaviour. This will allow us to better analyse the asymmetries in the bank risk-taking considering potential structural breaks due to the introduction of the various prudential tools or macroeconomic shocks.

3.1 Empirical model

The strategy we adopted to analyse the risk-taking channel can be described as follow. We set the bank's Z-score as our dependent variable. Among control variables, we include macroeconomic and monetary variables. Our key explanatory variable is the change in Fed rate at time $(t-1)$ and is supposed to have different slopes across regimes. The other covariate regression coefficients are assumed to be regime independent. The threshold variable is the Taylor gap at time $(t-2)$. This specification allows to consider the effect of change in monetary rates (at the moment of decision-making $(t-1)$) on banks soundness, depending on the stance the monetary policy the preceding quarter $(t-2)$. The underlying idea is to determine how banks do globally behave regarding monetary policy. The data generating process can be written as follow:

$$Z_{i,t} = \lambda_i + \delta' f(\Delta MP_{t-1}, TGAP_{t-2}) + \sum_{j=0}^1 \beta_j \Delta X_{1,t-j} + \phi X_{2i,t-1} + UNC + \sum_{j=1}^4 \eta_j SD_t + \varepsilon_{i,t}$$

where f represents a non-linear function between the Fed rate and the threshold variable $TGAP_{t-2}$ with :

$$\delta' f(\Delta MP_{t-1}, TGAP_{t-2}) = \delta_1' \Delta MP_{t-1} * I(TGAP_{t-2} \leq \gamma) + \delta_2' \Delta MP_{t-1} * I(TGAP_{t-2} > \gamma)$$

in the case of a single threshold model,

$X_{1,t}$ and $X_{2i,t}$ are respectively macroeconomic variables and bank-specific variables that will be presented in the next subsection (Subsection 3.2), UNC is a dummy referring to period

of unconventional measures (2009q1 to 2015q4), and SD are seasonal dummies.

The regime dependent variable is the previous change in fed rate. As already stated, the choice of this variable is motivated by the unclear effect of monetary rate on bank risk-taking that was evidence in the existing literature.

To perform our regression analysis, we should include key monetary, macroeconomics and bank variables that could better explain the variations of the banks Z-score.

3.2 Macroeconomic and banks' specific variables

According to theoretical and empirical literature many factors may influence bank's risk-taking behaviour. We try to assess their impact on the bank's risk and include them in our model. They are related to:

- **Monetary variables**

Remember that our key variable is the monetary interest rate (Fed effective rate) whose impact on the bank will be appreciated according to the monetary stance. Let's recall that to account for the accommodative or restrictive stance of the monetary policy, we estimate the Taylor gap (TGap) which is the deviation of the Fed effective interest rate from the Taylor interest rate given by Taylor(1993). A positive Taylor gap indicates relatively high monetary policy rates (tight monetary conditions), while negative Taylor gap proxies for low rates (soft conditions).

In addition to short-term rate (changes in Fed effective rate), the spread between long-term and short-term rate (the slope of the yield curve=10-years bonds yield minus 2-years bonds yield) may also drive the bank's risk-taking behaviour. To account for the long-run relation between monetary policy and bank's risk we then include (the change in the slope of the yield curve).

Moreover, the use of unconventional measures such as quantitative easing (purchase of 10 year mortgage backed securities, 10 year treasury securities, federal debts securities, etc.) since 2009 may have significant impact on the effects that monetary shocks could have on bank risk. To avoid such an influence, we introduce a dummy *UNC*, which takes the value 1 from 2009q1 to 2015q4. This dummy refers to the period when the Fed introduced unconventional measures.

- **Macroeconomic variables**

It is important to control for macroeconomic shocks.

- The economic growth: we can expect that economic activities impact banks' soundness since banks are principal fund providers to firms. So, the financial positions of banks depends (at least partly) on those of firms. Using GDP growth, we can control for business impact on bank soundness. Hence, GDP growth captures the part of change in banks Z-score that stems from the credit demand side.
- The systemic risk: Moreover, banks operate in financial systems that are often subject to stress that could, in turn, impacts their soundness. Thus, we use the financial stress index (FSI) to capture the impact of the system stress on the bank soundness.
- The real estate market: Housing prices could affect banks' risk through their decision-making. For this reason, we control for housing prices fluctuations through changes in the Shiller national house price index (HP).
- Stock market: Banks do operate in stock markets and are impacted by changes in assets price. For this purpose, we account for stock markets return (SM) via changes in the S&P return.

However, banks' overall risk can be affected also by unforeseen changes to the riskiness of its assets, that is the risk occurring after their acquisition that are largely beyond the banks' control. In other words, during economic downturn, loans are riskier, and we can expect that bank's risk increase because credit demand become riskier, instead of bank choosing to hold riskier assets. We enter the macroeconomic variables in the regressions at both current values and one-quarter lag values to account for their impact on the banks' risk-taking (at time of decision-making, i.e. at period $(t - 1)$) and soundness (i.e. at time t). For stationary concerns, except housing price index which is double differentiated, macroeconomic and monetary variables are first differentiated.

The results of the unit root tests using the Augmented Dickey-Fuller test are provided in Table 2.22.

Table 2.22: Unit root tests on time series data

Variables	Test statistic		
	Level	First difference	Second difference
<i>MP</i>	-2.923	-3.626**	-
ΔGDP	-5.534***	-	-
<i>HP</i>	-2.817	-1.700	-6.928***
<i>FSI</i>	-2.856	-7.603***	-
<i>Slope</i>	-2.172	-5.390***	-
<i>SM</i>	-1.413	-6.157***	-

Each number represents the test statistic $Z(t)$

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Since macroeconomic variables (*MP*, ΔGDP , *HP*, *SM*, *Slope* and *FSI*) are common to all banks we run unit root test for time series variables. As results in Table 2.22 show, housing price index appears stationary at the double differentiation stage, while the remaining variables are stationary at the first differentiation stage.

- **Bank's specific variables**

As stated in the existing literature, banks' risk-taking behaviour may differ according to the bank specific characteristics. Then, we need to control for banks heterogeneity.

- The bank size: we need to control for the possible existence of economies of scale. Due to moral hazard and agency cost, larger banks have access to better liquidity sources, and may be likely to hold less capital and liquidity. However, larger banks present complex balance sheets and face a more stringent regulation. Thus, the bank size affects Z-score through its effects on bank equity. For this purpose, we use bank's size (log total assets) as banks are heterogeneous through their size.
- The bank efficiency: banks evolve in a competing environment and employ different production technologies that trigger differential in technical efficiency. For this reason, we include bank efficiency (total income to total cost ratio) to control for differences in technical efficiency (Delis and Kouretas, 2011; Boyd et al., 2006).
- The bank's liquidity: We also include bank liquidity (net loan to deposits and short-term funding ratio) as it appears to be a relevant factor influencing bank

risk behaviour (Altunbas et al., 2010). Another reason is that banks that finance their assets mostly with short term liabilities (maturity transformers) are more exposed to refinancing problems (illiquidity) in the event of economic downturn.

- The bank lending growth: since the main activity of banks is lending, we can expect that bank that lend more encounter an increase of its assets and a decrease of its Z-score. We then include lending expansion (EXLEND) as in Altunbas et al. (2010) to control for lending growth.

Since individual specific variable (Z, Liq, Efficiency, Size, Exlend) are related to panel data, we run panel unit root test on the latter. The results of panel unit root tests are given in Table 2.23.

Table 2.23: Unit root tests on panel data

Variables	Test statistic		
	Level	First difference	Second difference
Z	-12.5247***	-	-
Liq	-10.841***	-	-
Eff	-30.1864***	-	-
Size	-2.8876***	-	-
Exlend	-93.2384***	-	-

Each number represents the Levin-Lin-Chu adjusted statistic t^*

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

As shown in Table 2.23, for bank's specific variables, we run the Levin-Lin-Chu panel unit root test. This test seems appropriated since we have moderate-sized panels (194 individuals and 82 observation per individual). Our sample fits well the recommendation of Levin, Lin, and Chu since it is recommended to have between 10 and 250 individuals and 25 to 250 observations per individual. The results of the unit root test prove that bank's specific variables are level stationary.

Summary statistics of variables used in our analysis are given in table 2.24.

Table 2.24: Summary statistics of the variables used in the regressions (1995q1-2015q4)

Variables	Obs	Mean	Std.Dev	Min	Max	1rst quartile	3rd quartile
Z	13,968	3.073	2.895	-4.692	20.97	1.113	4.431
ΔMP	13,968	-0.074	0.43	-1.43	0.59	-0.06	0.025
TGAP	13,968	-0.863	1.617	-3.559	2.751	-2.176	0.19
ΔGDP	13,968	2.20	2.58	-8.200	7.800	1	3.75
$\Delta^2 HP$	13,968	.0285	1.164	-3.58	3.81	-0.53	0.445
ΔFSI	13,968	-0.020	0.49	-1.439	2.934	-0.183	0.168
$\Delta Slope$	13,968	1.81	1.185	-0.63	3.61	0.77	2.73
ΔSM	13,968	2.14	10.5	-30	35.4	-2.21	7.43
Liq	13,968	0.813	0.172	0.18	2.934	0.715	0.912
Eff	13,968	0.494	0.494	-5.157	7.175	0.297	0.667
Size	13,968	7.808	1.721	2.55	14.76	2.55	14.74
Exlend	13,774	0	0.0905	-0.683	3.77	-0.0268	0.00948

As Table 2.24 indicates, the average bank's Z-score over the whole period is 3.07, with minimum value of -4.69 and a maximum of 20.97. In addition, we can notice that 75% of observations of Z -score over the whole period are at most equal to 4.431. Moreover, it appears that monetary policy can be considered in average as accommodative since the Taylor gap is negative (-0.86). And monetary policy appears to be more often accommodative since 75% of observations related to the Taylor gap are below 0.19. Having a look at the bank liquidity ratio, we can say that the bank liquidity is satisfying since net loans represents in average 81% of deposits and short-term debts. Furthermore, banks appear to be in average less efficient since their operational revenues represent less than half of their operational costs, as given by the average efficiency ratio of 0.494.

The correlation matrix of variables used in our analysis are given in Table 2.25.

Table 2.25: Correlation matrix between variables used in regressions

Variables	Z	ΔMP	TGAP	ΔGDP	$\Delta^2 HP$	ΔFSI	$\Delta Slope$	ΔSM	Liq	Eff	Size	Exlend
Z	1											
ΔMP	0.0276	1										
TGAP	0.00420	-0.103	1									
ΔGDP	0.0747	0.450	0.0911	1								
$\Delta^2 HP$	-0.0307	0.0791	0.0142	0.0609	1							
ΔFSI	0.0324	-0.259	-0.0853	-0.148	-0.122	1						
$\Delta Slope$	-0.0206	-0.656	0.286	-0.346	-0.236	0.147	1					
ΔSM	-0.00610	0.02618	-0.0187	0.478	0.1488	-0.472	-0.0856	1				
Liq	-0.215	-0.0393	-0.0374	-0.0940	-0.116	0.0187	0.0298	-0.0500	1			
Eff	0.202	0.0346	0.0616	0.0773	0.131	0.0107	-0.0139	-0.00750	0.118	1		
Size	0.0625	0.0118	-0.148	-0.0686	-0.0887	-0.00590	-0.0198	0.0119	-0.0233	0.108	1	
Exlend	-0.0140	0	0	0	0	0	0	0	0.0359	0.0150	-0.00540	1

Given Table 2.25, our variables are not (or weakly) correlated since correlation matrix are lower than 0.5. This said, our regressions may not suffer from auto-correlation bias.

Before running the threshold analysis, we start by applying a linear models to our data in view of supporting our point of view related to the existence of non-linearity within the risk-taking channel of monetary policy.

3.3 Results of the linear models

We estimated using OLS and panel fixed-effect (henceforth FE). The use of fixed-effect model is appropriated since the Hausman test for random effect reject the null of consistency and efficient of the random effect model. Using fixed-effect model lead us to not include time invariant factor such as localisation dummies, since they are inconclusive. Moreover, the panel fixed-effect model is likely to eliminate influence stemming from localization factor and other time invariant factors.

In line with the previous discussion, the baseline linear specification can be written as follow:

$$Z_{i,t} = \beta_0 + \alpha Z_{i,t-1} + \sum_{j=0}^1 \beta_j \Delta MP_{t-j} + \sum_{j=0}^1 \gamma_j TGap_{t-j} + \sum_{j=0}^1 \delta_j \Delta GDP_{t-j} + \sum_{j=0}^1 \varphi_j \Delta SLOPE_{t-j} + \sum_{j=0}^1 \omega_j \Delta HP_{t-j} + \sum_{j=0}^1 \Omega_j \Delta SM_{t-j} + \sum_{j=0}^1 \lambda_j \Delta FSI_{t-j} + \tau LIQ_{i,t-1} + \vartheta EFF_{i,t-1} + \rho SIZE_{i,t} + \theta EXLEND_{i,t} + \eta UNC + \varepsilon_{i,t}$$

with:

$Z_{i,t}$: Individual bank Z-score at time t

ΔMP_t : Quarterly change in monetary interest rate at time t

$TGap_t$: Gap between Fed interest rate and Taylor rule rate [Taylor rate is estimated following Taylor (1993)]

ΔGDP_t : GDP growth at time t

$\Delta Slope_t$: Change in the slope of the yield curve (10-Year Treasury Const. Maturity Minus 2-Years Treasury Const. Maturity)

$\Delta^2 HP_t$: Quarterly pace of change in the housing price index at time t

ΔFSI_t : Change in financial stress index at time t

ΔSM_t : quarterly percentage change in the stock market index at time t

$Liq_{i,t}$: Liquidity ratio of bank i at time t (Net Loan/[Deposits+Short-term debts])

$Eff_{i,t}$: Operational efficiency ratio of bank i at time t (Operational income to Operational cost ratio)

$Size_{i,t}$: Natural logarithm of total assets of bank i at time t

$Exlend_{i,t}$: Excessive lending growth (excess lending growth over average lending growth of other banks) of bank i at time t

UNC : dummy which takes the value 1 from 2009q1 to 2015q4 and 0 otherwise, and refers to the period when the Fed introduced unconventional measures.

We also analyse data for heteroskedasticity and cross section dependence. The results are again the null of homoscedasticity and cross-section independence. We then, run the panel least-square dummy variable (PLSDV) which also control for endogeneity and is an alternative to IV gmm model. This regression assumes, on the one hand, heteroskedasticity of disturbances, on the other hand, contemporaneously correlation of disturbances across panels. For robustness checking, we also run a regression with Driscoll-Kraay (henceforth D-K) standard errors regression which is robust to heteroskedasticity and cross-section dependence. Since the estimation sample covers the period from 1998q1 to 2015q4, the quarterly frequency of our dataset allows us to work with a long panel (time period that extends over 84 periods), which does not require the use of an Arellano and Bond (1991) type of estimator to address the dynamic structure. So, we don't need to run the Arellano-Bond GMM estimator since the dynamic panel bias becomes insignificant.

The results of different regressions are presented in Table 2.26.

We can easily see that all the linear regressions (OLS, panel FE, PLSDV and Driscoll-Kraay) provide quasi equivalent results since all coefficient are at the same sign and are significative (or not). But, the OLS regression appears less good than the other regressions since there are heteroskedasticity and cross-section dependence. However, counteracting adverse effect of heteroskedasticity and cross-section dependence do provide quite similar results to that of the panel FE regression. Only the R-squared and the standard deviation of different coefficients change.

Looking at the results, it appears that banks tend to take more risk when they were riskier in the precedent period. A decrease in Z-score of 1 unit during the previous quarter leads to a decrease of about 0.9 units in the current quarter. The explanation could be the persistence of risk. That is, when bank become riskier, it loose the confidence of investors and face a decrease in its profits. Then, it enters a vicious spiral where losses and risk are self-fuelling.

It is noteworthy that the impact of monetary policy on bank's risk is not significant. Moreover, the effect of low interest rate on bank's risk is unclear. A decrease of interest rate coupled with low interest rate in the previous period tend to decrease bank's soundness.

Conversely, A decrease of interest rate coupled with low interest rate in the current period tend to foster bank's soundness. This result is inconsistent with the risk-taking channel theory which states that lowering interest rate would rise bank risk appetite.

Table 2.26: OLS, panel fixed-effect, panel least-square dummy variable, and Driscoll-Kraay standard errors

The dependent variable is the banks' Z-score (Z_t)				
EXPLANATORY VARIABLES	OLS	FE	PLSDV	D-K
Z_{t-1}	0.984***	0.835***	0.867***	0.835***
ΔGDP_{t-1}	0.0138***	0.0172***	0.004**	0.0172***
ΔGDP_t	0.0132***	0.0188***	0.006**	0.0188***
ΔMP_{t-1}	0.0183	0.0381**	-0.0256*	0.0381
ΔMP_t	-0.0139	-0.0277	0.033	-0.0277
$TGAP_{t-1}$	0.0195*	-0.00879	0.0122	-0.0088
$TGAP_t$	-0.0204**	-0.0102	0.002	-0.0102
$\Delta MP_{t-1} * TGAP_{t-1}$	-0.0540***	-0.0476***	-0.0265**	-0.0476***
$\Delta MP_t * TGAP_t$	0.0255***	0.0359***	0.0274***	0.0359**
ΔSM_{t-1}	-0.0655	-0.0729	-0.217***	-0.0728
ΔSM_t	-0.455***	-0.443***	-0.259***	-0.4432***
$\Delta^2 HP_{t-1}$	-0.00755**	-0.00891***	0.001	-0.0089
$\Delta^2 HP_t$	-0.0104***	-0.0119***	0.006	-0.0119
$\Delta Slope_{t-1}$	0.0267	0.0384**	0.0229	0.0384
$\Delta Slope_t$	-0.00269	0.0275	0.014	0.0275
ΔFSI_{t-1}	-0.0217*	-0.000216	0.0201*	0.00022
ΔFSI_t	-0.104***	-0.107***	-0.099***	-0.1067***
LIQ_{t-1}	-0.133***	-0.179***	-0.132***	-0.179***
EFF_{t-1}	0.0564***	0.249***	0.234***	0.249***
$Size_{t-1}$	-0.00266	-0.0531***	-0.071***	-0.0531**
$EXLEND_{t-1}$	0.251***	0.193***	0.214***	0.193***
$EXLEND^2_{t-1}$	-0.0626***	-0.0618***	-0.072**	-0.0618***
UNC	0.0974***	0.0412***	-0.02***	0.0412
Constant	0.0349	0.809***		0.809***
Observations	13,580	13,580	13,580	13,580
Number of Banks	194	194	194	194
R-squared	0.979	0.837	0.972	0.8374

*** p<0.01, ** p<0.05, * p<0.1

TGAP is the deviation of the Fed effective rate from the Taylor 1993 rule based rate. The 1993 Taylor rule rate is estimated as follow $i = r + \pi + 0.5(\pi - \pi^*) + 0.5y$. The dummy variable UNC take the value 1 between 2009q1 and 2015q4 and 0 otherwise, and refers to a period of unconventional monetary policy measures.

However, these results should be taken cautiously since there could be non-linear impact of monetary shock on bank's risk.

As we can see, linear models show shortcomings in the appreciation of monetary policy effects on banks risk. We propose to show how a non-linear model, specifically the threshold-effects

panel model, would address these shortcomings. The following section presents the results of the non-linear analysis of the risk-taking channel of monetary policy.

4 Threshold analysis applied to the risk-taking monetary policy: results and discussion

In this section we hit the focal point of our analysis since the analysis results may help to contribute to the construction of the theory of risk-taking channel by testing threshold effects in the risk-taking channel of monetary policy. Implementing a non-dynamic panel threshold model, we intend to evidence potential threshold effect. This model will help us to detect threshold values below or above which the impact of monetary policy on risk-taking behaviour is supposed to change or to have a perverse effect.

The results of our analysis is subdivided into two parts. The first part refers to the threshold test and deals with the significant number of thresholds to be included in the model. The second part is related to the threshold analysis in the impact of monetary policy on bank's risk according to the number of regimes provided by the the threshold test.

4.1 Results and discussion of the Threshold test

Following Hansen (1999) we test the existence of a threshold value in the Taylor gap against the null hypothesis of no threshold. The results provided in Table 2.27 reject the null hypothesis and support the presence of a threshold at -0.1898.

Table 2.27: Single Threshold Test

Threshold estimator (level = 95)						
model	Threshold	Lower	Upper			
Th-1	-0.1898	-0.3295	-0.1791			
Threshold effect test (bootstrap = 300)						
Threshold	RSS	MSE	Fstat	Prob	Crit10	Crit5
Single	7739.5115	0.5729	63.83	0.0567	58.5655	64.8390

As the F statistic is highly significant we run a test for a double thresholds model. The double-threshold model tests H_0 (single-threshold model) against H_1 (double-threshold model). But

the results in Table 2.28 are clearly against a double threshold model and so comfort the single threshold model.

Table 2.28: Double Threshold Test

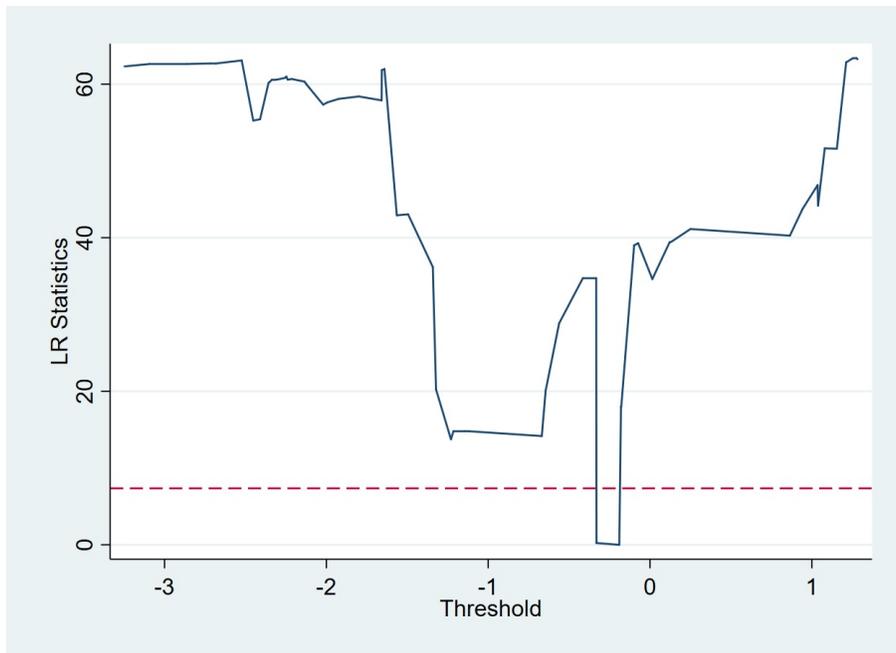
Threshold estimator (level = 95)			
model	Threshold	Lower	Upper
Th-1	-0.1898	-0.3295	-0.1791
Th-21	-1.9933	-2.2469	-1.4948
Th-22	-0.1791	-1.9933	0.8647

Threshold effect test (bootstrap = 300 300)						
Threshold	RSS	MSE	Fstat	Prob	Crit10	Crit5
Single	7739.5115	0.5729	63.83	0.0567	58.5655	64.8390
Double	7728.1773	0.5720	19.81	0.1233	20.1466	24.1681

As the threshold tests reject the linear model and support the existence of a single threshold value, we fit a single threshold model which provide an estimator of -0.1898 with 95% confidence interval in $[-0.3295, -0.1791]$.

Figure 2.5 shows the likelihood ratio between the threshold model and the linear model for different potential thresholds.

Figure 2.5: Likelihood ratio of the threshold analysis



A rapid overview of the graph related to the likelihood ratio also provides information on the potential existence of a threshold and comforts the results of the preceding threshold tests. As explained when presenting the test and inference of the threshold model of Hansen (1999), the region above the dashed horizontal line refers to the no rejection limit of the null hypothesis (no threshold). And the upper limit to the maximum number of existing thresholds is given by the number of dips in this graph related to the likelihood ratio. A look at Figure 2.5 evidences one major dip around the value of -0.1898 in the threshold variable (here the Taylor gap at $(t-2)$) and corresponds to the identified threshold.

Now, let's turn to the results of the threshold analysis in the risk-taking channel of monetary policy.

4.2 Results and discussion of the threshold analysis

The results of the threshold analysis are given in Table 2.29 and an interesting result is that the impact of monetary policy on banks soundness effectively depends on the previous monetary stance.

Table 2.29 evidences a threshold value of -0.1898, implying a change in the impact of monetary shocks if the monetary rate is 18.98 basis points below the Taylor rule. However, there are differences in the magnitude of the effects. Below this threshold value, an interest rate cut increases bank fragility since a 1% decrease in the monetary rate when the Taylor gap is -18.98 basis points or lower, induces around a 0.19 unit decrease in the bank's Z-score. This decrease in bank soundness could result from the bank's excessive risk-taking. Conversely, a 1% interest rate reduction when the Taylor gap is greater than -18.98 basis points, increases bank soundness by some 0.08 units.

The threshold analysis confirms the existence of a threshold in the deviation of the monetary interest rate from the Taylor rule at which the effects of the monetary rate on bank fragility changes. The effect of changes to monetary policy on bank soundness depends on the monetary stance. Remember that we refer to the Taylor gap (deviation of interest rate from the Taylor rule based interest rate) when speaking of monetary stance. And we consider as accommodative monetary policy, regime where interest rate are below the Taylor rule rate. Conversely, monetary policy is considered as restrictive if monetary interest rate are higher than the Taylor rule rate. Hence, our results show that when monetary policy is accommodative, a decrease in interest is harmful for the bank's soundness since the further lowering of interest rate may depress the bank's profit. However, when monetary policy is assumed to be restrictive (monetary interest rate above the Taylor rule rate) then bank's

soundness foster following decreasing interest rate since banks may benefit from reducing refinancing costs that may compensate for losses in their intermediation revenue.

Table 2.29: Threshold analysis on the Taylor gap

The dependent variable is the the Z-score (Z_t) and measures the bank's soundness

EXPLANATORY VARIABLES	(1)
Threshold variable $q_{i,t}$	$TGAP_{t-2}$
Threshold value γ	-0.1898*
ΔGDP_{t-1}	0.0368***
ΔGDP_t	0.0343***
ΔSM_{t-1}	-0.220*
ΔSM_t	-0.0450
$\Delta^2 HP_{t-1}$	-0.00621
$\Delta^2 HP_t$	0.00735
$\Delta Slope_{t-1}$	-0.0148
$\Delta Slope_t$	0.0287
ΔFSI_{t-1}	0.199***
ΔFSI_t	-0.0138
LIQ_{t-1}	-0.146
EFF_{t-1}	1.276***
$Size_{t-1}$	-0.0569
$EXLEND_{t-1}$	-0.134
$EXLEND_{t-1}^2$	-0.0541
UNC	-0.322***
ΔMP_{t-1} if $TGAP_{t-2} \leq \gamma$	0.189***
ΔMP_{t-1} if $TGAP_{t-2} > \gamma$	-0.0763**
Constant	2.896***
Observations	13,580
Number of Banks	194

*** p<0.01, ** p<0.05, * p<0.1

The Taylor gap (TGap) is the deviation of the monetary rate from the Taylor rule based rate. Following Taylor (1993) $i = r + \pi + 0.5(\pi - \pi^*) + 0.5y$, where r is the natural interest rate (set at 2%), π^* is the inflation target set at 2% and y is the output gap. The dummy variable UNC take the value 1 between 2009q1 and 2015q4, and 0 otherwise and refers to a period of unconventional monetary policy measures.

Our results question the existence of a monetary policy risk-taking channel. So far, interest rate cuts have been considered to drive banks' risk-taking behaviour. Our findings tend to reconcile the idea of monetary easing and its opponents. While monetary easing has been decried at long as factor of risk-taking, it appears that it may be profitable for banks and supports their soundness. We show that the effects of monetary policy on bank risk, change according to the Taylor gap threshold value. Thus, when the monetary rate is, to a certain extent, already below the Taylor rate, monetary easing is undesirable. In a low interest rate environment, banks already suffer from a spread cut, and a further decrease in the interest rate will depress their profit, making riskier alternatives more attractive. This is consistent

with the “search for yield” notion developed by Rajan (2005) and supports the notion of a monetary policy risk-taking channel.

However, when monetary policy is restrictive (monetary interest rate is above the Taylor rule), the negative impact of monetary policy on bank soundness vanishes. In this type of regime, an interest rate cut is beneficial to the bank and, therefore, increasing the interest rate is undesirable. An interest rate cut, rather than triggering bank fragility, fosters bank soundness if the interest rate are greater than the Taylor rule (positive Taylor gap). In the case of a restrictive monetary policy, banks will have to bear higher refinancing costs. A decrease in the interest rate will allow the banks to benefit from a decrease in refinancing costs, to the extent that they do not face spread contraction. This is consistent with the findings in Smith (2002) that low interest rates are beneficial to banks and reduce their incentive for risk, since their opportunity costs decrease. Alternatively, the negative effects of a restrictive monetary policy might dry up liquidity, and reduce investments and future profits. Also, as Gan (2004) shows, a higher interest rate may reduce the bank’s franchise value and lead to more risk-taking. This is consistent with “gambling for resurrection” behaviour (Kane, 1989). A higher interest rate entails a decrease in the banks’ net worth and leads to “gambling for resurrection”, since risky strategies become more attractive. Our results also support the findings in Agur and Demertzis (2012) that a rise in interest rates, by increasing the cost of bank financing, reduces bank profits. To compensate for this loss, banks turn to riskier (more profitable) assets.

Our findings are consistent with the Deutsche Bundesbank (2018, p.27) statement that: *“The net interest margins generated by banks, which constitute a significant part of their profitability, can come under pressure in prolonged periods of accommodative monetary policy and low interest rates. At the same time, low interest rates can also have a positive impact on profitability, e.g. in the form of reduced loan loss provisions; however, these effects may not be strong enough to compensate for decreasing net interest margins”.*

There are two important implications of our study. First, it reopens the debate on the necessity for the triptych price stability/output stability/financial stability in Central Banks’ objectives. It offers support to those in favor of including financial stability issues in Central Banks’ objectives, since monetary rates influence financial agents’ behaviours. The second implication, which follows from the first one, is related to use of the Taylor rule as an indicator of the risk of threat against financial stability. In fact, as we evidence that monetary policy (easing or tightening) may deter financial stability according to the deviation of monetary rate from the Taylor rule rate, it is obvious that the Taylor rule can provide an early warning

of the risk of a threat to financial stability. An augmented Taylor rule that accounts for financial stability is appropriate for this. The main underlying idea is that risk-taking and crisis prevention should be the tasks of both the regulatory and the monetary authorities. Our results reject the conventional or reactive view upheld by Bernanke (2002) that stipulate that Central Banks should be used to mop up after the crisis and should not be used for financial stability concerns. It is clear that our conclusions support the proactive view of monetary policy (Borio and White, 2004; Woodford, 2012) that encourage monetary policy to lean against the wind and to include financial concerns in its objectives. However, what weight should be given to the financial stability in the monetary rule function? Moreover, which financial indicator may be used as proxy for financial stability in the monetary function? Further work is needed along the lines of an augmented Taylor rule.

Regardless of the threshold analysis, the threshold-independent variables exhibit diverse effects on bank risk. GDP growth has a positive impact on bank soundness: economic expansion tends to ameliorate banks' and their customers' balance sheets, triggering a reduction of risk. Also, economic expansion increases the volume of safe projects, leading banks to reduce their risk (Jimenez et al., 2008).

Our results also provide information on the impact of the overall system stability on the bank's risk. There is a significant positive relation between bank soundness and changes in the previous period financial stress index. This positive relation can be explained by the fact that when the financial system is negatively affected (increase in the FSI, $\Delta FSI > 0$), banks tend to behave well to withstand this negative shock. However, there is a negative (non-significant) relation between the financial stress index (ΔFSI_t) and bank soundness (Z_t) in the same period, which might suggest that when the financial system receives a negative hit, this negative shock is transmitted to the banks during the same period.

Furthermore, the results highlight a negative impact of unconventional monetary policy on bank's risk. Our results show that banks were impacted negatively by the period of unconventional policy measures: the coefficient of the dummy *UNC* is negative and significant. This result is consistent with the findings in Plescau and Cocris (2016) that banks' risk-taking increases with Central Banks' use of unconventional instruments.

Looking at the bank variables, our results indicate that operational efficiency has a positive impact on bank soundness. This is consistent with Fiordelisi et al. (2010) findings that a decrease in bank efficiency is associated to an increase in the bank's future risk (see also Nitoi and Spulbar 2016). Our result could be explained by the fact that efficient banks, compared to less efficient ones, may have more possibilities to reduce their operational costs. They can

then increase their profits, which increases their soundness.

Also, credit expansion negatively affects bank soundness, but the impact appears to be not significant.

Our results have some important implications. Therefore, we need to test their robustness.

4.3 Robustness check

In this subsection, we provide some robustness tests in relation, on the one hand, to the regression model, and to the monetary policy and monetary stance, on the other hand.

4.3.1 *Controlling for potential influence of macroeconomic and banks specific variables*

We test various specification to check the robustness of our estimations. The use of different specifications is aimed at checking whether the threshold effect is subject to influence from some of the variables included in the regression.

We regress the bank Z-score on the lagged values of the macroeconomic and bank-specific variables (model 2) to check that our threshold effect does not depend on the economic condition prevailing at time t . We estimate model 3 to check whether the threshold still holds without accounting for banks specificity, i.e. if we remove the bank-specific variables from our baseline specification. The final specification (model 4) is our baseline model to which we add an interaction between change in the fed interest rate and the unconventional period within each regime (below and above the threshold value). To test the impact of monetary policy during the period of unconventional policy, we include an interaction between the dummy *UNC* and the monetary variable. This is mainly to check whether our threshold effect remains robust to the potential impact of a period of unconventional policy.

Table 2.30 presents the results of the robustness tests.

All three additional specifications confirm the existence of a threshold value in the deviation from the Taylor rule at $(t - 2)$. Our results appear robust to any changes to the regression and show the existence of a threshold effect in the impact of monetary policy. Although the threshold value (-1.2300) in model 4 is lower than in models 1, 2 and 3 (-0.1898), the reverse marginal effects of monetary policy are still at play.

Table 2.30: Robustness check of the threshold analysis

The dependent variable is the Z-score (Z_t) and measures the bank's soundness

EXPLANATORY VARIABLES	(2)	(3)	(4)
Threshold variable $q_{i,t}$	$TGAP_{t-2}$	$TGAP_{t-2}$	$TGAP_{t-2}$
Threshold value γ	-0.1898**	-0.1898***	-1.2300**
ΔGDP_{t-1}	0.0412***	0.0567***	0.0339***
ΔGDP_t		0.0572***	0.0357***
ΔSM_{t-1}	0.00192	-0.700***	-0.551***
ΔSM_t		-0.118	-0.160
$\Delta^2 HP_{t-1}$	-0.0134**	-0.00656	-0.00672
$\Delta^2 HP_t$		0.0272***	0.0197***
$\Delta Slope_{t-1}$	-0.00797	-0.0438*	-0.0328
$\Delta Slope_t$		0.0237	0.149***
ΔFSI_{t-1}	0.175***	0.265***	0.265***
ΔFSI_t		-0.00880	-0.00834
LIQ_{t-1}	-0.222		-0.0237
EFF_{t-1}	1.301***		1.330***
$Size_{t-1}$	-0.110**		-0.244***
$EXLEND_{t-1}$	-0.137		-0.122
$EXLEND_{t-1}^2$	-0.0521		-0.0745
UNC	-0.298***	-0.623***	
ΔMP_{t-1} if $TGAP_{t-2} \leq \gamma$	0.221***	0.329***	0.510***
ΔMP_{t-1} if $TGAP_{t-2} > \gamma$	-0.0495	-0.157***	-0.0618**
$\Delta MP_{t-1} * UNC$ if $TGAP_{t-2} \leq \gamma$			1.009***
$\Delta MP_{t-1} * UNC$ if $TGAP_{t-2} > \gamma$			-3.254***
Constant	3.423***	2.979***	4.072***
Observations	13,580	13,580	13,580
Number of Banks	194	194	194

*** p<0.01, ** p<0.05, * p<0.1

The dummy variable "UNC" take the value 1 between 2009q1 and 2015q4, and 0 otherwise and refers to a period of unconventional monetary policy measures.

The Taylor gap (TGap) is the deviation of the monetary rate from the Taylor rule rate. The Taylor rule rate is estimated following Taylor (1993) $i = r + \pi + 0.5(\pi - \pi^*) + 0.5y$, where r is the natural interest rate (set at 2%), π^* is the inflation target set at 2% and y is the output gap.

Monetary expansion in a regime of already low interest rates, weakens bank soundness, inducing more risk-taking. However, an interest cut is beneficial to the banks in a monetary policy regime that is fairly restrictive. Hence, the positive and negative impacts of monetary expansion have mutually superior marginal effects depending on the monetary regime in the previous quarter.

The results of model 4 indicate that the impact of a monetary shock is more important during a period of unconventional policy. In this specification, the effects of monetary policy are more important during a period of unconventional policy than in normal times. In a low monetary regime ($TGAP_{t-2} \leq \gamma$), the impact of monetary shock on bank soundness is

twice that in normal times. In a high monetary regime ($TGAP_{t-2} > \gamma$), this impact is 50 times higher than in a normal period. This is because the unconventional period corresponds to the post-crisis period, which is also a period of recovery. Hence, banks are likely to be more sensitive to monetary policy during this period since their recovery is not complete. Banks soundness becomes more sensitive to changes in monetary interest rate during an unconventional period combined with a restrictive policy. The differential of bank Z-score sensitivity to a monetary policy during an unconventional period relative to a normal period, triples for a high monetary regime compared to a low monetary regime. This result suggests that the monetary authorities need to be more vigilant when introducing unconventional policy measures since they could amplify reversal of the desired effect.

Ceteris paribus, economic expansion, the steepness of the yield curve and bank efficiency have a positive impact on bank soundness. Economic expansion and a more steeply sloped yield curve increase the number of safe projects and decrease banks risk. Efficient banks are able to control their costs and, thus, increase their profits, and have fewer incentives to engage in risky projects.

When the system receives a negative hit, the banks tend to behave cautiously, leading to a reduction of their risk in the next period, as shown by the positive relation between the change in the FSI at $(t - 1)$ and the bank Z-score at time t .

Bank size has a negative effect on bank soundness, which highlights the potential perverse effect of an implied “too big to fail” policy on the risk-taking behaviour of large banks. The “too big to fail” policy suggests that the government will bailout large failing banks to avoid important damages to the entire economy in case of bankruptcy of these banks. Guided by this certainty of being rescued in the event of difficulty, large banks will be more inclined to take risks.

The threshold analysis appears robust to changes in the model specification. It is therefore necessary to also check for robustness using various computations of our threshold variable, i.e. the monetary stance.

4.3.2 Alternative measures of monetary policy rate and stance

The threshold analysis, using the effective Fed interest rate and Taylor’s (1993) rule to compute the Taylor gap, provides evidence of a threshold value in the Tgap at $(t - 2)$ at which the impact of monetary policy on banks risk changes.

In this section, we continuous robustness tests, including two major changes to the Taylor

gap estimation.

First, we allow for another measure of the Taylor rule, which puts greater weight on output stability, following Taylor (1999) (weight of 1 instead of 0.5 on the output gap). Use of Taylor's 1999 rule rather than the 1993 rule, has proven to better stabilize output and inflation and more closely match the Fed's optimal control of interest rates. Thus, the Taylor 1999 rule is preferred by most researchers. In this section we use the Taylor (1999) rule to compute the Taylor gap.

The Taylor 1999 rule is given by:

$$i = r + \pi + 0.5(\pi - \pi^*) + y$$

Similarly to the 1993 Taylor rule, r is the natural interest rate (set at 2%), π^* is the inflation target set at 2% and y is the output gap. Again, since quarterly data have short frequency and do not allow smoothing of the fluctuations in price levels, we estimate inflation π as the moving average of the GDP deflator on the last four quarters.

A second novelty is related to the monetary interest rate used to compute the Taylor gap. Since the effective Fed interest rate has a Zero Lower Bound (ZLB), it may fail to reflect the real monetary policy stance since some unconventional measures were introduced after 2009. It is obvious that negative interest rate may lead to some friction that differs from that associated with positive interest rate. In fact, the friction associated with negative interest rate is that interest rate on banks' deposit does not reprice when policy rates are cut to a level below zero. This is because the rate that banks pay on deposits appears to be floored at zero, while most other rates paid or received by banks do adjust to rate cuts under negative interest rate. This suggests that banks that are particularly reliant on retail deposits for their funding should be particularly impacted by negative interest rate. To deal with the limitation of Fed interest rate, we check the robustness of our results using the shadow Fed Fund rate instead of the effective Fed interest rate to compute the Taylor gap. The advantage of using the shadow rate is that it is not constrained by the ZLB and takes account of unconventional measures not reflected in the main refinancing interest rate. We employ the shadow Fed Fund rate computed by Wu and Xia (2015) to estimate a new Taylor gap.

Figure 2.6 depicts the shadow Fed rate computed by WU and Xia (2015).

Note that the shadow Fed rate deviates from the effective Fed rate, starting in 2009, and becomes negative up to the end of 2015.

Figure 2.6: Wu and Xia shadow Fed Funds rate

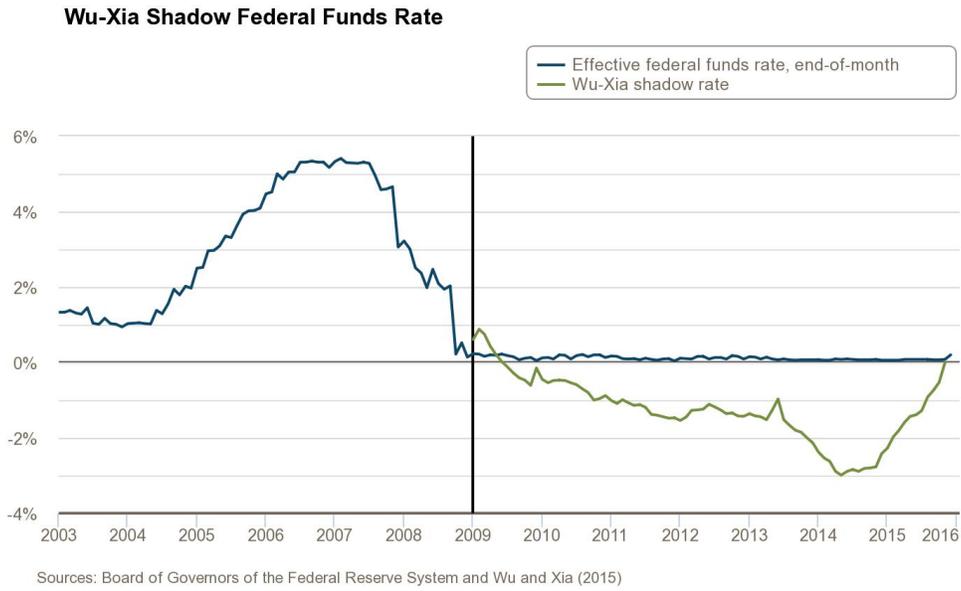
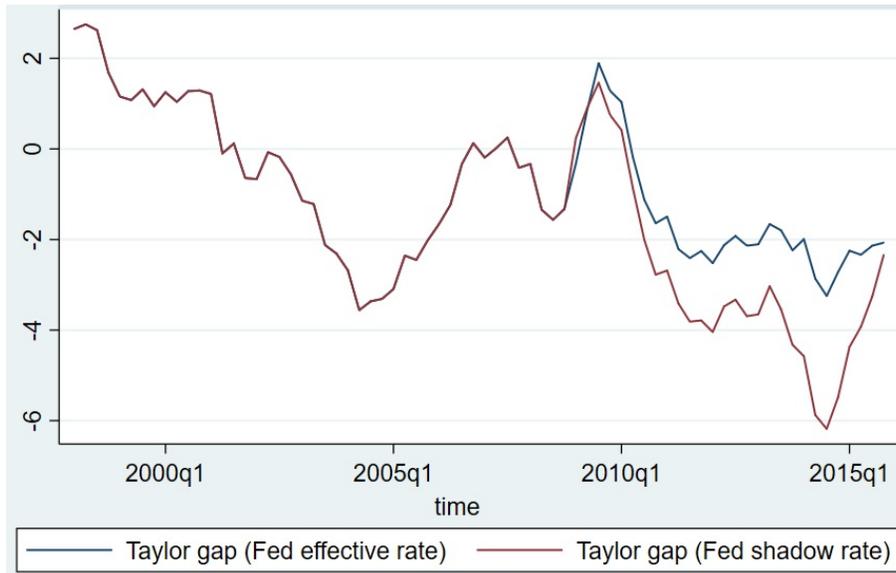


Figure 2.7 gives a bird's eye on the Taylor gap computed using the 1993 Taylor rule and on the one hand, the shadow Fed rate computed by WU and Xia (2015) and .

Figure 2.7: Taylor gaps using Fed effective rate and using the shadow Fed Funds rate



Given that the Fed effective rate and the shadow Fed rate differ starting in 2009, the Taylor gaps, using each of the interest rates (shadow and effective rate) remain stable up to 2009 and then differ up to 2015.

We then estimates three additional Taylor gaps :

- The gap between the shadow Fed rate and the 1993 Taylor rule (model 5)
- The gap between the effective Fed rate and the 1999 Taylor rule (model 6)
- The gap between the shadow Fed rate and the 1999 Taylor rule (model 7)

Table 2.31 presents the results of different regressions. Model 5 uses the Taylor gap estimated as the difference between the shadow Fed rate and the 1993 Taylor rule. Models 6 and 7 are tested using the gap between the 1999 Taylor rule and, respectively, the effective Fed rate and the shadow Fed rate.

Table 2.31: Threshold analysis on the Taylor gap

The dependent variable is the Z-score (Z_t)			
EXPLANATORY VARIABLES	(5)	(6)	(7)
Threshold variable $q_{i,t}$	$TGAP_{Shadow-Taylor93,t-2}$	$TGAP_{Fed-Taylor99,t-2}$	$TGAP_{Shadow-Taylor99,t-2}$
Threshold value γ	-1.233**	-0.6083 ***	-0.7739 ***
ΔGDP_{t-1}	0.0356***	0.0375***	0.0373***
ΔGDP_t	0.0392***	0.0415***	0.0415***
ΔSM_{t-1}	-0.347***	-0.242*	-0.228*
ΔSM_t	-0.338**	-0.406***	-0.407***
$\Delta^2 HP_{t-1}$	-0.0026	-0.00131	-0.000595
$\Delta^2 HP_t$	0.0102**	0.00274	0.00296
$\Delta Slope_{t-1}$	-0.019	-0.0102	-0.00535
$\Delta Slope_t$	0.162***	0.157***	0.158***
ΔFSI_{t-1}	0.290***	0.301***	0.307***
ΔFSI_t	-0.0189	-0.00713	-0.00845
LIQ_{t-1}	-0.0319	-0.0319	-0.0354
EFF_{t-1}	1.329***	1.333***	1.332***
$Size_{t-1}$	-0.239***	-0.239***	-0.238***
$EXLEND_{t-1}$	-0.122	-0.121	-0.121
$EXLEND_{t-1}^2$	-0.0739	-0.0750	-0.0751
ΔMP_{t-1} if $TGAP_{t-2} \leq \gamma$	0.537***	0.507***	0.518***
ΔMP_{t-1} if $TGAP_{t-2} > \gamma$	-0.068***	-0.0620**	-0.0621**
Constant	4.041***	4.028***	4.027***
Observations	13,580	13,580	13,580
Number of Banks	194	194	194

*** p<0.01, ** p<0.05, * p<0.1

$TGAP_{Shadow-Taylor93,t-2}$ is the deviation of the shadow Fed rate from the Taylor 1993 rule based rate at time t-2. The Taylor 1993 rule rate is estimated as follow $i = r + \pi + 0.5(\pi - \pi^*) + y$. $TGAP_{Fed-Taylor99,t-2}$ is the deviation of the effective Fed rate from the Taylor 1999 rule based rate at time t-2. $TGAP_{Shadow-Taylor99,t-2}$ is the deviation of the shadow Fed rate from the Taylor 1999 rule based rate at time t-2. The Taylor 1999 rule rate is estimated as follow $i = r + \pi + 0.5(\pi - \pi^*) + y$, where r is the natural interest rate (set at 2%), π^* is the inflation target set at 2%, π is the inflation rate and y is the output gap. The Fed shadow rate is taken from Wu and Xia (2015).

The results of these regressions confirm the existence of threshold values in the Taylor gap of -1.23%, -0.60% and -0.77%, leading the effects of monetary policy to reverse. The differential in threshold values stems from the changes in the variables included in the calculation of the Taylor gaps (effective/shadow Fed rates and Taylor 1993/1999 rules). The results indicate that the impact of monetary policy reverses when the effective Fed rate is -60.83 basis points below the Taylor 1999 rule. The results also suggest a reversal in the impact of monetary policy when the shadow Fed rate is -123 basis points below the Taylor 1993 rule or -77 basis points below the Taylor 1999 rule.

Hence, whatever the Taylor rule, there is a threshold in the Taylor gap from which the negative impact of monetary easing fades away in favour of positive impact. Moreover, even in presence of unconventional monetary policy, this result still holds. Monetary policy easing positively and negatively affects bank's risk given the monetary stance. We can conclude that the impact of monetary policy on banks soundness depends, effectively, on the prevailing "real" monetary stance. The "real" monetary stance refers to the monetary stance given by the shadow fed rate.

The results in Table 2.31 prove that our findings are robust to change in the Taylor gap estimation, although threshold values are slightly lower than those obtained in the previous analysis (-0.1898). This implies that the impact of monetary policy shocks reverses when the effective Fed interest rate (the shadow Fed rate) is already below the Taylor rule. Below these threshold values, any interest rate cut increase bank fragility since a 1% decrease in the monetary rate in the low interest regime, induces around a 0.51 unit decrease in the bank Z-score. This decrease in bank soundness can be explained by excessive risk-taking by the banks. Conversely, a 1% interest rate reduction in the high interest regime, leads to a slight improvement (0.07 units) in bank soundness.

In a nutshell, our results evidence the existence of a threshold in the deviation of the monetary rate from the Taylor rule rate from which the positive and negative impacts of monetary policy on bank's risk have greater influence than each other. These results are robust whatever the econometric model or the Taylor gap indicator that is used in our analysis.

Conclusion

In this chapter, we further examine the risk-taking channel using a non-linear approach, namely a non-dynamic threshold model. The use of this approach is mainly driven by opposing findings in theoretical and empirical literature. In fact, it has been established that low interest rate can have positive and negative impact on bank's risk. On the one hand, low interest rates induce higher bank's risk through search for yield or by enabling bad borrowers to enter the credit market. On the other hand, low interest rates induce low refinancing and opportunity cost, and increase bank's franchise value, leading to a decrease in the bank's risk incentive.

While existing literature addresses the question of the impact of monetary policy on bank's risk in a unilateral way (admitting only either positive or negative effects of monetary policy on bank's risk), we think that these two (opposing) effects simultaneously act and depending to their intensity, the resulting effect is either positive or negative. To support our point of view, through a non-dynamic threshold model, we identify different monetary regimes (deviation of the monetary rate from the Taylor rule) where the effect of changes in the monetary rate might differ. Although some empirical research on the monetary policy risk-taking channel already exist, we are the first, to our knowledge, to analyse this channel using a panel threshold model.

We found that the impact of monetary shocks on bank risk, instead of being linear, depends on the deviation of the monetary rate from the Taylor rule based interest rate. On the one hand, when monetary policy is accommodative (monetary rate below the Taylor rule), an interest rate cut triggers bank fragility, due, probably, to a greater appetite for risk. This first result implies that in low interest rate environment, banks already face margin depression. A further decrease of interest amplify this depression and offset potential gains stemming from decreasing costs. On the other hand, when monetary policy is considered as restrictive (monetary rate above the Taylor rule), monetary easing is beneficial for the banks. This second result can be explained by the fact that the gains for banks in terms of lower refinancing costs, following decrease in interest rate, is sufficient large to offset the margin losses they can endure. Our findings highlight the presence of positive and negative marginal effects of monetary policy on bank risk, and we show that these marginal effects are mutually greater depending on the previous monetary stance.

By shedding light on the non-linear impact of monetary policy on banks risk-taking behaviour, our findings have important implications for monetary and prudential policy. They contribute

to the debate on the possibility of a financial stability side to Central Banks objectives. On the one hand, our findings call for monetary authorities to pay more attention to financial stability when setting interest rates, and on the other hand they suggest that banking supervisors should consider the potential effects of monetary shocks depending on the interest rate regime when conducting banking supervision. In sum, our results suggest that monetary authorities should not only consider the impact of interest rate shocks on banks risk-taking behaviour but should also consider deviations from the Taylor rule.

However, these results can not be considered free of reproach. First of all, the results of this analysis are related only to the American banking system. Broadening the analytical framework to include several countries (such as EU countries) may help to examine whether the non-linear impact of monetary policy on bank risk still holds on an international level. Second, the impact of banking regulation was not taken into account in our analysis. While the interactions between the two policies are clearly established, the impact of monetary policy on risk cannot be fully assessed without taking prudential regulation into account. The reason why we did not account for prudential policy in our analysis is that all the banks of our sample are located in the same country and then they are subject to the same intensity of regulation. Enlarging the analytical framework to include several countries seems appropriate to take into account the difference in the stringency of prudential policy. Finally, our study was conducted on surviving banks in 2015, thus omitting banks that failed during the analysis period. The latter could provide important information on the risk-taking channel. Taking these banks into account in a more detailed analysis would therefore make sense in order to better understand the contours of the risk-taking channel of monetary policy. This analysis requires the use of econometric models adapted to unbalanced panel data.

Chapter 3

MONETARY AND PRUDENTIAL POLICY COORDINATION: IMPACT ON BANK'S RISK-TAKING

This chapter is based on a joint research with Olivier BRUNO.

The implications of monetary policy in terms of financial stability has been largely discussed and presented in chapter 1. It has been shown that monetary policy pursuing its objectives of GDP growth and inflation stability affects the bank's risk-taking behaviour. It was also established that monetary and prudential policy may interfere. On the one hand, Monetary policy may deter the effectiveness of prudential policy in mitigating the bank's risk. On the other hand, prudential policy, while addressing risk-taking, may reduce credit volume and also make it difficult for monetary policy to reach its goals. We prove in chapter 2 that the effect of monetary policy on bank's risk is non-linear. A monetary easing as well as a monetary contraction may lead to more risk-taking according to the prevailing monetary stance. These results shed light on the necessity to further study the impact of monetary policy on banks risk-taking behaviour and its interaction with prudential policy.

In this chapter, we model the choice of the optimal risk level of a bank that seeks to maximize its profit under a regulatory capital constraint, assuming a risk sensitive capital requirement ratio. Through this modelling, we assess the impact of a change in monetary policy, designed as a change in risk-free rates, on the optimal risk choice of the bank and examine how it interferes with micro- and macroprudential policy.

Our findings are as follows. First, the bank's risk-taking behaviour following a change in monetary interest rate is driven by two opposing effects: the expected net marginal intermediation gain and the additional capital provisioning. Hence, we find that a decrease in the risk-free interest rate could lead either to an increase or to a decrease in the bank's optimal risk level. If the expected net marginal intermediation gain following an increase in risk is enough to cover the rise in additional capital provisioning, a monetary easing pushes up the bank's equilibrium risk level. Conversely, if the expected net marginal intermediation gain following an increase in risk is lower than the additional capital provisioning, then the bank finds it optimal to decrease its risk level following monetary easing. Thus, the effects of monetary policy on bank's risk mostly depend on the sensitivity of the capital requirement ratio to risk. We evidence the existence of a couple (risk sensitivity of the bank's net intermediation margin; risk sensitivity of the regulatory capital ratio) that encourages risk-taking in the event of a fall in interest rates. When the risk sensitivity of the capital requirement is lower than the risk sensitivity of the bank's net intermediation margin, then the well-known bank risk channel of monetary policy works. That is, decreased interest rate whets bank's risk appetite and leads to an increase in the bank's optimal risk level. In that case the bank could take more risk without facing prohibitive additional capital charge. However, when the capital requirement is more sensitive to risk than the bank's intermediation margin, the bank's risk-taking channel of monetary policy reverses. A decreased interest rate lead to

a fall in the bank's optimal risk level. A prudential tool that is more risk sensitive than the bank's intermediation margin makes it most costly to take more risk. Then, the bank finds it profitable to reduce risk since lowering risk level induces lower capital provisioning (and higher leverage) that will offset the loss in interest margin (decrease in the risk premium). So, the effects of monetary policy on bank's risk-taking behaviour are not independent from the "strength" of the microprudential policy.

Second, we establish that changes in monetary policy have implications also in terms of the probability and cost of bank failure. The presence of a deposit insurance makes the bank free of reimbursing deposits in case of failure. Since the bank could take more risk following any change in monetary rate, on the one hand, it decreases the probability of success (i.e. decrease in financial stability) and increases the probability of default (and thus the probability for the whole economy to bear the cost of a crisis). On the other hand, higher risk induces lower leverage (fewer projects are financed). Consequently, the resulting effect on the expected cost of bank failure is not unique. The final impact of change in monetary policy on the expected cost of a bank failure depends on the bargaining forces of four effects: the price effect, the risk-taking effect, the fragilization effect and the leverage effect. Hence, any change in monetary policy is followed by either an increase or a decrease in the expected social cost of bank failure. It appears that in some cases, the single microprudential is sufficient to ensure both a more stable financial system and a lower resolution cost in case of bankruptcy. However, in other cases, the increase in the resolution cost of a bank failure is mainly driven by the leverage effect. Then, a macroprudential policy, such as a leverage ratio must be coupled to microprudential policy to achieve these two goals. In these latter cases, it can be possible for the regulator to attenuate the increase in the resolution cost by imposing a leverage ratio which may limit the increase in the bank's leverage.

These findings raise the question of the determination of the "optimal" risk sensitivity of the microprudential tool, i.e. the risk sensitivity of the capital requirement ratio that will offset the incentive to risk-taking. In fact, if it is easy to prove the existence of such risk sensitivity level, its implementation is not obvious. That is the reason why a proper coordination between monetary policy and microprudential policy appears necessary.

The features of our model are close to those existing in the literature on banking regulation (Dell'Ariccia and Marquez, 2006; Van den Heuvel, 2008; Covas and Fujita, 2010; Agur and Demertzis, 2019). Our model adapts features of the model developed by Dell'Ariccia and Marquez (2006), where they analyse the incentives for independent bank regulators with financially integrated jurisdictions to form a regulatory union. Contrary to them, we analyse

the interaction of monetary and prudential policy in a single country framework. The question of coordination in a country has been tackled by Jeanne and Korinek (2013). In their model, monetary policy has a resolution objective that triggers more ex-ante risk-taking. Setting an ex-ante prudential policy allows to solve the time inconsistency problem of monetary authority. In our model, we consider monetary and prudential policy as exogenous, and the two policies play at each period contrary to them where monetary and prudential policies are assumed to play separately only in each period. Another model that is closer to ours is that of Agur and Demertzis (2019) which model the transmission of monetary policy to bank's risk-taking and its interaction with prudential policy. They show that a change in the monetary policy rate affects the regulator's entire trade-off in an ambiguous way depending on two countervailing effects: the profit effect and the leverage effect. According to the profit effect, a higher rate increases the bank's funding costs, hence, reduces its profitability. Due to deposit insurance, the bank has less to lose from a risky strategy and then takes more risk. The leverage effect induces bank's risk to drop following monetary contraction since a higher policy rate makes debt more expensive. Then, the bank opts to deleverage, and has more "skin-in-the-game" leading to invest in projects with lower default risk. They also show that the regulator allows interest rate changes to partly "pass through" to bank soundness by not neutralizing the bank risk channel of monetary policy. We complement their analysis by taking into account the capital cost and evidence that the effects of change in monetary rate on the bank's risk also depends on the risk sensitivity of the microprudential tool.

The rest of the chapter is organized as follows. Section 1 describes the model by presenting the agents and the assumptions. The bank's problem is examined in section 2 while the bank risk channel of monetary policy and its interaction with prudential policy are analysed in section 3. Section 4 analyses the implication of monetary policy in terms of expected cost of bank failure. Section 5 gives an overview of the outcomes of different combination in terms of risk-taking and expected cost of bank failure. And section 6 concludes.

1 The structure of the model

We propose a model where a bank chooses its optimal asset risk level under various banking regulation and monetary policy. There are 5 types of agents in the economy: savers that are assumed to provide banks with an inelastic deposits offer; borrowers that are assumed to have inelastic credit demand in order to finance projects with different risk profiles; a representative bank, a monetary and a prudential authority.

The bank chooses the optimal risk level of projects it may finance to maximize its profit

under given monetary and prudential policy. There is no information asymmetry as each agent acts knowing perfectly what the others do. Monetary policy and prudential policy authorities know perfectly how their actions affect the bank's optimal decisions, whereas the bank optimally reacts to the features of monetary and prudential policies.

1.1 Monetary and Prudential policies

We assume that monetary and prudential policies are exogenous and that the two policies are independent and act in an uncoordinated manner.

In general, monetary policy's aim is to regulate inflation and output gap by setting interest rates. As established by preceding studies, monetary policy also affects the financial system (Bernanke and Gertler, 1995; Bernanke et al., 1996; Smith, 2002; Rajan, 2005; Adrian and Shin, 2009; De Nicolo et al. 2010). Since we develop a partial equilibrium model, we do not consider the macroeconomic objectives of monetary policy but assume these objectives as exogenous to our model. We focus only on the impact of change in interest rate on the financial system and seek to determine how a change in interest rate impacts the bank's optimal risk choice. Hence, changes in the risk-free interest rate δ are used as proxy for monetary policy.

Prudential policy, for its part, deals with micro- and macroprudential policy. In our model, we focus on the microprudential side by considering that the prudential regulator acts through a capital requirement ratio (microprudential tool) and aims at strengthening bank soundness. The capital requirement ratio has been largely considered as efficient to deter the bank's risk-taking (mitigating the risk-taking behaviour that stems from limited liability and deposit insurance). In this model, we model the microprudential policy through a risk sensitive capital requirement ratio, following the Basel III logic. The microprudential policy in our model allows the regulator to set the risk sensitivity of the capital requirement ratio.

Besides the objective of financial stability, we assume that the regulator also care about the expected cost of a crisis resolution for the society. The expected cost of bank failure can be declined into the frequency and severity of a crisis. On the one side, bank's risk-taking does not only threats the financial stability, but also increases the probability of default which translates into higher probability of crisis (higher frequency of crisis). On the other side, the higher bank's leverage the more severe the crisis since the deposit insurance (which increases the moral hazard and risk-taking by the banks) leads the government (and so the whole society) to bear the cost of the resolution once the crisis materializes. In this sense, we consider that the regulator also aims at reducing the expected cost of bank failure.

For consistency in the sequence of actions, we assume that monetary policy and prudential regulator set respectively interest rates and the prudential tool at the same time.

1.2 The representative bank

The representative bank is financed by capital and deposits. The bank collects deposits from households at a cost δ which is also the risk-free interest rate set by the monetary policy. We assume that deposits are covered by a deposit insurance and that the supply of deposit is inelastic to the risk-free interest rate. It means that the bank can collect an indefinite amount of deposit paying δ . The bank is also endowed with a fix amount of capital \bar{K} that is a more costly form of financing than deposits (Gorton and Winton (2002) and Repullo (2004)), and we define ρ as the cost of capital, with $\rho > \delta$.

The bank faces a continuum of risky projects that it can finance thanks to capital and deposit. We assume that there is an inelastic demand of financing for each level of risk. Moreover, the return of risky projects is assumed to be an increasing function of their level of risk whereas their probability of success is decreasing with their risk level.

A project's risk level is measured by $\alpha \in [0, 1]$, $R(\alpha, \delta)$ and $P(\alpha)$ are respectively the gross return and the probability of success of a project according to its level of risk α . We make the following assumptions on these two functions.

H1. The safe project ($\alpha = 0$) yields the risk-free interest rate ($R(0, \delta) = \delta$) with a probability of success $P(0) = 1$, whereas the higher risky project ($\alpha = 1$) yields the maximum gross return of $R(1, \delta) = \bar{R}$ with a probability of success $P(1) = 0$.

H2. The gross return is an increasing concave function of the projects' level of risk with $\frac{\partial R(\alpha, \delta)}{\partial \alpha} = R'_\alpha(\alpha, \delta) > 0$, $\frac{\partial^2 R(\alpha, \delta)}{\partial \alpha^2} = R''_\alpha(\alpha, \delta) \leq 0$, $\lim_{\alpha \rightarrow 0} R'_\alpha(\alpha, \delta) \rightarrow +\infty$ and $\lim_{\alpha \rightarrow 1} R'_\alpha(\alpha, \delta) \rightarrow 0$.

H3. The probability of success is a decrease concave function of the projects' level of risk with $\frac{\partial P(\alpha)}{\partial \alpha} = P'_\alpha(\alpha) < 0$, $\frac{\partial^2 P(\alpha)}{\partial \alpha^2} = P''_\alpha(\alpha) \leq 0$, $\lim_{\alpha \rightarrow 0} P'_\alpha(\alpha) \rightarrow 0$ and $\lim_{\alpha \rightarrow 1} P'_\alpha(\alpha) \rightarrow -\infty$.

H4. The gross return of a project is positively related to the risk-free interest rate and $\frac{\partial R(\alpha, \delta)}{\partial \delta} = R'_\delta(\alpha, \delta) > 0$.

Lemma: The maximum expected return is obtained for the level of risk $0 < \bar{\alpha} < 1$.

Proof: see Appendix 1.

The bank is confronted with a risk-sensitive prudential regulation and must hold an amount of capital in line with the risk level of the asset it finances. We define L as the total amount of risky assets financed by the bank and the minimum level of regulatory capital the bank must hold is given by $k(\alpha)L$ with $k(\alpha)$ a measure of the risk-sensitive regulatory capital ratio. In accordance with the Basel III banking regulation, we assume that $k(\alpha)$ is an increasing concave function of the risk of the asset with $\frac{\partial k(\alpha)}{\partial \alpha} = k'_\alpha(\alpha) > 0$, $\frac{\partial^2 k(\alpha)}{\partial \alpha^2} = k''_\alpha(\alpha) \leq 0$, $k(0) = \underline{k} > 0$ and $k(1) = \bar{k} < 1$. It means that a minimum level of capital is required even for financing a safe asset and that the level of capital for financing the riskier asset as a maximum value.

Finally, the objective of the bank is to maximize its profit by choosing the assets risk level it finances under the constraint given by the available amount of capital, which means:

$$\begin{aligned} \max_{\alpha} \pi(\alpha, \delta) &= LR(\alpha, \delta)P(\alpha) - (L - \bar{K})\delta P(\alpha) - \bar{K}\rho \\ \text{s.t. } \bar{K} &\geq k(\alpha)L \end{aligned} \quad (3.1)$$

The first part of the equation ($LR(\alpha, \delta)P(\alpha)$) is the expected revenue of the bank. $(L - \bar{K})$ is the total amount of deposit that is required to finance the amount L of assets. The cost of these deposits is equal to δ and due to limited liability and deposit insurance, the bank payback deposits only in case of success, with probability $P(\alpha)$. Thus, $(L - \bar{K})\delta P(\alpha)$ is the cost of deposits in case of bank's success. The last term of the profit function, $\bar{K}\rho$ is a measure of the capital cost paid even in case of failure.

As capital is costly, the bank doesn't hold excess capital over the regulatory level (Repullo and Suarez (2004)) and we have $\bar{K} = k(\alpha)L$.

Consequently, the bank maximizes the following profit function:

$$\begin{aligned} \max_{\alpha} \pi(\alpha, \delta) &= LR(\alpha, \delta)P(\alpha) - (L - k(\alpha)L)\delta P(\alpha) - k(\alpha)L\rho \\ \max_{\alpha} \pi(\alpha, \delta) &= L[R(\alpha, \delta)P(\alpha) - (1 - k(\alpha))\delta P(\alpha) - k(\alpha)\rho] \end{aligned} \quad (3.2)$$

Finally, we assume that the bank makes its choice knowing the monetary and the prudential policies.

2 The bank's problem

The representative bank chooses the risk level α^* that maximizes its profit given the regulatory standards and the value of the risk-free interest rate fixed by monetary policy.

$$\max_{\alpha} \pi(\alpha, \delta) = L[R(\alpha, \delta)P(\alpha) - (1 - k(\alpha))\delta P(\alpha) - k(\alpha)\rho] \quad (3.2')$$

Proposition 1

- i) There is a unique risk level $\alpha^* \in]0; 1[$ that maximizes the bank's profit and $\alpha^* < \bar{\alpha}$;
- ii) For α^* , there is a credit volume $L^* = \frac{\bar{K}}{k(\alpha^*)}$ that determines the bank's equilibrium leverage ratio.

Proof: see Appendix 2.

The rationale of proposition 1 is that the bank's choice results from the interaction of two effects: the profit effect and the regulatory effect.

The profit effect is as follows. Recall that the bank's primary objective is to maximize its profit. For a given risk-free interest rate, the bank increases its revenue via risk premium by investing in risky projects. Albeit increasing risk level increases the bank's revenue, it decreases the probability of success of the projects as well. Then, *ceteris paribus*, the profit effect results in the trade-off between increasing revenue (via more risk) and decreasing probability of getting this revenue. According to Lemma 1, we know that this profit effect is maximum for $\bar{\alpha}$.

The regulatory effect stems from the change in the regulatory capital following a change in the risk level chosen by the bank. When the bank increases its risk level, the regulatory capital increases, reducing deposit financing. However, since the cost of capital is higher than the deposits cost, the marginal funding cost increases with the risk. Then, the bank's profit decreases.

So, when the expected marginal gain of additional risk ($R'_{\alpha}(\alpha, \delta)P(\alpha) + R(\alpha, \delta)P'_{\alpha}(\alpha)$) is higher than the marginal funding cost ($(1 - k(\alpha))\delta P'_{\alpha}(\alpha) + k'_{\alpha}(\alpha)(\rho - \delta P(\alpha))$), the bank profit is increasing with α ($\frac{d\pi(\alpha, \delta)}{d\alpha} > 0$). Conversely, the bank's profit decreases ($\frac{d\pi(\alpha, \delta)}{d\alpha} < 0$) when taking additional risk triggers a marginal funding cost higher than the expected marginal gain.

Thus, there exists a unique risk level $\alpha^* \in]0; 1[$ with $\alpha^* < \bar{\alpha}$ that maximizes the bank profit, i.e. there is a unique risk level that equals the expected marginal gain and the marginal funding cost.

After the bank has determined its optimal risk level α^* , it is then possible to determine $k(\alpha^*)$. Since the capital is costly and assumed to be fixed at level \bar{K} , the bank will provision exactly the capital amount required to comply with the regulation. That is, for the risk level α^* , the bank will finance an amount L^* of projects such that the credit volume $L^* = \frac{\bar{K}}{k(\alpha^*)}$. Hence, the bank's leverage is endogenously determined.

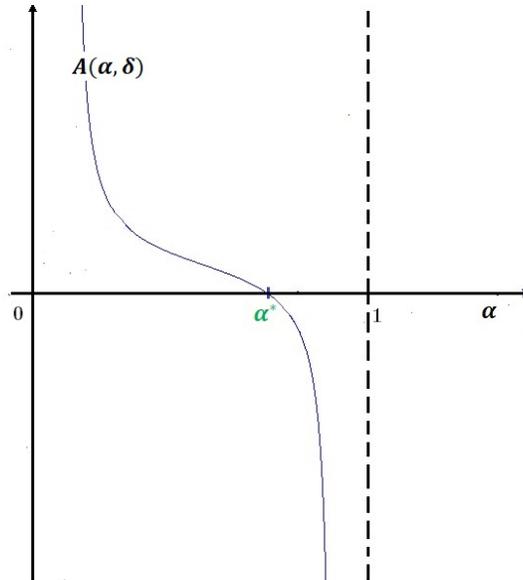
We can give a graphical illustration of proposition 1.

Let's denote $A(\alpha, \delta) = \frac{d\pi(\alpha, \delta)}{d\alpha}$,

$$A(\alpha, \delta) = R'_\alpha(\alpha, \delta)P(\alpha) + R(\alpha, \delta)P'_\alpha(\alpha) + k'_\alpha(\alpha)\delta P(\alpha) - [1 - k(\alpha)]\delta P'_\alpha(\alpha) - k'_\alpha(\alpha) * \rho$$

The equilibrium risk level chosen by the bank is such that $A(\alpha^*, \delta) = 0$. Figure 3.1 gives an illustration of the $A(\alpha, \delta)$ curve.

Figure 3.1: Illustrative curve of $A(\alpha, \delta)$



According to Appendix 2, $A(\alpha)$ is a continuous decreasing function on $]0; 1[$ with $\lim_{\alpha \rightarrow 0} A(\alpha, \delta) \rightarrow +\infty$ and $\lim_{\alpha \rightarrow 1} A(\alpha, \delta) \rightarrow -\infty$. That there is a unique $\alpha^* \in]0; 1[$ so that $A(\alpha^*, \delta) = 0$.

It is important here to emphasize that the bank's optimal risk level depends on the risk-free interest rate (δ) and the prudential policy that determines the sensitivity of the regulatory

capital ($k(\alpha)$) to the level of risk. This raises the question of the impact of monetary policy on the bank's risk-taking behaviour. We address this point in the following section.

3 Impact of monetary policy on bank risk-taking

According to the existing literature on banking regulation, monetary accommodation has been proven to whet bank's risk appetite (Bernanke and Gertler, 1995; Rajan, 2005; Altunbas et al., 2010). However, restrictive monetary policy could also impair bank soundness (Smith, 2002; Gan, 2004; Ngambou Djatche, 2019). In this section, we show that changes in monetary policy may lead either to an increase or to a decrease in the bank's risk level according to the strength of the prudential tool.

Let's examine the effects that can have a change in the monetary interest rate on the bank's optimal risk level in presence of a microprudential policy. Remind that a change in monetary policy is captured by a change in the risk-free interest rate, δ .

We have proven that the optimal level of risk chosen by the bank is such that $A(\alpha^*, \delta) = 0$. Consequently, the impact of a change on the risk-free interest on the bank's optimal risk level depends on the sensitivity of function $A(\alpha^*, \delta)$ to δ .

Proposition 2:

Under the assumption that $R'_\delta(\alpha^*, \delta) - [1 - k(\alpha^*)] \geq 1$, we have:

- i) If $\frac{|P'_\alpha(\alpha^*)|}{P(\alpha^*)} * (R'_\delta(\alpha^*, \delta) - [1 - k(\alpha^*)]) > k'_\alpha(\alpha^*)$, a decrease in the risk-free interest rate leads to a rise in the equilibrium level of risk chosen by the bank;
- ii) If $\frac{|P'_\alpha(\alpha^*)|}{P(\alpha^*)} * (R'_\delta(\alpha^*, \delta) - [1 - k(\alpha^*)]) < k'_\alpha(\alpha^*)$, a decrease in the risk-free interest rate leads to a fall in the equilibrium level of risk chosen by the bank;

Proof. See Appendix 3.

$R'_\delta(\alpha^*, \delta) - [1 - k(\alpha^*)] \geq 1$ means that the gross return of a risky project must be sufficiently sensitive to a change in the risk-free interest rate. In that case, although a decrease in the risk-free interest rate ($\Delta\delta < 0$) leads to a decrease in the deposits costs (since $0 < \frac{\partial[1-k(\alpha^*)]\delta}{\partial\delta} = [1 - k(\alpha^*)] < 1$), it produces a deeper decrease in the projects' return rate as well. Put it differently, the change in monetary rate, by changing the intermediation revenue, will lead the equilibrium to move.

From proposition 2, $\frac{|P'_\alpha(\alpha^*)|}{P(\alpha^*)}$ denotes the percentage change in the probability that a project

succeeds following a change in the risk level. $\frac{|P'_\alpha(\alpha^*)|}{P(\alpha^*)} * R'_\delta(\alpha^*, \delta)$ refers to the marginal impact on the project revenue of change in the risk level caused by a change in the risk-free interest rate. $\frac{|P'_\alpha(\alpha^*)|}{P(\alpha^*)} * [1 - k(\alpha^*)]$ is the marginal impact on the deposits funding of change in the risk level induced by a change in the risk-free interest rate. Thus, $\frac{|P'_\alpha(\alpha^*)|}{P(\alpha^*)} * (R'_\delta(\alpha^*, \delta) - [1 - k(\alpha^*)])$ measures the net (net of deposits cost) marginal impact on the bank return of change in the risk level produced by a change in the risk-free interest rate. Given that $R'_\delta(\alpha^*, \delta) - [1 - k(\alpha^*)] \geq 1$, we have $\frac{|P'_\alpha(\alpha^*)|}{P(\alpha^*)} * (R'_\delta(\alpha^*, \delta) - [1 - k(\alpha^*)]) > 0$. Finally, $k'(\alpha^*)$ represents the risk sensibility of the capital requirement ratio and measures the additional capital provisioning following a change in the bank's risk level.

The bank's risk-taking behaviour will then be the result of a trade-off between two effects: the net marginal gain of additional unit of risk and the additional capital provisioning following an additional unit of risk. The first effect can be interpreted as a price effect whereas the second effect is close to a quantity effect. Given that the bank's total capital is give, this additional capital provision leads to a decrease in the total level of bank's financing.

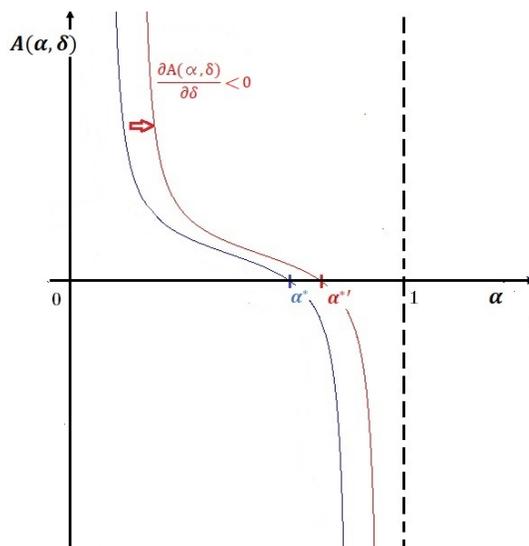
If the net marginal gain of additional risk is greater than the additional capital provisioning (price effect higher than quantity effect), i.e. if $\frac{|P'_\alpha(\alpha^*)|}{P(\alpha^*)} * (R'_\delta(\alpha^*, \delta) - [1 - k(\alpha^*)]) > k'_\alpha(\alpha^*)$, following monetary easing, the bank will find it optimal to take additional risk to increase its profit without fear of facing higher additional capital provisioning. In other words, following a decrease in monetary rate, the bank will take more risk as the expected net marginal intermediation gain is enough to cover the decrease in leverage. Here, the rationale is that a decrease in risk-free interest rate depletes the bank's profit. Since the risk sensitivity of the capital requirement ratio is lower than the expected marginal intermediation gain, the bank will take more risk to restore its benefit. A prudential tool that is less sensitive to risk than the bank's intermediation margin allows the bank to increase its revenue via more risk-taking without facing higher additional capital provision.

Figure 3.2 illustrates the impact of change of monetary policy on the bank's equilibrium risk level when the net marginal gain of additional risk is greater than the additional capital provisioning.

As depicted in Figure 3.2, the blue line represents the derivative of the bank's profit that determines its initial optimal risk level α^* given prudential and monetary policy. Then, when the net marginal gain of additional risk is greater than the additional capital provisioning, a monetary easing leads to an increase of the bank's optimal risk level.

However, if the net marginal gain of additional risk is lower than the additional capital

Figure 3.2: Negative impact of monetary easing on bank's risk



provisioning (price effect lower than quantity effect), i.e. if $\frac{|P'_\alpha(\alpha^*)|}{P(\alpha^*)} * (R'_\delta(\alpha^*, \delta) - [1 - k(\alpha^*)]) < k'_\alpha(\alpha^*)$, the bank will find it optimal to decrease its risk level following a monetary easing. In fact, the bank deters its revenue by decreasing its risk level. But at the same time, since the capital requirement is more risk sensitive than the bank's intermediation margin, the bank benefits from a rise in leverage (via less capital provisioning). Hence, the bank will decrease its risk level until these two effects are balanced.

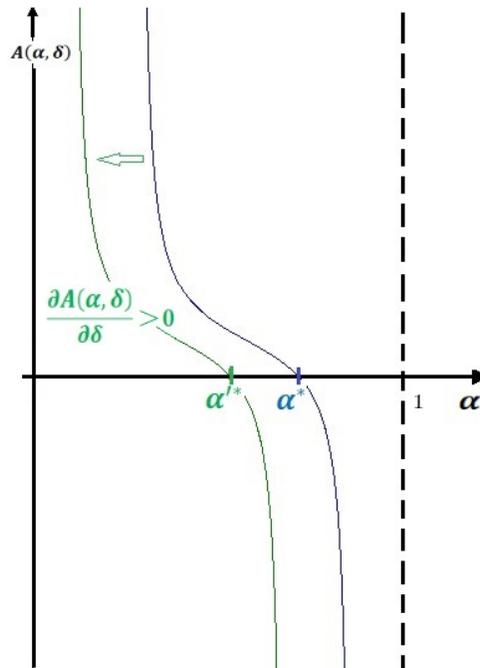
Figure 3.3 gives a bird's eye on how the bank's optimal risk level moves following change in monetary policy when the net marginal gain of additional risk is lower than the additional capital provisioning.

As depicted in Figure 3.3, the blue line represents the derivative of the bank's profit that determines its initial optimal risk level α^* given prudential and monetary policy. When the net marginal gain of additional risk is lower than the additional capital provisioning, a monetary easing triggers a decrease (green line) of the bank's optimal risk level. That is, a monetary contraction may lead the bank to increase its risk level.

In a nutshell, monetary tightening and monetary easing may lead the bank to take more risk depending on the risk sensitivity of both the bank's intermediation margin and the capital requirement ratio.

Given these findings, it appears that monetary policy effects on bank's risk is not independent from the risk sensitivity of the microprudential tool. Moreover, we can wonder whether more risk-taking necessarily translates into more important damage to the economy in the event

Figure 3.3: Positive impact of monetary easing on bank's risk



of a crisis. Now, let's examine the question of the coordination of monetary and prudential policies regarding not only the preventive side of prudential policy but also its resolution side.

4 The bank's risk and the social cost of bankruptcy

As shown in the preceding section, monetary policy, seeking to reach its objectives of price and GDP growth stability, may impact the banking soundness. In addition to the bank fragility, there is a social cost of bank failure which stems from the existence of the deposit insurance. The latter leads the bank not to internalize the cost of a bankruptcy since the bank repays deposits only in case of success. So, in case of failure the entire deposit repayment is at the charge of the government. In this sense, we assume that the objective of the prudential regulator is to mitigate both the bank's risk and the expected cost of banking failure.

Here, we analyse how the micro- and macroprudential policy may interfere with the monetary policy and derive the results in terms of financial stability (impact on bank's optimal risk level) and social cost of banking failure. Recall that in line with Basel III, it is assumed that the regulator care about the soundness of the individual bank (microprudential side). In addition, we assume that the regulator is also concerned about the implications of a banking crisis for the economy (macroprudential side), precisely in terms of the expected cost of bank

failure (frequency and severity of crises). Hence, the regulator is also supposed to act such as to reduce the cost of a crisis resolution.

4.1 Monetary policy, microprudential policy and the expected cost of bank failure

In this subsection, we focus on the impact of a change in monetary rate on the expected cost of bank failure.

As said before, the expected cost of bank failure refers to the possibility that the bank fails and that the deposit repayment remains at the charge of the government. In fact, when the bank takes risk, it induces a probability of failure $(1 - P(\alpha))$ which also refers to the frequency of crises. In case of banking failure, the deposit insurance leads the government to support the deposits cost $([L - \bar{K}]\delta)$ which refers to the cost of the crisis resolution and captures the severity of the crisis.

The expected social cost of the financial crisis is then given by:

$$C(\alpha, \delta) = (1 - P(\alpha))(L - \bar{K})\delta \quad (3.3)$$

Since $L = \frac{\bar{K}}{(k(\alpha))}$, we can write equation 3.3 as follows:

$$C(\alpha, \delta) = (1 - P(\alpha))\left(\frac{1}{(k(\alpha))} - 1\right)\delta\bar{K} \quad (3.3')$$

As we can see, the expected social cost of banking failure clearly depends on the risk-free interest rate, δ , and the risk level, α , which itself determines the probability of failure, $1 - P(\alpha)$, and the capital requirement ratio, $k(\alpha)$.

Hence, the total differential of the social cost is given by:

$$dC = \frac{\partial C}{\partial \delta} \cdot d\delta + \frac{\partial C}{\partial \alpha} \cdot d\alpha$$

We can then recompose this equation and write:

$$dC = \left[\frac{\partial C}{\partial \delta} + \frac{\partial C}{\partial \alpha} \cdot \frac{d\alpha}{d\delta} \right] \cdot d\delta \quad (3.4)$$

Let's examine the impact of the risk-free interest rate on the cost of bank failure.

From equation 3.4, it is noticeable that the change in the cost of the bank failure following a change in the monetary interest rate depends on different factors.

- $\frac{\partial C}{\partial \delta}$: which can be defined as the expected price effect which stems from changes in the risk-free interest rate, *ceteris paribus*. Any change in the risk-free interest rate induces the social cost to moves in the same direction, i.e. $\frac{\partial C}{\partial \delta} > 0$. The higher the risk-free interest rate the more costly the crisis resolution, all things remaining unchanged;
- $\frac{d\alpha}{d\delta}$: which is defined as the risk-taking effect. Its sign determines the impact of the change in the risk-free rate on the bank's risk appetite. As shown in the preceding section, the effect of monetary policy on bank risk depends on the risk sensitivity of the capital requirement (see Proposition 2 in Section 4). When the capital requirement is less risk sensitive than the bank's intermediation margin, a monetary easing leads to more risk-taking, i.e. $\frac{d\alpha}{d\delta} < 0$. Inversely, when the capital requirement is more risk sensitive than the bank's intermediation margin, a monetary easing induces a reduction in the bank's risk, i.e. $\frac{d\alpha}{d\delta} > 0$;
- $\frac{\partial C}{\partial \alpha}$: which captures the impact of a change in the bank equilibrium risk level on the cost of bank failure. This impact stems from two effects since changes in α impact the social cost through a change in both the probability of failure and the capital requirement ratio (the bank's leverage), and:

$$\frac{\partial C}{\partial \alpha} = \frac{\partial(1 - P(\alpha))}{\partial \alpha} \cdot \left[\frac{1}{k(\alpha)} - 1 \right] + \frac{\partial\left(\left[\frac{1}{k(\alpha)} - 1\right]\right)}{\partial \alpha} \cdot (1 - P(\alpha))$$

Let's denote $Frag = \frac{\partial(1-P(\alpha))}{\partial \alpha} \cdot \left[\frac{1}{k(\alpha)} - 1\right]$ and $Lev = \frac{\partial\left(\left[\frac{1}{k(\alpha)} - 1\right]\right)}{\partial \alpha} \cdot (1 - P(\alpha))$.

In this sense, the two components of effect of a change in the bank's risk on the cost of bank failure are:

- $Frag = \frac{\partial(1-P(\alpha))}{\partial \alpha} \cdot \left[\frac{1}{k(\alpha)} - 1\right]$ that can be interpreted as a fragilization effect which is positively correlated to the bank's risk level. In fact since the the probability of default increases with the risk level ($\frac{\partial(1-P(\alpha))}{\partial \alpha} > 0$), and that $k(\alpha) < 1$ which induces that $\left[\frac{1}{k(\alpha)} - 1\right] > 0$, we have $\frac{\partial(1-P(\alpha))}{\partial \alpha} \cdot \left[\frac{1}{k(\alpha)} - 1\right] > 0$. A rise in the bank's risk level triggers a hike in the probability of default (frequency of crises), then the expected social cost increases, *ceteris paribus*;
- $Lev = \frac{\partial\left(\left[\frac{1}{k(\alpha)} - 1\right]\right)}{\partial \alpha} \cdot (1 - P(\alpha))$ that can be interpreted as a leverage effect and captures the effect of the bank's leverage on the expect cost of a crisis resolution.

All things remaining unchanged, the higher the bank's leverage the more expensive is the cost of a crisis resolution. However, this effect is negatively correlated to the bank's risk level. A rise in the bank's risk level tightens the capital requirement ratio which decreases the bank's leverage. On the one hand, the higher the risk level the more capital the bank should provision and then the lower the deposit proportion, i.e. $\frac{\partial([\frac{1}{k(\alpha)}-1])}{\partial\alpha} < 0$. On the other hand, for any non null risk level, the probability of default is positive, i.e. $(1-P(\alpha)) > 0$. As a result, the leverage effect is negatively correlated to the bank's risk, i.e. $\frac{\partial([\frac{1}{k(\alpha)}-1])}{\partial\alpha} \cdot (1-P(\alpha)) < 0$. Hence, all things being equal, the higher the risk level the higher the capital requirement, the lower the bank's leverage and the lower the social cost.

Finally, equation 3.4 can be written as follows:

$$dC = \left[\frac{\partial C}{\partial \delta} + (Frag + Lev) \cdot \frac{d\alpha}{d\delta} \right] \cdot d\delta \quad (3.4')$$

This equation describes the various effects that determine the change in the social cost following a change in the risk-free rate. The overall effect then depends on the combination of four effects: the price effect, the risk-taking effect, the fragilization effect and the leverage effect. As a result, the direction in which the social cost moves following a change in monetary policy depends on the relative intensity of these four different effects.

To have a precise understanding of the underlying intuition, let's analyse the changes in the cost of bank failure following, on the one hand, a monetary easing ($d\delta < 0$), and on the other hand, a monetary contraction ($d\delta > 0$). Note that any change in the monetary policy and the bank's risk can be negatively ($\frac{d\alpha}{d\delta} < 0$) or positively ($\frac{d\alpha}{d\delta} > 0$) related. In the following development, we will successively examine each case.

4.2 Impact of monetary easing on the expected cost of bank failure

The decrease in the risk-free interest rate ($d\delta < 0$) entails a direct decrease in the expected social cost (the price effect), since $\frac{\partial C}{\partial \delta} > 0$. However, this decrease of interest rate has an indirect effect on the social cost given that there is an increase in the bank's risk or not.

Case 1: The bank's risk increases with decreased interest rate, $\frac{d\alpha}{d\delta} < 0$.

We can summarize the overall mechanism as follows. Recall that the total differential in the

social cost is given by:

$$dC = \left[\begin{array}{c} + \\ \frac{\partial C}{\partial \delta} + (Frag + Lev) \cdot \frac{d\alpha}{d\delta} \end{array} \right] \cdot d\delta \quad (-)$$

With $\frac{\partial C}{\partial \delta}$ the price effect, $\frac{d\alpha}{d\delta}$ the risk-taking effect, *Frag* the fragilization effect and *Lev* the leverage effect.

Monetary easing directly decreases the cost of a bank failure (the price effect). However, the bank's risk increases following monetary easing (the risk-taking effect), the probability of default also increases (the fragilization effect) since $\frac{\partial(1-P(\alpha))}{\partial \alpha} \cdot [\frac{1}{(k(\alpha))} - 1] > 0$. Then, bank failures become more frequent. At the same time, the loan volume decreases (the leverage effect) in response to the tightening of the capital requirement, $\frac{\partial([\frac{1}{(k(\alpha))}-1])}{\partial \alpha} \cdot (1 - P(\alpha)) < 0$, which results in a decrease in the cost of crisis. Finally, the effective cost of crisis resolution (driven by the price effect and the leverage effect) decreases but the resolution mechanism is frequently activated (due to the fragilization effect). As a result:

- The expected social cost decreases, $dC < 0$, if the decrease in the magnitude of crises (driven by the price effect and the leverage effect) is large enough to compensate for the increase in the frequency of crises (the fragilization effect);
- The expected social cost increases, $dC > 0$, if the decrease in the magnitude of crises (driven by the price effect and the leverage effect) does not compensate for the increase in the frequency of crises (the fragilization effect).

However, it appears that the risk-taking effect is an important element in the variation in the cost of bank failure. This is because the risk-taking effect determines the frequency (fragilization effect) and also the magnitude (through the leverage effect) of crisis.

Since $d\delta < 0$, we can derive that:

$$dC > 0 \Leftrightarrow \frac{\partial C}{\partial \delta} + (Frag + Lev) \cdot \frac{d\alpha}{d\delta} < 0$$

$$(Frag + Lev) \cdot \frac{d\alpha}{d\delta} < -\frac{\partial C}{\partial \delta}$$

Assuming that there is a risk-taking following a decrease in interest rate, $\frac{d\alpha}{d\delta} < 0$, then $dC > 0$ if $\frac{d\alpha}{d\delta} < -\frac{\partial C}{\partial \delta} / [Frag + Lev] \equiv S_1 < 0$.

That is, there is a threshold (S_1) in the response of the bank's risk to monetary easing below

which a monetary easing whets bank's risk and entails an increase in the expected cost of bank failure. Below this threshold, the increase in the expected cost is mainly driven by the fragilization effect. In other words, although the price and leverage effects decrease the cost of resolution in the event of crisis, the higher frequency of crises makes it costly to solve crisis. However, when the response of the bank's risk to monetary easing is above this threshold (S_1) a monetary easing whets bank's risk but there is a decrease in the expected cost of bank failure. In this latter case, the decrease in the interest rate and in the bank's leverage makes it cheaper to solve crises even though they are more frequent.

Now, let's examine how change in interest rate may impact the expected cost of bank failure when there is no risk-taking following a monetary easing.

Case 2: The bank's risk decreases with decreased interest rate, $\frac{d\alpha}{d\delta} > 0$.

The total differential in the social cost is still given by:

$$dC = \left[\overset{+}{\frac{\partial C}{\partial \delta}} + (Frag + Lev) \cdot \overset{+}{\frac{d\alpha}{d\delta}} \right] \overset{(-)}{d\delta}$$

The decrease in the risk-free interest rate entails a direct decrease in the expected social cost (the price effect), since $\frac{\partial C}{\partial \delta} > 0$. However, this decrease of interest rate has an indirect effect on the social cost. As the bank's risk decreases following a monetary easing, the probability of default also decreases (the fragilization effect plays positively) since $\frac{\partial(1-P(\alpha))}{\partial \alpha} \cdot [\frac{1}{k(\alpha)} - 1] > 0$, and the crises are less frequent. The loan volume increases simultaneously (the leverage effect) in response to the loosening of the capital requirement, $\frac{\partial([\frac{1}{k(\alpha)} - 1])}{\partial \alpha} \cdot (1 - P(\alpha)) < 0$, and increases the cost of crisis resolution. As a result:

- The social cost decreases, $dC < 0$, if the net change in the magnitude of crises (resulting from the power relationship between the price effect and the leverage effect) is lower than the decrease in the frequency of crises (the fragilization effect);
- The social cost increases, $dC > 0$, if the net change in the magnitude of crises (resulting from the power relationship between the price effect and the leverage effect) is higher than the decrease in the frequency of crises (the fragilization effect).

In line with the preceding development (since $d\delta < 0$), there is a threshold in the risk-taking effect which may determine an increase or a decrease in the expected cost of bank failure.

We can derive that:

$$dC > 0 \Leftrightarrow \frac{\partial C}{\partial \delta} + (Frag + Lev) \cdot \frac{d\alpha}{d\delta} < 0$$

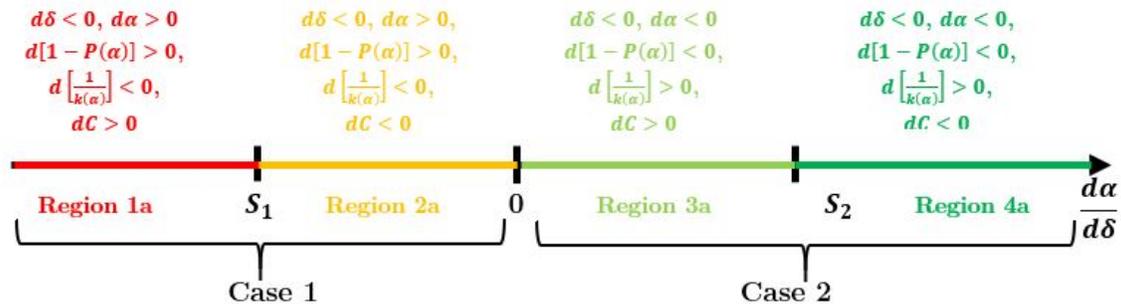
$$(Frag + Lev) \cdot \frac{d\alpha}{d\delta} < -\frac{\partial C}{\partial \delta}$$

Since $\frac{d\alpha}{d\delta} > 0$, then $dC > 0$ if $0 < \frac{d\alpha}{d\delta} < -\frac{\partial C}{\partial \delta} / [Frag + Lev] \equiv S_2$.

That is, when monetary policy does not whet bank's risk appetite, there is a threshold (S_2) in the response of the bank's risk to monetary easing below which there is an increase in the expected cost of bank failure. Below this threshold (S_2), the higher bank's leverage makes it more expensive to solve crises albeit crises become rare (less frequent) and that deposits are cheaper (lower interest rate). However, when the response of the bank's risk to monetary easing is above this threshold (S_2) a monetary easing lowers the bank's risk level and is followed by a decrease in the expected cost of bank failure. There are two possible reasons. First, the lower expected cost of crises resolution may be due to the fact that the occurrence of crises becomes almost improbable (near-zero frequency of crisis). Second, while the frequency of crises is lower, the combination of the increase in the bank's leverage with the decrease in deposits cost (the price effect) is such that the effective cost of a crisis become smaller.

Given the conditions mentioned above, there are four possible scenarios that can be depicted using Figure 3.4.

Figure 3.4: Decomposition of the effects of monetary easing on the expected social cost of bank failure.



As depicted in Figure 3.4, we can observe that monetary easing have different effects on bank's risk and the resulting effects on the expected social cost are not unique. Let's describe each region of the graph.

- Region 1a: in this region, a monetary easing leads to an increase of the bank's risk level. This increase in the risk entails an increase in the probability of default (higher frequency of crises). However, the increase in the bank's risk level also induces a decrease in the bank's leverage (magnitude of a crisis) due to a tightening of the capital requirement. However, the increase in the probability of default is sufficiently high to exceed the decrease both in the price and in the volume of deposits. In other words, the effective cost of crisis is smaller, but since crises become more frequent, the overall expected cost of crises resolution increases.

$$d\delta < 0 \implies Price < 0;$$

$$d\alpha > 0 \implies \begin{cases} Frag > 0 \\ Lev < 0 \end{cases} \implies dC > 0 \quad \text{Since } Frag^+ > (Lev^- + Price^-)$$

- Region 2a: a monetary easing leads to an increase of the bank's risk level. This increase in the risk triggers an increase in the probability of default (higher frequency of crises). However, the increase in the bank's risk level also induces a decrease in the bank's leverage (magnitude of a crisis) due to a tightening of the capital requirement. Finally, the decrease in the magnitude of a crisis, driven by the decrease both in the risk-free interest rate (the price effect) and in the volume of deposits (the leverage effect), is sufficient to overcome the increase in the frequency of crises driven by the increase in the probability of default. As a result, there is a decrease in the expected cost of bank failures since crises are frequent but are cheaper.

$$d\delta < 0 \implies Price < 0;$$

$$d\alpha > 0 \implies \begin{cases} Frag > 0 \\ Lev < 0 \end{cases} \implies dC < 0 \quad \text{Since } Frag^+ < (Lev^- + Price^-)$$

- Region 3a: there is a decrease in the bank's risk level as a response to a monetary easing. This decrease in the risk results in a decrease in the probability of default (lower frequency of crises). However, the decrease in the bank's risk level induces an increase in the bank's leverage (magnitude of a crisis) due to a loosening of the capital requirement. Therefore, the situation is such that there is an increase in the severity of the crisis because the increase in the magnitude of a crisis driven by the hike in the volume of deposits (the bank's leverage) exceeds the decrease in its magnitude driven by a fall in the deposits cost (due to the decrease in the interest rate). Finally, the increase in the magnitude of a crisis increases the expected cost of crises resolution even if crises become less frequent (decrease in the probability of default). That is, there is

an increase in the expected social cost of a bank failure.

$$d\delta < 0 \implies Price < 0;$$

$$d\alpha < 0 \implies \begin{cases} Frag < 0 \\ Lev > 0 \end{cases} \implies dC > 0 \quad \text{Since } Lev^+ > (Frag^- + Price^-)$$

- Region 4a: like in region 3a, in response to a monetary easing, there is a decrease in the bank's risk level and in the probability of default (lower frequency of crises). There is also a higher bank's leverage (magnitude of a crisis) due to a loosening of the capital requirement. But, there is a decrease in the severity of crises because the decrease in their magnitude driven by a fall in the deposits cost (due to the decrease in the interest rate) exceeds the increase in their magnitude of a crisis driven by the hike in the volume of deposits (the bank's leverage). And since the crises also become less frequent (decrease in the probability of default), consequently, there is a decrease in the expected social cost of a bank failure.

$$d\delta < 0 \implies Price < 0;$$

$$d\alpha < 0 \implies \begin{cases} Frag < 0 \\ Lev > 0 \end{cases} \implies dC < 0 \quad \text{Since } Lev^+ < (Frag^- + Price^-)$$

In sum, it appears that monetary easing has different effects in terms of risk-taking and in terms of expected cost of bank failure. The main point is that even if monetary easing could induce more risk-taking, it does not necessarily translate into higher expected cost of bank failure. After having examined how the expected social cost of bank failure is impacted by a monetary easing, let's turn to the impact of a monetary contraction.

4.3 Impact of monetary contraction on the expected cost of bank failure

The increase in the risk-free interest rate entails a direct increase in the expected social cost (the price effect), since $\frac{\partial C}{\partial \delta} > 0$. Besides this direct effect, the increase in interest rate indirectly impacts the social cost given that there is an increase in the bank's risk or not.

Case 1': The bank's risk decreases with increased interest rate, $\frac{d\alpha}{d\delta} < 0$.

Similarly to what we stated in the preceding subsection (i.e. 4.2), recall that the total

differential in the social cost is given by:

$$dC = \left[\begin{array}{c} + \\ \frac{\partial C}{\partial \delta} + (Frag + Lev) \cdot \frac{d\alpha}{d\delta} \end{array} \right] \cdot d\delta \quad (+)$$

With $\frac{\partial C}{\partial \delta}$ the price effect, $\frac{d\alpha}{d\delta}$ the risk-taking effect, *Frag* the fragilization effect and *Lev* the leverage effect.

A monetary tightening makes a crisis resolution more expensive. So, it induces a direct increase in the expected cost of bank failure (the price effect). As the bank's risk decreases following monetary contraction (the risk-taking effect), the probability of default also decreases (the fragilization effect) since $\frac{\partial(1-P(\alpha))}{\partial \alpha} \cdot [\frac{1}{k(\alpha)} - 1] > 0$. In other words, the frequency of crises decreases. At the same time, the loan volume increases (the leverage effect) in response to looser capital requirement, $\frac{\partial([\frac{1}{k(\alpha)} - 1])}{\partial \alpha} \cdot (1 - P(\alpha)) < 0$, and exacerbates the magnitude of a crisis. As a result:

- The expected social cost increases, $dC > 0$, if the increase in the magnitude of the crisis (driven by the price effect and the leverage effect) is larger than the decrease in the frequency of crises (driven by the fragilization effect);
- The expected social cost decreases, $dC < 0$, if the increase in the magnitude of the crisis (driven by the price effect and the leverage effect) is smaller than the decrease in the frequency of crises (driven by the fragilization effect).

Again, we can show that there is a threshold value in the risk-taking effect that determines whether the cost of bank failure may increase or decrease following a monetary contraction.

Given that $d\delta > 0$, we can derive that:

$$dC > 0 \Leftrightarrow \frac{\partial C}{\partial \delta} + (Frag + Lev) \cdot \frac{d\alpha}{d\delta} > 0$$

$$(Frag + Lev) \cdot \frac{d\alpha}{d\delta} > -\frac{\partial C}{\partial \delta}$$

Since $\frac{d\alpha}{d\delta} < 0$, then $dC > 0$ if $\mathbf{0} > \frac{d\alpha}{d\delta} > -\frac{\partial C}{\partial \delta} / [Frag + Lev] \equiv \mathbf{S}_3$.

So, there is a threshold (S_3) in the response of the bank's risk to monetary contraction above which, although a monetary contraction reduces bank's risk, there is an increase in the expected cost of bank failure. However, when the response of the bank's risk to monetary contraction is below this threshold (S_3) the expected cost of bank failure decreases. Below

this threshold, following a monetary contraction, the frequency of crises decreases enough to compensate for the increase in their magnitude.

Case 2’: The bank’s risk decreases with increased interest rate, $\frac{d\alpha}{d\delta} > 0$.

Once more, the total differential in the social cost is given by:

$$dC = \left[\begin{array}{c} + \\ \frac{\partial C}{\partial \delta} + (Frag + Lev) \cdot \frac{d\alpha}{d\delta} \end{array} \right] \cdot d\delta \quad (+)$$

As stated in case 1’, the increase in the risk-free interest rate directly increases the expected social cost (the price effect), since $\frac{\partial C}{\partial \delta} > 0$. However, this increased interest rate increases the bank’s risk. As a result, the probability of default also increases (the fragilization effect), and so do the frequency of crises. At the same time, the loan volume decreases (the leverage effect) in response to a tighter capital requirement, decreasing the severity of a crisis. To sum up:

- The social cost increases, $dC > 0$, if the increase in the frequency of crises (due to the fragilization effect) exceeds the change in their magnitude (resulting from the price effect and the leverage effect power relationship);
- The expected social cost decreases, $dC < 0$, if the net decrease in the magnitude of crises (resulting from the price effect and the leverage effect power relationship) is larger than the increase in their frequency (due to the fragilization effect).

As in case 1’, we can evidence a threshold value in the risk-taking effect that imply either an increase or a decrease in the cost of bank failure following a monetary contraction according to the position from this threshold.

We can derive that:

$$\begin{aligned} dC > 0 &\Leftrightarrow \frac{\partial C}{\partial \delta} + (Frag + Lev) \cdot \frac{d\alpha}{d\delta} > 0 \\ &(Frag + Lev) \cdot \frac{d\alpha}{d\delta} > -\frac{\partial C}{\partial \delta} \end{aligned}$$

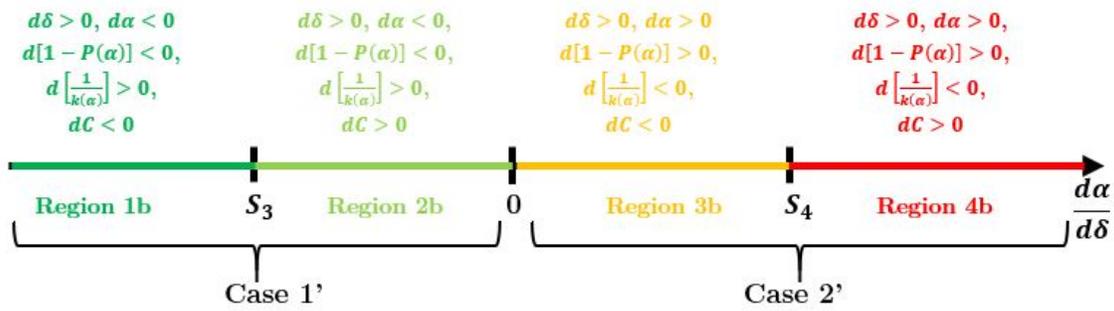
Since $\frac{d\alpha}{d\delta} > 0$, then $dC > 0$ if $\frac{d\alpha}{d\delta} > -\frac{\partial C}{\partial \delta} / [Frag + Lev] \equiv S_4 > 0$.

When monetary contraction does whet bank’s risk appetite, there is also a threshold (S_4) in

the response of the bank's risk to monetary contraction above which there is an increase in the expected cost of bank failure. However, when the response of the bank's risk to monetary contraction is below this threshold (S_4) a monetary contraction increases the bank's risk level but there is a decrease in the expected cost of bank failure.

Given the above conditions, there are four possible scenarios that can be depicted using Figure 3.5.

Figure 3.5: Decomposition of the effects of monetary contraction and bank's risk on the expected social cost of bank failure.



As depicted in Figure 3.5, we can observe that monetary contraction also has different effects on bank's risk and that the resulting effects on the expected social cost of bank failure are also ambiguous. Let's describe each region of the graph.

- Region 1b: in this region, a monetary contraction leads to a decrease in the bank's risk level. The decrease in the risk entails a decrease in the probability of default, i.e. there is a decrease in the frequency of crises. However, the bank's leverage increases (leverage effect) due to a loosening of the capital requirement. Nevertheless, the decrease in the frequency of crises is sufficient to compensate for the increase in their magnitude (stemming from the increase both in the price and in the bank's leverage). The resulting effect is a decrease in the expected social cost of a bank failure.

$$d\delta > 0 \implies Price > 0;$$

$$d\alpha < 0 \implies \begin{cases} Frag < 0 \\ Lev > 0 \end{cases} \implies dC < 0 \quad \text{Since} \quad Frag > (Lev + Price)$$

- Region 2b: a monetary contraction leads to a decrease in the bank's risk level. The decrease in the risk translates into a more stable financial system, making crises less frequent. However, the bank's leverage increases (leverage effect) due to a loosening of the capital requirement. Finally, the increase in the magnitude of crises

(stemming from the increase both in the price and in the bank's leverage) is sufficient to compensate for the decrease in their frequency. This leads to an increase in the expected social cost of a bank failure.

$$d\delta > 0 \implies Price > 0;$$

$$d\alpha < 0 \implies \begin{cases} Frag < 0 \\ Lev > 0 \end{cases} \implies dC > 0 \quad \text{Since } \overset{-}{Frag} < (\overset{+}{Lev} + \overset{+}{Price})$$

- Region 3b: there is an increase in the bank's risk level following a monetary contraction. The increase in the risk translates into a more unstable financial system, making crises more frequent. However, the bank's leverage decreases (leverage effect) due to a tightening of the capital requirement. Finally, the net decrease in the magnitude of crises (stemming from the power relationship between the price and the leverage effects) is sufficient to compensate for the increase in their frequency. Then, there is a decrease in the expected social cost of a bank failure.

$$d\delta > 0 \implies Price > 0;$$

$$d\alpha > 0 \implies \begin{cases} Frag > 0 \\ Lev < 0 \end{cases} \implies dC < 0 \quad \text{Since } \overset{+}{Frag} < (\overset{-}{Lev} + \overset{+}{Price})$$

- Region 4b: in this region, there is also an increase in the bank's risk level as a response to a monetary contraction. The increase in the risk makes the system more unstable, inducing more frequent crises. However, the bank's leverage decreases (leverage effect) due to a tightening of the capital requirement. But, the net change in the magnitude of crises (stemming from the power relationship between the price and the leverage effects) is insufficient to compensate for the increase in their frequency. So, there is an increase in the expected social cost of a bank failure.

$$d\delta > 0 \implies Price > 0;$$

$$d\alpha > 0 \implies \begin{cases} Frag > 0 \\ Lev < 0 \end{cases} \implies dC > 0 \quad \text{Since } \overset{+}{Frag} > (\overset{-}{Lev} + \overset{+}{Price})$$

As we can see in Sections 3 and 4, the impact of monetary policy in terms of financial stability and expected social cost of bank failure highly depends on the risk sensitivity of the microprudential tool (here the capital requirement ratio). On the one hand, the strength of the capital requirement ratio determines how the bank responds to change in the risk-free interest rate. On the other hand, this strength of the capital requirement ratio also determines the force with which the leverage effect counter the fragilization effect in defining

the response of the social cost to change in monetary policy. Then, it appears interesting to examine the macroprudential policy to be implemented according to monetary stance and the different situations (Region 1a to Region 4b).

5 Combination of monetary policy with prudential policy

The previous sections show that a change in monetary policy has different consequences in terms of bank soundness and social cost. We have situations where a monetary easing induces a increase in the bank's risk and is followed by an decrease in the expected social cost, and vice versa.

We can summarize the preceding analysis (from Section 4) in Table 3.1

Table 3.1: Summary of regions of changes in risk and cost of bank failure

Effect of Monetary policy on the bank's risk	Monetary Policy		Change in the cost of bank failure
	$d\delta < 0$	$d\delta > 0$	
$\frac{d\alpha}{d\delta} < 0$	Region 2a	Region 1b	$dC < 0$
	Region 1a	Region 2b	$dC > 0$
$\frac{d\alpha}{d\delta} > 0$	Region 4a	Region 3b	$dC < 0$
	Region 3a	Region 4b	$dC > 0$

Let's first define each combination of monetary policy with prudential policy using an efficiency criteria. We consider as:

- efficient (or totally efficient) any combination of monetary policy with prudential policy leading to a decrease in both the bank's risk and the expected social cost of bank failure;
- partially efficient any combination of monetary policy with prudential policy leading to a decrease in only one of the two objective variables. In this case, we can consider two types of partial efficient combination:
 - a partial efficient (combination) of type 1: any combination of monetary policy with prudential policy leading to an increase in the bank's risk but to a decrease in the expected social cost of bank failure;

- a partial efficient (combination) of type 2: any combination of monetary policy with prudential policy leading to a decrease in the bank’s risk but to an increase in the expected social cost of bank failure.
- inefficient (or totally inefficient) any combination of monetary policy with prudential policy leading to an increase in both the bank’s risk and the expected social cost of bank failure.

Let’s now examine each combination successively.

Regions 4a and 1b are regions where the combinations of monetary policy with microprudential tool are considered as (totally) efficient since they lead to a positive outcome in terms of more stable financial system and lower cost of crises resolution. In fact, these combinations lead to a decrease in both the bank’s risk and the expected social cost of bank failure. In other words, in each of these cases, the microprudential tool is set such that a monetary easing, in one case, or a monetary contraction, in the other case, leads the bank to reduce its risk level, fostering the financial stability. In addition, the lower risk level entails a relaxation of the regulatory constraint, leading to an increase in the bank’s leverage, and in the amount of financed projects (the credit volume granted to the economy). At the same time, the combination of monetary policy with the microprudential tool is such that the expected cost of bank failure is also reduced.

Conversely, regions 1a and 4b are regions where the combinations of monetary policy and microprudential tool are considered as (totally) inefficient since the outcome for the economy is negative. In fact, these combinations are such that there is an increase in both the bank’s risk and the expected social cost of bank failure. In short, the microprudential tool is set such that a monetary easing, in one hand, or a monetary contraction, in the other hand, triggers more risk-taking, jeopardizing the financial stability. In addition, the higher risk level implies a tightening of the regulatory constraint, leading to a decrease in the credit volume provided to the economy. Simultaneously, the combination of monetary policy with the microprudential tool is such that the expected cost of bank failure grows up. As we have already shown, in Regions 1a and 4b, the increase in the expected social cost is driven by a high increase in the probability of default. That is, a need for a more risk sensitive microprudential tool that limits the increase in the bank’s risk level may appear effective in limiting the increase in the expected cost of bank failure. In other words, a more stringent microprudential policy may be effective both in limiting the increase in the probability of default and in offsetting the increase in the social cost as well.

Finally, the remaining cells in Table 3.1 refer to combination of monetary policy with microprudential policy that are considered as partially efficient.

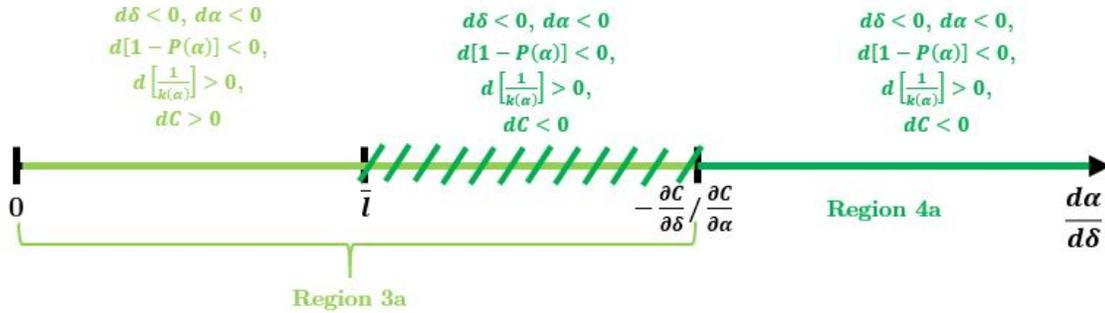
For instance, Regions 2a and 3b are regions where the combination of monetary policy and microprudential tool is partially efficient of type 1 since the outcome for the economy is negative in terms of financial stability and positive in terms of expected cost of bank failure. These combinations are such that there is an increase in the bank's risk but a decrease in the expected social cost of bank failure. In other words, the microprudential tool is set such that a monetary easing, in one hand, or a monetary contraction, in the other hand, leads the bank to take more risk, thus threatening the financial stability. The higher risk level implies a tightening of the regulatory constraint, leading to a decrease in the bank's leverage (decrease in the amount of financed projects by the bank). However, the combination of monetary policy with the microprudential tool is such that the expected cost of bank failure goes down.

Regions 3a and 2b are regions where the combination of microprudential tool and monetary policy is partially efficient of type 2 since the outcome for the economy is positive in terms of financial stability and negative in terms of expected cost of bank failure. In fact, these combinations are such that there is a decrease in the bank's risk but an increase in the expected social cost of bank failure. In other words, the microprudential tool is set such that a monetary easing, in one hand, or a monetary contraction, in the other hand, lowers the bank's risk, then fostering the financial stability. Besides, the lower risk level implies a relaxation of the regulatory constraint, leading to an increase in the bank's leverage (increase in the amount of financed projects). Nevertheless, the combination of monetary policy with the microprudential tool is such that the cost of bank failure grows up. Albeit, the monetary easing leads the bank to reduce its risk level, this induces an increase in the bank's leverage which itself exacerbates the severity of crises, and increases the expected social cost of bankruptcy. In this sense, although the microprudential tool improves the soundness of individual bank, it fails in mitigating the increases in the magnitude of crises. A macroprudential tool such as a cap on the leverage ratio may be suitable to complement the microprudential policy in such a case. In fact, imposing a leverage ratio may oblige the bank to not grant more loans even if it chooses a lower risk level. Hence, introducing a leverage ratio may limit the bank's leverage and may limit the increase in the expected social cost at the expense of the funding of the economy (amount of financed projects).

Let's consider Figure 3.4 and focus on Region 3a to illustrate the fact that introducing a leverage ratio may help in containing the expected social cost in this specific case. The result

is given on Figure 3.6

Figure 3.6: Changes induced by a leverage ratio on the expected social cost of bank failure in region 3a.



Given that in Region 3a monetary easing is followed by a decrease in the bank's risk and an increase in the expected social cost of a bank failure, there is a minimum leverage ratio \bar{l} that allows the social cost to decrease. In this case, imposing a minimum leverage ratio \bar{l} limits the increase in the bank's leverage following a decrease in the bank's risk. The resulting effect is an enlargement of Region 4 at the expense of Region 3. The more binding the leverage ratio the smaller the region 3. In other words, the more constraining is the leverage ratio the more likely is the fact that the decrease in the cost driven by the decrease both in the price and in the probability of default exceeds the increase in cost driven by the increase in the volume of deposits. Put it differently, it may be possible for the regulator to attenuate the magnitude of the crisis by mitigating the bank's leverage. However, the more constraining the leverage ratio the lower the bank's leverage and the lower the amount of financed projects. That is, the macroprudential regulator faces a trade-off between either reducing the cost of bank failure followed by lower funding of the economy or ensuring a higher funding of the economy while facing the risk of a more severe crisis.

In a nutshell, the combination of monetary and prudential policies produces different outcomes for the economy in terms of financial stability (the bank's risk level) and in terms of the expected cost of bank failure. The combination can be totally efficient and no additional action is needed. It can be inefficient and a better calibration of the microprudential tool is suitable. When the combination of monetary and microprudential policies is such that there is lower risk but higher expected cost in the event of a crisis, then a leverage ratio appears to be effective to counteract the increase in this cost since the latter is driven by a leverage effect.

Conclusion

We built a partial equilibrium model of bank regulation and interaction with monetary policy, with perfect information. The two policies are assumed to be exogenous. The monetary policy set interest rate piloting inflation and GDP growth. Prudential regulator cares about the financial stability and is endowed with a capital requirement ratio that is risk sensitive (and increases with bank's risk).

We show that the bank's optimal risk level is determined according the risk-free interest rate and the intensity of the microprudential policy. Assuming the level of capital is exogenous fixed, the bank's leverage is then endogenously determined. Our model shows that monetary policy effectively impacts financial stability, thus supporting the existing literature on the bank risk channel of monetary policy. However, we show that the impact of monetary interest rate on the bank's risk is not independent from the sensitivity of the capital requirement to risk. A monetary easing or tightening could lead to more risk-taking according to risk sensitivity of the microprudential tool. For instance, when the risk sensitivity of the capital requirement is lower than the risk sensitivity of the bank's intermediation margin, the well-known risk-taking channel of monetary policy operates. In this case, decreased interest rates push up the bank's risk. Inversely, when the risk sensitivity of the capital requirement is higher than the risk sensitivity of the bank's intermediation margin, the bank's risk drops following monetary easing.

However, any change in monetary policy do also have important implication in terms of expected social cost of a bank failure. There is a direct effect that stems from change in the deposit cost following changes in the monetary policy. There is also an indirect effect (the risk-taking effect) driven by changes in the bank's risk. This indirect effect leads also two possible effects on the expected social cost: the fragilization effect and the leverage effect. The final change in the social cost of a bank failure depends on the relative intensity of these effects. In fact, a monetary easing can lead to more risk-taking but be followed by a decrease in the expected cost of bank failure. This is the case when the magnitude of the price effect and the leverage effect is larger than the magnitude of the fragilization effect. Furthermore, the analysis highlights cases where a more stringent microprudential tools is effective in mitigating both financial fragility and the expected social cost of a bank failure. There are some cases where a macroprudential tool, such as a leverage ratio, may complement the microprudential tool in limiting the cost of bank failure. This is particularly the case when there is a decrease in the bank's risk but an increase in the expected cost of bank failure induced by a leverage effect.

The main policy implication of our findings is that monetary and prudential policies must be coordinated. In fact, since the effect of monetary policy on bank's risk is not unique, it appears necessary for economic authorities to best manage the coordination of these two policies. If the coordination is mismanaged, the policy-mix (monetary and microprudential policy) may generate more instability and induce higher expected cost of bank failure. In the same vein, a mismanagement of the combination of microprudential policy with macroprudential policy may generate undesired outcomes in terms of providing funds to the economy (reduction of the bank's leverage and so the amount of financed projects) without much improvement in terms of financial stability. Even if prudential and monetary policies target two separate goals, financial stability for the former, and GDP growth and stable inflation for the second, their interaction should be well understood by policymakers for their combined effects to be fine tuned. Note that our study focus on a precise microprudential tool, the capital requirement ratio. It does not account for liquidity issues as introduced by Basel III.

Appendices of chapter 3

Appendix 1: Proof of lemma 1

The expected return of a project is given by:

$$R^e(\alpha, \delta) = R(\alpha, \delta)P(\alpha)$$

Let's show that there is a unique $\bar{\alpha}$, with $0 < \bar{\alpha} < 1$, such that $R^e(\alpha, \delta)$ is maximum for $\bar{\alpha}$.

$$\frac{\partial R^e(\alpha, \delta)}{d\alpha} = R'_\alpha(\alpha, \delta)P(\alpha) + R(\alpha, \delta)P'_\alpha(\alpha) = R_\alpha^{e'}(\alpha, \delta)$$

According to our assumptions, we have:

1. $\lim_{\alpha \rightarrow 0} P'_\alpha(\alpha) \rightarrow 0$, $\lim_{\alpha \rightarrow 0} R'_\alpha(\alpha, \delta) \rightarrow +\infty$ and $\lim_{\alpha \rightarrow 0} R_\alpha^{e'}(\alpha, \delta) \rightarrow +\infty$
2. $\lim_{\alpha \rightarrow 1} P'_\alpha(\alpha) \rightarrow -\infty$, $\lim_{\alpha \rightarrow 1} P(\alpha) \rightarrow 0$ and $\lim_{\alpha \rightarrow 1} R_\alpha^{e'}(\alpha, \delta) \rightarrow -\infty$
3. $\frac{\partial^2 R^e(\alpha, \delta)}{\partial \alpha^2} = R_\alpha^{e''}(\alpha, \delta) = R''_\alpha(\alpha, \delta)P(\alpha) + R(\alpha, \delta)P''_\alpha(\alpha) + 2R'_\alpha(\alpha, \delta)P'_\alpha(\alpha) < 0$

As $R_\alpha^{e'}(\alpha, \delta)$ is continuous on $[0; 1]$, there is a unique $0 < \bar{\alpha} < 1$, such that $R^e(\alpha, \delta)$ is maximum for $\bar{\alpha}$.

Appendix 2: Proof of proposition 1

i) We prove that there is a unique risk level that maximizes the bank's profit

Let's denote $A(\alpha, \delta) = \frac{d\pi(\alpha, \delta)}{d\alpha}$ with $\pi(\alpha, \delta) = L[R(\alpha, \delta)P(\alpha) - (1 - k(\alpha))\delta P(\alpha) - k(\alpha)\rho]$

We have:

$$A(\alpha, \delta) = P(\alpha)[R'_\alpha(\alpha, \delta) + k'_\alpha(\alpha)\delta] + P'_\alpha(\alpha)[R(\alpha, \delta) - [1 - k(\alpha)]\delta] - k'_\alpha(\alpha)\rho$$

Let's show that there is a unique interior solution $\alpha^* \in]0; 1[$ such that $A(\alpha^*, \delta) = 0$.

$A(\alpha, \delta)$ is a continuous function for $\alpha \in [0; 1]$.

For $\alpha = 0$, we have:

$$A(0, \delta) = P(0)[R'_\alpha(0, \delta) + k'_\alpha(0)\delta] + P'_\alpha(0)[R(0, \delta) - [1 - k(0)]\delta] - k'_\alpha(0) * \rho$$

Since $P(0) = 1$, $R(0, \delta) = \delta$, and $k(0) = \underline{k}$, we can write

$$A(0, \delta) = R'_\alpha(0, \delta) + P'_\alpha(0)\underline{k}\delta + k'_\alpha(0)(\delta - \rho)$$

According to our assumptions, we have:

- $\lim_{\alpha \rightarrow 0} P'_\alpha(\alpha) \rightarrow 0$
- $\lim_{\alpha \rightarrow 0} R'_\alpha(\alpha, \delta) \rightarrow +\infty$

Therefore, $A(0, \delta) \rightarrow +\infty$

For $\alpha = 1$, we have:

$$A(1, \delta) = P(1)[R'_\alpha(1, \delta) + k'_\alpha(1)\delta] + P'_\alpha(1)[R(1, \delta) - [1 - k(1)]\delta] - k'_\alpha(1)\rho$$

Since $P(1) = 0$, $R(1, \delta) = \bar{R}$, and $k(1) = \bar{k}$, we can write

$$A(1, \delta) = P'_\alpha(1)[\bar{R} - (1 - \bar{k})\delta] - k'_\alpha(1)\rho$$

According to our assumptions, $\lim_{\alpha \rightarrow 1} P'_\alpha(1) \rightarrow -\infty$ and $\bar{R} > \delta$, $\bar{R} - (1 - \bar{k})\delta > 0$

Moreover, since $k'_\alpha(1)\rho > 0$, we can conclude that $A(1, \delta) \rightarrow -\infty$.

Finally, $A'_\alpha(\alpha, \delta) = \frac{\partial A(\alpha, \delta)}{\partial \alpha}$ is equal to

$$\begin{aligned} A'(\alpha, \delta) = & P'_\alpha(\alpha)[R'_\alpha(\alpha, \delta) + k'_\alpha(\alpha)\delta] + P(\alpha)[R''_\alpha(\alpha, \delta) + k''_\alpha(\alpha)\delta] \\ & P''_\alpha(\alpha)[R(\alpha, \delta) - (1 - k(\alpha))\delta] + P'_\alpha(\alpha)[R'_\alpha(\alpha, \delta) + k'_\alpha(\alpha)\delta] \\ & - k''_\alpha(\alpha)\rho \end{aligned}$$

$$A'(\alpha, \delta) = 2P'_\alpha(\alpha)[R'_\alpha(\alpha, \delta) + k'_\alpha(\alpha)\delta] + P(\alpha)[R''_\alpha(\alpha, \delta) + k''_\alpha(\alpha)\delta] \\ + P''_\alpha(\alpha)[R(\alpha, \delta) - (1 - k(\alpha))\delta] - k''_\alpha(\alpha)\rho$$

Let's remind that:

- $R'_\alpha(\alpha, \delta) > 0$ and $R''_\alpha(\alpha, \delta) < 0$
- $P'_\alpha(\alpha) < 0$ and $P''_\alpha(\alpha) < 0$
- $k'_\alpha(\alpha) > 0$ and $k''_\alpha(\alpha) < 0$
- And $R(\alpha, \delta) - (1 - k(\alpha))\delta > 0$

As a result, we have:

- $2P'_\alpha(\alpha)[R'_\alpha(\alpha, \delta) + k'_\alpha(\alpha)\delta] < 0$
- $P(\alpha)[R''_\alpha(\alpha, \delta) + k''_\alpha(\alpha)\delta] < 0$
- $P''_\alpha(\alpha)[R(\alpha, \delta) - (1 - k(\alpha))\delta] < 0$
- And $k''_\alpha(\alpha)\rho < 0$

We can rewrite $A'_\alpha(\alpha, \delta)$ as follows:

$$A'_\alpha(\alpha, \delta) = k''_\alpha(\alpha)[P(\alpha)\delta - \rho] + 2P'_\alpha(\alpha)[R'_\alpha(\alpha, \delta) + k'_\alpha(\alpha)\delta] + P(\alpha)R''_\alpha(\alpha, \delta) + P''_\alpha(\alpha)[R(\alpha, \delta) - (1 - k(\alpha))\delta]$$

Let's find the condition on $k''_\alpha(\alpha)$ such that $A'_\alpha(\alpha, \delta) < 0$.

$$A'_\alpha(\alpha, \delta) < 0 \Leftrightarrow k''_\alpha(\alpha) > -\frac{X}{Y}$$

With:

$$X = 2P'_\alpha(\alpha)[R'_\alpha(\alpha, \delta) + k'_\alpha(\alpha)\delta] + P(\alpha)R''_\alpha(\alpha, \delta) + P''_\alpha(\alpha)[R(\alpha, \delta) - (1 - k(\alpha))\delta]$$

$$\text{and } Y = P(\alpha)\delta - \rho$$

This condition supposes that the capital requirement function should be concave, but not concave enough.

So under the condition that $0 > k''_\alpha(\alpha) > -\frac{X}{Y}$, we can conclude that $A'_\alpha(\alpha, \delta) < 0$. Consequently, $A(\alpha, \delta)$ is a decreasing function on $]0;1[$. Moreover, since $A(\alpha, \delta)$ moves from

positive to negative value ($A(0, \delta) \rightarrow +\infty$ and $A(1, \delta) \rightarrow -\infty$), and is strictly decreasing, there is a unique $\alpha^* \in]0; 1[$ such that $A(\alpha^*, \delta) = 0$

Furthermore, as $A'_\alpha(\alpha, \delta) < 0$, we can deduce that the bank's profit curve is inverted U-shaped and $\pi(\alpha^*, \delta)$ is a maximum.

ii) Since the bank chooses its optimal risk α^* , the bank will finance the amount of projects $L^* = \frac{\bar{K}}{k(\alpha^*)}$. In other words, the bank leverage is endogenously determined since it depends on the bank's risk choice.

Appendix 3: Proof of proposition 2

We seek to determine the impact of the monetary policy on the bank's optimal risk level, α^* . In other words, we aim at determining the sign of $\frac{d\alpha^*}{d\delta}$. To reach our objective, we use the total differential in the $A(\alpha, \delta)$.

Let's remind that $A(\alpha, \delta) = P(\alpha)[R'_\alpha(\alpha, \delta) + k'_\alpha(\alpha)\delta] + P'_\alpha(\alpha)[R(\alpha, \delta) - [1 - k(\alpha)]\delta] - k'_\alpha(\alpha) * \rho$

The total derivative of $A(\alpha, \delta)$ (according both to α and δ) is given by:

$$dA(\alpha, \delta) = A'_\alpha(\alpha, \delta).d\alpha + A'_\delta(\alpha, \delta).d\delta$$

Where $A'_\alpha(\alpha, \delta)$ and $A'_\delta(\alpha, \delta)$ are the partial derivatives of $A(\alpha)$ according respectively to α and δ .

Consequently:

$$dA(\alpha^*, \delta) = 0 \Leftrightarrow A'_\alpha(\alpha^*, \delta).d\alpha^* + A'_\delta(\alpha^*, \delta).d\delta = 0$$

$$A'_\alpha(\alpha^*, \delta).d\alpha^* = -A'_\delta(\alpha^*, \delta).d\delta$$

$$\text{and } \frac{d\alpha^*}{d\delta} = -\frac{A'_\delta(\alpha^*, \delta)}{A'_\alpha(\alpha^*, \delta)}$$

In the proof of proposition 1, we have shown that $A'_\alpha(\alpha^*, \delta) < 0$. This means that the sign of $\frac{d\alpha^*}{d\delta}$ mainly depends on the sign of $A'_\delta(\alpha^*, \delta)$,

$$A'_\delta(\alpha^*, \delta) = P'_\alpha(\alpha^*)[R'_\delta(\alpha^*, \delta) - (1 - k(\alpha^*))] + k'_\alpha(\alpha^*)P(\alpha^*)$$

Since $P'_\alpha(\alpha^*) < 0$, $k'_\alpha(\alpha^*) > 0$, $P(\alpha^*) > 0$ and under the assumption that $R'_\delta(\alpha^*, \delta) - [1 - k(\alpha^*)] > 1$, we have:

- $A'_\delta(\alpha^*, \delta) < 0$ if $|P'_\alpha(\alpha^*)|[R'_\delta(\alpha^*, \delta) - (1 - k(\alpha^*))] > k'_\alpha(\alpha^*)P(\alpha^*)$, and $\frac{d\alpha^*}{d\delta} < 0$. The bank's risk decreases with monetary rates if the net expected marginal gain of taking additional risk does not overcome the marginal funding cost induced by the strengthening of the capital requirement ratio.
- $A'_\delta(\alpha^*, \delta) > 0$ if $|P'_\alpha(\alpha^*)|[R'_\delta(\alpha^*, \delta) - (1 - k(\alpha^*))] < k'_\alpha(\alpha^*)P(\alpha^*)$, and $\frac{d\alpha^*}{d\delta} > 0$. The bank's risk increases with monetary rates if the net expected marginal gain of taking additional risk overcomes the marginal funding cost induced by the strengthening of the capital requirement ratio.
- $A'_\delta(\alpha^*, \delta) = 0$ if $|P'_\alpha(\alpha^*)|[R'_\delta(\alpha^*, \delta) - (1 - k(\alpha^*))] = k'_\alpha(\alpha^*)P(\alpha^*)$, and $\frac{d\alpha^*}{d\delta} = 0$. The bank's optimal risk level remains unchanged whatever the change in the monetary rates. In that case, the bank has no interest in changing its level of risk, otherwise it will have to suffer loss of profit.

GENERAL CONCLUSION

The main objective of this thesis was to study the link between monetary policy - prudential policy - and bank risk in order to determine the conditions for strengthening financial stability.

In the first chapter, we had made a survey of theoretical and empirical work on risk-taking channel of monetary policy and the coordination of monetary policy with prudential policy. This literature review provided a clearer picture of the impact of monetary policy on banking risk and its interaction with prudential policy. As a result, monetary and prudential policies interact. The implications of monetary policy in terms of risk-taking and hence financial stability may argue in favour of including a financial stability component in the objectives of monetary policy. However, this integration cannot take place without a better understanding of the various effects of monetary policy on bank risk. An analysis of the work on the link between monetary policy and banking risk highlights the conflicting forces driven bank's risk-taking behaviour. On the one hand, monetary easing, depleting the bank's interest margin and increasing borrowers' creditworthiness, may lead to more risk-taking (Rajan, 2005; De Nicolò et al., 2010; Borio and Zhu, 2012). On the other hand, monetary easing translate into lower refinancing cost and higher charter value, leading the bank to reduce its risk-taking (Smith, 2002; Agur and Demertzis, 2012; Korinek and Simsek, 2016). The presence of such forces, that are not exclusive, suggests that the impact of monetary policy on bank risk is by no means unique. This calls for a deeper analysis of the risk-taking channel, accounting for possible non-linearities. This questioning is the basis of Chapter 2.

Moreover, the interaction between monetary and prudential policies raises the question of their coordination. Existing work on this issue identifies the effect of monetary policy on banking risk independently from prudential policy, in order to determine the best conditions for their coordination. However, it appears that considering the interaction of these two policies on banks' risk-taking behaviour would be a better way of determining the optimal conditions for their coordination. Moreover, while risk-taking is the main source of financial crises, the implications of monetary and prudential policy coordination for the cost of crisis resolution deserve particular attention. Chapter 3 of the thesis is based on this perspective.

In the second chapter, we have revisited the empirical analysis on the risk-taking channel by identifying the existence of threshold effects of the impact of monetary policy on banks' risk. This empirical analysis is based on the two opposing forces determining the effect of monetary policy on bank's risk as mentioned in chapter 1. While monetary authorities set interest rate following some rules, namely the Taylor rule, we assumed that the impact of monetary policy on bank's risk will depend on the deviation of interest rate from a Taylor rule based interest rate. To realize our analysis, we gathered financial information on 194

US banks and US macroeconomic data over the period 1998Q1-2015Q4. We opted for a backward risk measure, the Z-score which measures the bank financial soundness or bank insolvency and is inversely related to the probability the bank will become insolvent (Roy, 1952; Boyd et al. 2006; Lepetit et al 2008; Lepetit et Strobel, 2013; Delis et al., 2014; Lepetit et Strobel, 2015). The lower the bank's Z-score, the higher the risk of insolvency. We realized our study thanks a non-dynamic Thresholds Panel Model inked on Hansen's (1999) model. In our specification, the threshold variable is the difference between monetary rates and rates from the 1993' Taylor rule. We check for robustness using different specification and using the Fed shadow interest rate computed by Wu and Xia (2015) to address the problem of the Zero Lower Bound (ZLB) in the effective Fed interest rate.

The results evidence a threshold in the deviation of the interest rate from the Taylor rule based interest rate from which the effect of policy rate on bank's risk reverses. So far, interest rate cuts have been considered to drive banks' risk-taking behaviour. Our findings tend to reconcile the idea of monetary easing and its opponents. We show that the effects of monetary policy on bank risk, change after the Taylor gap threshold value. Thus, when the monetary rate is, to a certain extent, already below the Taylor rate, monetary easing is undesirable. In a low interest rate environment, banks already suffer from margin losses, and a further decrease in the interest rate will depress their profit, making riskier alternatives more attractive. This is consistent with the "search for yield" notion developed by Rajan (2005) and supports the notion of a monetary policy risk-taking channel. However, when the interest rate is above the Taylor rule, the negative impact of monetary policy on bank soundness fades. In this regime, an interest rate cut is beneficial to the bank and, therefore, increasing the interest rate is undesirable. An interest rate cut, rather than triggering bank fragility, fosters bank soundness if there is in place a restrictive monetary policy (positive Taylor gap). If interest rate increase, banks will have to bear higher refinancing costs which may offset the gains realised on margin.

The third chapter has been consecrated to a theoretical modelling. This chapter is driven by the two first chapters and tries to analyse if monetary policy effects on banks risk may be assessed independently from the strength of the prudential tool. We developed a partial equilibrium model to study policy-mix (between prudential and monetary policy). This chapter aims to complement the existing literature by analysing conditions under which the combination of monetary and prudential policy is optimal in terms of financial stability and expected cost of bank failure. In our model, banks face a continuum of risky projects and there is no information asymmetry. They choose their optimal risk level and finance the projects exhibiting this level of risk. The leverage is endogenously determined since according to the

optimal risk level, the bank determine how much credit volume to finance in order to comply with the regulation, given that the capital is assumed fixed. There is deposit insurance, i.e. banks repay deposits only in case the financed projects succeed. Banks decisions are affected by monetary and prudential policy. The monetary policy is assumed to be exogenous (not affected by banks neither by the other policy) and independent from the prudential policy (no policy coordination). Monetary policy aims at ensuring price stability and economic growth, but also affects banking system. The partial equilibrium allows to account for monetary policy in a financial system assuming a stable macroeconomic sphere.

We find that the bank chooses its optimal risk level under the bargaining of two effects: the profit effect and the regulatory effect. The bank's optimal risk level is such that the two effects equalize. Moreover, we find that the impact of monetary rate on bank's risk is not unique and is not independent from the sensitivity of the capital requirement to risk. A monetary easing or tightening could lead to more risk-taking according to risk sensitivity of the microprudential tool. For instance, when the risk sensitivity of the bank's intermediation margin is higher than the risk sensitivity of the capital requirement ratio, then the bank can take more risk (increasing its revenue) without facing important decrease in the level of financing. In this case, a fall in risk-free interest rate (which reduces the bank's revenues) encourages the bank to take more risk in order to maintain its profits. This is, the well-known risk-taking channel of monetary policy operates. Inversely, when the risk sensitivity of the capital requirement is higher than the risk sensitivity of the bank's intermediation margin, the bank's risk drops following monetary easing.

In addition to its effects on bank's risk, monetary policy also has ambiguous effects on the expected social cost of bank failure. Any change in monetary policy directly impacts the expected social cost of bankruptcy through the deposit cost. This direct effect can be considered as a "price effect". Moreover, monetary policy indirectly affects the expected social cost through its action on the bank's risk, i.e. the risk-taking effect. From this latter effect, we can derive two other effects: the "fragilization effect" and the "leverage effect" stemming respectively to change in the probability of failure and to change in the bank's leverage (due to change in the capital requirement ratio). Then, it appears that bank's risk and the expected social cost of a bank failure can move in the same direction (increase or decrease together) or move in opposite direction. Furthermore, the analysis highlights cases where a more stringent microprudential tools is effective in mitigating financial fragility and reducing the expected social cost of a bank failure. However, there are situations where the increase in the expected social cost of bankruptcy is driven by the leverage effect. In such cases, there is a need of a macroprudential tool like a leverage ratio that may limit the increase in the

bank's leverage. Therefore, using a leverage ratio, the regulator limits the expected cost of a crisis at the expense of the financing of the economy since there is a decrease in the volume of projects that the bank can finance. In this context, the regulator may face a trade-off between capital regulation necessary to limit risks and the need to promote credit activity essential for economic growth.

The results of this thesis have important policy implications. First, it reopens the debate on the necessity for the triptych price stability/output stability/financial stability in Central Banks' objectives. It offers support to those in favour of including financial stability issues in Central Banks' objectives, since monetary rates influence financial agents' behaviours. The second implication, which stems from the first one, is related to use of the Taylor rule as an indicator of the risk of financial weakening. An augmented Taylor rule that accounts for financial stability is appropriate for this and further work is needed along these lines. The main underlying idea is that risk-taking and crisis prevention should be the tasks of both the regulatory and the monetary authorities. Central Banks should not only make "repairs" but also should take account of financial stability concerns when setting interest rates. Our findings call for monetary authorities to pay more attention to financial stability when setting interest rates and suggest that banking supervisors should consider the potential effects of monetary shocks depending on the interest rate regime when conducting banking supervision. Moreover, our results suggest that monetary authorities should not only consider the impact of interest rate shocks on banks risk-taking behaviour but should also consider deviations from the Taylor rule.

Furthermore, our results provide also arguments in favour to more coordination of monetary and prudential policy for a better outcome in terms of financial stability and social cost of a crisis. For a better outcome in terms of financial stability, monetary and microprudential policy should act in opposite direction. That is, in the event of decreasing interest rate, the capital requirement ratio must be tightened in view to mitigate the bank's risk. If it is established that monetary authorities must account for the impact of their policy on bank's risk behaviour, then the prudential authority must account for the prevailing monetary and regulatory environment in which the change in monetary policy occurs before taking any action. We are well founded in thinking that the impact of monetary policy on bank's risk is not independent, one the one side, from the deviation of monetary interest rate from the Taylor rule, and from the strength of the microprudential policy, on the other side. So, in its concern to avoid significant cost in the event of a crisis, the regulator should better appreciate the situation in order to take the appropriate action. For instance, a macroprudential measure, if inappropriate, can be harmful to the economy instead, i.e. limiting the credit

volume without mitigating risk-taking and cost of crisis resolution. Ultimately, the results emphasise the need to further improve prudential measures by integrating factors not yet taken into account.

However, the analysis carried out in this thesis are susceptible to improvement. First, the empirical analysis does not account for banks that fails during the crisis. In this sense, an econometric analysis dealing with unbalanced panel data may be suitable. Second, including banks from other regions may help in taking the effect of different intensity of the regulation on the risk-taking channel into account. Third, the issue of the policy coordination does not cover all the externalities of monetary and prudential policy, and their interaction with other policies. The fiscal policy should be included in the analysis of the coordination of monetary and prudential policy, since fiscal policy interact with each of these policies as shown by Cecchetti (2016). So, further study is needed.

CONCLUSION GENERALE

L'objectif principal de cette thèse était d'étudier le lien entre la politique monétaire, la politique prudentielle et le risque bancaire afin de déterminer les conditions de renforcement de la stabilité financière.

Dans le premier chapitre, nous avons fait un tour d'horizon des travaux théoriques et empiriques sur le canal de la prise de risque de la politique monétaire et sur la coordination de la politique monétaire avec la politique prudentielle. Cette revue de la littérature a permis de mieux cerner l'impact de la politique monétaire sur le risque bancaire et son interaction avec la politique prudentielle. Il est établi que les politiques monétaires et prudentielles interagissent. Les implications de la politique monétaire en termes de prise de risque et donc de stabilité financière plaideraient en faveur de l'inclusion d'une composante de stabilité financière dans les objectifs de la politique monétaire. Cependant, cette intégration ne peut se faire sans une meilleure compréhension des différents effets de la politique monétaire sur le risque bancaire. L'analyse des travaux sur le lien entre la politique monétaire et le risque bancaire met en évidence des forces contradictoires qui animent le comportement de prise de risque des banques. D'une part, l'assouplissement monétaire réduit la marge d'intérêt de la banque, accroît la solvabilité des emprunteurs, et peut conduire à une plus grande prise de risques (Rajan, 2005 ; De Nicolò et al., 2010 ; Borio et Zhu, 2012). D'autre part, l'assouplissement monétaire se traduit par un coût de refinancement plus faible et une valeur résiduelle plus élevée de la banque, conduisant la banque à réduire sa prise de risque (Smith, 2002 ; Agur et Demertzis, 2012 ; Korinek et Simsek, 2016). La présence de telles forces, qui ne sont pas exclusives, suggère que l'impact de la politique monétaire sur le risque bancaire n'est en aucun cas univoque. Cela nécessite une analyse plus approfondie du canal de prise de risque, en tenant compte des éventuelles non-linéarités. Cette interrogation pose le fondement du chapitre 2.

Par ailleurs, l'interaction entre les politiques monétaire et prudentielle pose la question de leur coordination. Les travaux existants analysent les meilleures conditions pour un policy-mix en identifiant l'effet de la politique monétaire sur le risque bancaire indépendamment de la politique prudentielle (Jeanne and Korinek, 2013; Agur and Demertzis, 2019). Cependant, il apparaît que la prise en compte de l'interaction de ces deux politiques sur le comportement des banques en matière de prise de risque serait un meilleur moyen de déterminer ces conditions. En outre, si la prise de risque est la principale source de crises financières, les implications de la coordination des politiques monétaires et prudentielles sur le coût de la résolution des crises méritent une attention particulière. Le chapitre 3 de la thèse s'inscrit dans cette perspective.

Dans le deuxième chapitre, nous avons repris l'analyse empirique sur le canal de la prise

de risque en identifiant l'existence d'effets de seuil de l'impact de la politique monétaire sur le risque des banques. Cette analyse empirique est fondée sur les deux forces opposées qui déterminent l'effet de la politique monétaire sur le risque des banques, comme mentionné dans le chapitre 1. Alors que les autorités monétaires fixent le taux d'intérêt en suivant certaines règles, à savoir la règle de Taylor, nous avons supposé que l'impact de la politique monétaire sur le risque des banques dépendait de l'écart du taux d'intérêt par rapport à un taux d'intérêt basé sur la règle de Taylor. Pour réaliser notre analyse, nous avons recueilli des informations financières sur 194 banques américaines et des données macroéconomiques américaines sur la période 1998-2015. Nous avons opté pour une mesure du risque globale, le Z-score. Ce dernier mesure la solidité financière ou l'insolvabilité de la banque et est inversement lié à la probabilité que la banque devienne insolvable (Roy, 1952 ; Boyd et al. 2006 ; Lepetit et al 2008 ; Lepetit et Strobel, 2013 ; Delis et al. 2014 ; Lepetit et Strobel, 2015). Plus le Z-score de la banque est faible, plus le risque d'insolvabilité de celle-ci est élevé. Nous avons réalisé notre étude grâce à un modèle de panel non dynamique à effets de seuil fondé sur le modèle de Hansen (1999). Dans notre spécification, la variable seuil est la différence entre le taux d'intérêt monétaire et le taux de la règle de Taylor de 1993. Nous avons testé la robustesse de nos résultats, d'une part, en utilisant des spécifications différentes, et d'autre part, en utilisant les taux d'intérêt implicites de la Fed calculés par Wu et Xia (2015) pour résoudre le problème que pose la limite en zéro du taux d'intérêt nominal effectif de la Fed.

Les résultats mettent en évidence un seuil dans la déviation du taux d'intérêt par rapport au taux d'intérêt basé sur la règle de Taylor à partir duquel l'effet d'une variation du taux d'intérêt sur le risque de la banque s'inverse. Jusqu'à présent, il a été considéré que les baisses de taux d'intérêt étaient le moteur du comportement des banques en matière de prise de risque. Nos conclusions tendent à relativiser ces résultats. Nous montrons que les effets de la politique monétaire sur le risque bancaire, changent après la valeur seuil dans l'écart à la règle de Taylor. Ainsi, lorsque le taux monétaire est, dans une certaine mesure, déjà inférieur au taux de Taylor, l'assouplissement monétaire n'est pas souhaitable. Dans un environnement de taux d'intérêt bas, les banques souffrent déjà de pertes de marge, et une nouvelle baisse du taux d'intérêt réduirait davantage leurs marges, rendant plus attractives les alternatives plus risquées. Cela est conforme à la notion de "recherche de rendement" développée par Rajan (2005). Cependant, lorsque le taux d'intérêt est supérieur à la règle de Taylor, l'impact négatif de la politique monétaire sur la solidité des banques s'estompe et s'inverse. Dans ce régime, une réduction des taux d'intérêt est bénéfique pour la banque. Une baisse des taux d'intérêt, plutôt que de conduire à la fragilité des banques, favorise la solidité des banques en présence d'une politique monétaire restrictive (écart de Taylor

positif). En cas d'augmentation des taux d'intérêt, les banques devront supporter des coûts de refinancement plus élevés qui peuvent évincer les gains réalisés sur la marge.

Le troisième chapitre a été consacré à une modélisation théorique. Il s'inspire des deux précédents chapitres et tente déterminer si les effets de la politique monétaire sur le risque des banques peuvent être évalués indépendamment de l'intensité de l'outil prudentiel. Nous avons développé un modèle d'équilibre partiel pour étudier le policy-mix (entre les politiques prudentielles et monétaires). Ce chapitre vise à compléter la littérature existante en analysant les conditions sous lesquelles la combinaison d'une politique monétaire et prudentielle est optimale en termes de stabilité financière et de coût attendu d'une faillite bancaire. Dans notre modèle, les banques sont confrontées à un continuum de projets risqués et il n'y a pas d'asymétrie d'information. Elles choisissent leur niveau de risque optimal et financent les projets présentant ce niveau de risque. Le levier bancaire est déterminé de manière endogène puisque, en fonction du niveau de risque optimal, la banque détermine le volume de crédit à financer pour se conformer à la réglementation, étant donné que son stock de capital est supposé fixe. Il existe une assurance-dépôts, c'est-à-dire que les banques ne remboursent les dépôts qu'en cas de réussite des projets financés. Les décisions des banques sont influencées par les politiques monétaires et prudentielles. La politique monétaire est supposée être exogène et indépendante de la politique prudentielle.

Nous constatons que la banque choisit son niveau de risque optimal en réponse à deux effets: l'effet profit et l'effet régulation. Le niveau de risque optimal de la banque est tel que les deux effets s'égalisent. En outre, l'impact d'une variation de taux d'intérêt sur le risque de la banque n'est pas univoque et dépend de la sensibilité de l'exigence de fonds propres au risque. Un assouplissement ou un resserrement monétaire entraîne une prise de risque plus importante en fonction de la sensibilité au risque de l'outil microprudentiel. Par exemple, lorsque la sensibilité au risque de la marge d'intermédiation de la banque est supérieure à celle du ratio d'exigence de fonds propres, la banque peut alors prendre plus de risque (augmentant ses revenus). Dans ce cas, une baisse du taux d'intérêt monétaire (qui réduit les revenus de la banque) encourage la banque à prendre plus de risques afin de maintenir ses bénéfices. Inversement, lorsque la sensibilité au risque de l'exigence de fonds propres est supérieure à celle de la marge d'intermédiation de la banque, le risque de la banque diminue à la suite de l'assouplissement monétaire.

Outre ses effets sur le risque de la banque, la politique monétaire a également des effets ambigus sur le coût social attendu de la faillite bancaire. Tout changement de politique monétaire a un impact direct sur le coût social attendu de la faillite par le biais du coût des

dépôts. Cet effet direct peut être considéré comme un "effet prix". En outre, la politique monétaire affecte indirectement le coût social attendu par son action sur le risque de la banque, c'est-à-dire l'effet prise de risque. De ce dernier effet, on peut déduire deux autres effets : l'"effet fragilisation" et l'"effet levier" résultant respectivement de la modification de la probabilité de défaut et de la modification du levier de la banque (en raison de la modification du ratio de fonds propres). Il apparaît alors que le risque de la banque et le coût social attendu d'une faillite bancaire peuvent évoluer dans le même sens ou en sens opposés. Par ailleurs, l'analyse met en évidence les cas où un outil microprudentiel plus rigoureux est efficace pour atténuer la fragilisation du système financier et réduire le coût social attendu d'une faillite bancaire. Toutefois, il existe des situations où l'augmentation du coût social attendu d'une faillite est due à l'effet de levier. Dans de tels cas, il est nécessaire de disposer d'un outil macroprudentiel tel qu'un ratio de levier qui permettrait de limiter l'augmentation du levier bancaire. Par conséquent, en utilisant un ratio de levier, le régulateur limite le coût attendu d'une crise au détriment du financement de l'économie puisqu'il y a une diminution du volume des projets que la banque peut financer. Dans ce contexte, le régulateur peut être confronté à un compromis entre la réglementation des fonds propres nécessaire pour limiter les risques et la nécessité de promouvoir l'activité de crédit essentielle à la croissance économique.

Les résultats de cette thèse ont des implications politiques importantes. Tout d'abord, elle relance le débat sur la nécessité du triptyque stabilité des prix/stabilité de la production/stabilité financière dans les objectifs des banques centrales. Elle apporte un soutien aux partisans de l'inclusion des questions de stabilité financière dans les objectifs des banques centrales, puisque les taux monétaires influencent les comportements des agents financiers. La deuxième implication, qui découle de la première, est liée à l'utilisation de la règle de Taylor comme indicateur du risque de fragilisation du système financier. Une règle de Taylor augmentée qui tient compte de la stabilité financière est appropriée à cet effet et des travaux supplémentaires sont nécessaires dans ce sens. L'idée principale qui en découle est que la prise de risque et la prévention des crises devraient être les tâches des autorités réglementaires et monétaires. Les banques centrales devraient non seulement effectuer des "réparations" mais aussi prendre en compte les préoccupations de stabilité financière lors de la fixation des taux d'intérêt. Nos conclusions appellent les autorités monétaires à accorder plus d'attention à la stabilité financière lors de la fixation des taux d'intérêt et suggèrent que les superviseurs bancaires prennent en compte les effets potentiels des chocs monétaires en fonction du régime de taux d'intérêt dans l'ajustement des règles prudentielles. De plus, nos résultats suggèrent que les autorités monétaires ne devraient pas seulement considérer l'impact des taux d'intérêt sur le comportement de prise de risque des banques mais devraient également considérer les déviations de ces taux à la règle de Taylor.

En outre, nos résultats fournissent également des arguments en faveur d'une plus grande coordination des politiques monétaires et prudentielles pour un meilleur résultat en termes de stabilité financière et de coût social d'une crise. Pour obtenir de meilleurs résultats en termes de stabilité financière, les politiques monétaire et microprudentielle devraient agir en sens inverse. En particulier, le ratio d'exigence de fonds propres doit être suffisamment sensible afin de limiter la prise de risque des banques lors de période de baisse des taux d'intérêt. S'il est établi que les autorités monétaires doivent tenir compte de l'impact de leur politique sur le comportement de la banque en matière de risque, l'autorité prudentielle doit alors tenir compte de l'environnement monétaire et réglementaire dans lequel le changement de politique monétaire se produit avant de prendre toute mesure. En fait, nous sommes fondés à penser que l'impact de la politique monétaire sur le risque de la banque n'est pas indépendant, d'une part, de l'écart du taux d'intérêt monétaire par rapport à la règle de Taylor et, d'autre part, de l'intensité de l'outil microprudentielle. Ainsi, dans son souci d'éviter des coûts importants en cas de crise, le régulateur devrait mieux apprécier la situation afin de prendre les mesures appropriées. Par exemple, une mesure macroprudentielle, si elle est inappropriée, peut nuire à l'économie, c'est-à-dire limiter le volume de crédit sans atténuer la prise de risque et le coût de la résolution de la crise. En définitive, nos résultats soulignent la nécessité d'améliorer davantage les mesures prudentielles en intégrant des facteurs qui ne sont pas encore pris en compte.

Toutefois, les analyses effectuées dans le cadre de cette thèse sont susceptibles d'être améliorées. Tout d'abord, l'analyse empirique ne tient pas compte des banques qui ont fait faillite pendant la crise. En ce sens, une analyse économétrique portant sur des données de panel non équilibrées pourrait être appropriée. Deuxièmement, l'inclusion de banques d'autres régions peut aider à prendre en compte l'effet de l'intensité des différentes réglementations sur le canal de prise de risque. Troisièmement, la question de la coordination des politiques ne couvre pas toutes les externalités des politiques monétaires et prudentielles, et leur interaction avec d'autres politiques. La politique budgétaire pourrait être incluse dans l'analyse de la coordination des politiques monétaires et prudentielles, puisque la politique budgétaire interagit avec chacune d'elles, comme le montre Cecchetti (2016).

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