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Nestor Odjoumani

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Nestor ODJUMANI

Essais sur les impacts macroéconomiques de l'incertitude mondiale

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en vue de l'obtention du doctorat de Sciences économiques de l'Université Paris
Nanterre
sous la direction de M. Dramane COULIBAY (Université Paris Nanterre)

Jury *

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Résumé

Cette thèse contribue à la littérature sur l'incertitude mondiale, à travers trois essais. Le premier essai fait une analyse comparative de l'effet des chocs de l'incertitude mondiale sur les conditions économiques d'un groupe de 20 pays développés et d'un autre groupe de 96 pays en développement et émergents, en utilisant un modèle vectoriel autorégressif en panel. Le deuxième essai approfondit l'analyse en se focalisant sur le rôle de l'ouverture commerciale et financière et du développement financier dans la transmission des chocs de l'incertitude mondiale. Cette deuxième contribution est menée à l'aide d'un modèle vecteur autorégressif interactif en panel sur un échantillon de 107 pays, dont 20 pays développés et 87 pays en développement et émergents. Enfin, le troisième essai étudie les effets des chocs mondiaux d'incertitude et financiers sur le prix mondial du pétrole, en utilisant un modèle vectoriel autorégressif dont les chocs sont conjointement identifiés avec les restrictions de signe.

Mots clés : incertitude macroéconomique, pays développés et pays en développement, variables macroéconomiques, prix du pétrole, vecteur autorégressif en panel, restrictions de signes.

Abstract

This thesis contributes to the literature on global uncertainty, through three essays. The first essay makes a comparative empirical analysis of the effect of uncertainty shocks on economic conditions of a group of 20 developed countries and a group of 96 developing and emerging countries, using a panel vector autoregressive model. The second essay deepens the analysis by exploring the role of openness and financial development in the transmission of global uncertainty shocks. This second contribution employs an interacted panel vector autoregressive on a sample of 107 countries, including 20 developed countries and 87 developing and emerging countries. Finally, the third essay examines the effects of global uncertainty and financial shocks on oil price, using a structural vector autoregressive vector model in which shocks are jointly identified with sign restrictions.

Keywords : macroeconomic uncertainty, developed and developing countries, macroeconomic variables, oil prices, panel vector autoregression, sign restrictions.

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Note de synthèse

Introduction

Depuis la seconde moitié des années 2000 et surtout la crise des subprimes de 2008, le débat sur l'incertitude macroéconomique a été accentué. En particulier, avec le papier pionnier de Bloom (2009), l'incertitude a pris une place importante dans la recherche académique en macroéconomie. Ceci s'explique par la profondeur de la crise financière, avec le fait que la plupart des prévisions économiques ont été déjouées par cette crise. En effet, l'économie mondiale a fait face à une baisse drastique de la production, de l'investissement, de la consommation et du crédit.

Le risque indique une situation dans laquelle les agents ont une connaissance de la probabilité des événements, tandis que l'incertitude correspond à une situation où la probabilité d'un événement n'est pas prévisible (Knight, 1921). Comme l'incertitude correspond à l'imprévisibilité, dans la modélisation théorique, elle est capturée par le choc sur le second moment (Bloom, 2009) ou le choc de risque (Christiano et al., 2014) .

La littérature récente sur l'incertitude peut être divisée en deux groupes : le premier portant sur la manière de mesurer l'incertitude, et le second groupe sur les conséquences macroéconomiques des chocs d'incertitude.

Afin d'évaluer empiriquement les chocs d'incertitude sur l'activité économique, plusieurs manières de mesurer l'incertitude ont été proposées, en se basant soit sur la volatilité des marchés boursiers (Bloom, 2009), soit sur les prévisions (Jurado et al., 2015; Rossi and Sekhposyan, 2015) ou soit sur les événements politiques et économiques (Baker et al., 2016; Caldara and Iacoviello, 2018; Ahir et al., 2018).

L'incertitude se transmet à l'économie à travers plusieurs canaux dont les principaux sont : les options réelles (Bernanke, 1983; McDonald and Siegel, 1986; Pindyck, 1991; Dixit and Pindyck, 1994; Boyle and Guthrie, 2003; Bloom, 2009), l'épargne de précaution (Fernandez-Villaverde et al., 2011; Fogli and Perri, 2015; Guerrieri and Lorenzoni, 2017) et les frictions financières (Arellano et al., 2019; Christiano et al., 2014). Le canal des options réelles représente le fait que, face à l'incertitude, les entreprises préfèrent reporter leur décision d'investissement, en présence d'irréversibilité ou des coûts d'ajustements de l'investissement. Concernant le canal de l'épargne de précaution, il reflète l'épargne supplémentaire causée par l'incertitude, entraînant une baisse de la demande de consommation. Enfin, le canal des frictions financières correspond au fait que, dans un environnement d'incertitude forte, pour se couvrir contre le risque de défaut des projets d'investissement, les intermédiaires financiers chargent une prime de risque, conduisant à une hausse du coût de financement externe et une baisse de l'investissement.

Cette thèse contribue à la littérature sur les conséquences macroéconomiques de l'incertitude mondiale. Après avoir exposé dans le Chapitre 1 la littérature sur l'incertitude, cette thèse apporte trois contributions. La première contribution dans le Chapitre 2 étudie la transmission des chocs d'incertitude mondiale en distinguant les pays développés des pays en développement. La deuxième contribution dans le Chapitre 3 porte sur le rôle du

développement financier et de l'ouverture commerciale et financière dans la transmission des chocs d'incertitude mondiale. La troisième contribution dans le Chapitre 4, concerne l'influence de l'incertitude mondiale couplée avec les chocs financiers sur les fluctuations du prix mondial du pétrole.

Effets de l'incertitude mondiale : pays développés vs pays émergents et en développement

Motivation

Dans le sillage de la crise financière de 2008-2009, le papier phare de Bloom (2009) a relancé le débat sur les conséquences économiques des chocs d'incertitude. Plusieurs travaux antérieurs s'étaient intéressés aux conséquences macroéconomiques de l'incertitude, comme Bernanke (1983), McDonald and Siegel (1986), Pindyck (1991), Dixit and Pindyck (1994) et Boyle and Guthrie (2003).

Malgré cet engouement de la littérature sur l'impact des chocs d'incertitude, la plupart des études portent sur les pays industrialisés avec peu d'attention aux pays émergents et en développement. Le Chapitre 2 comble ce vide en étudiant la transmission des chocs de l'incertitude mondiale en comparant les pays développés aux pays émergents et en développement. Il faut noter qu'à travers le commerce et la finance internationales, l'incertitude mondiale entraîne des fluctuations (de l'incertitude) dans les pays ouverts. En lien avec les canaux de transmission de l'incertitude (options réelles, épargne de précaution, frictions financières), l'impact des chocs de l'incertitude mondiale devrait dépendre des caractéristiques des économies.

Concernant le canal des options réelles, qui est tel que, suite à une forte incertitude, les entreprises sont incitées à reporter leur décision d'investissement en présence de l'irréversibilité ou des coûts d'ajustements de l'investissement (Bernanke, 1983; McDonald and Siegel, 1986; Pindyck, 1991; Dixit and Pindyck, 1994; Boyle and Guthrie, 2003; Bloom, 2009), on peut penser que ce canal devrait être relativement plus opérant dans les pays émergents et en développement comparativement aux pays industrialisés. Par exemple, le degré d'irréversibilité de l'investissement peut s'accroître avec la qualité et les régulations administratives, comme les contrôles des capitaux. En effet, les processus de contrôle des capitaux empêchent les investisseurs nationaux et étrangers de vendre leurs actifs et de réaffecter leurs fonds (Pindyck, 1991). Cependant, un système financier moins développé avec de fortes contraintes de financement peuvent atténuer l'effet de ce canal. A cet égard, Boyle and Guthrie (2003) montrent que les contraintes financières réduisent l'intérêt d'attendre la réalisation des investissements en présence d'incertitude élevée puisque, la menace d'un déficit de financement futur conduit les entreprises à faire des investissements précoces sous-optimaux. Il y a donc une ambiguïté sur le fait que le canal des options réelles soit plus important ou non dans les pays émergents et en développement que dans les économies développées.

On peut aussi penser que le canal de l'épargne de précaution est plus important dans les pays émergents et en développement du fait que, en raison du faible niveau de développement de leur système financier, les ménages font face à des contraintes de crédits et donc réalisent beaucoup d'épargne de précaution comme assurance individuelle contre une incertitude élevée (Guerrieri and Lorenzoni, 2017). De plus, le manque de protection

sociale dans les pays en développement oblige les ménages à épargner davantage pour des motifs de précaution en cas de forte incertitude (Engen and Gruber, 2001).

Le canal des frictions financières, qui correspond à une prime de risque très élevée pour financer les projets en présence d'incertitude élevée et entraînant une baisse de l'investissement, interagit évidemment avec le niveau de développement financier. Comme pour le canal des options réelles, il existe une ambivalence quant à savoir si le canal des frictions financières est plus important pour les pays moins développés caractérisés par un faible niveau de développement financier.

Stratégie empirique, données et résultats empiriques

Pour étudier la transmission de l'incertitude mondiale sur l'activité économique, une approche de modèle vectoriel autorégressif en panel avec des variables exogènes (panel VARX) est employée comme dans Carriere-Swallow and Céspedes (2013). Dans cette approche, les variables exogènes incluent l'indice de l'incertitude mondiale et une variable capturant l'activité financière mondiale (en excluant les Etats-Unis).

Pour réaliser cette étude, nous avons considéré un échantillon de 116 pays répartis en deux groupes, à savoir : 20 pays développés et 96 pays émergents et en développement. Les données sont annuelles et couvrent la période 1997-2017. Les pays sont sélectionnés en fonction de la disponibilité des données afin d'avoir un panel cylindré qui est nécessaire pour utiliser la méthode d'estimation des panels dynamiques de Hahn and Kuersteiner (2002) corrigeant le biais de Nickell (1981). De plus, les Etats-Unis sont exclus de l'échantillon

afin d'avoir l'exogénéité des variables pour l'incertitude et l'activité financière mondiale.

En outre, les petits pays de moins de 1 million d'habitants sont exclus.

L'incertitude mondiale est mesurée par l'indice GEPU (*Global Economic Policy Uncertainty*) construit par Davis (2016), comme une moyenne pondérée en fonction du PIB des indices nationaux EPU (*Economic Policy Uncertainty*) pour 20 économies majeures : Australie, Brésil, Canada, Chili, Chine, France, Allemagne, Grèce, Inde, Irlande, Italie, Japon, Mexique, Pays-Bas, Russie, Corée du Sud, Espagne, Suède, Royaume-Uni et Etats-Unis. Pour faire une analyse de robustesse, il a été utilisé deux mesures alternatives de l'incertitude mondiale : l'indice EPU des Etats-Unis calculé par Baker et al. (2016) ; et l'indice WUI (*World Uncertainty Index*) construit par Ahir et al. (2018) au niveau mondial en tant que moyenne des WUI individuels de 143 pays qui est calculé en utilisant les rapports par pays de *Economist Intelligence Unit* (EIU).

Pour tenir compte de l'activité financière mondiale, l'indice boursier *S&P500* est utilisé, comme dans la littérature (Bloom, 2009; Baker et al., 2016; Carriere-Swallow and Cespedes, 2013). Les variables capturant les conditions économiques sont : le PIB réel (PPA, 2011 USD), la consommation réelle (PPA, 2011 USD), l'investissement réel (PPA, 2011 USD) et l'indice des prix à la consommation (IPC), tous tirés de Penn World Table (PWT 9.1, Feenstra et al., 2015). Le PIB réel, la consommation réelle et l'investissement réel sont exprimés par habitant en divisant leur valeur par la population totale, également pris dans le PWT.

Les résultats montrent que le choc d'incertitude mondiale entraîne une baisse du PIB, de la consommation, de l'investissement et des prix dans les deux groupes de pays. L'ampleur des baisses du PIB, des prix à la consommation et de l'investissement est à peu près similaire

pour les deux groupes de pays, tandis que la baisse de la consommation est beaucoup plus prononcée pour les pays en développement et émergents. Ces résultats sont robustes en utilisant différentes mesures de l'incertitude mondiale. Le résultat montrant qu'une forte incertitude mondiale entraîne une baisse plus forte de la consommation dans les économies moins développées semble refléter le fait que l'épargne de précaution soit plus importante dans ces pays en raison de leur faible niveau de développement financier et du manque de protection sociale.

Rôle de l'ouverture commerciale et financière et du développement financier dans la transmission des chocs d'incertitude

Motivation

Comme susmentionné l'incertitude mondiale affecte les économies via trois canaux principaux (options réelles, épargne de précaution et frictions financières) et son effet devrait dépendre des caractéristiques des pays en lien avec ces différents canaux. Ainsi, le Chapitre 3 approfondit l'analyse en examinant la manière dont les caractéristiques individuelles des pays modifient la transmission des chocs d'incertitude mondiale. Ces caractéristiques sont : l'ouverture commerciale, l'ouverture financière et le développement financier.

Tout d'abord, pour chacun de ces canaux, les chocs de l'incertitude mondiale se transmettent sur une économie ouverte à travers l'ouverture commerciale et financière. A cet égard, Ahir et al. (2018) montrent que l'incertitude est beaucoup plus synchronisée entre pays ayant de forts liens commerciaux et financiers. Par ailleurs, Caldara and Iacoviello (2018) montrent que le degré d'ouverture commerciale compte de manière significative

à l'exposition de l'entreprise au risque géopolitique. De plus, Fernandez-Villaverde et al. (2011) trouvent que, pour une économie ouverte, une forte volatilité des taux d'intérêts réels induite par l'incertitude, engendre une contraction de l'activité économique avec des fuites de capitaux.

Comme mentionné plus haut, le degré de développement financier interagit avec les trois canaux de transmission de l'incertitude, conduisant à une ambiguïté sur comment cette interaction s'opère. Un système financier peu développé avec de fortes contraintes de crédit peut atténuer l'effet des options réelles, en affaiblissant l'opportunité de reporter les projets d'investissement en présence de fortes incertitudes (Boyle and Guthrie, 2003). Cependant, dans un environnement financier sous-développé, les contraintes de crédit conduisent les ménages à réaliser beaucoup plus d'épargne de précaution pour faire face à une forte incertitude (Guerrieri and Lorenzoni, 2017). Enfin, le degré de développement financier interagit avec le canal des frictions financières de deux manières différentes. D'une part, un faible développement financier peut amplifier l'impact négatif de l'incertitude à travers les frictions financières, puisque les entreprises sont pénalisées avec l'augmentation du coût du financement externe due à la hausse des primes de risque. D'autre part, dans un système financier moins développé, le financement externe étant moins important, l'investissement devrait être moins affecté par l'incertitude à travers les frictions financières.

Stratégie empirique, données et résultats empiriques

Pour étudier l'impact de l'incertitude conditionnelle aux caractéristiques des pays, une approche vectorielle autorégressive en panel interactif (IPVAR) est employée comme dans Towbin and Weber (2013). Etant donné que l'incertitude mondiale et le S&P 500 sont

communs et exogènes à tous les pays, des restrictions d'exogénéité sont imposées par pour ces variables (comme dans Carriere-Swallow and Cespedes (2013)).

L'étude empirique porte sur un échantillon de 107 pays, dont 20 pays développés et 87 pays en développement et émergents, sur la période 1997-2017. Les pays sont sélectionnés en se basant sur la disponibilité des données, spécifiquement afin d'avoir suffisamment d'observations sur les variables d'interaction. Comme dans le précédent chapitre, l'échantillon exclut les Etats-Unis pour assurer l'exogénéité des variables de l'incertitude mondiale et de l'activité financière mondiale. Par ailleurs, les pays ayant moins d'un million d'habitants sont aussi exclus de l'analyse.

Comme le précédent chapitre, pour mesurer l'incertitude mondiale nous nous basons sur l'indice GEPU (*Global Economic Policy Uncertainty*) construit par Davis (2016). Pour la robustesse, nous considérons l'indice WUI (*World Uncertainty Index*) construit par Ahir et al. (2018). De même, l'indice S&P500 est utilisé pour prendre en compte l'activité financière mondiale. Les mêmes variables endogènes du chapitre précédant, prises de Penn World Table (PWT 9.1, Feenstra et al. (2015)), sont utilisées pour refléter les conditions économiques, à savoir, le PIB réel (PPP, 2011 USD) par tête, la consommation réelle (PPP, 2011 USD) par tête, l'investissement réel (PPP, 2011 USD) par tête et l'indice des prix à la consommation.

Quant aux variables d'interactions (ouverture commerciale, ouverture financière, développement financier) permettant de tenir compte des caractéristiques, elles sont décrites comme suit. L'ouverture commerciale est calculée comme la somme des exportations et des importations en pourcentage du PIB, et est collectée de la base des indicateurs de développement de la Banque mondiale. L'indicateur d'ouverture financière utilisée est l'indice

d'ouverture du compte de capital (KAOPEN) construit par Chinn and Ito (2006). Concernant l'indicateur du développement financier, il est issu de la base de données de l'indice de développement financier du Fonds Monétaire International (Svirydzenka, 2016). Cette base fournit plusieurs indicateurs sur les institutions financières et les marchés financiers en termes de profondeur (taille et liquidité), d'accès (possibilité des individus et entreprises à accéder aux services financiers) et d'efficacité (capacité des institutions à fournir des services financiers à faible coût). Les institutions financières comprennent les banques, les compagnies d'assurance, les fonds mutuels, les fonds de pensions, et d'autres institutions financières non bancaires ; les marchés financiers, quant à eux, comprennent les marchés boursiers et obligataires. La base fournit six sous-indices qui sont agrégés en indices de niveau supérieur, afin de calculer un indice de développement des institutions financières (FI), un indice de développement des marchés financiers (FM) et, au niveau le plus agrégé, l'indice de développement financier (FD). Chaque indice est normalisé entre 0 et 1 ; une valeur plus élevée indique un développement financier plus élevé.

Les résultats montrent que la transmission des chocs de l'incertitude mondiale n'est pas modifiée de manière significative par aucun des deux piliers d'ouverture (ouverture commerciale ou financière). Cependant, l'impact négatif de l'incertitude mondiale est considérablement atténué par le développement des institutions financières. Plus précisément, les résultats indiquent que l'atténuation de l'impact est due au développement des institutions financières en termes d'efficacité (capacité des institutions à fournir des services financiers à faible coût) et non en termes de profondeur (taille et liquidité) ou d'accès (possibilité des individus et entreprises à accéder aux services financiers). Dans une certaine mesure, les résultats de ce chapitre sont en phase avec ceux du chapitre précédent montrant que

les chocs d'incertitude mondiale entraînent une baisse de la consommation plus prononcée pour les pays en développement et émergents ayant des systèmes financiers peu efficaces.

Effet des chocs mondiaux d'incertitude et financier sur le prix du pétrole

Motivation

A suite de la crise financière mondiale de 2008-2009, la chute drastique du prix du pétrole a accentué le débat sur la réponse de ce dernier aux chocs d'incertitude mondiale et aux chocs financiers (Bloom, 2009 ; Caldara et al., 2016 ; Alquist and Kilian, 2010 ; Joëts et al., 2017). Ainsi, ce chapitre contribue à la littérature sur les conséquences de l'incertitude économique en évaluant la réponse du prix du pétrole aux chocs d'incertitude et financier tout en tenant compte de la forte corrélation entre l'incertitude et la détérioration des conditions financières.

Empiriquement, il est très difficile de distinguer l'incertitude économique de la volatilité sur les marchés financiers, conduisant à mesurer indirectement l'incertitude macroéconomique par la volatilité des marchés financiers tels que le VIX ou le VXO, comme dans Bloom (2009). La spéculation financière sur les marchés à terme du pétrole peut influencer le prix du pétrole au comptant, car les pressions spéculatives sur les prix du pétrole à terme peuvent se propager au marché physique du pétrole brut (Kilian, 2014). En outre, les perturbations sur les marchés financiers peuvent affecter la dynamique des prix du pétrole en influençant la demande mondiale (car une baisse de la demande mondiale induit une pression à la baisse sur le prix du pétrole). Par ces trois principaux canaux (options

réelles, épargne de précaution, frictions financières), l'incertitude macroéconomique peut faire baisser le prix du pétrole en affaiblissant la demande mondiale. En effet, via le canal des options réelles, se référant à la décision des firmes de reporter l'investissement dans une situation d'incertitude élevée et en présence d'irréversibilité ou de coût d'ajustements de l'investissement (Bernanke, 1983 ; McDonald and Siegel, 1986 ; Pindyck, 1991 ; Dixit and Pindyck, 1994 ; Boyle and Guthrie, 2003 ; Bloom, 2009), l'incertitude entraîne une baisse des investissements et de la demande globale. Quant au canal de l'épargne de précaution, représentant l'excès d'épargne suite à une montée de l'incertitude (Lelan, 1968), il entraîne une baisse de la consommation et donc de la demande globale. Par le canal des frictions financières, l'incertitude macroéconomique est particulièrement liée au choc financier. Ce canal, se référant à une forte prime de risque facturée par les intermédiaires financiers pour se couvrir dans un environnement d'incertitude plus élevée (Christiano et al., 2014 ; Gilchrist-et-al .2014 ; Arellano-et-al.2019), entraîne une augmentation du coût du financement externe et une baisse des investissements et de la demande mondiale.

Stratégie empirique, données et résultats empiriques

Comme dans Caldara et al. (2016), pour examiner comment le prix du pétrole réagit à la fois à l'incertitude et aux chocs financiers, cette étude se base sur un modèle vectoriel autorégressif (VAR) en identifiant de manière jointe les deux chocs par la restriction des signes avec un critère de fonction de pénalité. Cette approche permet de retracer la réaction du prix du pétrole à la fois à l'incertitude et aux chocs financiers tout en tenant compte de la forte corrélation entre les deux chocs.

Cette étude utilise des données mensuelles s'étalant de janvier 1997 à décembre 2018.

Contrairement à Caldara et al. (2016) qui utilisent l'indice VXO et la mesure de Jurado et al. (2015) pour représenter l'incertitude macroéconomique, nous nous basons sur l'indice GEPU de Davis (2016), comme dans les chapitres précédents. Par ailleurs, pour la robustesses, nous considérons aussi l'indice EPU des Etats-Unis calculé par Baker et al. (2016) et l'indice WUI construit par Ahir et al., 2018. Comme dans Caldara et al. (2016), les conditions financières mondiales sont représentées par l'indice EBP (excédent de prime obligataire) calculé par Gilchrist and Zakrajsek (2012). Le prix mondial du pétrole est mesuré par l'indice du pétrole brut de West Texas Intermediate (WTI).

Les résultats de ce chapitre montrent qu'en réponse à une incertitude accrue, les conditions financières se détériorent immédiatement ; et en réponse à la détérioration des conditions financières, l'incertitude économique augmente immédiatement. Tout en tenant compte de cette forte corrélation entre l'incertitude et les conditions financières, nous constatons que les chocs mondiaux d'incertitude et financiers induisent tous les deux une chute drastique du prix du pétrole. Les résultats sont robustes aux différentes mesures de l'incertitude mondiale.

Ces résultats sont très évocateurs dans le contexte actuel de la pandémie Covid-19 qui a provoqué une incertitude mondiale sans précédent avec d'énormes turbulences financières et, une chute historique du prix du pétrole en territoire négatif, pour la première fois de l'histoire.

Conclusion

A travers trois essais, cette thèse contribue à la littérature sur les conséquences macroéconomiques de l'incertitude mondiale. La première contribution (Chapitre 2) a pour l'objet

d'examiner la transmission de l'incertitude mondiale en comparant les économies développées aux économies en développement et émergentes. Cette analyse est motivée par le fait que la transmission des chocs d'incertitude mondiaux peut dépendre des caractéristiques des pays, en lien avec les principaux canaux (options réelles, épargne de précaution et frictions financières) via lesquels l'incertitude affecte les économies. Cette étude empirique est réalisée à l'aide d'un modèle VAR en panel avec variables exogènes (indices d'incertitude et des marchés financiers). Les données utilisées sont annuelles et couvrent 20 pays développés et 96 pays en développement et émergents, sur la période 1997-2017. Les résultats de cette première contribution de la thèse montrent que les chocs d'incertitude mondiaux causent une baisse du PIB, de la consommation, de l'investissement et des prix à la consommation dans les deux groupes de pays. En comparant les deux groupes de pays, l'ampleur de la baisse du PIB, des prix à la consommation et de l'investissement est très similaire, tandis que la chute de la consommation est beaucoup plus prononcée pour les économies en développement et émergentes. Ainsi, le canal de l'épargne de précaution semble important dans la transition des chocs d'incertitude dans les économies en développement et émergentes, en raison de leur faible niveau de développement financier et du manque de protection sociale.

La deuxième contribution (Chapitre 3), quant à elle, approfondit l'analyse en examinant comment les caractéristiques de chaque pays, telles que l'ouverture commerciale, l'ouverture financière et le développement financier, influencent la transmission des chocs d'incertitude mondiaux. A cette fin, le Chapitre 3 se base sur un modèle panel VAR interactif. L'analyse empirique couvre un échantillon de 107 pays, dont 20 pays développés et 87 pays en développement et émergents, sur la période de 1997 à 2017. Les résultats de cette contribution

montrent que la transmission des chocs d'incertitude mondiaux n'est pas significativement affectée, ni par l'ouverture commerciale, ni par l'ouverture financière. Cependant, le développement des institutions financières atténue l'impact négatif de l'incertitude mondiale. Cet effet d'atténuation est due au développement des institutions en termes d'efficacité (capacité des institutions financières à fournir des services à faibles coûts) et non en termes de profondeur (taille et liquidité) ou accès (capacité des particuliers et des entreprises à accéder aux services financiers).

La troisième contribution (Chapitre 4) a pour but d'analyser comment le prix mondial du pétrole réagit aux chocs mondiaux d'incertitude et financier. L'analyse est motivée par le fait que l'incertitude mondiale et les chocs financiers sont fortement liés et que les deux peuvent influencer le prix du pétrole. Cette étude utilise un modèle VAR dont les deux chocs sont conjointement identifiés sur la base des restrictions de signes avec une approche de fonction de pénalité. Les données utilisées sont mensuelles et couvrent la période de 1997 à 2017. Les résultats de cette dernière contribution montrent qu'une forte incertitude mondiale détériore les conditions financières, des fluctuations sur les marchés financières augmentent l'incertitude macroéconomique en même temps, les chocs mondiaux d'incertitude et financier causent tous les deux une chute du prix mondial du pétrole.

Nos résultats sont très pertinents dans le contexte actuel de la pandémie Covid-19 causant une récession historique associée à d'énormes fluctuations financières et une baisse historique du prix du pétrole.

Avec l'onde de choc du Covid-19, nous pouvons conclure que la recherche sur l'incertitude mondiale sera encore amplifiée. De nouvelles recherches sur l'incertitude mondiale sont prometteuses et devraient continuer d'étudier l'impact des chocs de l'incertitude mondiale

dans d'autres dimensions, comme les inégalités.

Chapitre 1

An overview of the existing literature on global uncertainty

1.1. Introduction

Since the second half of the 2000s and especially with the 08-09 global financial crisis, uncertainty has become an important field of research in economics. With the seminal paper of Bloom (2009), the debate on uncertainty has become more central than ever in research in economics. The reason is the fact that global economic activity was extremely bleak in the aftermath of the global financial crisis, with most economic forecasts being foiled by the subprime crisis. This sluggish economy was characterized by drastic decline in output, consumption, investment and credit.

The modern definition of uncertainty is from Knight (1921). According to Knight (1921), risk indicates a situation where agents have the knowledge of distribution

of probabilities of events, while uncertainty corresponds to a situation where the probability of an event is not predictable. Since uncertainty corresponds to unpredictability, in theoretical modelling it is captured by a shock in second moment (Bloom, 2009) or a shock in risk (Christiano et al., 2014). Generally, the concept of uncertainty corresponds to a mixture of risk and uncertainty (Bloom, 2014). To evaluate empirically the economic consequences of uncertainty, many approaches have been used to measure it. These include measure based on stock market volatility (Bloom, 2009), forecasting (Jurado et al., 2015 ; Rossi and Sekhposyan, 2015 ; Ahir et al., 2018) and, economic and political events (Baker et al., 2016 ; Caldara and Iacoviello, 2018).

In the literature, there are many channels through which uncertainty shocks may impact economic outcomes. The main channels include : real options (Bernanke, 1983 ; McDonald and Siegel, 1986 ; Pindyck, 1991 ; Dixit and Pindyck, 1994 ; Boyle and Guthrie, 2003 ; Bloom, 2009), precautionary saving (Fernandez-Villaverde et al., 2011 ; Fogli and Perri, 2015 ; Guerrieri and Lorenzoni, 2017) and financial frictions (Arellano et al., 2019 ; Christiano et al., 2014). Real options effect corresponds to the fact that, following a rise in uncertainty, firms prefer to postpone investment decision, in presence of irreversibility or adjustment costs in investment. Precautionary saving is the extra-saving caused by uncertainty about future income, leading to a decline in consumption demand. Finally, financial frictions channel corresponds to the fact that, in a higher uncertainty environment, to cover against default risk of investment projects, financial intermediaries charge a premium, causing a rise in the cost of firm

external financing and a fall in investment. Depending on the underlying channel, the transmission of uncertainty should depend on the characteristics of a given country.

The aim of this chapter is to present an overview of the literature on economic uncertainty. This chapter is structured as follow. Section 1.2 discusses the literature on how uncertainty is measured in order to evaluate its impact on economic outcomes. Section 1.3 then presents the literature on the macroeconomic effects of uncertainty shocks while exposing the transmission channels. Finally, Section 1.4 concludes and outlines some issues on uncertainty that are treated in this thesis.

1.2. Measuring uncertainty

In order to evaluate empirically the economic consequences of uncertainty shocks, many measures have been continuously proposed since the seminal work of Bloom (2009). This section presents the most popular measures of uncertainty.

1.2.1. *Stock market volatility as a proxy for uncertainty*

The standard approach to measure uncertainty is based on stock market volatility. The two commonly used measure of stock market volatility are the VIX and the VXO indices. The VIX is the most widely used indicator of U.S. stock-market volatility and it measures the option-implied volatility of S&P 500 index of the Chicago Board Options Exchange (CBOE) over the following 30 days. The VXO index is similar to the VIX, but it based on the CBOE S&P100 index. The VXO is available starting in January 1986, while the VIX that starts in January 1990. In its seminal

paper, Bloom (2009) use the VXO index to empirical show the adverse impact of uncertainty shock on the US economy, estimating vector autoregressive (VAR) model. Following Bloom (2009), the VXO index has been widely used. For instance, Carriere-Swallow and Cespedes (2013) considers the VXO index to investigate the impact of uncertainty shock in emerging countries. Caldara et al. (2016) also uses the VXO index to jointly investigate the impact of uncertainty and financial shocks, estimating a Bayesian VAR.

1.2.2. Uncertainty measures based on forecasts

In the literature, some proxies of uncertainty are based on forecasts. These proxies can be grouped in two types : (i) measures based on forecaster disagreement and (ii) measures based on forecast errors.

1.2.2.1. Measures based on forecaster disagreement

Bloom (2009) also proxies uncertainty by the standard deviation of US GDP forecasts using the Philadelphia Federal Reserve Bank's Livingstone survey of professional forecasters. Following Bloom (2009), Bachmann et al. (2013) measures uncertainty by a cross-sectional dispersion or disagreement of forecasting for the US using the Philadelphia Federal Reserve Bank's Third District Business Outlook Survey, and for Germany using the Business Climate Index of IFO (Institut für Wirtschaftsforschung). Estimating VAR model for these countries, Bachmann et al. (2013) find that increase in business uncertainty leads to a persistent adverse impact

on economic activity.

1.2.2.2. Measures based on forecast errors

Some papers (Jurado et al., 2015; Rossi and Sekhposyan, 2015) have proposed macroeconomic uncertainty based on forecast error. This was particularly motivated by the fact that, using stock market volatility to measure uncertainty, we cannot distinguish between expected and unexpected movements. Indeed, as noticed by Jurado et al. (2015), stock market volatility can vary over time due to changes in leverage and risk aversion, even if there is no variation in uncertainty about economic fundamentals. To deal with this issue, Jurado et al. (2015) propose a new macroeconomic uncertainty index which is based on the implied forecast errors for real economic activity obtained through a factor model using hundreds of economic and financial series. By construction, this index is as free as possible both from the assumptions in any theoretical models, and from dependencies on any set of observable series.

Like Jurado et al. (2015), Rossi and Sekhposyan (2015) propose another new index based on forecast errors. Unlike the index of Jurado et al. (2015) that focuses on the variance of the forecast errors, the index proposed by Rossi and Sekhposyan (2015) measures the unconditional probability of observing the realized value. More specifically, this index is the percentile in the historical distribution of forecast errors associated with the realized forecast. To account for the asymmetry in uncertainty, they propose an overall, a downside and an upside measure of uncertainty. The

index of Rossi and Sekhposyan (2015) is different from that of Jurado et al. (2015) because the variance of the forecast error may remain the same even if the ex ante predictive uncertainty (measured by certain deciles of forecast error distribution) changes. Besides, the index of Rossi and Sekhposyan (2015) has the advantage of distinguishing between upside and downside uncertainty. Estimating a VAR model on US data and comparing its index to other measures, Rossi and Sekhposyan (2015) find that the downside measure has a larger impact on output.

Furthermore, Scotti (2016) proposes a macroeconomic uncertainty index estimating a dynamic factor model on agents' uncertainty about the current state of the economy. The index was constructed at daily frequency for the United States, euro area, the United Kingdom, Canada, and Japan. Comparing its index with other uncertainty measure for the United States, Scotti (2016) finds that uncertainty has a weak impact when it is related to real activity only.

1.2.3. Uncertainty measure based on firm- or industry-level data

Some measures of macroeconomic uncertainty are relied on firm- or industry-level data. This is the case of the seminal paper of Bloom (2009) that also proxies uncertainty by the quarterly cross-sectional standard deviation of pretax firm-level profit growth rates, the monthly standard deviation of the firm-level stock returns, and the annual cross-sectional standard deviation of the industry-level total factor productivity (TFP) growth rates.

In the same vein, Bloom et al. (2007) compute the standard deviation of the

daily returns on a year by year basis, for a panel of UK manufacturing firms.

Besides, Bloom et al. (2018) proxy uncertainty by the standard deviation of total-factor productivity (TFP) shocks estimated as the residual from the first-order autoregressive equation for the logarithms of TFP, at establishment-level, firm-level and industry-level for the U.S.

Furthermore, Gilchrist et al. (2014) construct a firm-level uncertainty computed as the firm-specific standard deviation of daily idiosyncratic returns over the firm fiscal quarter and fiscal year.

These papers find adverse economic impacts of uncertainty, using their corresponding measures based on firm- or industry-level data.

1.2.4. Measuring base on economic and political events

In the most recent literature, the Economic and Political Uncertainty (EPU) developed by Baker et al. (2016) has received a particular attention. This new index is based on newspaper coverage frequency. Baker et al. (2016) first computed a monthly EPU index for the U.S. since 1985, reflecting the frequency of articles in 10 leading U.S. newspapers that contain the following trio of terms : “economic” or “economy” ; “uncertain” or “uncertainty” ; and one or more of “Congress”, “deficit”, “Federal Reserve”, “legislation”, “regulation” or “White House”. Some important events are well reflected in the U.S. EPU index : presidential elections, Gulf Wars I and II, the 9/11 attacks, the 2011 debt ceiling.¹ Based on the same approach, the authors also set

1. For more information, see the dedicated website <https://www.policyuncertainty.com>.

up EPU indexes for 11 other countries, including all G10 economies. Baker et al. (2016) find that an increase in EPU index lead declines in investment, output, and employment, estimating a VAR model for the U.S and panel VAR for 12 major economies. Estimating a variety of linear regressions over the period 1900-2014, Aroui et al. (2016) find that an increase in US EPU has a significant negative impact on stock returns that is stronger and persistent during periods of extreme volatility.

Davis (2016) computes a global economic policy uncertainty (GEPU) index as a GDP-weighted average of national EPU indices for 20 countries : Australia, Brazil, Canada, Chile, China, France, Germany, Greece, India, Ireland, Italy, Japan, Mexico, the Netherlands, Russia, South Korea, Spain, Sweden, the United Kingdom, and the United States. GEPU index is available at monthly frequency from January 1997.²

Since uncertainty measures were mostly constructed for advanced economies, Ahir et al. (2018) construct a new country uncertainty index, called World Uncertainty Index (WUI), for 143 individual countries, at quarterly frequency from 1996 onwards. The WUI is computed using frequency counts of “uncertainty” (and its variants) in the Economist Intelligence Unit (EIU) country reports that discuss major political and economic developments, and contain analysis and forecasts of political, policy and economic conditions. Ahir et al. (2018) also compute the time series of the WUI at the global level (using simple average and GDP weighted average), income level (advanced, emerging, and low-income economies), and regional level (Africa, Asia and the Pacific, Europe, Middle East and Central Asia, and Western Hemis-

2. For more information on GEPU and other indices mentioned below (WUI, WTUI), see also the website of EPU (<https://www.policyuncertainty>).

phere). The authors find that the WUI is associated with higher economic policy uncertainty and stock market volatility, and lower GDP growth. Comparing across countries, they also find that WUI is significantly higher in developing countries. Finally, estimating a panel VAR model, we find that a positive innovation in the WUI causes a significant fall in output.

Building on their work on the WUI, Ahir et al. (2018) also develop a World Trade Uncertainty (WTU) index that measures uncertainty related to trade for the same 143 individual countries, on a quarterly basis since 1996, and using the EIU country reports. The WTU index is constructed counting the occurrence of the word “uncertainty” near a word linked to trade in the EIU country reports.

Due to growing interest in economic policy uncertainty, Husted et al. (2020) construct a monetary policy uncertainty (MPU) index based on public perception about Federal Reserve monetary policy actions and consequences. Using a VAR model, the authors show that an increase in MPU causes larger credit spreads and lower output.

Finally, Caldara and Iacoviello (2018) develop a Geopolitical Risk (GPR) index at monthly frequency, starting in 1985. GPR index counts the occurrence of words related to geopolitical tensions in leading international newspapers. It captures well the important geopolitical events such as the Gulf Wars, the 9/11 attacks, the 2014 Russia-Ukraine crisis, and the Paris terrorist attacks. Estimating a VAR model on U.S. data, they find that an increase in GPR index causes persistent fall in industrial production, employment and international trade.

1.2.5. *Synthesis*

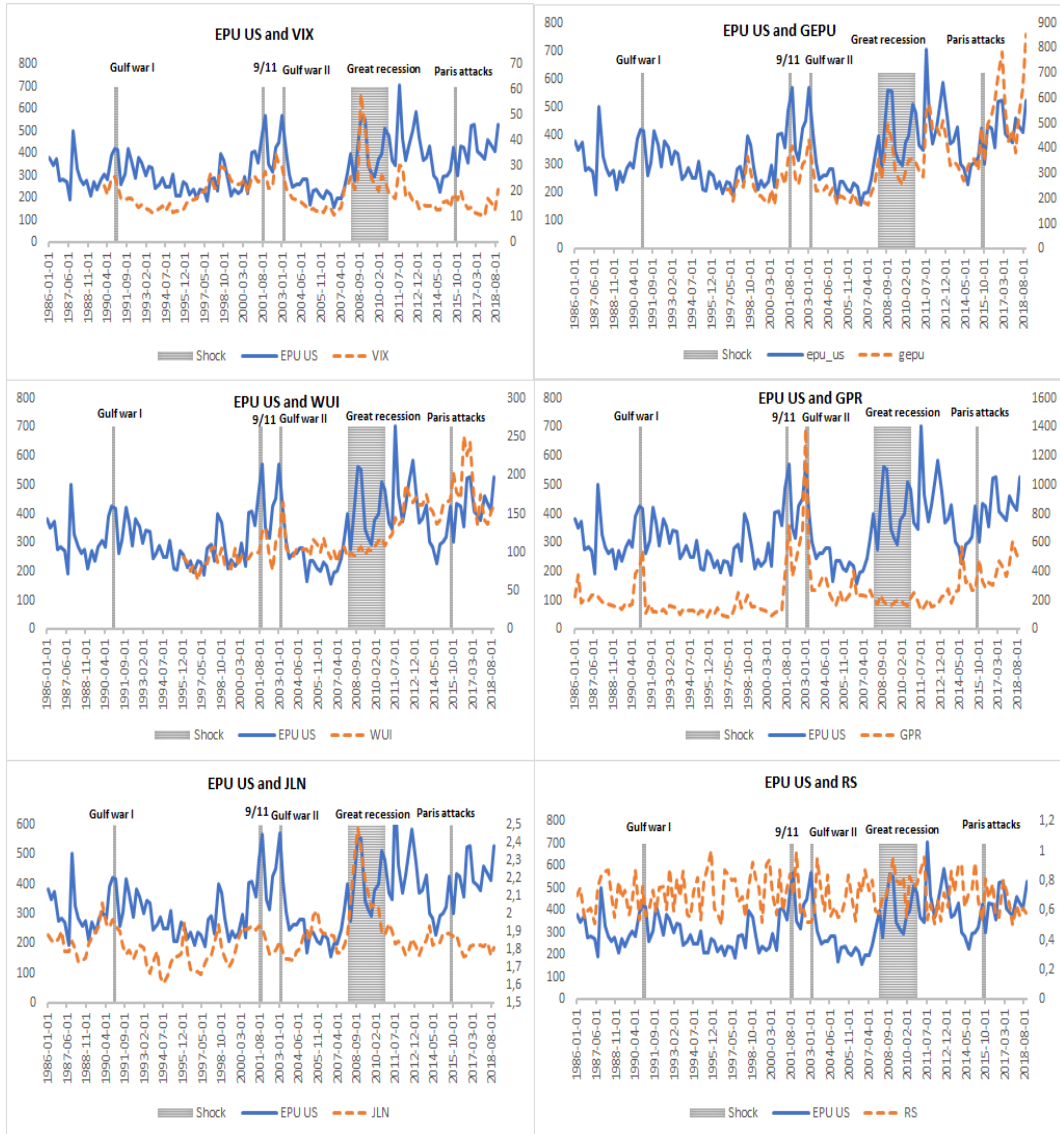
Given that the concept of uncertainty is a mixture of risk and uncertainty, there is no perfect measure, leading to various proxies. As noted by Bloom (2014), it is important to develop a wider set of uncertainty measures, in order to capture all aspects of uncertainty : time horizon of uncertainty (short-run versus long-run uncertainty), types of uncertainty (demand versus supply, technology versus policy), or the nature of uncertainty (risk versus Knightian). In this regard, relying on a dynamic factor model, Charles et al. (2018) compute an uncertainty composite indicator (UCI) based on three different sources of uncertainty—financial, political, and macroeconomic—for the US economy over the period 1985-2015. Estimating a structural VAR model, they find that this composite index captures well the most important part of uncertainty which is fundamental for business cycle fluctuations.

Even existing measures do not capture the same aspect of uncertainty, they generally reflect well some important events, such as the Gulf Wars and the 9/11 attacks. This is highlighted by Figure 1.1 showing other measures against EPU index that is becoming the most commonly used measure of uncertainty. Table 1.1 also indicates that some existing measures are intercorrelated.

1.3. **Transmission channels of uncertainty shock**

There are many channels through uncertainty shocks may adversely impact economic activity. This section presents three main channels mentioned in the literature.

FIGURE 1.1 – Dynamics of different measures of uncertainty



Notes : EPU US stands for Economic Policy Uncertainty index (Baker et al., 2016) for US, WUI stands for the World Uncertainty Index of Ahir et al. (2018) at global level, JLN stands for the uncertainty measure of Jurado et al. (2015), RS stands for the uncertainty measure of Rossi and Sekhposyan (2015), and GPR stands for the Geopolitical Risks index (Caldara and Iacoviello, 2018). Sources : Author's calculation based on data from Datastream (for VIX), Baker et al. (2016) (for EPU), Jurado et al. (2015), Rossi and Sekhposyan (2015), and Caldara and Iacoviello (2018).

nature.³ These are : (i) real options, (ii) precautionary saving, and (iii) financing constraints.

3. See Bloom (2014) for other channels.

TABLE 1.1 – Correlation between different measures of uncertainty

	EPU US	VIX	GEPU	WUI	GPR	JLN	RS
EPU US	1.0000						
VIX	0.3968	1.0000					
GEPU	0.7677	0.0600	1.0000				
WUI	0.4466	-0.3790	0.7133	1.0000			
GPR	0.3092	-0.0330	0.3091	0.2341	1.0000		
JLN	0.2212	0.4985	0.0193	-0.1488	-0.1320	1.0000	
RS	-0.1507	0.1451	-0.2451	-0.1542	-0.2655	0.2042	1.0000

Notes : EPU US stands for Economic Policy Uncertainty index (Baker et al., 2016) for US, GEPU represents Global Economic Policy index of Davis (2016), WUI stands for the World Uncertainty Index of Ahir et al. (2018) at global level, JLN stands for the uncertainty measure of Jurado et al. (2015), RS stands for the uncertainty measure of Rossi and Sekhposyan (2015), and GPR stands for the Geopolitical Risks index (Caldara and Iacoviello, 2018). Sources : Author's calculation based on data from Datastream (for VIX), Baker et al. (2016) (for EPU), Jurado et al. (2015), Rossi and Sekhposyan (2015), and Caldara and Iacoviello (2018).

1.3.1. Real options

The *real options* is one of the main channels through which uncertainty shocks influence economic activity (Bernanke, 1983 ; McDonald and Siegel, 1986 ; Pindyck, 1991 ; Dixit and Pindyck, 1994 ; Boyle and Guthrie (2003) ; Bloom, 2009). The idea is as follows : when firms face higher uncertainty, in presence of irreversibility or adjustment costs in investment, they have higher opportunity to postpone investment decision. In other words, they adopt a “wait-and-see” attitude, since higher uncertainty rises the *real-option value* to waiting for new information. This results in a fall in investment that is accompanied with a drop in hiring and output. The channel of the real options effect was previously rationalized by Bernanke (1983) and, later, reviewed in Pindyck (1991). This channel received a particular attention in Bloom (2009) who developed a model with a time-varying second moment and a mix of labor and capital adjustment costs. Numerically solving and estimating

this model on firm-level data, Bloom (2009) show that macroeconomic uncertainty shock produces a rapid drop in aggregate output and employment, because higher uncertainty encourage firms to postpone their investment and hiring. Bloom (2009) also jointly estimate labor and capital adjustment costs and bring out that, contrary to labor adjustment costs, capital adjustment costs matter more.

1.3.2. *Precautionary saving*

The second main channel through which macroeconomic uncertainty may affect economic outcomes is *precautionary saving*. The precautionary saving corresponds to the extra-saving caused by uncertainty about future income. It is worth noting that the channel of precautionary saving effect is not in the seminal paper of Bloom (2009). Precautionary saving was first theoretically rationalized by Lelan (1968) who shows that, in presence of uncertainty about future income, agent with decreasing risk aversion rises saving while delaying consumption. The fall in consumption demand causes a decline in consumer price, and likely induces economic contraction in the short run, while the long-run impact is ambiguous.

One can believe that, for a closed economy (where savings equals investment), higher uncertainty may have positive effect on output, because increase in saving goes with the same increase in investment. However, with price stickiness (as in New Keynesian framework), higher uncertainty may cause economic downturn even in a closed economy, because fall in prices will not be sufficient to clear markets (Bloom, 2014). For example, calibrating DSGE model with labor market search frictions on

US economy, Leduc and Liu (2016) show that the presence of nominal rigidities reinforces the adverse impact of uncertainty so that results from DSGE can match the empirical pattern from the VAR. Basu and Bundick (2017) also find that model with flexible prices cannot replicate the empirical evidence from a structural VAR, while the model with nominal price rigidity is consistent with this empirical evidence.

In an open economy context, Ghosh and Ostry (1997) incorporate macroeconomic uncertainty in the intertemporal model of the current account, and show that higher uncertainty in national cash flow (output less investment less government consumption) causes more saving for precautionary motives. Using data for the United States, Japan, and the United Kingdom, Ghosh and Ostry (1997) find empirical support for their theoretical prediction. In the same vein, Fogli and Perri (2015) build a standard open economy model with time varying macroeconomic uncertainty to quantitatively corroborate the empirical evidence that higher uncertainty causes residents to save more, leading to an accumulation of foreign assets. Building small open economy with incomplete asset markets and time-varying volatility in the real interest rates, Fernandez-Villaverde et al. (2011) find that increase in real interest rate volatility causes a contraction in economic activity with capital outflows. Gourio et al. (2013) develop a two-country model with different exposure to global disaster, and find that risky country has a lower interest rate due to higher precautionary savings. And a rise in disaster probability causes an appreciation of the exchange rate of this country, because its marginal utility increases more. Finally, studying the effects of a credit crunch on consumer spending in an heterogeneous-agent incomplete-market

model, Guerrieri and Lorenzoni (2017) show that an unexpected permanent fall in consumers' borrowing capacity, causes constrained consumers to repay their debt, and unconstrained consumers to rise their precautionary savings.

1.3.3. Financial frictions

Financial frictions are the third main channels through which macroeconomic uncertainty adversely impacts economy conditions. The underlying mechanisms is that higher uncertainty increases the probability of default, leading to a rise in default premium. In fact, in uncertain environment, financial intermediaries would have the difficulty to evaluate the quality of investment projects. To cover against default risk, financial intermediaries charge a premium. This leads to a rise in the cost of firm external financing, and fall in investment.

Some papers (Christiano et al., 2014 ; Gilchrist et al., 2014 ; Arellano et al., 2019) explore the macroeconomic impact of uncertainty in presence of financial frictions. Christiano et al. (2014) incorporate the financial accelerator mechanism pioneered by Bernanke et al. (1999) in a standard monetary DSGE (dynamic stochastic general equilibrium) model with risk shocks. Calibrating on US data, they find that, fluctuations in risk are the most important shock driving the business cycle. Besides, Gilchrist et al. (2014) develop a model with heterogeneous firms that are subject to time-varying idiosyncratic uncertainty, non-convex capital adjustment frictions, and frictions in both debt and equity markets. They show that uncertainty fluctuations and innovations in credit spreads both affect the effective supply of credit and in-

vestment. Arellano et al. (2019) also build a model with heterogeneous firms facing default risk and time-varying volatility shocks to analyze the interconnection between uncertainty shocks with financial frictions. Contrary to Gilchrist et al. (2014) who focus on the dynamics of investment with frictionless labor market, Arellano et al. (2019) find that fluctuations in the volatility of idiosyncratic productivity shocks causes large contractions in economic activity associated with worsened credit conditions.

Caldara et al. (2016) empirically explore the interaction between financial and uncertainty shocks. Estimating a Structural VAR in which shocks are identified based on penalty function approach developed by Faust (1998) and Uhlig (2005), they find evidence that the Great Recession was likely caused by a combination of financial and uncertainty shocks.

1.4. Conclusion

Given that the World is highly interconnected with increasingly uncertainty, the literature on uncertainty is growing. There are two strands of the literature on uncertainty : one on developing uncertainty measures and, the other on assessing the macroeconomic consequences of uncertainty shocks.

This thesis aims to contribute on the second strand about the macroeconomic consequences of global uncertainty fluctuations. It provides three contributions to this literature. The first contribution in Chapter 2 concerns the impact of global uncertainty on economic activity by comparing developed countries to developing

and emerging countries. Indeed, since existing studies focus generally on developed countries, Chapter 2 makes a comparative analysis of the impact of uncertainty on the economic activity in developed economies against developing and emerging countries. This is motivated by the fact that the transmission of global uncertainty shocks may depend on country characteristics, particularly according to whether country is highly industrialized or not. This analysis is conducted estimating a panel VARX on 20 highly industrialized countries and 96 developing and emerging countries, over the period 1997-2017. These countries are selected based on data availability.

To better understanding why the impact of global uncertainty shocks is not the same for the group of developed economies and the group of developing and emerging economies, Chapter 3 explores how some country characteristics alter the transmission of global uncertainty shocks. These characteristics include international trade openness, international financial openness and financial development. Indeed, the transmission of global uncertainty may depend on the degree of trade openness and finance openness, since it is through international trade and finance that global uncertainty induces uncertainty in an open economy. Concerning financial development, the underlying idea is the degree of financial development interacts with all the three main channels through which global uncertainty impact economic activity. The empirical analysis in Chapter 3 relies on a Interacted Panel VAR (IPVAR) where the interaction variable is the level of financial development, the degree of trade openness or the degree of financial openness. Based on data availability, the sample covers 107 countries over the period 1997-2017. These countries 20 developed

countries and 87 developing and emerging countries.

The third (final) contribution in Chapter 4 focuses the influence of global economic uncertainty on oil price. The analysis consists in assessing the impact of global uncertainty and financial shock on oil price dynamics while accounting the impact of global financial shock. This is important because the two shocks are strongly associated. To trace out the impact of the two shocks on oil price, this chapter relies on VAR framework by jointly identifying the two shocks by sign restrictions with the penalty function approach.

This thesis ends with a conclusion that summarizes all the results obtained from the three essays.

Chapitre 2

Macroeconomic impacts of global uncertainty : developed countries vs developing and emerging countries

2.1. Introduction

Since the seminal paper of Bloom (2009) in the midst of the 2008-09 global financial crisis, there is a growing literature on the macroeconomic consequences of uncertainty shocks. Previously, the macroeconomic consequences of uncertainty were the focus of many papers, such as Bernanke (1983), McDonald and Siegel (1986), Pindyck, 1991, Dixit and Pindyck, 1994, Boyle and Guthrie (2003), among others.

Despite the growing literature on the economic impact of uncertainty shocks, most studies focus on industrialized countries with a little focus on less developing

economies. This chapter fills this gaps by comparing the transmission of global uncertainty shocks across group of economies (group of developed economies vs group of developing and emerging economies). Through international trade and finance, global uncertainty induces uncertainty in an open economy. Depending on the underlying channel, the impact of global uncertainty shock should depend on the characteristics of a given economy. The main channels include : real options (Bernanke, 1983, McDonald and Siegel, 1986, Pindyck, 1991, Dixit and Pindyck, 1994, Boyle and Guthrie, 2003 ; Bloom, 2009), precautionary saving (Fernandez-Villaverde et al., 2011 ; Fogli and Perri, 2015 ; Guerrieri and Lorenzoni, 2017) and financial frictions (Arellano et al., 2019 ; Christiano et al., 2014). Real options correspond to the fact that, following in rise in uncertainty, firms prefer to postpone investment decision, in presence of irreversibility or adjustment costs in investment. Precautionary saving represents the extra-saving caused by uncertainty about future income, leading to a decline in consumption demand and then consumer price. Finally, financial frictions channel refers to the fact that, in a higher uncertainty environment, to cover against default risk of investment projects, financial intermediaries charge a premium. This results in a rise in the cost of firm external financing, and fall in investment.

Concerning real options effect, one can believe that this channel, which is based on investment adjustment costs, should be more important for developing and emerging countries compared to industrialized economies. For instance, the degree of irreversibility in investment may increase with bureaucratic quality and regulations such capital controls. The later make impossible for domestic and foreign investors to

sell their assets and reallocate their funds (Pindyck, 1991). However, less-developed financial systems or strong financing constraints may mitigate the real options effect. Indeed, Boyle and Guthrie (2003) show that financing constraint lowers the value of waiting to invest in presence of higher uncertainty because the threat of a future funding shortfall leads the firm to undertake sub-optimal early investment. So, there is an ambiguity on whether the channel through real options effect is more important for less developed countries compared to industrialized economies.

One can unequivocally think that precautionary saving channel is more important in less developed countries compared to industrialized countries. Indeed, because of lower financial development in developing and emerging countries, household face more credit constraints and then make more precautionary saving as self-insurance against higher uncertainty (Guerrieri and Lorenzoni, 2017). Besides, the lack of social insurance in less developed countries causes household to save more for precautionary motives when they face greater income uncertainty (Engen and Gruber, 2001).

With regards to the channel of financial frictions, as the two other channels, it obviously interacts with the degree of financial development, and there is also an ambiguity whether it is more important for less developed economies characterized by lower financial development. On the one hand, the adverse effect of uncertainty through financial frictions may be amplified by lower financial development, because the increase in the cost of external financing will be more pronounced and firms will be easily credit constrained. On the other hand, external financing is less important in less developed financial system, making aggregate investment less affected by

uncertainty shocks through financial frictions.

The study relies on a panel VAR estimated on 20 developed countries and 96 developing and emerging countries¹, over the period 1997-2017. This study is related to the work of Carriere-Swallow and Cespedes (2013) that compare the impact of uncertainty in 20 developed countries and 20 emerging countries, using quarterly data. Contrary to Carriere-Swallow and Cespedes (2013), we generalize the analysis to larger group of countries including many developing countries, using annual data. Besides, instead of relying on stock market volatility used in Carriere-Swallow and Cespedes (2013) that captures uncertainty about equity returns, our study considers the most recent developed indices of global uncertainty that aims to reflect economic and political uncertainty, and not just uncertainty about equity returns.

Our results show evidence that higher global uncertainty causes a drop in GDP, consumption, investment and price in both groups of countries. However, the drop in consumption is more pronounced in developing and emerging countries compared with developed economies. This finding holds using different measures of global uncertainty.

The rest of this chapter is structured as follows. Section 2.2 presents the empirical strategy and describes data. Section 2.3 presents and discusses the empirical results. Finally, Section 2.4 concludes.

1. Since boundary between developing and emerging economies is particularly less clear nowadays, we consider a sole group of developing and emerging countries.

2.2. Empirical strategy and data

2.2.1. Empirical strategy

Following Carriere-Swallow and Cespedes (2013), to investigate the transmission of global uncertainty to economic outcomes, we consider a panel vector autoregression with exogenous variables (VARX), in which exogenous variables include global uncertainty index and a variable capturing global financial activity.² Following Lütkepohl (2005), Section 10.6., our panel VARX can be written :

$$Y_{it} = \sum_{s=1}^p A_s Y_{it-s} + \sum_{s=0}^q B_s X_{it-s} + u_i + c_i t + \varepsilon_{it} \quad (2.1)$$

where $i = 1, \dots, N$ and $t = 1, \dots, T$ represent respectively country and time indices; $Y_{it} = (y_{it}^1, \dots, y_{it}^K)'$ is a $(K \times 1)$ vector of endogenous variables, $X_t = (x_t^1, \dots, x_t^L)'$ is a $(L \times 1)$ vector of exogenous variables common to all countries; A_s for $s = 1, \dots, p$ are fixed $(K \times K)$ coefficient matrices, B_s for $s = 0, \dots, q$ are fixed $(K \times L)$ coefficient matrices; $u_i = (u_i^1, \dots, u_i^K)'$ is a fixed $(K \times 1)$ vector of country fixed effects; $c_i t$ represent country-specific time trends; $\varepsilon_{it} = (\varepsilon_{it}^1, \dots, \varepsilon_{it}^K)'$ is a $(K \times 1)$ vector of residuals for endogenous variables assumed to have the following characteristics : $E(\varepsilon_{it}) = 0_{K \times 1}$, $E(\varepsilon_{it}\varepsilon_{it}') = \Sigma$ for all i and t , $E(\varepsilon_{it}\varepsilon_{is}') = 0$ for all $t \neq s$.

2. As in Carriere-Swallow and Cespedes (2013), with drop the US in the analysis, variables capturing global uncertainty and global financial conditions are considered to be exogenous to domestic variables, for each country under consideration. Preliminary analysis shows that the global variables are not affected by domestic variables, for each individual country. Therefore, to improve the quality of statistical inference, we consider (panel) VARX approach.

When the number of individuals (N) is large relative to the time series dimension (T), ordinary least squares (OLS) estimation with fixed effects does not yield consistent estimates (known as the Nickell bias, Nickell, 1981). In the other hand, GMM estimator is recommended for samples with large N and small T . Given the dimension of our sample ($T=21$ and $N=20$ for developed countries or $N=96$ for developing and emerging countries), following d'Albis et al. (2019) the model is estimated by the bias-corrected fixed-effects estimator developed by Hahn and Kuersteiner (2002). This technique is appropriate when $0 < N/T < \infty$ (as in our case).³

It is worth noting that some potential country heterogeneity in our panel data set is mitigated by including country-fixed effects (u_i) and country-specific time trends (c_it).

After estimating the model, we compute the impulse response functions, i.e. the responses of endogenous variables to structural shocks of endogenous variables and to innovations in exogenous shocks (sometimes called multiplier analysis). Since our focus is on the responses of endogenous variables to an exogenous variable (global uncertainty), the identification of structural shocks of endogenous variables does not matter here (See Lütkepohl, 2005, Section 10.6.).

3. See Hahn and Kuersteiner (2002) who find, among others, the efficiency of the bias-corrected estimator measured by the root mean squared error (RMSE) comparing it to the generalized method of moments estimator.

2.2.2. *Data*

Our data set covers 116 countries, including 20 developed countries and 96 developing and emerging countries⁴ over the period 1997-2017. Countries are selected based on data availability in order to have a balanced panel that is required in the bias-corrected fixed-effects estimation of Hahn and Kuersteiner (2002). Besides, we drop US in sample in order to have the exogeneity of variables for global uncertainty and global financial activity. Furthermore, we exclude small countries with a population of less than 1 million.

To proxy for global uncertainty, we first consider the global economic policy uncertainty (GEPU) index computed by Davis (2016), as a GDP-weighted average of national EPU indices for 20 countries : Australia, Brazil, Canada, Chile, China, France, Germany, Greece, India, Ireland, Italy, Japan, Mexico, the Netherlands, Russia, South Korea, Spain, Sweden, the United Kingdom, and the United States. For robustness analysis, we also use two alternative proxies for global uncertainty : the US economic policy uncertainty (EPU) index computed by Baker et al. (2016) and, the World Uncertainty index (WUI) constructed by Ahir et al. (2018) at the global level as GDP weighted average of the individual WUI of 143 countries that is computed using frequency counts of “uncertainty” (and its variants) in the Economist Intelligence Unit (EIU) country reports that discuss major political and economic developments, and contain analysis and forecasts of political, policy and economic conditions. EPU index for US is available at monthly frequency from January 1985;

4. The lists of the two groups of countries are provided in Appendix.

GEPU is available at monthly frequency from January 1997; and WUI is available on a quarterly basis from 1996. To have annual data for these indices, we take their annual averages.

Following the literature (Bloom, 2009; Baker et al., 2016; Carriere-Swallow and Cespedes, 2013), S&P 500 stock index, taken from Datastream, is used to account for global financial activity. Variables capturing economic conditions are real GDP (PPP, 2011 USD), real consumption (PPP, 2011 USD), real investment (PPP, 2011 USD) and consumer price, all taken from Penn World Table (PWT 9.1, Feenstra et al., 2015). Real GDP, consumption and investment are expressed per capita dividing by total population that is also taken from PWT.

Table 2.1 reports the summary statistics of country macroeconomic variables. As expected, the average level of GDP, consumption and investment per capita is higher in developed countries than in developing and emerging countries. This is also the case of consumer price index, reflecting the Balassa Samuelson effect.

TABLE 2.1 – Summary statistics

Variables	All	Developed countries	Developing and emerging countries
GDP per capita (PPP, 2011 USD)	12379.49	32779.31	8129.528
Consumption per capita (PPP, 2011 USD)	6726.639	17816.66	4416.217
Investment per capita (PPP, 2011 USD)	3269.177	8792.196	2118.547
Consumer price (relative to US)	0.501	0.930	0.411

Sources : Sources : Author's calculation based on data from Penn World Table (PWT 9.1, Feenstra et al., 2015).

2.3. Empirical Results

2.3.1. Main finding

We begin the empirical analysis by estimating the panel VARX system on all the sample, where endogenous variables are log real GDP per capita, log consumer price, log real consumption per capita, log real investment per capita, and exogenous variables are uncertainty index and log S&P 500. Panel unit root tests reject the null hypothesis of the unit root on detrended variables (with country-specific linear trend).⁵ We then consider, a VAR model on variables in levels while accounting for country heterogeneity (by including country-specific effects and country-specific time trends). In any case, these macroeconomic variables must enter in levels if they have unit roots. Indeed, they should be cointegrated if they are integrated, and using the first difference of integrated variables in the VAR may lead to a loss of information when a cointegration relation exists. Using AIC (Akaike information criterion) and BIC (Bayesian information criterion), we choose $p=1$ and $q=1$ so as to eliminate any serial correlation in the residuals. The confidence intervals are obtained by Monte Carlo simulations with 5000 replications.

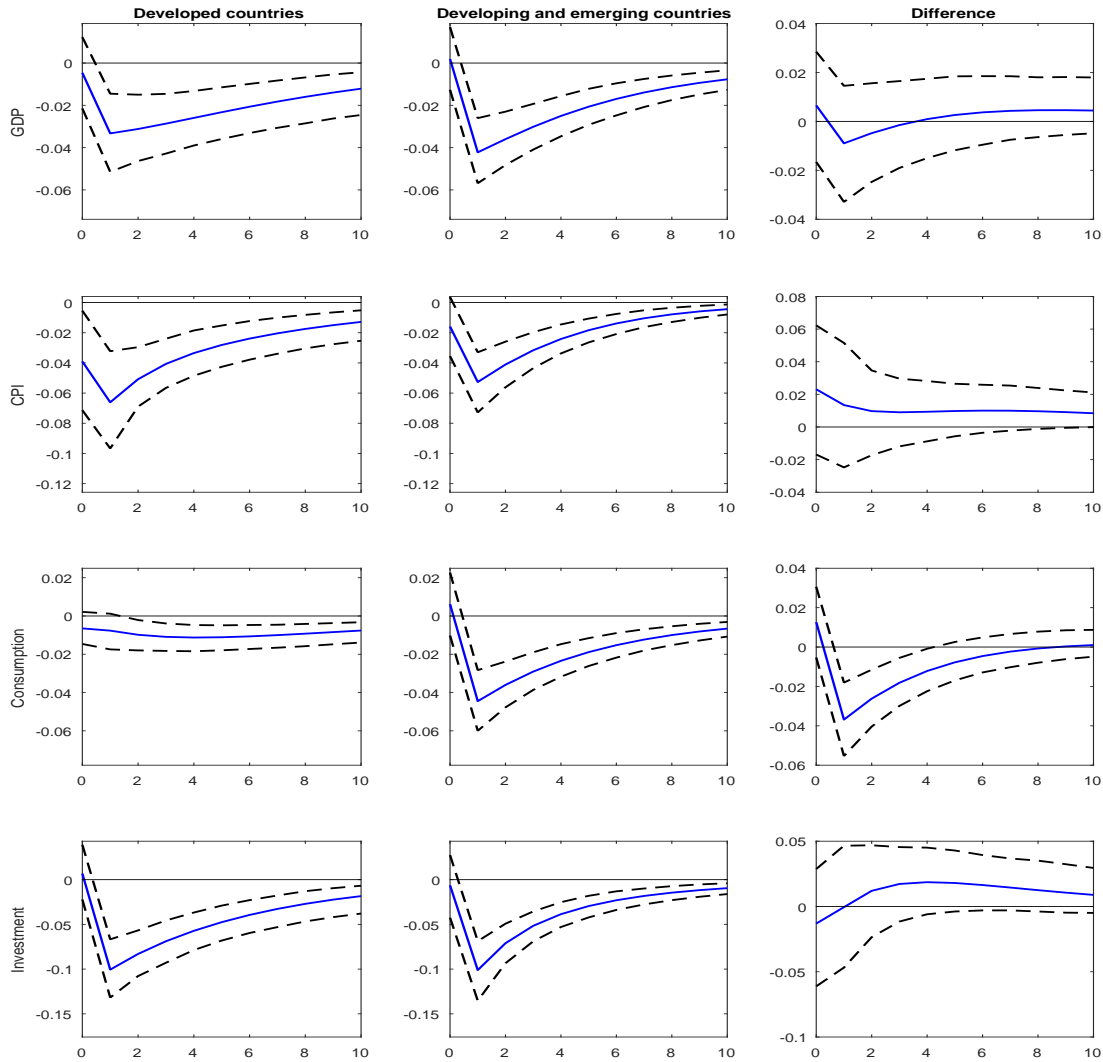
Figure 2.1 displays the responses of endogenous variables to a shock on GEPU index; while Table 2.2 reports the values of estimated responses for some periods after the shock. The size of this shock represents one unit increase in GEPU. In

5. Some studies such as Bloom (2009) and Carriere-Swallow and Cespedes (2013) consider cyclical variables using the Hodrick-Prescott (HP) filter. However, as shown by Hamilton (2018), HP filter has important shortcomings including the fact that it “*introduces spurious dynamic relations that have no basis in the underlying data-generating process*”(Hamilton, 2018).

Figure 2.1 and Table 2.2, the first and the second columns report respectively the impact for the group of developed markets and the group of developing and emerging markets; while the third column displays the difference between the first and the second column (the impact for developing and emerging countries minus the impact for developed countries).⁶ In response to the shock, GDP per capita falls for both of the group of developed countries and the group of developing and emerging countries. The response of GDP is not significant at the year of the shock and significant from one to ten years after the shock. Our estimates reveal that GDP per capita significantly decrease at the peak (one year after the shock) by 0.033% for developed countries and by 0.042% for developing and emerging countries. However, the values for the two groups are not significantly different. For both groups of countries, the decline in GDP is accompanied with significant drop in consumer price, consumption and investment. Consumer price falls at the peak (one year after the shock) by 0.066% and 0.053% for developed markets, and developing and emerging economies, respectively. As for GDP, the magnitude of decline in consumer price is significantly different for the two groups. At the peak, drop in consumption per capita for the two groups is respectively 0.011% (three years after the shock) and 0.045% (one year after the shock); and the impact for developing and emerging being significantly higher. For the two groups, investment falls by roughly the same value (0.101%) at the peak (one year after the shock).

6. The two samples being independent, the impulse responses of the differences are computed as the difference in impulse responses (the same logic applies to the corresponding confidence intervals).

FIGURE 2.1 – Responses to global economic policy uncertainty (GEPU)



Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

2.3.2. Robustness analysis

This subsection aims at checking the robustness of the aforementioned results. This robustness analysis is conducted through two dimensions : using alternative measures of uncertainty (US economic policy uncertainty and World uncertainty

TABLE 2.2 – Responses to global economic policy uncertainty (GEPU)

	Developed countries	Developing and emerging countries	Difference
GDP			
Year 0	-0.005	0.002	0.007
Year 1	-0.033*	-0.042*	-0.009
Year 2	-0.031*	-0.036*	-0.005
Year 5	-0.023*	-0.021*	0.003
Year 10	-0.012*	-0.008*	0.004
Consumer price			
Year 0	-0.039*	-0.016	0.023
Year 1	-0.066*	-0.053*	0.013
Year 2	-0.051*	-0.041*	0.010
Year 5	-0.028*	-0.018*	0.010
Year 10	-0.013*	-0.004*	0.008
Consumption			
Year 0	-0.006	0.006	0.013
Year 1	-0.008	-0.045*	-0.037*
Year 2	-0.010*	-0.036*	-0.026*
Year 5	-0.011*	-0.019*	-0.008
Year 10	-0.008*	-0.007*	0.001
Investment			
Year 0	0.007	-0.006	-0.013
Year 1	-0.101*	-0.101*	-0.001
Year 2	-0.083*	-0.071*	0.012
Year 5	-0.048*	-0.030*	0.018
Year 10	-0.018*	-0.010*	0.009

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

index) and considering alternative specification of the model (without S&P500).

2.3.2.1. *Alternative measures of uncertainty*

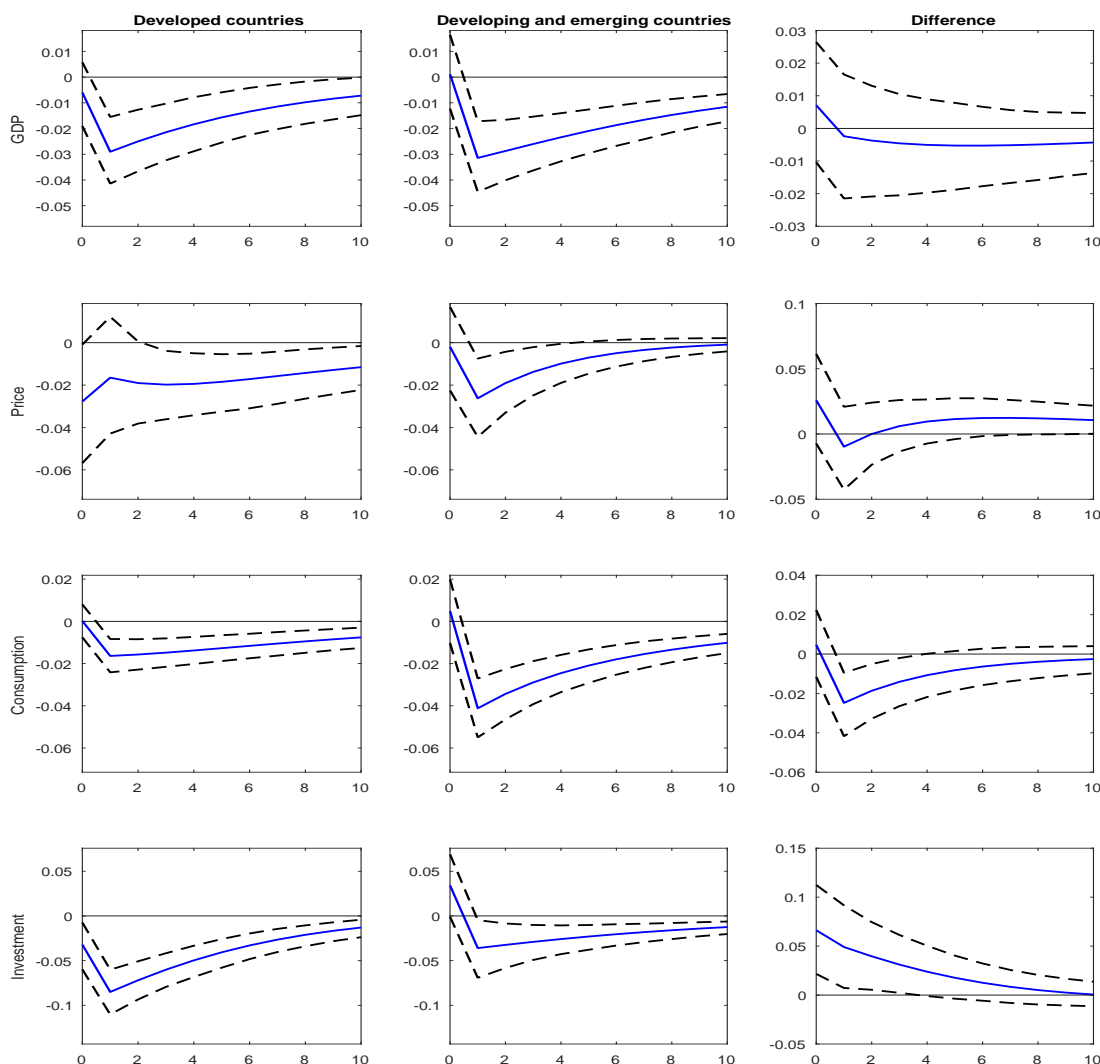
The results above are obtained using US EPU constructed by Baker et al. (2016), as a proxy for uncertainty. To check the robustness of our finding, two alternative

measures of uncertainty are considered here : the US EPU index constructed by Davis (2016) and the World uncertainty index (WUI) developed by Ahir et al. (2018).

Figure 2.2 and Table 2.3 show the responses to a shock representing one unit increase in US EPU. As above, this shock induces a drop in GDP, consumer price, consumption and investment, for all groups of countries. Indeed, in response to this shock, GDP significantly declines by 0.029% and 0.031% at the peak (one year after the shock) for the group of developed countries and the group of developing and emerging countries, respectively ; and the difference between these values is not significant. Consumer price falls insignificantly by 0.028% at the peak (the year of the shock) in developed economies, while it declines significantly by 0.026% at the peak (one year after the shock) in developing and emerging economies ; and the difference between the falls in consumer price for the two groups is not significant. As in GEPU, the drop in consumption is significantly higher in developing and emerging countries. Indeed, consumption falls significantly, at the peak (one year after the shock) by 0.016% in developed markets and by 0.041% in developing and emerging markets. Contrary to the estimations using GEPU, here, the magnitude in investment fall is significantly higher in developed countries : at the peak (one year after the shock), investment falls significantly by 0.085% in developed countries and by 0.036% in developing and emerging countries.

As a second alternative measure of uncertainty, we rely on WUI of Ahir et al. (2018). The corresponding responses are shown in Figure 2.3 and Table 2.4. In response to a shock representing one unit increase in WUI, GDP falls significantly at

FIGURE 2.2 – Responses to US economic policy uncertainty (EPU)



Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

the peak (one year after the shock) by 0.031% in developed economies and by 0.044% in developing and emerging economies. The response in GDP fall is significantly higher for the group of developing and emerging economies only at the year of the shock. Consumer price falls significantly, at the peak (the year of the shock), by 0.086% in developed countries and by 0.059% in developing and emerging economies ;

TABLE 2.3 – Responses to US economic policy uncertainty (US EPU)

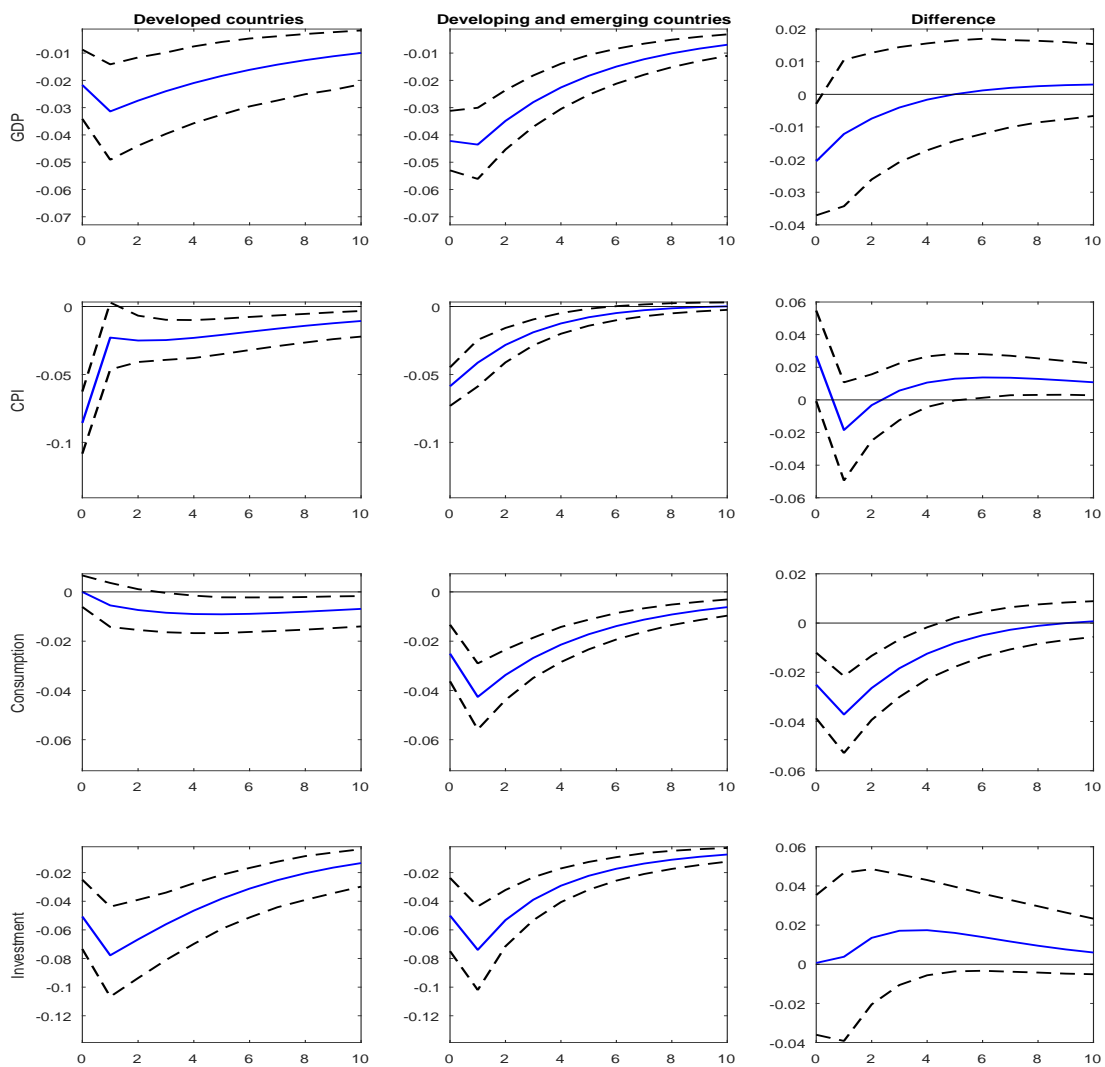
	Developed countries	Developing and emerging countries	Difference
GDP			
Year 0	-0.006	0.001	0.007
Year 1	-0.029*	-0.031*	-0.002
Year 2	-0.025*	-0.029*	-0.004
Year 5	-0.016*	-0.021*	-0.005
Year 10	-0.007	-0.012*	-0.004
Consumer price			
Year 0	-0.028	-0.002	0.026
Year 1	-0.017	-0.026*	-0.010
Year 2	-0.019	-0.019*	0.000
Year 5	-0.018*	-0.007	0.011
Year 10	-0.012*	-0.001	0.011*
Consumption			
Year 0	0.000	0.005	0.005
Year 1	-0.016*	-0.041*	-0.025*
Year 2	-0.016*	-0.034*	-0.019*
Year 5	-0.013*	-0.021*	-0.008
Year 10	-0.008*	-0.010*	-0.003
Investment			
Year 0	-0.032*	0.034	0.066*
Year 1	-0.085*	-0.036*	0.049*
Year 2	-0.072*	-0.032*	0.040*
Year 5	-0.041*	-0.023*	0.018
Year 10	-0.013*	-0.012*	0.001

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

the fall in consumer price is significantly higher for the group of developing and emerging countries from six years after the shock. The results in Figure 2.3 and Table 2.4 also confirm that the fall in consumption is significantly higher in developing and emerging countries : consumption falls significantly by 0.009% at the peak (five years after the shock) in developed economies and by 0.043% at the peak (one year after

the shock) in developing and emerging economies. The drop in investment is not significantly different for the two groups of countries : at the peak (one year after the shock), investment significantly declines by 0.078% for developed countries and by 0.074% for developing and emerging countries.

FIGURE 2.3 – Responses to World uncertainty index (WUI)



Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

TABLE 2.4 – Responses to World uncertainty index (WUI)

	Developed countries	Developing and emerging countries	Difference
GDP			
Year 0	-0.022*	-0.042*	-0.021*
Year 1	-0.031*	-0.044*	-0.012
Year 2	-0.027*	-0.035*	-0.007
Year 5	-0.018*	-0.018*	0.000
Year 10	-0.010*	-0.007*	0.003
Consumer price			
Year 0	-0.086*	-0.059*	0.027
Year 1	-0.023*	-0.041*	-0.018
Year 2	-0.025*	-0.028*	-0.003
Year 5	-0.021*	-0.008*	0.013
Year 10	-0.011*	0.000	0.011*
Consumption			
Year 0	0.000	-0.025*	-0.025*
Year 1	-0.005	-0.043*	-0.037*
Year 2	-0.007	-0.034*	-0.026
Year 5	-0.009*	-0.017*	-0.008
Year 10	-0.007*	-0.006*	0.001
Investment			
Year 0	-0.051*	-0.050*	0.001
Year 1	-0.078*	-0.074*	0.004
Year 2	-0.067*	-0.053*	0.013
Year 5	-0.038*	-0.022*	0.016
Year 10	-0.013*	-0.007*	0.006

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

2.3.2.2. *Alternative specification*

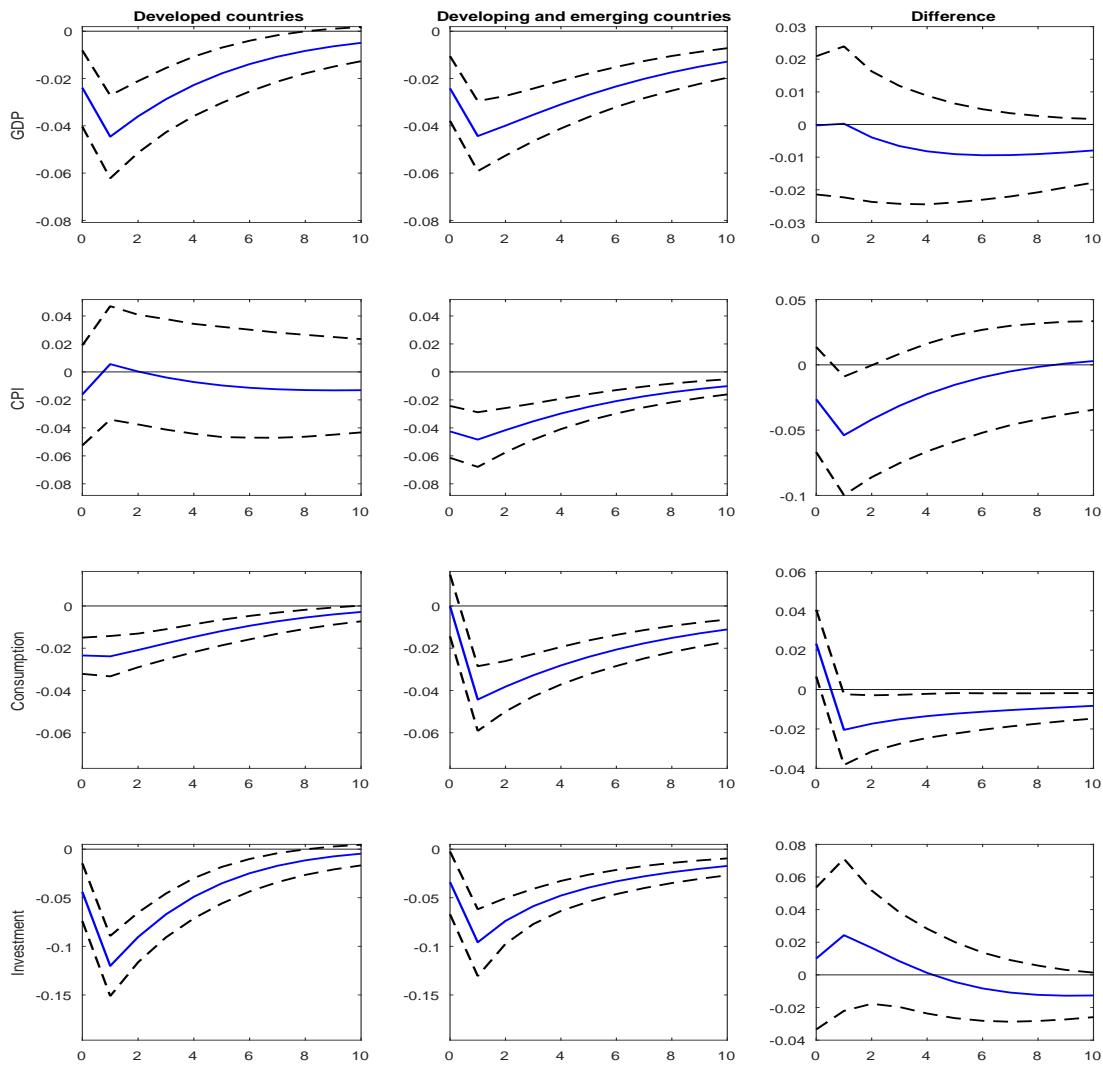
The estimations above concern models without the log of S&P500 index to account global financial conditions. As in Baker et al. (2016), we check the robustness of the finding while dropping S&P500 index. The corresponding results, using GEPU

as the measure of uncertainty, are indicated in Figure 2.4 and Table 2.5. The results corroborate the evidence that global uncertainty shock causes a drop in GDP, prices, consumption and investment for the two groups of developed economies and developing and emerging economies. On impact, the drop in consumption is significant for developed countries and non-significant for developing and emerging countries. From one year after the shock, the magnitude of consumption fall in developing and emerging economies becomes significantly higher. Therefore, considering a model without S&P500 index does not alter our finding that higher global uncertainty leads to fall in GDP, prices, consumption and investment for all groups of countries, but with stronger drop in consumption in developing and emerging markets.

2.3.3. Discussion

To sum up, the results highlight that a rise in global uncertainty causes a drop in GDP, consumer price, consumption and investment, for both group of developed countries and group of developing and emerging countries. The magnitudes of falls in GDP, consumer price and investment are roughly similar for the two groups, while the decline in consumption is much stronger for the group of developing and emerging markets. We can then ask why only the reaction of consumption significantly varies across markets and why this not the case for investment (the reactions of GDP and consumer price are generally the consequences of those of consumption and investment). To answer, one must rely on the channels through which a rise in uncertainty may impact economic outcomes. The channel through real options effect

FIGURE 2.4 – Responses to global economic policy uncertainty (GEPU), without S&P500 index



Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

is that, due to investment adjustment costs, firms prefer to postpone investment decision in presence of higher uncertainty. We can think that, this channel should be more important in developing and emerging countries because of bureaucratic quality and regulations such capital controls. Particularly, in presence of capital controls,

TABLE 2.5 – Responses to global economic policy uncertainty (GEPU), without S&P500 index

	Developed countries	Developing and emerging countries	Difference
GDP			
Year 0	-0.024*	-0.024*	0.000
Year 1	-0.045*	-0.044*	0.000
Year 2	-0.036*	-0.040*	-0.004
Year 5	-0.018*	-0.027*	-0.009
Year 10	-0.005	-0.013*	-0.008
Consumer price			
Year 0	-0.016	-0.043*	-0.026
Year 1	0.006	-0.048*	-0.054*
Year 2	0.000	-0.042*	-0.042
Year 5	-0.010	-0.025*	-0.015
Year 10	-0.013	-0.010*	0.003
Consumption			
Year 0	-0.023*	0.000	0.023*
Year 1	-0.024*	-0.044*	-0.020*
Year 2	-0.021*	-0.038*	-0.017*
Year 5	-0.012*	-0.024*	-0.012*
Year 10	-0.003	-0.011*	-0.008*
Investment			
Year 0	-0.044*	-0.034*	0.010
Year 1	-0.120*	-0.096*	0.024
Year 2	-0.090*	-0.074*	0.017
Year 5	-0.035*	-0.040*	-0.004
Year 10	-0.005*	-0.017*	-0.013

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

domestic and foreign investors are allowed to sell their assets and reallocate their funds (Pindyck, 1991). However, the real options effect may be dampened by the low degree of financial development in less developed countries. In fact, as established by Boyle and Guthrie (2003), in a less developed financial environment, financing

constraint reduces the value of waiting to invest in presence of higher uncertainty since firms make sub-optimal early investment in response to the threat of a future funding shortfall. Therefore, there is an ambiguity on whether the channel through real options effect is more important in less developed countries; and this ambiguity is in line with our result that, the response of investment to uncertainty shock is roughly the same for the group of developed economies and the group of developing and emerging economies.

The second channel that is the precautionary saving refers to the extra-saving made by household in response to higher uncertainty in future income. There are some reasons that make this channel more important in less developed countries, and explaining why the response of consumption to uncertainty shock is stronger in developing and emerging countries. First, in developing and emerging countries where financial systems are not well developed, credit constraints magnify precautionary saving caused by higher uncertainty because households save more and then reduce consumption demand, as self-insurance against uncertainty when they are face credit constraints (Guerrieri and Lorenzoni, 2017). Besides, the lack of social insurance in less developed markets leads household to save more for precautionary motives in response to greater income uncertainty (Engen and Gruber, 2001).

Concerning the third channel through financial frictions, it obviously interacts with the degree of financial development. There is an ambiguity whether this channel is more important for developing and emerging countries with less developed financial systems, and this ambiguity is also in line with our evidence that the reaction of

investment to higher uncertainty is roughly the same for the two groups of countries. On the one hand, in developing and emerging countries where financial development is not deep, the adverse effect of uncertainty through financial frictions may be stronger, because firm will face higher cost of external financing and will be easily credit constrained. On the other hand, external financing being less important in an environment with less developed financial systems, investment should be less influenced by uncertainty shocks through financial frictions.

To sum up, our evidence that higher uncertainty causes stronger fall in consumption in developing and emerging economies seems reflect the fact that, precautionary saving is more important in these countries due to their low level of financial development and the lack of social insurance. In addition, the non-significant difference in the reactions of investment (and may be GDP) between group of countries seems reflect the ambiguity on the fact that the channels through real options effect and financial frictions are more important for less developed countries.

2.4. Conclusion

Since the 2008-09 global financial crisis and the seminal paper of Bloom (2009), there is a growing literature on the economic consequences of uncertainty shocks. Most studies focus on industrialized countries with a little focus on less developing economies. This chapter fills this gaps by exploring whether the transmission of uncertainty shocks differs across economies (the group of developed economies vs the group of developing and emerging economies). Estimating a panel VAR on 20 develo-

ped countries and 96 developing and emerging countries, over the period 1997-2017, our results show that global uncertainty shock causes a drop in GDP, consumption, investment and price in both groups of countries. The magnitudes of falls in GDP, consumer price and investment are roughly similar for the two groups, while the decline in consumption is much stronger for developing and emerging markets. This finding holds using alternative measures of global uncertainty.

Our evidence that higher uncertainty causes stronger fall in consumption in developing and emerging economies seems reflect the fact that precautionary saving is more important in these countries due to their low level of financial development and the lack of social insurance. Therefore, as policy implications, to mitigate the loss of welfare caused by higher uncertainty, less developed countries should implement policies aiming at promoting their financial system and social insurance.

Appendix

List of countries in the sample

Developed countries (20) Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

Developing and emerging countries (96) Albania, Algeria, Angola, Argentina, Bangladesh, Benin, Bolivia, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Central African Republic, Chad, Chile, China, Colombia, Congo. Dem. Rep., Congo. Rep., Costa Rica, Cote d'Ivoire, Dominican Republic, Ecuador, Egypt. Arab Rep., El Salvador, Ethiopia, Ghana, Greece, Guatemala, Guinea, Haiti, Honduras, Hong Kong, Hungary, India, Indonesia, Iran. Islamic Rep., Iraq, Jamaica, Jordan, Kenya, Korea, Kuwait, Lao PDR, Lebanon, Lesotho, Liberia, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Niger, Nigeria, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Romania, Rwanda, Saudi Arabia, Senegal, Sierra Leone, Singapore, South Africa, Sri Lanka, Sudan, Syrian Arab Republic, Tanzania, Thailand, Togo, Trinidad and Tobago, Tunisia, Turkey, Uganda, United Arab Emirates, Uruguay, Venezuela, Vietnam, West Bank and Gaza, Zambia, Zimbabwe.

Chapitre 3

The role of openness and financial development in the transmission of global uncertainty shock

This chapter is from a co-authored article with Dramane Coulibaly

3.1. Introduction

Uncertainty is widely known as one of the main causes of global recession. Since the seminal paper of Bloom (2009), there is a growing empirical studies exploring the transmission of uncertainty on economic outcomes. The chapter 3 contributes to this literature by investigating how some country characteristics alter the transmission of global uncertainty. We first examine how the impact of global uncertainty is influenced by openness. Two pillars of openness are considered : trade openness and

financial openness. We also analyze to what extent the level of financial development alters the transmission of global uncertainty.

In the literature, there are three main channels through which uncertainty impact economic performances. These are : real options effect (Bernanke, 1983, McDonald and Siegel, 1986, Pindyck, 1991, Dixit and Pindyck, 1994, Boyle and Guthrie, 2003 ; Bloom, 2009), precautionary saving (Fernandez-Villaverde et al., 2011; Fogli and Perri, 2015; Guerrieri and Lorenzoni, 2017) and financial frictions (Arellano et al., 2019 ; Christiano et al., 2014). Real option reflects the fact that, in presence of higher uncertainty, firms postpone investment decision due to irreversibility or adjustment cost in investment. Precautionary saving corresponds to the extra-saving resulted from uncertainty about future income, inducing a decline in consumption demand and then in consumer price. Finally, financial frictions channel is that higher uncertainty, by rising the default risk (and risk premia) of investment projects, induces an increase in the cost of firm external financing and a fall in investment.

It is obvious that, for each of the three channels, global uncertainty shocks transmit to an open economy through international trade and finance. For instance, Ahir et al. (2018) highlight that uncertainty is more synchronized between countries with strong trade and financial linkages. Caldara and Iacoviello (2018) find that exposure to trade openness significantly matters to industry exposure to geopolitical risk. Furthermore, Fernandez-Villaverde et al. (2011) find that, for an open economy, higher volatility in real interest rate caused by global uncertainty, induces a contraction in economic activity with capital outflows.

The degree of financial development also interacts with the three main channels. First, less-developed financial system or strong financing constraints may mitigate the real options effect. Indeed, as shown by Boyle and Guthrie (2003), in presence of higher uncertainty, financing constraints reduce the value of waiting to invest due to the fact that the threat of a future funding shortfall leads the firm to undertake sub-optimal early investment. Second, in less-developed environment, credit constraints lead household to make more precautionary saving as self-insurance against higher uncertainty (Guerrieri and Lorenzoni, 2017). Finally, the degree of financial development interacts with the financial frictions channel, in two contradictory ways. On the one hand, lower financial development may magnify the adverse impact of uncertainty through financial frictions, because firms will be easily credit constrained with rising in the cost of external financing. On the other hand, in a less developed financial system, external financing is less important and investment should be less affected by uncertainty through financial frictions.

This study is related to the paper of Carriere-Swallow and Cespedes (2013) that employs vector autoregression (VAR) approach to compare the impact of uncertainty in 20 developed countries and 20 emerging countries, with a particularly attention on financial development. Using quarterly from 1990 to 2011, they find that credit constraints can explain up to one-half of the adverse impact of uncertainty shocks on investment in emerging countries with less-developed financial markets. More recently, using a single equation approach (with instrumental variables estimation) with quarterly panel data set of 50 countries over the period 1971-2009, Karaman

and Yildirim-Karaman (2019) assess how financial development alters the impact of uncertainty. They find that financial development dampens the negative impact of uncertainty on output through both consumption and investment. Contrary to these studies, following Towbin and Weber (2013), we consider an Interacted Panel Vector Autoregression (IPVAR) framework on a broad sample of 107 countries over the period 1997-2017. The IPVAR approach allows exploring how the dynamic response of the economy to global uncertainty shocks is influenced by country characteristics such as (trade and financial) openness and financial development.

Our results show evidence that any pillar of openness (trade or financial openness) does not significantly alter the transmission of global uncertainty shocks, but financial institutions development significantly mitigates the adverse impact of global uncertainty on consumption. Specifically, we find that this significant mitigating impact is due to the development of financial institutions in terms of efficiency (ability of institutions to provide financial services at low cost and with sustainable revenues and the level of activity of capital markets) and not in terms of depth (size and liquidity) or access (ability of individuals and companies to access financial services).

The remainder of this chapter is structured as follows. Section 3.2 presents the empirical strategy and describes data. Section 3.3 presents and discusses the empirical results. Finally, Section 3.4 concludes.

3.2. Empirical model and data

3.2.1. Empirical model

To explore the impact of uncertainty conditional on country characteristics, as in Towbin and Weber (2013), we consider the following Interacted Panel VAR (IP-VAR)¹

$$Y_{it} = \sum_{s=1}^p (A_s^0 + A_s^1 x_{it}) Y_{it-s} + u_i + c_i t + \varepsilon_{it} \quad (3.1)$$

where $i = 1, \dots, N$ and $t = 1, \dots, T$ stand for respectively country and time indices; Y_{it} is a $(K \times 1)$ vector of variables comprising a measure of global uncertainty, log S&P500, log real GDP per capita, log consumer price, log real consumption per capita, log real investment per capita; x_{it} stands for country characteristics or the interaction term that can alter the dynamic relationship between the variables of the VAR system can be trade openness, financial openness or financial development; A_s^0 and A_s^1 for $s = 1, \dots, p$ are fixed $(K \times K)$ coefficient matrices $u_i = (u_i^1, \dots, u_i^K)'$ is a fixed $(K \times 1)$ vector of country fixed effects; $c_i t$ represent country-specific time trends; $\varepsilon_{it} = (\varepsilon_{it}^1, \dots, \varepsilon_{it}^K)'$ is a $(K \times 1)$ vector of residuals for endogenous variables assumed to have the following characteristics: $E(\varepsilon_{it}) = 0_{K \times 1}$, $E(\varepsilon_{it} \varepsilon_{it}') = \Sigma$ for all i and t , $E(\varepsilon_{it} \varepsilon_{is}') = 0$ for all $t \neq s$.

As in Towbin and Weber (2013), the model is estimated by OLS, since the Nickel bias (Nickell, 1981) can be neglected given the time dimension of the sample.²

1. An interacted-VAR was used by Caggiano et al. (2017) to explore whether the adverse impact of uncertainty shocks is stronger when the economy is at the Zero Lower Bound.

2. Without interaction, estimating OLS or by the bias-corrected fixed-effects estimator of Hahn and Kuersteiner (2002) (as in Chapter 2) provides roughly the same results, indicating that the Nickel bias can

Since global uncertainty S&P500 are common to all countries and exogenous, we impose block exogeneity for these variable (without interaction term, this is equivalent to the panel VARX model in Equation (2.1)).³ We also impose restriction so that the interaction term alters only the dynamic impact of global uncertainty on the other variables of the system.

As in Chapter 2, panel unit root tests reject the null hypothesis of the unit root on detrended annual variables (with country-specific linear trend). We consider a VAR model on variables in levels while including country-specific time trends.

Since our focus is on the reaction of endogenous variables to global uncertainty that is exogenous vis-à-vis the country variables of the VAR system, the identification of structural shocks of country variables does not matter here (See Lütkepohl, 2005, Section 10.6.).

3.2.2. *Data*

The empirical study relies on a sample of 107 countries (20 developed countries and 87 developing and emerging countries)⁴ over the period 1997-2017. Countries are selected based on data availability, particularly in order to have enough observations on interaction variables. The US is dropped in sample in order to have the exogeneity of variables for global uncertainty and global financial activity. We also exclude small countries with a population of less than 1 million.

be neglected.

3. Preliminary diagnostic show that variables global uncertainty and S&P500 are not influenced by any domestic variables, for each country under consideration.

4. The lists of countries are provided in Appendix.

As a proxy for global uncertainty, we use the global economic policy uncertainty (GEPU) index computed by Davis (2016), as a GDP-weighted average of national EPU indices for 20 countries : Australia, Brazil, Canada, Chile, China, France, Germany, Greece, India, Ireland, Italy, Japan, Mexico, the Netherlands, Russia, South Korea, Spain, Sweden, the United Kingdom, and the United States. To check the robustness of our results, we also consider the World Uncertainty index (WUI) constructed by Ahir et al. (2018) at the global level as GDP weighted average of the individual WUI of 143 countries that measures uncertainty related to trade for each individual country using the Economist Intelligence Unit (EIU) country reports.

To proxy for global uncertainty, we first consider the global economic policy uncertainty (GEPU) index computed by Davis (2016), as a GDP-weighted average of national EPU indices for 20 countries : Australia, Brazil, Canada, Chile, China, France, Germany, Greece, India, Ireland, Italy, Japan, Mexico, the Netherlands, Russia, South Korea, Spain, Sweden, the United Kingdom, and the United States. GEPU is available at monthly frequency from January 1997, while WUI is available on a quarterly basis from 1996. To have annual data, we take the annual averages of the monthly series.

S&P500 stock index, taken from Datastream, is used to account for global financial activity, as in Bloom (2009), Baker et al. (2016), and Carriere-Swallow and Cespedes (2013).

Country endogenous variables in the VAR system, taken from Penn World Table (PWT 9.1, Feenstra et al., 2015), are : real GDP (PPP, 2011 USD), real consumption

(PPP, 2011 USD), real investment (PPP, 2011 USD) and consumer price. Real GDP, consumption and investment are expressed per capita dividing by total population that is also taken from PWT.

Trade openness computed as the sum of exports and imports as a share of GDP is collected the World Bank's World Development Indicators (WDI). To proxy for financial openness, we use the capital account openness (KAOPEN) of Chinn and Ito (2006). This index is based on binary variables of cross-border financial transactions described in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER); a higher value indicates greater financial openness.

To proxy for financial development, we rely on IMF's Financial Development Index database (Svirydzenka, 2016).⁵ This database provides information on financial institutions and financial markets in terms of their depth (size and liquidity), access (ability of individuals and companies to access financial services) and efficiency (ability of institutions to provide financial services at low cost and with sustainable revenues and the level of activity of capital markets). Financial institutions consist of banks, insurance companies, mutual funds, pension funds, and other types of nonbank financial institutions; while financial markets comprises stock and bond markets. The data set includes six sub-indexes that inform how developed financial institutions and financial markets are along the three dimensions of depth, access and efficiency, noted as FID, FIA, FIE, FMD, FMA, and FME, where the letters D, A, and E stand for depth, access, and efficiency, respectively, and I and M stand for

5. For information on the proxies for financial development, see the pioneer studies of King and Levine (1993) Levine et al. (2000).

institutions and markets, respectively. These sub-indices are aggregated into higher-level indices, where the weights are obtained from principal component analysis, in order to compute an index of development of financial institutions (FI), an index of development of financial markets (FM), and at the most aggregated level the financial development (FD) index. Each index is normalized between 0 and 1; a higher value indicating greater financial development. The data set covers 183 countries from 1980 onwards, at annual frequency.

Table 3.1 reports the summary statistics of country macroeconomic variables. As expected, GDP, consumption and investment per capita are higher in developed countries than in developing and emerging countries. This also applies to consumer price, because of the Balassa Samuelson effect. The average level of trade openness is similar for the two groups of countries. The degree of financial openness and financial development is much greater in developed economies. And, each sub-index of financial development is higher in developed countries.

3.3. Empirical Results

3.3.1. The role of openness

In this subsection, we analyze how openness interacts with the transmission of global uncertainty shocks. We consider two pillars of openness : trade openness and financial openness. In the baseline specification, global uncertainty is proxied by GEPU index. Figures 3.1 and 3.2 show the responses using trade and financial

TABLE 3.1 – Summary statistics

Variables	All	Developed countries	Developing and emerging countries
GDP per capita (PPP. 2011 USD)	14945.320	37906.700	9666.847
Consumption per capita (PPP. 2011 USD)	8101.373	20425.740	5268.187
Investment per capita (PPP. 2011 USD)	3890.957	9812.746	2529.627
Consumption price (relative to US)	0.547	0.998	0.443
Trade openness (as % of GDP)	79.345	79.924	79.211
Financial openness index	0.484	2.254	0.077
Financial development index	0.346	0.729	0.257
Financial institutions development index	0.421	0.793	0.335
Financial institutions depth index	0.292	0.730	0.191
Financial institutions access index	0.303	0.703	0.211
Financial institutions efficiency index	0.638	0.796	0.602
Financial markets development index	0.270	0.649	0.180
Financial markets depth index	0.275	0.689	0.177
Financial markets access index	0.326	0.591	0.241
Financial markets efficiency index	0.366	0.653	0.267

Sources : Sources : Author's calculation based on data from Penn World Table (PWT 9.1, Feenstra et al., 2015), World Bank's World Development Indicators (WDI), IMF's Financial Development Index database (Svirydzenka, 2016), and Chinn and Ito (2006).

openness as interaction variable, respectively; while Tables 3.2 and 3.3 indicate the corresponding values for specific years after the shock. The size of the shock represents one unit increase in GEPU index. In these figures and tables, the first and the second columns report respectively the responses at a lower (20th) percentile and a higher (80th) percentile value of interaction variable⁶; while the third column displays the difference between the first and the second columns (the impact at high level minus the impact at lower level).

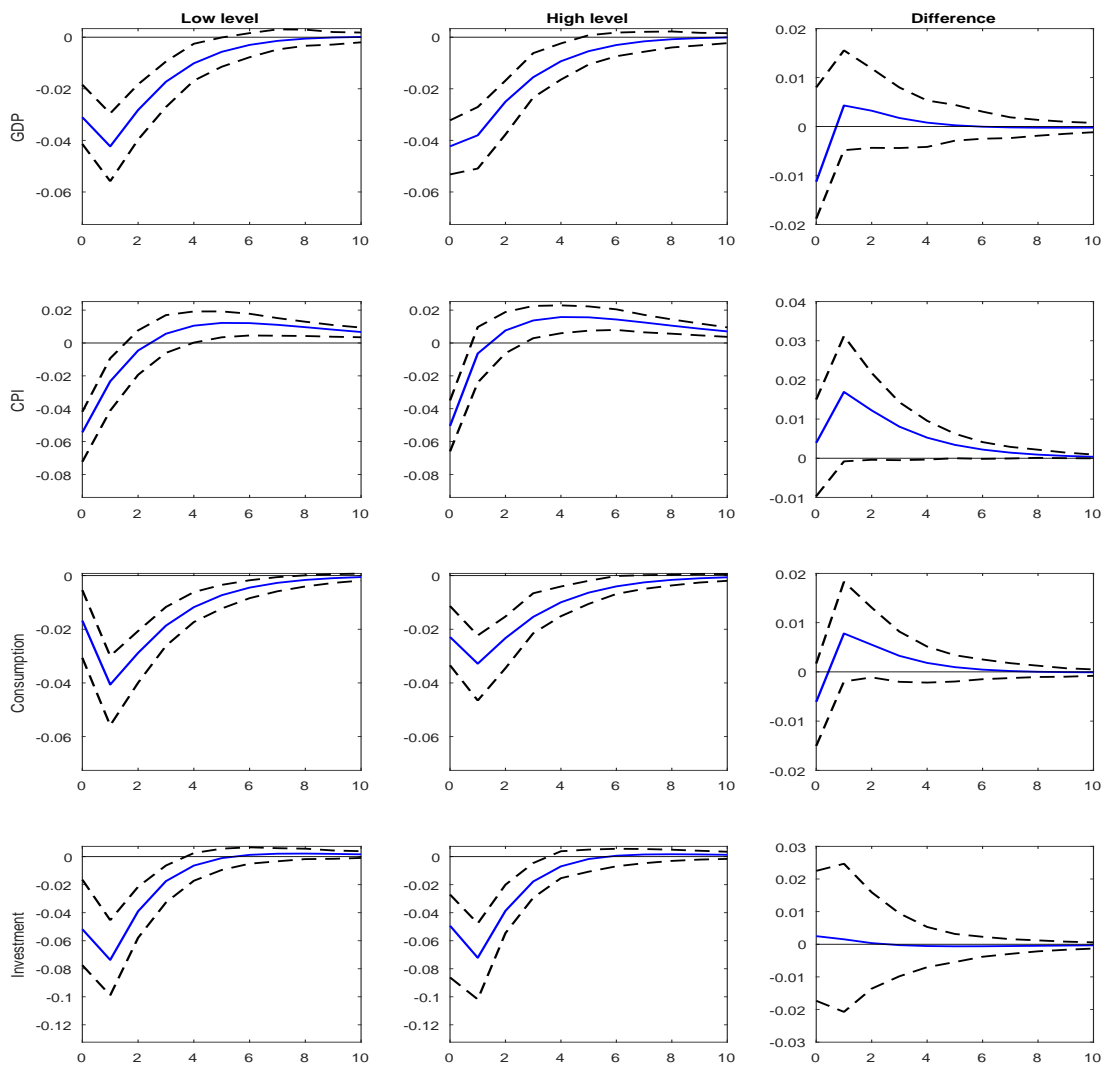
The results in Figure 3.1 and Table 3.2 show that, whatever the degree of openness to trade, higher uncertainty causes a significant decline in GDP, consumer price,

6. We choose these percentiles as in Towbin and Weber (2013). The finding remains unchanged if we consider other percentiles such as (25th vs 75th).

consumption and investment, for many years after this shock. For all horizons, the response of variables do not significantly differ according to the level of trade openness. Indeed, following an uncertainty shock, GDP per capita significantly falls by roughly 0.042% at the peak (one year after the shock for low level of trade openness and the year of the shock of high level of trade openness). The significant decline in consumer price at the peak (the year of the shock) is 0.054% of the low level of trade and 0.050% the high level of trade. For all levels of trade, the response of consumer price becomes significantly positive from four years after the shock. Consumption per capita significantly drops at the peak (one year after the shock) by 0.041% and 0.033% for low and high levels of trade, respectively. Finally, investment per capita significantly declines at the peak (one year after the shock) by 0.074% and 0.072% for the two levels of trade, respectively.

Figure 3.2 and Table 3.3 also indicate that the adverse impact of uncertainty does not significantly differ according to the degree of financial openness. The decline in all variables except consumer price is higher for high level of financial openness, but the difference in reaction is not significant. GDP per capita significantly drops at the peak (one year after the shock) by 0.033% for the low level of financial openness and by 0.046% for the high level of financial openness. At the peak (the year of shock), consumer price significantly declines by respectively 0.058% and 0.051% for the low and the high levels of financial openness. As using trade as interaction variable, the response of consumer price becomes significantly positive from four years after the shock. The significant fall in consumption per capita, at the peak (one year after the

FIGURE 3.1 – Responses to global economic policy uncertainty (GEPU), interaction with trade openness



Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

shock), is respectively 0.032% and 0.040% for the two levels of financial openness. Concerning investment per capita, its significantly decline at the peak (one year after the shock) is respectively 0.070% and 0.075%.

TABLE 3.2 – Responses to global economic policy uncertainty (GEPU), interaction with trade openness

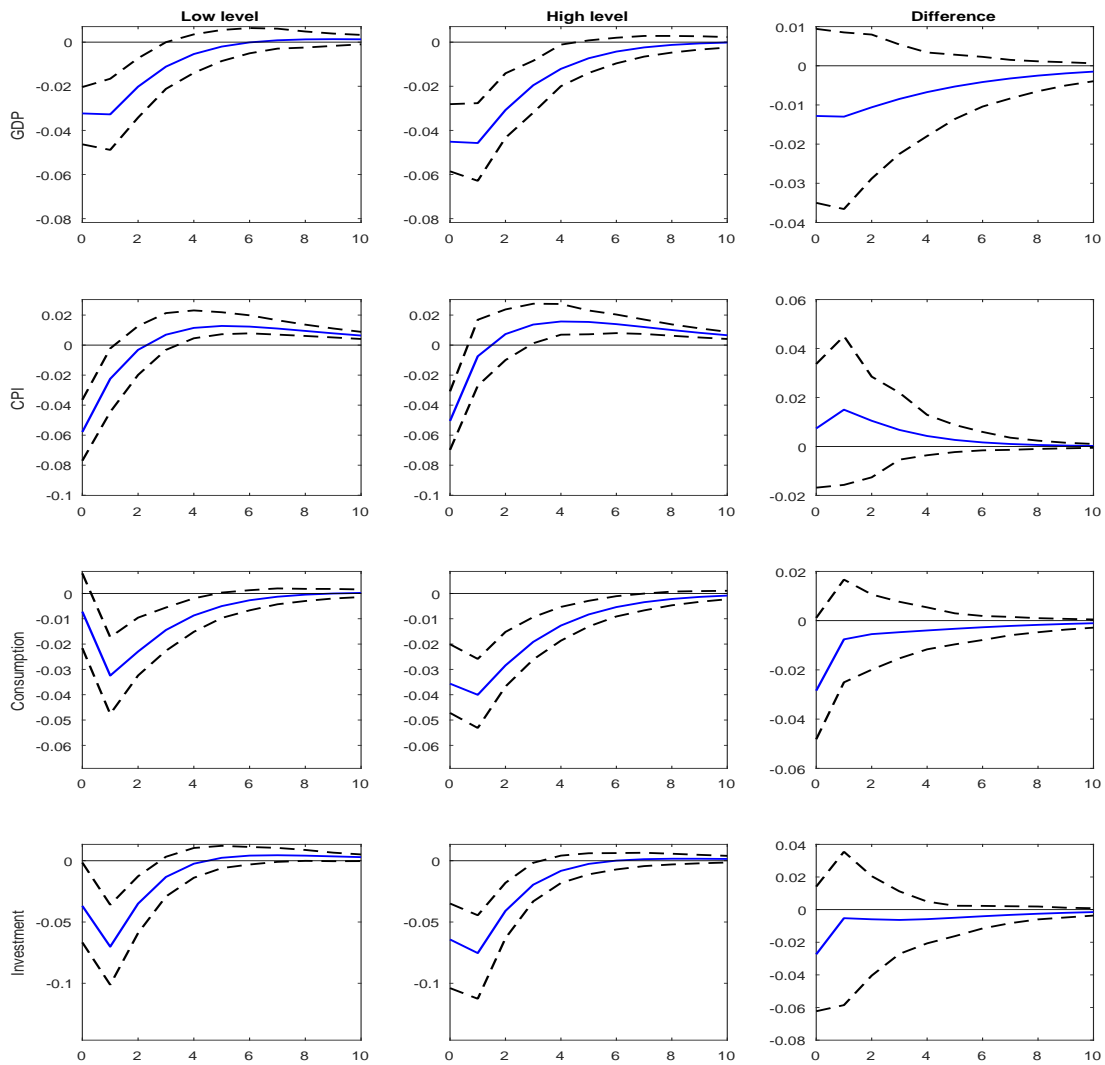
	Low	High	Difference
GDP			
Year 0	-0.031*	-0.042*	-0.011
Year 1	-0.042*	-0.038*	0.004
Year 2	-0.028*	-0.025*	0.003
Year 5	-0.006	-0.005	0.000
Year 10	0.000	0.000	0.000
Consumer price			
Year 0	-0.054*	-0.050*	0.004
Year 1	-0.023*	-0.006*	0.017
Year 2	-0.005	0.008	0.012
Year 5	0.012*	0.016*	0.003
Year 10	0.007*	0.007*	0.000
Consumption			
Year 0	-0.017*	-0.023*	-0.006
Year 1	-0.041*	-0.033*	0.008
Year 2	-0.029*	-0.023*	0.006
Year 5	-0.007*	-0.006*	0.001
Year 10	-0.001	-0.001	0.000
Investment			
Year 0	-0.052*	-0.049*	0.002
Year 1	-0.074*	-0.072*	0.002
Year 2	-0.039*	-0.039*	0.000
Year 5	-0.001*	-0.002*	-0.001
Year 10	0.002	0.001	0.000

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

3.3.2. *The role of financial development*

Here we explore how financial development interacts with the adverse impact to global uncertainty proxied by GEPU index. Instead of considering the aggregate financial development index (FD), we use separately the index of financial institutions development (FI) and the index of financial market development (FM). The

FIGURE 3.2 – Responses to global economic policy uncertainty (GEPU), interaction with financial openness



Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

corresponding dynamic responses are displayed respectively in Figures 3.3 and 3.4 ; and the values for specific periods are reported in Tables 3.4 and 3.5, respectively.

The results in Figure 3.3 and Table 3.4 indicate that higher uncertainty causes significant drops in GDP, consumer price, consumption and investment for many years,

TABLE 3.3 – Responses to global economic policy uncertainty (GEPU), interaction with financial openness

	Low	High	Difference
GDP			
Year 0	-0.032*	-0.045*	-0.013
Year 1	-0.033*	-0.046*	-0.013
Year 2	-0.020*	-0.031*	-0.011
Year 5	-0.002	-0.007	-0.005
Year 10	0.001	0.000	-0.001
Consumer price			
Year 0	-0.058*	-0.051*	0.007
Year 1	-0.022*	-0.007*	0.015
Year 2	-0.003	0.007	0.010
Year 5	0.013*	0.015*	0.003
Year 10	0.006*	0.007*	0.000
Consumption			
Year 0	-0.007	-0.036*	-0.028
Year 1	-0.032*	-0.040*	-0.008
Year 2	-0.023*	-0.028*	-0.005
Year 5	-0.005	-0.008	-0.003
Year 10	0.000	-0.001	-0.001
Investment			
Year 0	-0.037*	-0.064*	-0.027
Year 1	-0.070*	-0.075*	-0.005
Year 2	-0.035*	-0.041*	-0.006
Year 5	0.002	-0.003	-0.005
Year 10	0.003	0.001	-0.001

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

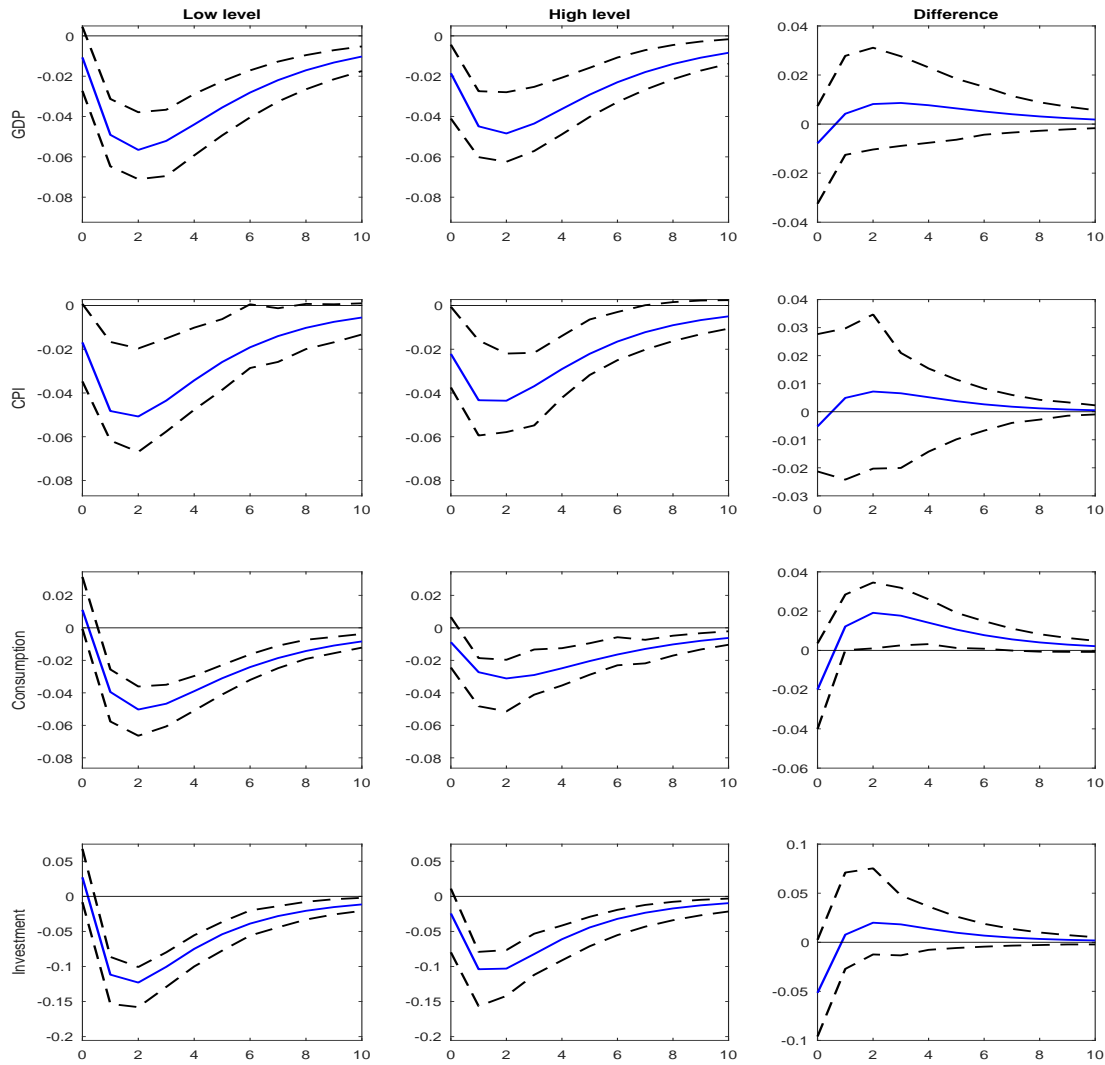
and whatever the degree of financial institutions development. However, consumption drop is significantly higher for the high level of financial institutions development, from one year to six years after the shock. Following a shock representing one unit increase in GEPU index, GDP per capita significantly declines at the peak (two years after the shock) by 0.057% for the low level of financial institutions de-

velopment and by 0.048% for the high level of financial institutions development. In response to this shock, consumer price significantly drops at the peak (two years after the shock) by 0.051% and 0.044% for the low and high levels of financial institutions development, respectively. At the peak (two years after the shock), the significant drop in consumption per capita is respectively 0.050% and 0.031% for the two levels of financial institutions development. For investment per capita, the corresponding values are respectively 0.123% and 0.103%.

Considering financial markets development as the interaction variable, estimations in Figure 3.4 and Table 3.5 indicate higher uncertainty provokes significant drop in GDP, consumer price, consumption and investment during many years, and the drop in any variable does not significantly differ according to the degree of financial markets development. Following a shock representing one unit increase in GEPU index, GDP per capita significantly falls at the peak (two years after the shock) by 0.041% for the low level of financial markets development and by 0.064% for the high level financial markets development. At the peak (two years after the shock), the significant decline in consumer price is 0.038% for the low level of financial markets development and 0.058% for the high level financial markets development. Consumption per capita significantly drops, at the peak (two years after the shock), by 0.043% and 0.037% for the two levels of financial markets development, respectively. Finally, for investment, the corresponding values are respectively 0.105% and 0.125%.

Exploring how financial development interacts with the adverse impact to glo-

FIGURE 3.3 – Responses to global economic policy uncertainty (GEPU), interaction with financial institutions development



Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

bal uncertainty, our results show that it is financial institutions development, and not financial markets development, that matters for the transmission of global uncertainty shock, and particularly on consumption. To further understand how the development of financial institutions matters, we investigate how financial institu-

TABLE 3.4 – Responses to global economic policy uncertainty (GEPU), interaction with financial institutions development

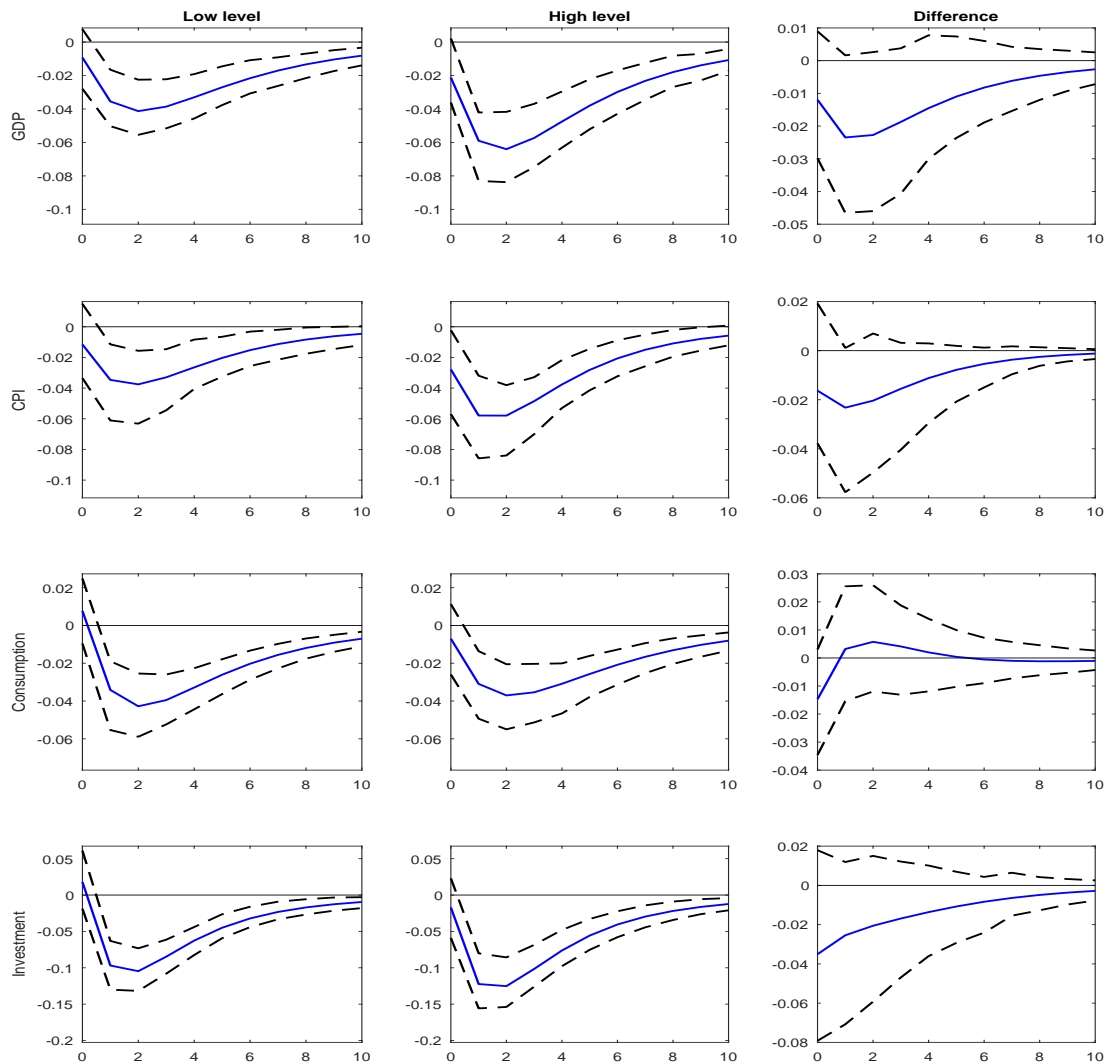
	Low	High	Difference
GDP			
Year 0	-0.011	-0.019*	-0.008
Year 1	-0.049*	-0.045*	0.004
Year 2	-0.057*	-0.048*	0.008
Year 5	-0.036*	-0.029*	0.006
Year 10	-0.010*	-0.008*	0.002
Consumer price			
Year 0	-0.017	-0.022*	-0.005
Year 1	-0.048*	-0.043*	0.005
Year 2	-0.051*	-0.044*	0.007
Year 5	-0.026	-0.022	0.004
Year 10	-0.005	-0.005	0.001
Consumption			
Year 0	0.011	-0.009	-0.020
Year 1	-0.039*	-0.027*	0.012*
Year 2	-0.050*	-0.031*	0.019*
Year 5	-0.031*	-0.020*	0.011*
Year 10	-0.008*	-0.006*	0.002
Investment			
Year 0	0.027	-0.024	-0.052
Year 1	-0.112*	-0.104*	0.008
Year 2	-0.123*	-0.103*	0.020
Year 5	-0.054*	-0.044*	0.010
Year 10	-0.012*	-0.010*	0.002

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

tions interact with global uncertainty in terms of their depth, access and efficiency. To this end, we use separately as the interaction the sub-index of financial institutions depth (FID), the sub-index of financial institutions access (FIA) and the sub-index of financial institutions efficiency (FIE).

The results using the degree of financial institutions depth as the interaction

FIGURE 3.4 – Responses to global economic policy uncertainty (GEPU), interaction with financial markets development



Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

variable are reported in Figure 3.5 and Table 3.5. These results show the impact of global uncertainty does not significantly differ according to the depth of financial institutions. The results in Figure 3.6 and Table 3.7 also indicate that the impact of global uncertainty does not significantly depend on the access to financial insti-

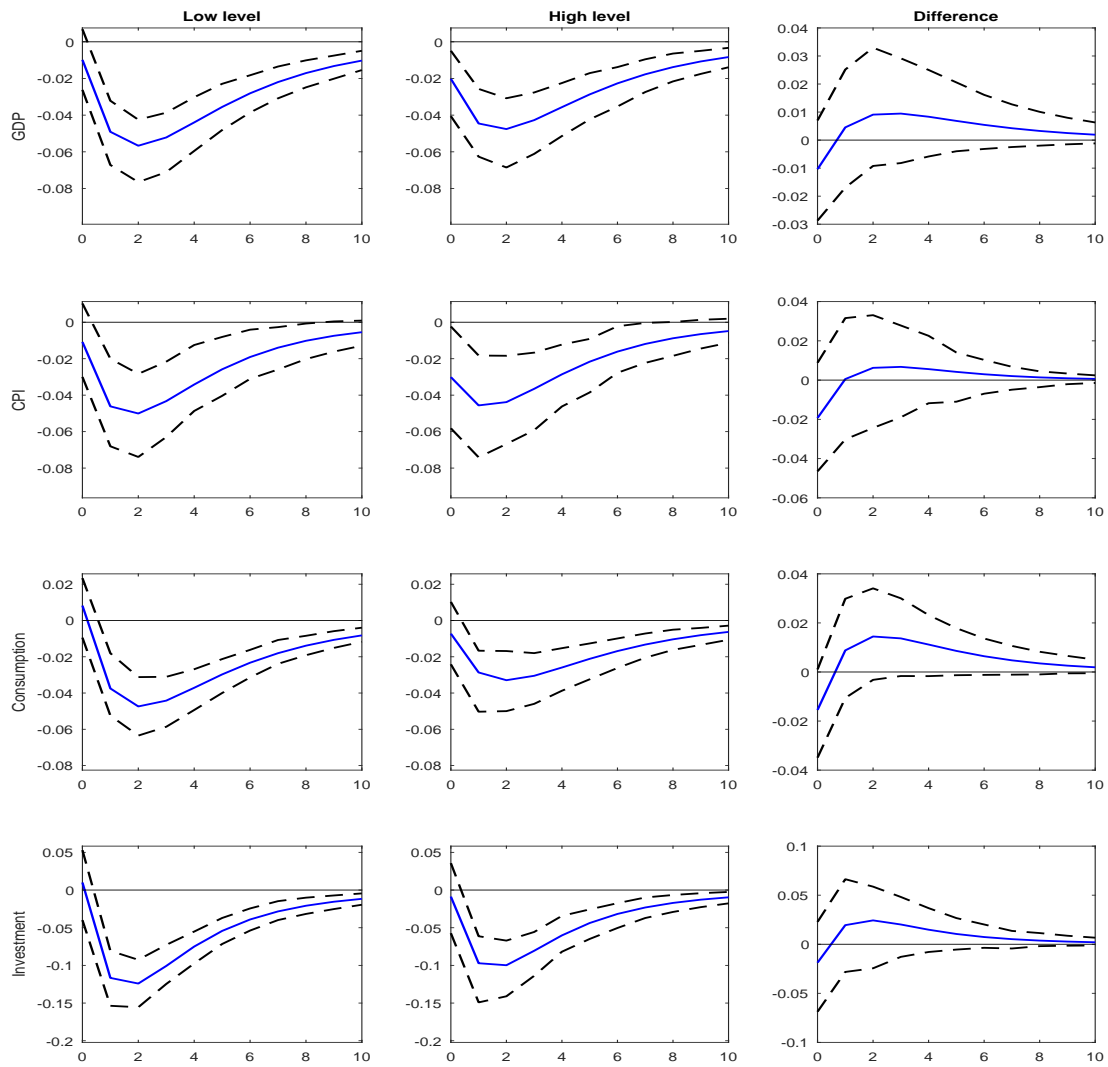
TABLE 3.5 – Responses to global economic policy uncertainty (GEPU), interaction with financial markets development

	Low	High	Difference
GDP			
Year 0	-0.009	-0.021	-0.012
Year 1	-0.036*	-0.059*	-0.023
Year 2	-0.041*	-0.064*	-0.023
Year 5	-0.027*	-0.038*	-0.011
Year 10	-0.008*	-0.011*	-0.003
Consumer price			
Year 0	-0.012	-0.028	-0.016
Year 1	-0.035*	-0.058*	-0.023
Year 2	-0.038*	-0.058*	-0.020
Year 5	-0.020*	-0.028*	-0.008
Year 10	-0.005	-0.006	-0.001
Consumption			
Year 0	0.008	-0.007	-0.015
Year 1	-0.034*	-0.031*	0.003
Year 2	-0.043*	-0.037*	0.006
Year 5	-0.026*	-0.026*	0.000
Year 10	-0.007*	-0.008*	-0.001
Investment			
Year 0	0.018	-0.017	-0.035
Year 1	-0.097*	-0.122*	-0.025
Year 2	-0.105*	-0.125*	-0.021
Year 5	-0.045*	-0.056*	-0.011
Year 10	-0.010*	-0.012*	-0.003

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

tutions. On the contrary, Figure 3.7 and Table 3.8 point out that the efficiency of financial institutions significantly alters the impact of global uncertainty, particularly, on consumption. Indeed, the drop in consumption is significantly for the higher low level of financial institutions efficiency, from one to eight years after the shock.

FIGURE 3.5 – Responses to global economic policy uncertainty (GEPU), interaction with financial institutions depth



Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

3.3.3. Sensitivity analysis

In this subsection, we explore the sensitivity of our finding, using alternative measure of uncertainty and excluding developed countries.

TABLE 3.6 – Responses to global economic policy uncertainty (GEPU), interaction with financial institutions depth

	Low	High	Difference
GDP			
Year 0	-0.010	-0.020*	-0.010
Year 1	-0.049*	-0.045*	0.005
Year 2	-0.057*	-0.048*	0.009
Year 5	-0.036*	-0.029*	0.007
Year 10	-0.010*	-0.008*	0.002
Consumer price			
Year 0	-0.011	-0.030*	-0.019
Year 1	-0.046*	-0.046*	0.001
Year 2	-0.050*	-0.044*	0.006
Year 5	-0.026*	-0.022	0.004
Year 10	-0.005	-0.005	0.001
Consumption			
Year 0	0.008	-0.007	-0.015
Year 1	-0.037*	-0.029*	0.009
Year 2	-0.047*	-0.033*	0.014
Year 5	-0.030*	-0.021*	0.009
Year 10	-0.008*	-0.006*	0.002
Investment			
Year 0	0.010	-0.009	-0.019
Year 1	-0.117*	-0.097*	0.019
Year 2	-0.124*	-0.100*	0.024
Year 5	-0.054*	-0.044*	0.010
Year 10	-0.012*	-0.010*	0.002

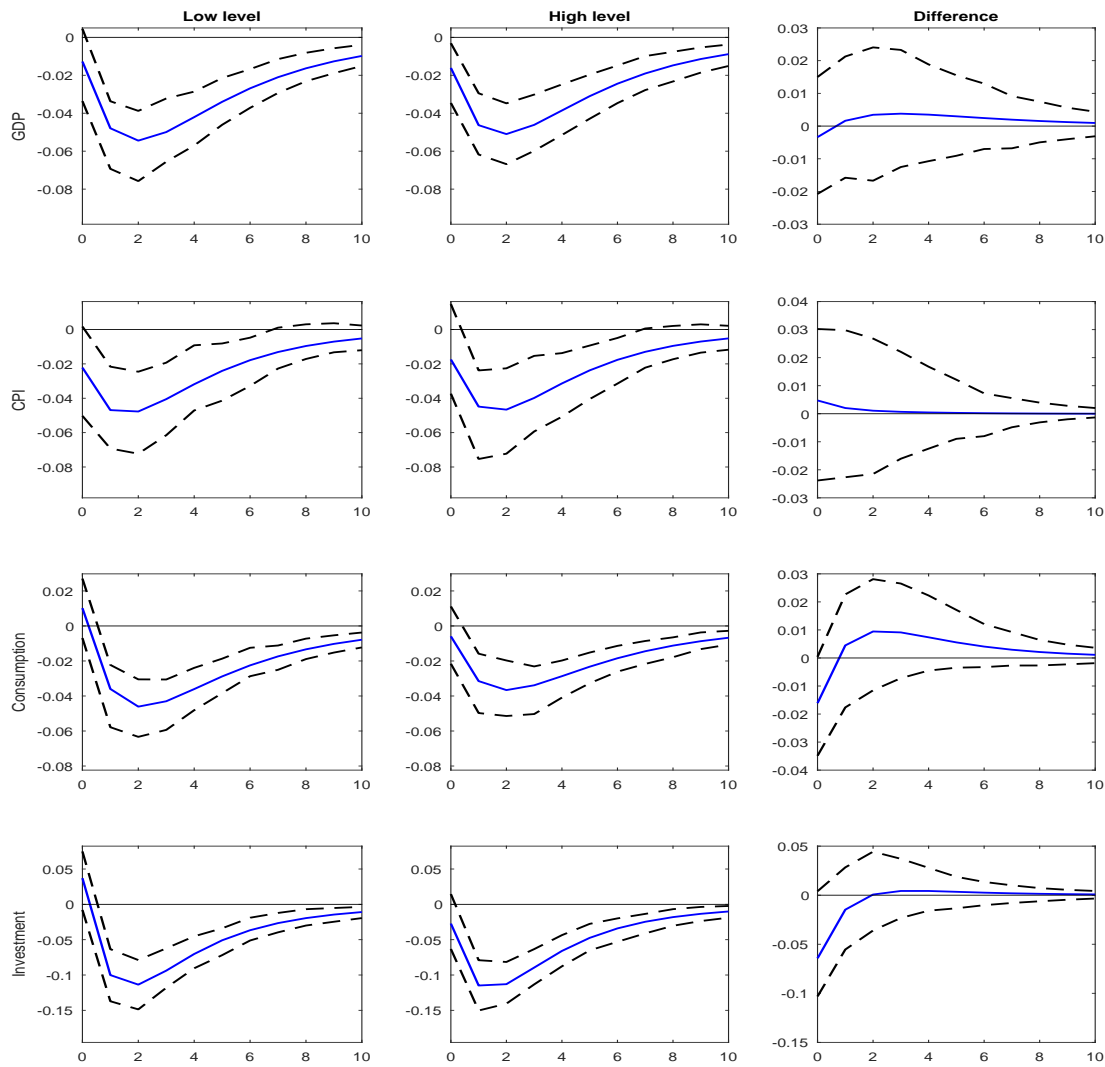
Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

3.3.3.1. *Alternative measure of uncertainty*

The above results are obtained using GEPU index as a proxy for global uncertainty. To check the sensitivity of the results, here we proxy global uncertainty by the World Uncertainty Index (WUI) developed by Ahir et al. (2018).

We first consider the sensitivity using openness variables as the interaction va-

FIGURE 3.6 – Responses to global economic policy uncertainty (GEPU), interaction with financial institutions access



Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

riable. Figure 3-A-1 and Table 3-A-1 report the responses to a shock on WUI with trade openness as the interaction variable ; while Figure 3-A-2 and Table 3-A-2 report the responses to the same with financial openness as the interaction variable. The results in Figures 3-A-1 and 3-A-2, and in Tables 3-A-1 and 3-A-2 roughly

TABLE 3.7 – Responses to global economic policy uncertainty (GEPU), interaction with financial institutions access

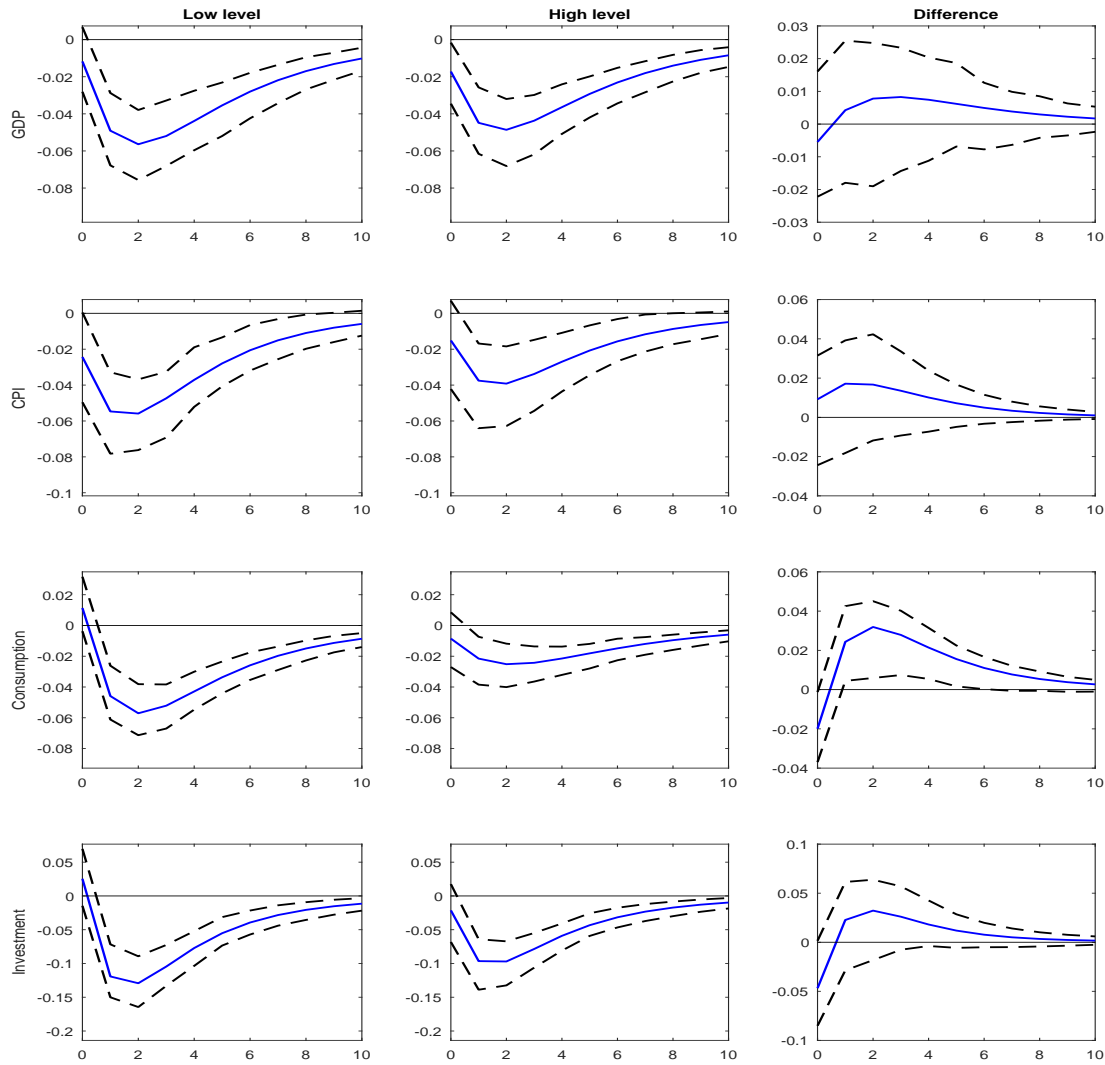
	Low	High	Difference
GDP			
Year 0	-0.013	-0.016*	-0.003
Year 1	-0.048*	-0.046*	0.002
Year 2	-0.054*	-0.051*	0.003
Year 5	-0.034*	-0.031*	0.003
Year 10	-0.010*	-0.009*	0.001
Consumer price index			
Year 0	-0.022	-0.017	0.005
Year 1	-0.047*	-0.045*	0.002
Year 2	-0.048*	-0.047*	0.001
Year 5	-0.024*	-0.024*	0.000
Year 10	-0.005	-0.005	0.000
Consumption per capita			
Year 0	0.010	-0.006	-0.016
Year 1	-0.036*	-0.031*	0.004
Year 2	-0.046*	-0.037*	0.009
Year 5	-0.029*	-0.023*	0.006
Year 10	-0.008*	-0.007*	0.001
Investment per capita			
Year 0	0.037	-0.027	-0.064
Year 1	-0.100*	-0.115*	-0.015
Year 2	-0.114*	-0.113*	0.001
Year 5	-0.051*	-0.047*	0.003
Year 10	-0.011*	-0.010*	0.001

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

confirm the previous finding that (trade and financial) openness does not significantly interact with the adverse impact of uncertainty shock. Although, the drop in GDP (consumption), at only the year of the shock, is significantly higher for the high level of trade (financial) openness.

We also check the robustness of the results with financial development as the

FIGURE 3.7 – Responses to global economic policy uncertainty (GEPU), interaction with financial institutions efficiency



Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

interaction variable. Since only the sub-index of financial institutions efficiency significantly interacts with the responses to uncertainty shock, we report the result using this sub-index as the interaction variable. The corresponding results are reported in Figure 3-A-3 and Table 3-A-3. These results corroborate our finding that

TABLE 3.8 – Responses to global economic policy uncertainty (GEPU), interaction with financial institutions efficiency

	Low	High	Difference
GDP			
Year 0	-0.012	-0.017*	-0.005
Year 1	-0.049*	-0.045*	0.004
Year 2	-0.056*	-0.049*	0.008
Year 5	-0.035*	-0.029*	0.006
Year 10	-0.010*	-0.008*	0.002
Consumer price			
Year 0	-0.024*	-0.015	0.009
Year 1	-0.055*	-0.038*	0.017
Year 2	-0.056*	-0.039*	0.017
Year 5	-0.028*	-0.021*	0.007
Year 10	-0.006	-0.005	0.001
Consumption			
Year 0	0.011	-0.009	-0.020
Year 1	-0.046*	-0.022*	0.024*
Year 2	-0.057*	-0.025*	0.032*
Year 5	-0.034*	-0.018*	0.016*
Year 10	-0.009	-0.006	0.003
Investment			
Year 0	0.025	-0.021	-0.047
Year 1	-0.119*	-0.097*	0.023
Year 2	-0.129*	-0.097*	0.032
Year 5	-0.055*	-0.043*	0.012
Year 10	-0.011*	-0.010*	0.002

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

financial institutions, in terms of efficiency, significantly influence the transmission of global uncertainty on consumption. Indeed, results in Figure 3-A-3 and Table 3-A-3 show that the drop in consumption per capita is significantly higher for the low of financial institutions efficiency, from one to five years after the shock.

3.3.3.2. Excluding developed countries

We check here the sensitivity of results by excluding developed countries. As in the baseline specification, GEPU index is used as the proxy for global uncertainty.

The responses with interaction with trade and financial openness are respectively displayed in Figures 3-A-4 and 3-A-5, and Tables 3-A-4 and 3-A-5. These results generally show that any pillar of openness does not significantly alter with the transmission of global uncertainty, when developed countries are dropped in the analysis. Then, our findings remain unchanged when focusing on developing and emerging countries.

As in the previous sensitivity analysis, we explore only the interaction with financial institutions efficiency on the sample excluding developed countries. The corresponding results reported in Figure 3-A-6 and Table 3-A-6 indicate that, dropping developed countries does not alter the finding that financial institutions efficiency significantly matters for the transmission of global uncertainty on consumption.

3.3.4. Discussion

To sum up, our analysis first shows evidence that any pillar of openness (trade or financial openness) does not significantly alter the transmission of global uncertainty shocks. So the exposure to international trade and finance seems not matter in the way global uncertainty impacts an economy. In other words, our findings suggest that whatever the degree of openness to trade and finance, global uncertainty adversely impacts in the same way.

We also find that the impact of financial development on the transmission of uncertainty shock depends on the dimensions of the financial system (depth, access, and efficiency). Specifically, our evidence shows that it is only in terms of efficiency that financial institutions development significantly mitigates the adverse impact of global uncertainty on consumption, while financial markets development does not significantly alter, through any of its dimension, the adverse impact of global uncertainty. This mitigating impact of financial institutions efficiency on consumption can be interpreted in line with the precautionary saving channel through which uncertainty influences an economy. Indeed, our evidence suggests that the efficiency of financial institutions, by reducing credit constraints of household, reduces the precautionary saving as self-insurance against higher uncertainty (Guerrieri and Lorenzoni, 2017).

Since the level of financial institutions efficiency is higher in developed countries than in developing and emerging economies, the finding from this chapter is line with the results in Chapter 2 that, following higher global uncertainty, developing and emerging countries suffer much strong fall in consumption.

3.4. Conclusion

Despite the growing literature on the economic consequences of global uncertainty, few papers have explored the role of country characteristics in the transmission of global uncertainty. To deal this gap, this chapter investigates how the dynamic response of the economy to uncertainty shocks is influenced by country

characteristics such as (trade and financial) openness and financial development. To this end, the study considers annual data on 107 countries over the period 1997-2017.

The results of this chapter show evidence that the transmission of global uncertainty shocks is not significantly altered by any pillar of openness (trade or financial openness). However, the adverse impact of global uncertainty is significantly mitigated by financial institutions development. Specifically, the results point out that this significant mitigating impact is due to the development of financial institutions in terms of efficiency (ability of institutions to provide financial services at low cost and with sustainable revenues and the level of activity of capital markets) and not in terms of depth (size and liquidity) or access (ability of individuals and companies to access financial services).

Therefore, in terms of policy recommendation, the finding from this chapter suggests that to mitigate the loss of welfare caused by higher uncertainty, less developed countries should implement policies aiming at promoting the efficiency of their financial institutions.

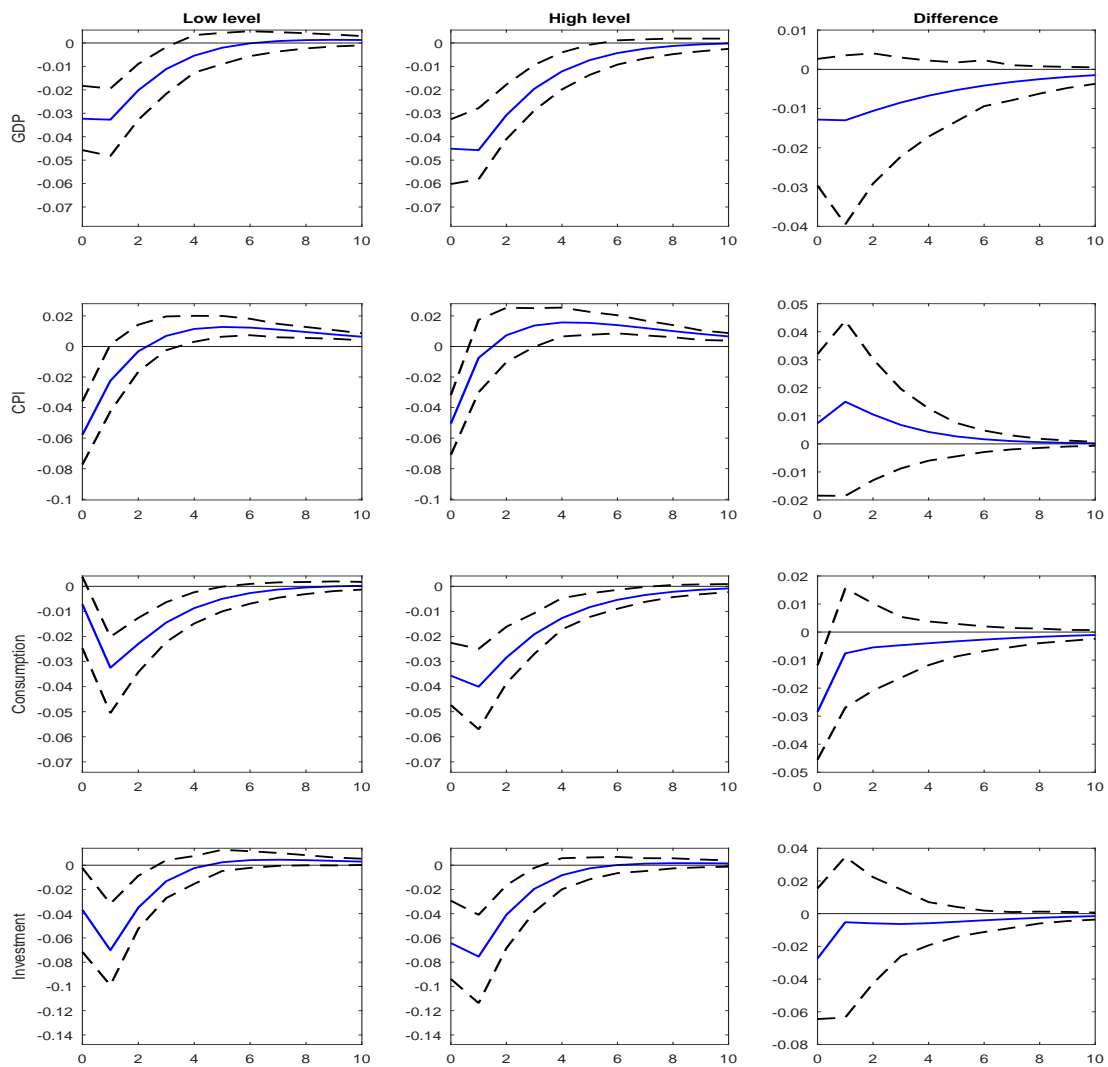
Appendix

List of countries in the sample

Developed countries (20) Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Ireland, Israel, Italy, Japan, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.

Developing and emerging countries (87) Albania, Algeria, Angola, Argentina, Bangladesh, Benin, Bolivia, Botswana, Brazil, Bulgaria, Burkina Faso, Burundi, Cambodia, Cameroon, Central African Republic, Chad, Chile, China, Colombia, Congo. Rep., Costa Rica, Cote d'Ivoire, Dominican Republic, Ecuador, Egypt. Arab Rep., El Salvador, Ghana, Greece, Guatemala, Guinea, Haiti, Honduras, Hong Kong, Hungary, India, Indonesia, Iran. Islamic Rep., Jamaica, Jordan, Kenya, Korea. Rep., Kuwait, Lao PDR, Lebanon, Liberia, Madagascar, Malawi, Malaysia, Mali, Mauritania, Mauritius, Mexico, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Niger, Nigeria, Oman, Pakistan, Panama, Paraguay, Peru, Philippines, Poland, Rwanda, Saudi Arabia, Senegal, Sierra Leone, Singapore, South Africa, Sri Lanka, Sudan, Tanzania, Thailand, Togo, Tunisia, Turkey, Uganda, United Arab Emirates, Uruguay, Venezuela. RB, Vietnam, Zambia.

FIGURE 3-A-1 – Responses to world uncertainty index (WUI), interaction with trade openness



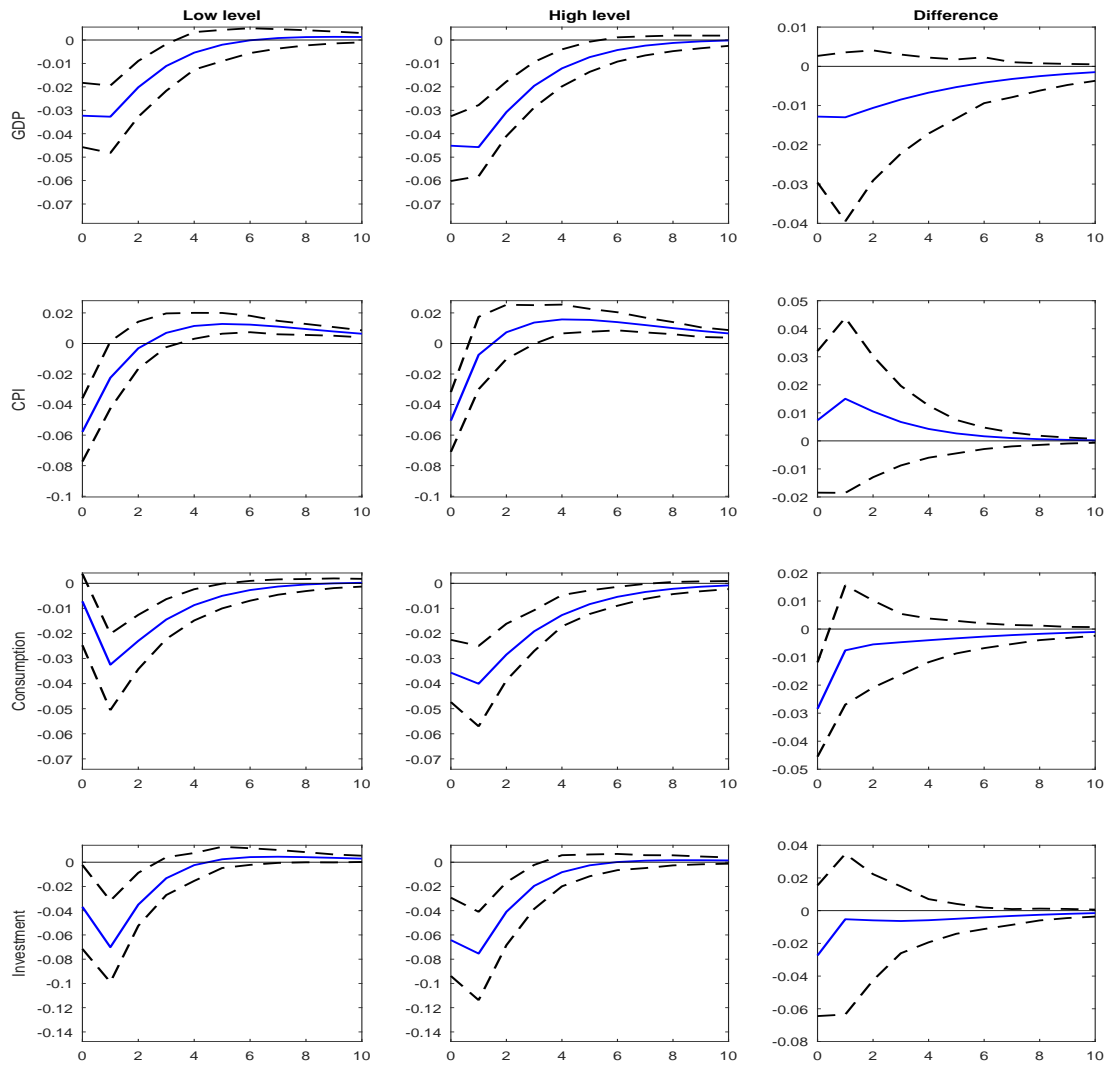
Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

TABLE 3-A-1 – Responses to world uncertainty index (WUI), interaction with trade openness

	Low	High	Difference
GDP			
Year 0	-0.031*	-0.042*	-0.011*
Year 1	-0.042*	-0.038*	0.004
Year 2	-0.028*	-0.025*	0.003
Year 5	-0.006	-0.005	0.000
Year 10	0.000	0.000	0.000
Consumer price			
Year 0	-0.054*	-0.050*	0.004
Year 1	-0.023*	-0.006*	0.017*
Year 2	-0.005	0.008	0.012*
Year 5	0.012*	0.016*	0.003
Year 10	0.007*	0.007*	0.000
Consumption			
Year 0	-0.017*	-0.023*	-0.006
Year 1	-0.041*	-0.033*	0.008
Year 2	-0.029*	-0.023*	0.006
Year 5	-0.007*	-0.006*	0.001
Year 10	-0.001	-0.001	0.000
Investment			
Year 0	-0.052*	-0.049*	0.002
Year 1	-0.074*	-0.072*	0.002
Year 2	-0.039*	-0.039*	0.000
Year 5	-0.001	-0.002	-0.001
Year 10	0.002	0.001	0.000

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

FIGURE 3-A-2 – Responses to world uncertainty index (WUI), interaction with financial openness



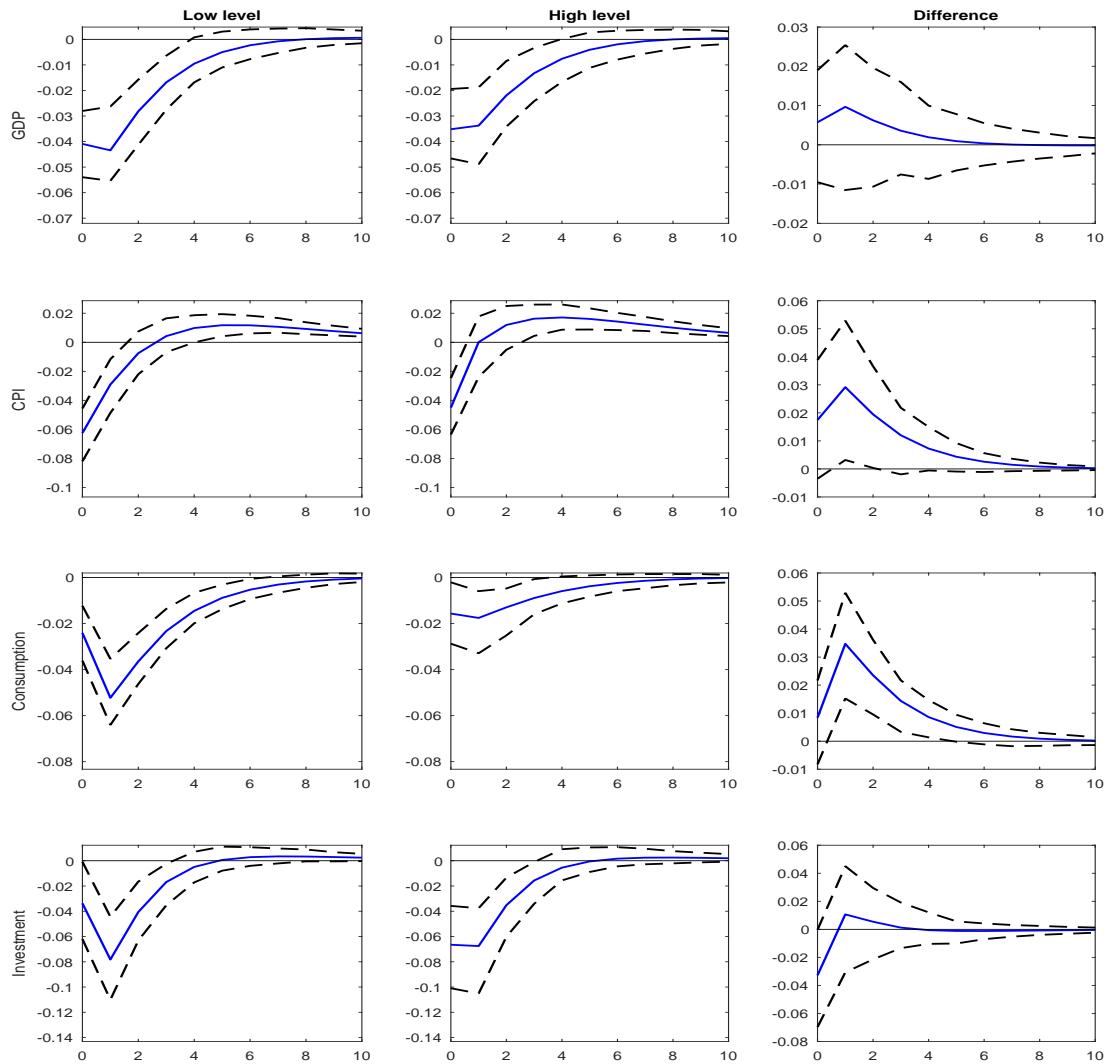
Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

TABLE 3-A-2 – Responses to world uncertainty index (WUI), interaction with financial openness

	Low	High	Difference
GDP			
Year 0	-0.032*	-0.045*	-0.013
Year 1	-0.033*	-0.046*	-0.013
Year 2	-0.020*	-0.031*	-0.011
Year 5	-0.002	-0.007	-0.005
Year 10	0.001	0.000	-0.001
Consumer price			
Year 0	-0.058*	-0.051*	0.007
Year 1	-0.022*	-0.007*	0.015
Year 2	-0.003	0.007	0.010
Year 5	0.013*	0.015*	0.003
Year 10	0.006*	0.007*	0.000
Consumption			
Year 0	-0.007	-0.036*	-0.028*
Year 1	-0.032*	-0.040*	-0.008
Year 2	-0.023*	-0.028*	-0.005
Year 5	-0.005	-0.008	-0.003
Year 10	0.000	-0.001	-0.001
Investment			
Year 0	-0.037*	-0.064*	-0.027
Year 1	-0.070*	-0.075*	-0.005
Year 2	-0.035*	-0.041*	-0.006
Year 5	0.002	-0.003	-0.005
Year 10	0.003	0.001	-0.001

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

FIGURE 3-A-3 – Responses to world uncertainty index (WUI), interaction with financial institutions efficiency



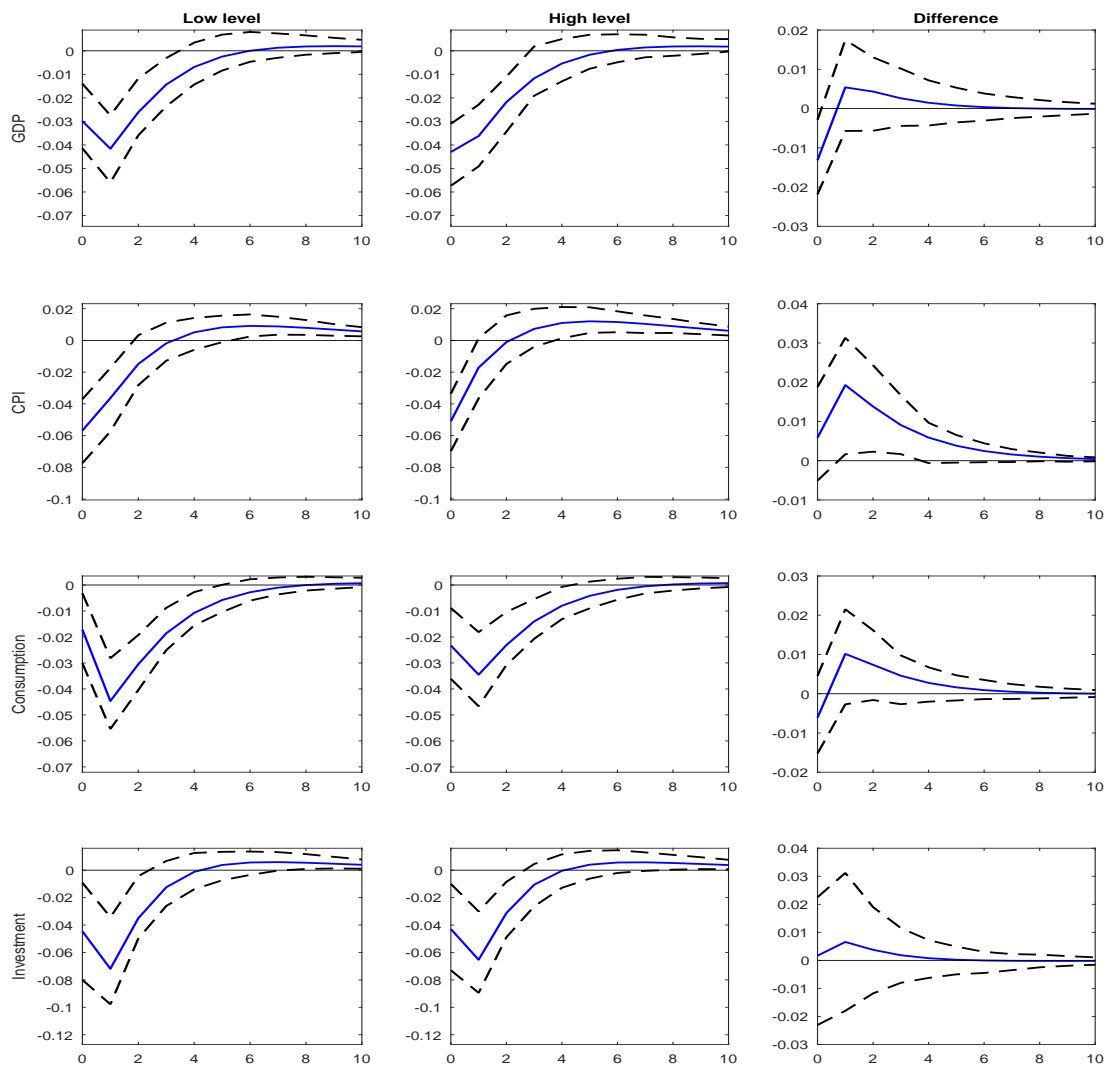
Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

TABLE 3-A-3 – Responses to world uncertainty index (WUI), interaction with financial institutions efficiency

	Low	High	Difference
GDP			
Year 0	-0.032*	-0.045*	-0.013
Year 1	-0.033*	-0.046*	-0.013
Year 2	-0.020*	-0.031*	-0.011
Year 5	-0.002	-0.007	-0.005
Year 10	0.001	0.000	-0.001
Consumer price			
Year 0	-0.058*	-0.051*	0.007
Year 1	-0.022*	-0.007*	0.015
Year 2	-0.003	0.007	0.010
Year 5	0.013*	0.015*	0.003
Year 10	0.006*	0.007*	0.000
Consumption			
Year 0	-0.007	-0.036*	-0.028*
Year 1	-0.032*	-0.040*	-0.008
Year 2	-0.023*	-0.028*	-0.005
Year 5	-0.005	-0.008	-0.003
Year 10	0.000	-0.001	-0.001
Investment			
Year 0	-0.037*	-0.064*	-0.027
Year 1	-0.070*	-0.075*	-0.005
Year 2	-0.035*	-0.041*	-0.006
Year 5	0.002	-0.003	-0.005
Year 10	0.003	0.001	-0.001

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

FIGURE 3-A-4 – Responses to global economic policy uncertainty (GEPU), interaction with trade openness, excluding developed countries



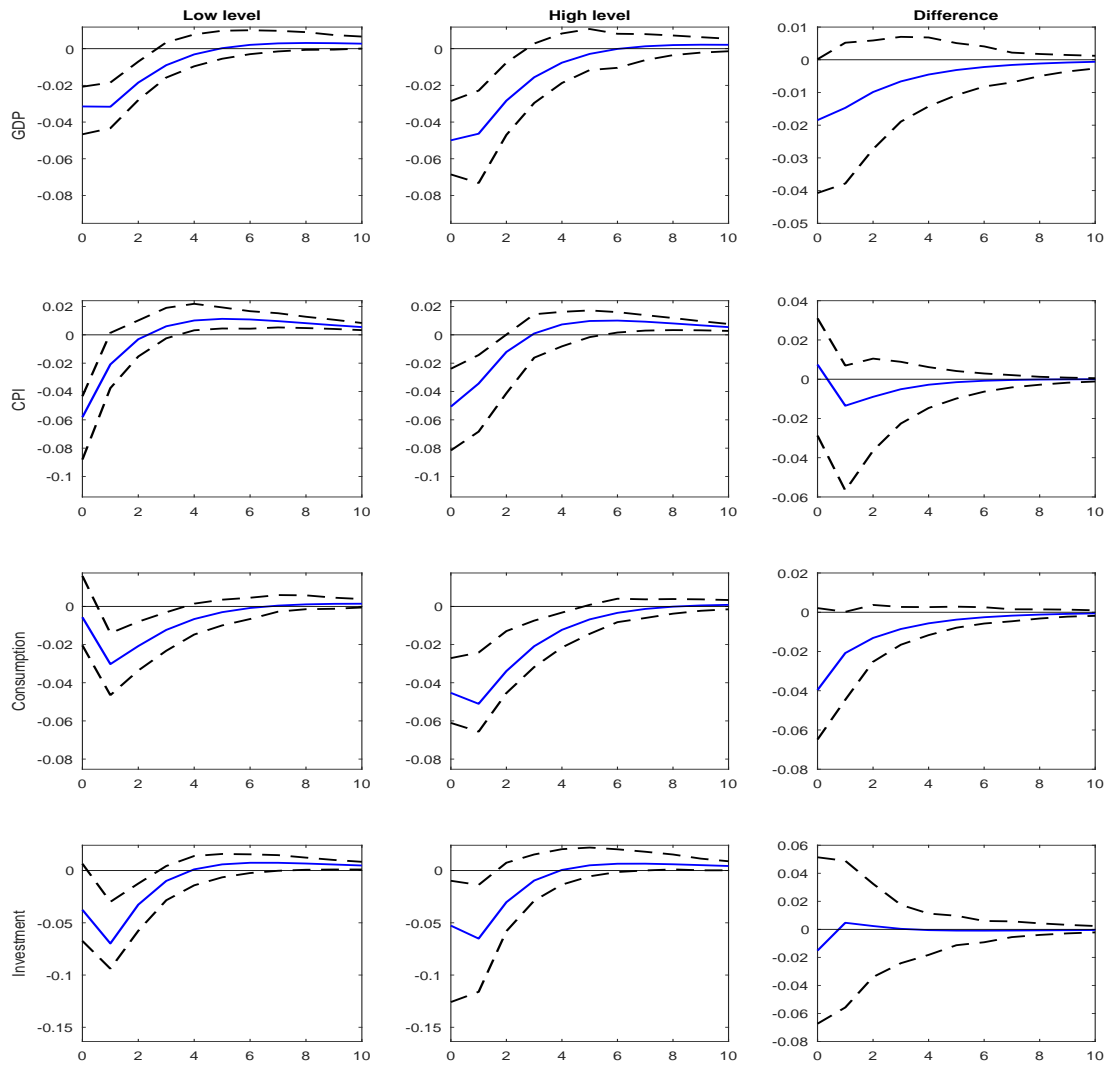
Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

TABLE 3-A-4 – Responses to to global economic policy uncertainty (GEPU), interaction
with trade openness, excluding developed countries

	Low	High	Difference
GDP			
Year 0	-0.030*	-0.043*	-0.013*
Year 1	-0.042*	-0.036*	0.005
Year 2	-0.026*	-0.022*	0.004
Year 5	-0.002	-0.002	0.001
Year 10	0.002	0.002	0.000
Consumer price			
Year 0	-0.057*	-0.051*	0.006
Year 1	-0.036*	-0.017*	0.019*
Year 2	-0.015	-0.001	0.014*
Year 5	0.008*	0.012*	0.004
Year 10	0.006*	0.006*	0.000
Consumption			
Year 0	-0.017*	-0.023*	-0.006
Year 1	-0.045*	-0.035*	0.010
Year 2	-0.030*	-0.023*	0.007
Year 5	-0.006	-0.004	0.002
Year 10	0.001	0.001	0.000
Investment			
Year 0	-0.045*	-0.043*	0.002
Year 1	-0.072*	-0.065*	0.007
Year 2	-0.035*	-0.031*	0.004
Year 5	0.004	0.004	0.000
Year 10	0.004	0.004	0.000

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

FIGURE 3-A-5 – Responses to global economic policy uncertainty (GEPU), interaction with financial openness, excluding developed countries



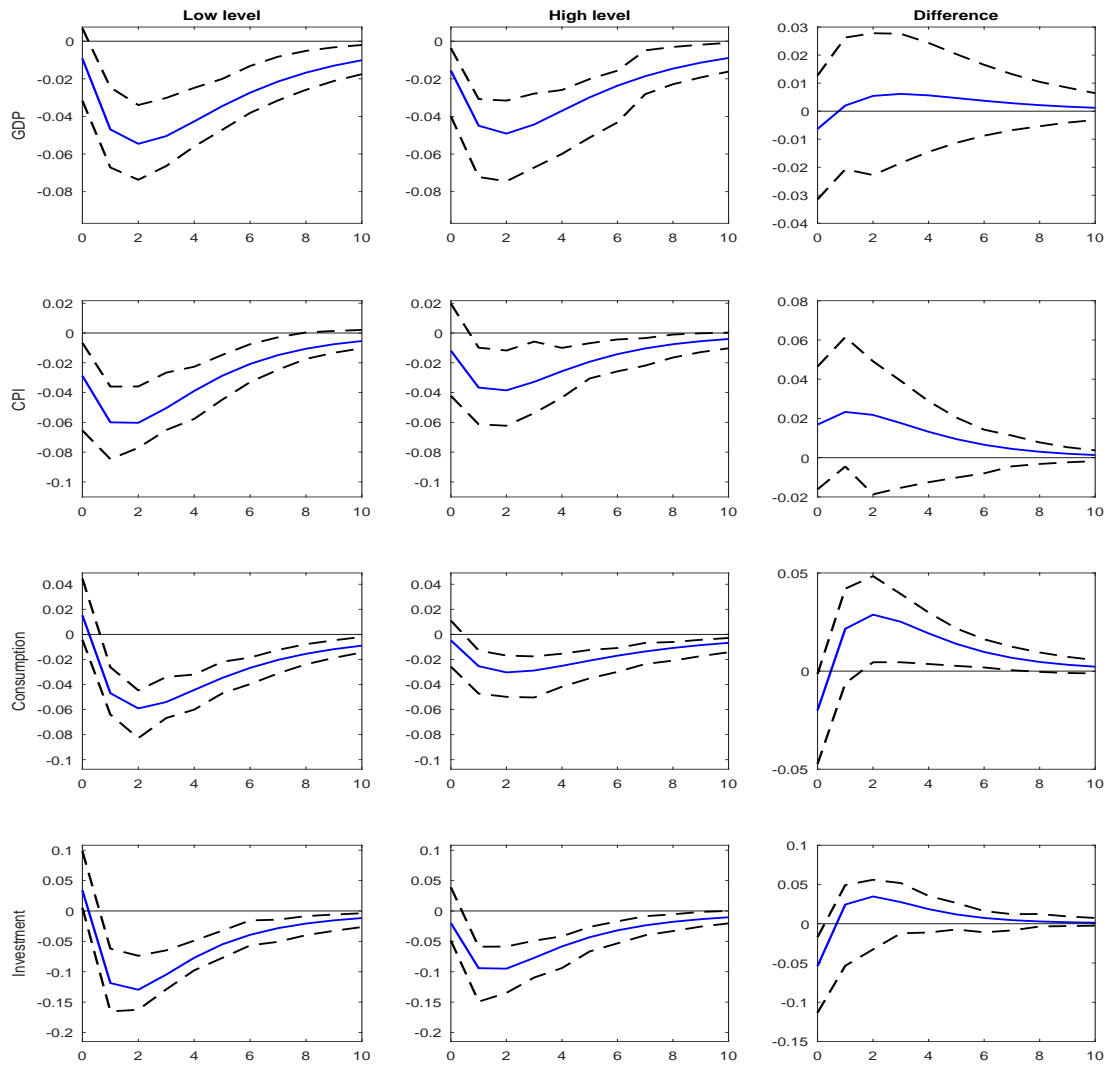
Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

TABLE 3-A-5 – Responses to to global economic policy uncertainty (GEPU), interaction
with financial openness, excluding developed countries

	Low	High	Difference
GDP			
Year 0	-0.031*	-0.050*	-0.018
Year 1	-0.032*	-0.046*	-0.015
Year 2	-0.018*	-0.028*	-0.010
Year 5	0.000	-0.003	-0.003
Year 10	0.003	0.002	-0.001
Consumer price			
Year 0	-0.058*	-0.051*	0.007
Year 1	-0.021*	-0.034*	-0.014
Year 2	-0.003	-0.012	-0.009
Year 5	0.011*	0.010*	-0.002
Year 10	0.005*	0.005*	0.000
Consumption			
Year 0	-0.006	-0.045*	-0.040
Year 1	-0.030*	-0.051*	-0.021
Year 2	-0.021*	-0.034*	-0.013
Year 5	-0.003	-0.007	-0.004
Year 10	0.001	0.001	-0.001
Investment			
Year 0	-0.038*	-0.053*	-0.015
Year 1	-0.070*	-0.065*	0.005
Year 2	-0.033*	-0.030	0.002
Year 5	0.006	0.005	-0.001
Year 10	0.005	0.004	0.000

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

FIGURE 3-A-6 – Responses to global economic policy uncertainty (GEPU), interaction with financial institutions efficiency, excluding developed countries



Notes : The solid line gives the estimated impulse responses. Dashed lines give the 90% confidence intervals generated by Monte Carlo with 5000 repetitions. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

TABLE 3-A-6 – Responses to to global economic policy uncertainty (GEPU), interaction with financial institutions efficiency, excluding developed countries

	Low	High	Difference
GDP			
Year 0	-0.009	-0.016	-0.006
Year 1	-0.047*	-0.045*	0.002
Year 2	-0.055*	-0.049*	0.005
Year 5	-0.035*	-0.030*	0.005
Year 10	-0.010*	-0.009*	0.001
Consumer price			
Year 0	-0.029*	-0.012	0.017
Year 1	-0.060*	-0.037*	0.023
Year 2	-0.060*	-0.039*	0.022
Year 5	-0.029*	-0.019*	0.009
Year 10	-0.005	-0.004	0.001
Consumption			
Year 0	0.015	-0.005	-0.020
Year 1	-0.047*	-0.025*	0.022
Year 2	-0.059*	-0.030*	0.029*
Year 5	-0.035*	-0.021*	0.014*
Year 10	-0.009*	-0.007*	0.002*
Investment			
Year 0	0.034	-0.020	-0.054*
Year 1	-0.119*	-0.094*	0.024
Year 2	-0.130*	-0.095*	0.035
Year 5	-0.055*	-0.043*	0.012
Year 10	-0.012*	-0.010*	0.001

Notes : Year 0 stands for the year of the shock. * denotes statistical significance at the 10% level. Shock represents one unit increase in uncertainty ; the responses are expressed in percentage change.

Chapitre 4

The impact of global uncertainty and financial shocks on oil price

4.1. Introduction

Following the 2007-2009 global financial crisis, the drastic drop in oil price has accentuated the debate on the responses of oil price to economic uncertainty and financial shocks (Bloom, 2009 ; Caldara et al., 2016 ; Alquist and Kilian, 2010 ; Joëts et al., 2017). This chapter contributes to the literature on the consequences of economic uncertainty by assessing the response of oil price to uncertainty and financial shocks while accounting for the strong correlation between macroeconomic uncertainty and tightening in financial conditions.

It is very tough empirically to distinguish economic uncertainty from volatility in financial markets, leading to proxy macroeconomic uncertainty by financial market

volatility such VIX or VXO, as in Bloom (2009). Financial speculation in oil futures markets can be a driver of oil spot price, since speculative pressures on oil futures prices may spill over to the physical crude oil market (Kilian, 2014). Besides, disturbances in financial markets can impact oil price dynamics by influencing global demand (since lower global demand induces downward pressure on oil price). Through its main channels—real options, precautionary channel and financial frictions—macroeconomic uncertainty may affect the dynamics of oil price by changing global demand. The real options channel refers to firm decision to postpone investment in a high uncertainty situation and in presence of irreversibility or adjustment costs in investment (Bernanke, 1983; McDonald and Siegel, 1986; Pindyck, 1991; Dixit and Pindyck, 1994; Boyle and Guthrie, 2003; Bloom, 2009). This causes a fall in investment and aggregate demand. Concerning precautionary saving channel, it represents the extra-saving made in order to compensate future income, following a rise in uncertainty (Lelan, 1968). With this extra-saving, as consumption drops, aggregate demand decreases. Through its financial frictions channel, macroeconomic uncertainty is particularly connected to financial shock. The financial frictions channel corresponds to the premium charged by financial intermediaries to cover against default risk, in a higher uncertainty environment (Christiano et al., 2014; Gilchrist et al., 2014; Arellano et al., 2019). This leads to a rise in the cost of firm external financing, and fall in investment and global demand (and then oil price).

In addition to the numerous papers on the relationship between oil price and economic activity (Hamilton, 1983, 2003; Kilian, 2008a,b,c, 2009), this chapter is re-

lated to some recent works on macroeconomic uncertainty. In particular, our study is related to that of Caldara et al. (2016) who employs the structural vector autoregressive (SVAR) framework with sign restrictions based on penalty function approach developed by Faust, 1998 and Uhlig (2005) to analyze the responses of economic to uncertainty and financial shocks. They found that the two shocks have adverse impact on economic outcomes and are important sources of macroeconomic disturbances. Our analysis is also related to the works of Kang et al. (2013), Antonakakis et al. (2014) and Joëts et al. (2017). Kang et al. (2013) use a SVAR model to investigate the dynamic impacts of US and non-US oil production shocks on economic policy uncertainty. Their results indicate that positive innovations in US oil production are associated with fall in US economic policy uncertainty; and an important part of variation in US economic policy uncertainty is due to oil supply shocks from US and non-US origins. Antonakakis et al. (2014) employs the (Diebold and Yilmaz, 2009, 2012) spillover index approach in VAR model to evaluate the link between oil price and the economic policy uncertainty index, using a sample of both net oil-exporting and net oil-importing countries. Their results indicate that oil price (uncertainty) responds negatively to uncertainty (oil price) shock. Finally, relying on structural threshold vector autoregressive (TVAR) model on a sample of 19 commodity markets, Joëts et al. (2017) found evidence that agricultural and industrial markets react strongly to the level and the variability of macroeconomic uncertainty. In addition, they found a disconnection between volatility and price uncertainty in oil market.

Following Caldara et al. (2016), we rely on sign restrictions with a penalty function criterion to examine how oil price reacts to both uncertainty and financial shocks. This approach allows to trace out the reaction of oil price to both global uncertainty and financial shocks while taking into account of the strong association between the two shocks.

To conduct our empirical investigation, we use monthly data spanning from January 1997 to December 2018. Contrary to Caldara et al. (2016) that use VXO and Jurado et al. (2015) measure to proxy for macroeconomic uncertainty, to proxy for global uncertainty, we consider considering global economic policy uncertainty index (GEPU) developed by Davis (2016), US EPU index computed by Baker et al. (2016), and world uncertainty index (WUI) constructed by Ahir et al., 2018. As in Caldara et al. (2016), global financial conditions are proxied by the excess bond premium (EBP) computed by Gilchrist and Zakrajsek (2012). Global oil price is measured by the West Texas Intermediate (WTI) crude oil index.

Our study show that in response to higher uncertainty, financial conditions deteriorate immediately ; and in response to tightening in financial conditions, economic uncertainty increases immediately. While accounting for this strong correlation between uncertainty and tightening in financial conditions, we find that, both uncertainty and financial shocks induce a drastic drop in oil price. Our results hold using different measures for global uncertainty.

Our results are very evocative in the current context of the pandemic Covid-19 that caused unprecedented global uncertainty with huge financial turbulence, and

historic drop in oil price.

The remainder of this chapter is structured as follows. Section 4.2 describes the econometric methodology and data. Section 4.3 presents and discusses the empirical results. Finally, Section 4.4 concludes.

4.2. Empirical methodology and data

This section presents the empirical strategy and data.

4-1. Empirical strategy

To assess the response of oil price to global uncertainty and financial shocks, we consider a vector autoregressive (VAR) model as follows :

$$Y_t = \sum_{i=1}^p \Gamma_i Y_{t-i} + \alpha + \beta t + \varepsilon_t \text{ for } t = 1, \dots, T \quad (4.1)$$

where Y_t denotes a 3×1 vector of endogenous variables including an index of global uncertainty, the measure of global financial conditions and the logarithm of oil price ; $\Gamma_i, i = 1, \dots, p$, stands for a $K \times K$ matrix of slop coefficients ; α is a $K \times 1$ vector of intercepts and β $1 \times K$ vector of trend coefficients ; ε_t is a $K \times 1$ vector of errors that are such that $E(\varepsilon_t) = 0_{3 \times 1}$, $E(\varepsilon_t \varepsilon_t') = \Sigma$ for t , $E(\varepsilon_t \varepsilon_s') = 0$ for all $t \neq s$.

Using the AIC (Akaike information criterion) and BIC (Bayesian information criterion) we set the lag length to four, so that to remove any autocorrelation in the residuals.

After estimated the VAR coefficient, following Caldara et al. (2016), we obtain the response of oil price by identifying structural shocks based on sign restrictions with penalty function developed by Faust (1998) and Uhlig (2005)¹. Let η_t the vector of structural shocks computed as follows :

$$\eta_t = A\varepsilon_t \quad (4.2)$$

where A is a $m \times m$ matrix such that $E(\eta_t\eta_t') = I_3$ or $AA' = \Sigma$.

In the sign restrictions with penalty function approach, instead of identifying all elements in the matrix A , a vector column a of A (the reaction of variables to a given structural shock) is identified by minimizing the following criterion function

$$\Psi(a) = \sum_j \sum_{h=0}^H \psi \left(\tau_j \frac{r_{j,h}(a)}{\sigma_k} \right) \quad (4.3)$$

where ψ is the function such that $\psi(x) = x$ if $x \leq 0$ and $\psi(x) = 100 \times x$ if $x > 0$, $r_{j,h}(a)$ is the response of the variable j to the impulse vector a at horizon h , σ_j is the standard error of variable j , $\tau_j = -1$ if the response of the variable j is restricted to be positive and $\tau_j = 1$ otherwise.²

As in Caldara et al. (2016), to identify global uncertainty and financial shocks, we follow the sequential procedure as in Mountford and Uhlig (2009). We first identify uncertainty shock with the penalty criterion (Mountford and Uhlig, 2009). Second, we then identify financial shock with the penalty criterion and the condition to be

1. See Fry and Pagan (2011) for a review on sign restrictions

2. This minimization problem is implemented using the Matlab *fmincon* algorithm.

orthogonal to uncertainty shock identified first. This procedure attribute as many variations of variables in the system as possible to uncertainty shock while allowing financial shock to contemporaneously impact uncertainty.

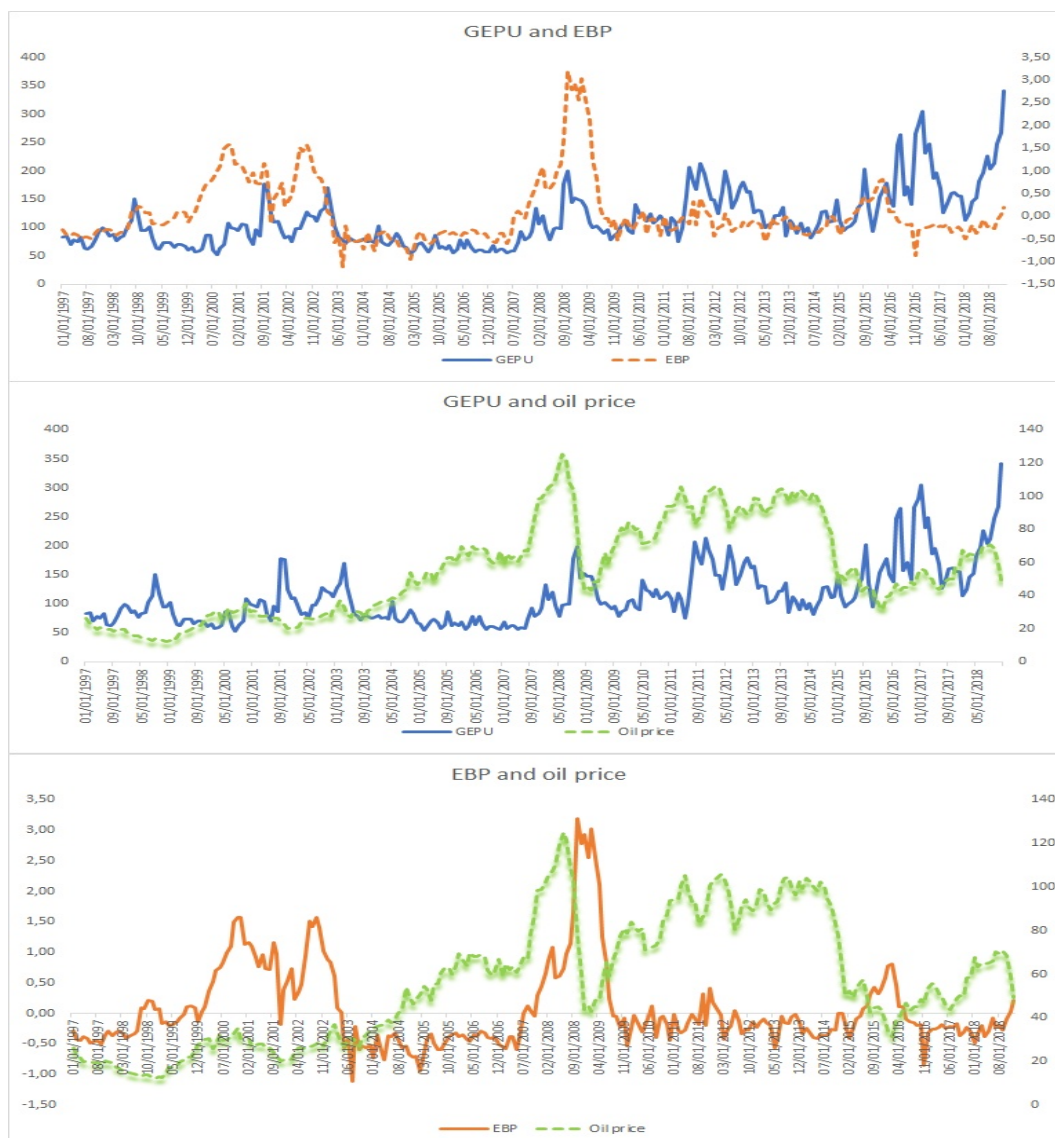
As in Uhlig (2005) we compute confidence bands based on a Bayesian approach by drawing from the posterior of the VAR coefficients and the variance-covariance matrix. We consider the 68% confidence interval that is commonly used in this approach

4-2. Data

This chapter uses time series data on a monthly frequency spanning from January 1997 to December 2018. The sample period is determined focusing on the availability of uncertainty measure. To measure global uncertainty, we first consider the global economic policy uncertainty (GEPU) index of Davis (2016), computed as a GDP-weighted average of national Economic Policy Uncertainty (EPU) indices for 20 countries : Australia, Brazil, Canada, Chile, China, France, Germany, Greece, India, Ireland, Italy, Japan, Mexico, the Netherlands, Russia, South Korea, Spain, Sweden and the United Kingdom. GEPU is available at monthly frequency from January 1997. For robustness analysis, we also use, as a proxy for global uncertainty, the US economic policy uncertainty (EPU) index computed by Baker et al. (2016). To measure global financial conditions, we rely on the Excess Bond Premium (EBP) of Gilchrist and Zakrajsek (2012) which represents the bond investors extra compensation to cover U.S. non-financial corporate credit risk. Global oil price is measured

by Western Texas Intermediate (WTI) price.

FIGURE 4-1 – Trend in uncertainty, financial conditions and price



Notes : GEPU represents Global Economic Policy index of Davis (2016), EBP is the Excess Bond Premium of Gilchrist and Zakrajsek (2012). Oil price is the Western Texas Intermediate (WTI) price.

Before conducting the econometric investigation, Figure 4-1 allows to conjecture graphically on the relationship between global uncertainty (measured by GEPU), financial conditions (measured by EBP) and oil price. At first glance, GEPU and

EBP display a positive relationship. Besides, peaks in GEPU and EBP generally coincide with oil price troughs.

4.3. Empirical results

In this section, we present our empirical results. We first discuss the results from the baseline specification with GEPU as the proxy for global. After that, we check the robustness of our results in two ways : (i) using alternative proxy for global uncertainty and (ii) considering alternative specification (with quadratic trend).

4-1. Baseline results

Figure 4-2 displays the responses to global uncertainty and financial shock in the baseline specification in which GEPU is the proxy for global uncertainty and uncertainty shock is identified before financial shock. Table 4-1 reports the estimated responses for specific periods after the shocks. The size of this shock represents one unit increase in the corresponding variable. Figure 4-2 and Table 4-1 shown a persistent and significant decline of GEPU and EBP to their own shocks. The response of EBP to GEPU shock is significantly positive during the first semester after the shock and becomes significantly negative. The response of GEPU to EBP shock is significantly negative on impact and become significantly positive at the fourth and eight months after the shock. Concerning oil price, it declines significantly in response to the two shocks. The negative response of oil price to GEPU shock is persistent and remains significant until at least five years after the shock. In response

to a shock representing one unit increase in GEPU index, oil price declines by 0.06% on impact and by -0.24% at the peak (eight month after the shock). The negative response of oil price to EBP shock is significant during fifteen months after the shock. The magnitude of this response is such that, in response to a shock representing one unit increase in EBP index, oil price decline by 4.35% on impact and 14.89% at the peak (one quarter after the shock).

TABLE 4-1 – Responses to global uncertainty and financial shocks

	0 month	1 month	1 quarter	1 year	5 years
<i>Responses to GEPU shock</i>					
GEPU	1.00*	0.82*	0.39*	0.20*	0.03*
EBP	3.82e-03*	4.87e-03*	3.05e-03*	-0.21e-03*	-0.98e-03*
Oil price	-0.06*	-0.13*	-0.22*	-0.24*	-0.08*
<i>Responses to EBP shock</i>					
GEPU	-15.98*	-1.96*	4.83*	7.26	0.98
EBP	1.00*	0.84*	0.81*	0.33*	-0.03*
Oil price	-4.35*	-10.72*	-14.89*	-8.95*	-2.69

Notes : Month 0 stands for the month of the shock. * denotes statistical significance at the 10% level. Shocks on uncertainty and financial conditions represent one unit increase in the corresponding variables; the response of oil price is expressed in percentage change.

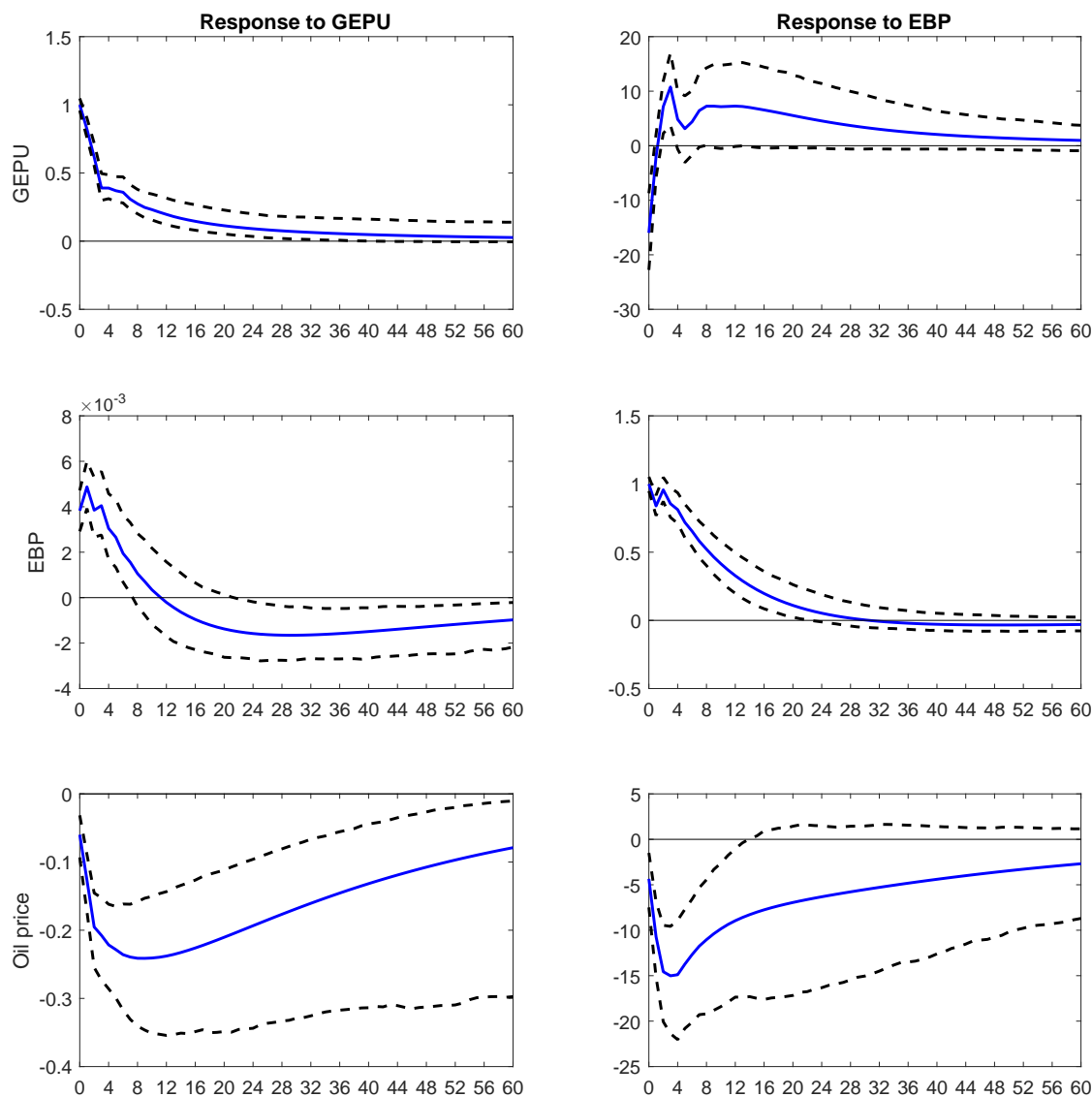
4-2. Robustness check

In this subsection, we check the robustness of our previous results, in two ways : (i) using alternatives measures for global uncertainty and (ii) including quadratic trend in the model.

4-2.1. Alternative measures of uncertainty

In baseline specification, we consider GEPU index as the proxy for global uncertainty. To check the sensitivity of our results, we use two alternative proxies for

FIGURE 4-2 – Response to global uncertainty and financial shocks



Notes : Month 0 stands for the month of the shock. The solid line gives the estimated impulse response. Dashed lines give the 68% confidence intervals computed by the Bayesian approach by tacking 5000 draws from the posterior of the VAR coefficients and the variance-covariance matrix of errors. Shock corresponds to one unit increase in uncertainty and in financial conditions; the response of oil price is expressed in percentage change.

global uncertainty : the US EPU index constructed by Davis (2016) and the World uncertainty index (WUI) developed by Ahir et al. (2018). EPU index for US is available at monthly frequency from January 1985, and WUI is available on a quarterly

basis from 1996. For WUI, estimations are then conducted on quarterly data with the lag length set to one. For a sake of comparison we consider the same period 1997-2018 as in the baseline. The corresponding results are shown in Figure 4-A-1 and Table 4-A-1 for US EPU index, and in Figure 4-A-2 and Table 4-A-2 for WUI.

With both alternative measures of uncertainty, we find a fall in oil price in response to uncertainty and financial shocks. Besides, as in the baseline, the impact of economic uncertainty shock on EBP is initially significantly positive (non significant using WUI) and becomes significantly negative later; while the impact of financial shock on economic uncertainty is initially significantly negative and becomes significantly positive later. However, with US EPU or WUI as a proxy for global uncertainty, the significant fall in oil price in response to uncertainty shock is less long-lasting, while the significant fall in oil price in response to financial shock becomes more long-lasting.

4-2.2. Including quadratic trend

The baseline specification includes a linear trend. We also check the sensitivity of our results using a quadratic trend. The impulse responses of this alternative specification are reported in Figure 4-A-3 and Table 4-A-3. The responses of uncertainty and financial conditions to shocks are very close to those of the baseline. As in the precedent robustness check, the significant fall in oil price in response to uncertainty shock is less long-lasting, while the significant fall in oil price in response to financial shock becomes more long-lasting.

4-3. Discussion

To sum up, we first find evidence confirming the strong correlation between global uncertainty and financial conditions. Indeed, in response to higher uncertainty financial conditions deteriorate immediately ; and in response to tightening financial conditions, economic uncertainty increases immediately. Our results also spotlight that both uncertainty and financial shocks induce a drastic drop in oil price.

The drop in oil price in response to tightening financial conditions is line with the argument that speculative pressures on oil futures prices may spill over to the physical crude oil market (Kilian, 2014). It may also reflect that the fact that disturbances in financial markets can impact oil price dynamic by influencing global demand.

The adverse impact of higher uncertainty on oil price may be explained in line with the three channels through which uncertainty influences economic activity. Through the three channels by lowering global demand, higher uncertainty may induce a drop in oil price. The first channel that is the real options refers to firm decision to postpone investment in a high uncertainty situation and in presence of irreversibility or adjustment costs in investment (Bernanke, 1983 ; McDonald and Siegel, 1986 ; Pindyck, 1991 ; Dixit and Pindyck, 1994 ; Boyle and Guthrie, 2003 ; Bloom, 2009), causing a fall in investment and aggregate demand. The precautionary saving channel corresponds to the extra-saving caused by higher uncertainty (Lelan, 1968). This extra-saving is associated with a in drop consumption and then in aggregate demand. Finally, financial frictions channel reflects the premium char-

ged by financial intermediaries to cover against default risk of investment projects, when uncertainty is high (Christiano et al., 2014; Gilchrist et al., 2014; Arellano et al., 2019). This results in a rise in the cost of firm external financing, and fall in investment and aggregate demand. Particularly, through financial frictions channel, economic uncertainty is connected to financial shock.

Our results corroborate the strong association between macroeconomic uncertainty and tightening in financial conditions brought out by Caldara et al. (2016) using VXO and Jurado et al. (2015) measure to proxy for macroeconomic uncertainty. We also confirm the finding of Antonakakis et al. (2014) that, employing the Diebold and Yilmaz (2009, 2012) spillover index approach in VAR model on a sample of both net oil-exporting and net oil-importing countries, showed that oil price responds negatively to economic policy uncertainty. Finally, our finding is also in line with the evidence from Joëts et al. (2017) that, estimating on structural threshold vector autoregressive (TVAR) model on a sample of 19 commodity markets and measuring macroeconomic uncertainty as in Jurado et al. (2015), found that agricultural and industrial markets react strongly to the level and the variability of macroeconomic uncertainty.

4.4. Conclusion

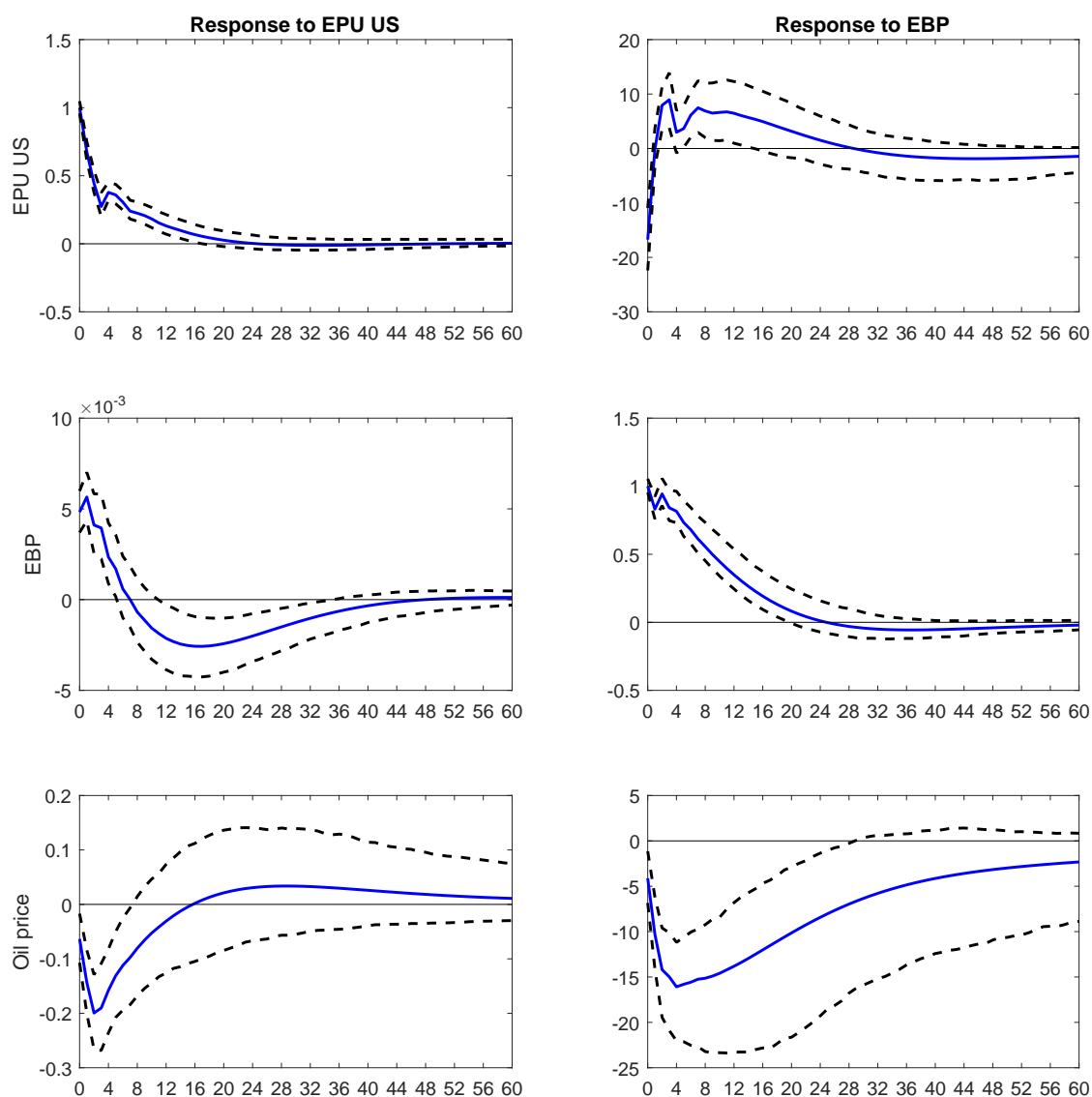
This chapter analyzes the impact of both global uncertainty and financial shocks on oil price. To this end, we rely on VAR framework and identify shock through sign restriction with penalty function approach. Based on monthly data spanning from

January 1997 to December 2018, we first find that, in response to higher uncertainty, financial conditions deteriorate immediately ; and in response to tightening in financial conditions, economic uncertainty increases immediately. While accounting for this strong correlation between uncertainty and tightening in financial conditions, our results evidence that both uncertainty and financial shocks induce a drastic drop in oil price. Our results hold when we use different measures for global uncertainty.

Our results are very evocative in the current Covid-19 pandemic that caused unprecedented global uncertainty with huge financial turbulence and a drop in oil price into negative territory, for the first time in history.

Appendix

FIGURE 4-A-1 – Response to global uncertainty and financial shocks, using US EPU



Notes : Month 0 stands for the month of the shock. The solid line gives the estimated impulse response. Dashed lines give the 68% confidence intervals computed by the Bayesian approach by tacking 5000 draws from the posterior of the VAR coefficients and the variance-covariance matrix of errors. Shock corresponds to one unit increase in uncertainty and in financial conditions; the response of oil price is expressed in percentage change.

TABLE 4-A-1 – Responses to global uncertainty and financial shocks, using US EPU

	0 month	1 month	1 quarter	1 year	5 years
<i>Responses to US EPU shock</i>					
US EPU	1.00*	0.68*	0.38*	0.13*	0.00
EBP	4.83e-03*	5.65e-03*	2.34e-03*	-2.13e-03	0.12e-03
Oil price	-0.06*	-0.14*	-0.16*	-0.03	0.01
<i>Responses to EBP shock</i>					
US EPU	-16.74	-0.15	2.99*	6.47	-1.44
EBP	1.00*	0.83*	0.82*	0.35*	-0.02
Oil price	-4.12*	-10.30*	-16.09*	-13.82*	-2.32

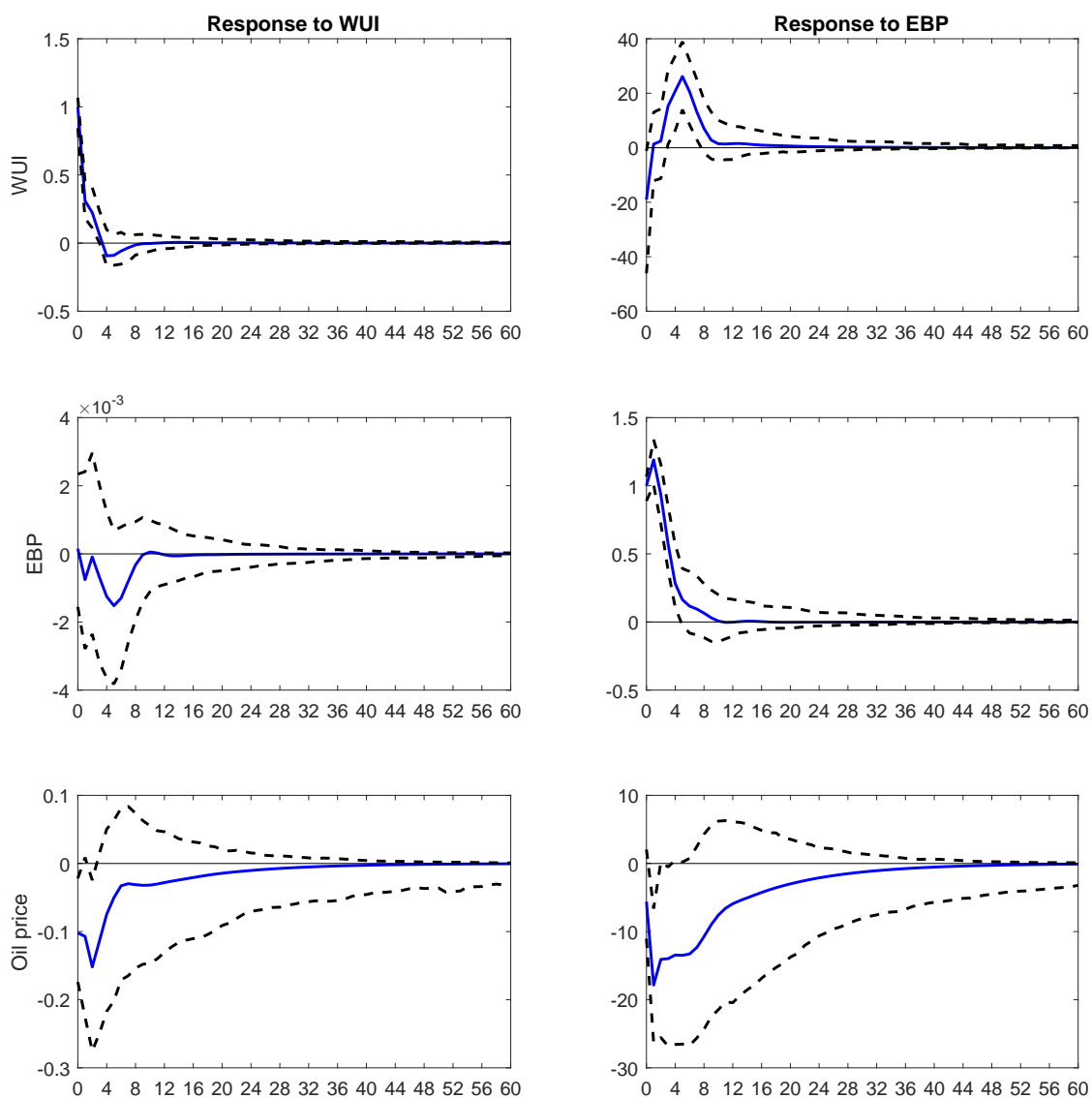
Notes : Month 0 stands for the month of the shock. * denotes statistical significance at the 10% level. Shocks on uncertainty and financial conditions represent one unit increase in the corresponding variables; the response of oil price is expressed in percentage change.

TABLE 4-A-2 – Responses to global uncertainty and financial shocks, using WUI

	0 month	1 month	1 quarter	1 year	5 years
<i>Responses to WUI shock</i>					
WUI	1.00*	0.31*	-0.09	0.00	0.00
EBP	0.15e-03	-0.76e-03	-1.25e-03	-0.03e-03	0.00e-03
Oil price	-0.10*	-0.11	-0.07*	-0.03	0.00
<i>Responses to EBP shock</i>					
WUI	-19.05	1.33	20.79	1.52	0.02
EBP	1.00*	1.19*	0.28*	0.00	0.00
Oil price	-5.61	-17.85*	-13.44*	-5.91	-0.10

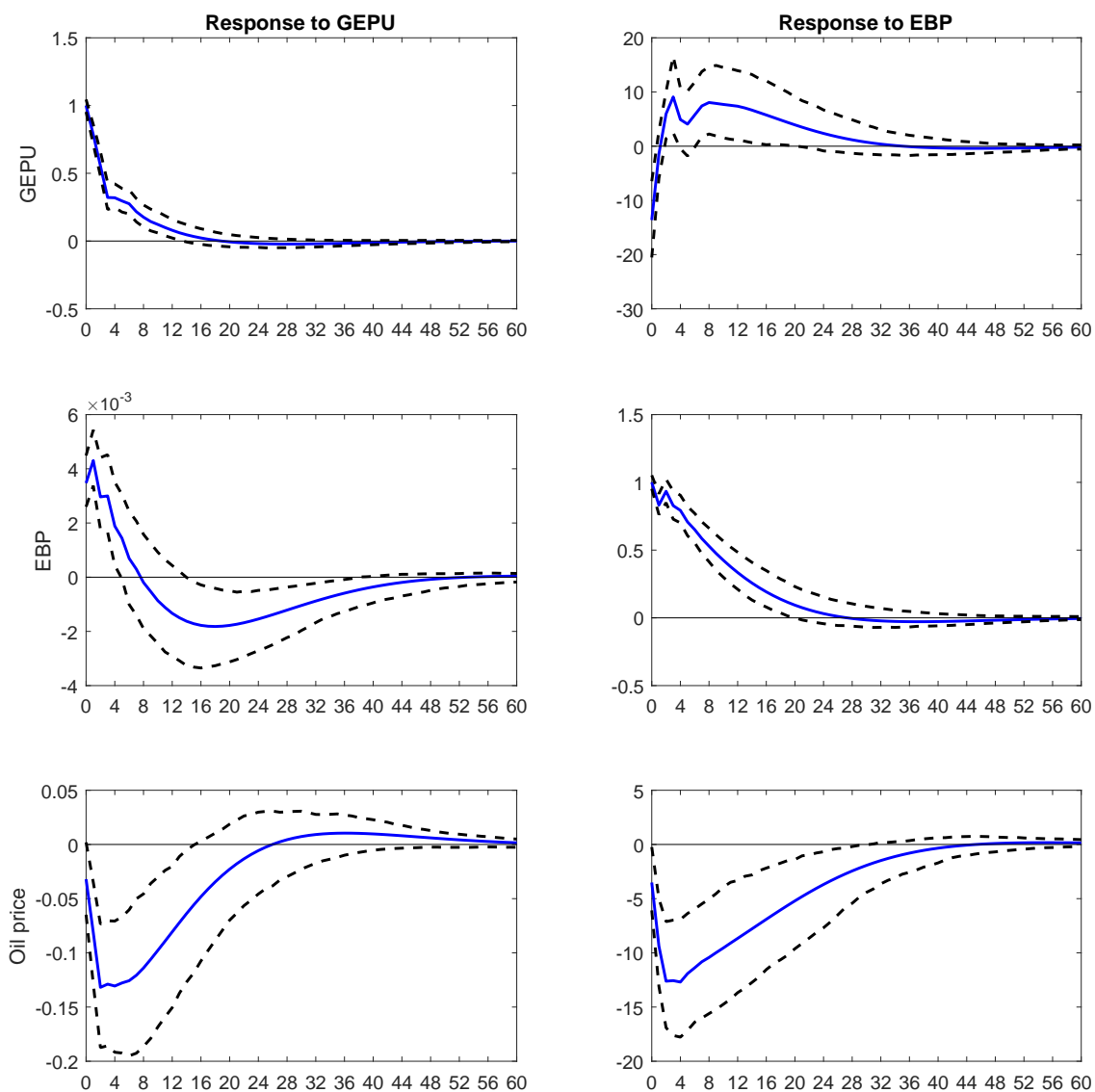
Notes : Month 0 stands for the month of the shock. * denotes statistical significance at the 10% level. Shocks on uncertainty and financial conditions represent one unit increase in the corresponding variables; the response of oil price is expressed in percentage change.

FIGURE 4-A-2 – Response to global uncertainty and financial shocks, using WUI



Notes : Month 0 stands for the month of the shock. The solid line gives the estimated impulse response. Dashed lines give the 68% confidence intervals computed by the Bayesian approach by tacking 5000 draws from the posterior of the VAR coefficients and the variance-covariance matrix of errors. Shock corresponds to one unit increase in uncertainty and in financial conditions ; the response of oil price is expressed in percentage change.

FIGURE 4-A-3 – Response to global uncertainty and financial shocks, quadratic trend



Notes : Month 0 stands for the month of the shock. The solid line gives the estimated impulse response. Dashed lines give the 68% confidence intervals computed by the Bayesian approach by tacking 5000 draws from the posterior of the VAR coefficients and the variance-covariance matrix of errors.

TABLE 4-A-3 – Responses to global uncertainty and financial shocks, quadratic trend

	0 month	1 month	1 quarter	1 year	5 years
<i>Responses to GEPU shock</i>					
GEPU	1.00*	0.79*	0.32*	0.08	0.00
EBP	3.47e-03*	4.31e-03*	1.89e-03*	-1.33e-03	0.04e-03
Oil price	-0.03*	-0.08*	-0.13*	-0.08*	0.00
<i>Responses to EBP shock</i>					
GEPU	-13.63	-1.43	4.92*	7.38	-0.18
EBP	1.00*	0.83*	0.79*	0.33*	0.00
Oil price	-3.51*	-9.37*	-12.69*	-8.67*	0.15

Notes : Month 0 stands for the month of the shock. * denotes statistical significance at the 10% level. Shocks on uncertainty and financial conditions represent one unit increase in the corresponding variables; the response of oil price is expressed in percentage change.

Conclusion générale

Through three essays, this thesis contributes to the literature on the macroeconomic consequences of global uncertainty. The first contribution (Chapter 2) examines the transmission of global uncertainty by comparing developed economies with developing and emerging economies. This analysis is motivated by the fact that, through its main transmission channels (real options, precautionary saving and financial frictions), the transmission of global uncertainty shocks may depend on country characteristics. This empirical study is carried out using a panel autoregressive vector. The data used are annual and cover 20 developed countries and 96 developing and emerging countries, cover the period 1997-2017. The results of this first contribution of the thesis show that the global uncertainty shocks lead to a fall in GDP, consumption, investment and prices in the two groups of countries. The magnitude of the decline in GDP, consumer prices and investment is roughly similar for both groups of countries, while the drop in consumption is much more pronounced for developing and emerging countries. The study points out that precautionary savings channel appears to play an important role in developing and emerging economies due to their low level of financial development and lack of social insurance.

The second contribution (Chapter 3) explores how individual country characteristics such trade openness, financial openness and financial development, influence the transmission of global uncertainty shocks. To this end, this Chapter employs an interacted panel vector autoregressive (IPVAR). The empirical analysis covers a sample of 107 countries including 20 developed countries and 87 developing and emerging countries, over period from 1997 to 2017. The results of this contribution show that the transmission of global uncertainty shocks is not significantly modified by any pillar of openness (trade openness or financial openness). However, the negative impact of global uncertainty is greatly mitigated by the development of financial institutions. More specifically, the results indicate that the mitigation of the impact is due to the development of institutions in terms of efficiency (ability of institutions to provide at low cost and with sustainable revenues and the level of activity of capital markets) and not in terms of depth (size and liquidity) or access (ability of individuals and companies to access financial services).

The third contribution (Chapter 4) empirically examines how both global uncertainty and financial shocks influence oil prices. The analysis is motivated by the fact that global uncertainty and financial shocks are strongly related and both may influence oil price. This study use the structural VAR model based on sign restrictions with a penalty function approach. The data used are monthly and cover the period from 1997 to 2017. The results of this last contribution show that an higher uncertainty deteriorates financial conditions and tightening in financial conditions increase economic uncertainty. And, while accounting for this strong correlation bet-

ween global uncertainty and financial shock, both uncertainty and financial shocks induce a drastic drop in oil price.

Our results are very evocative in the current the pandemic Covid-19 that caused unprecedented global uncertainty with huge financial turbulence and historic recession. The decline in global demand induces an unusual drop in oil price into negative territory for the first time in history.

Due to the shock wave of Covid-19, we can conclude that research on global uncertainty will be further amplified. In other words, research on global uncertainty is very promising.

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