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Risk and Macroeconomic Policy Challenges
Recent Evidence from the Eurozone

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Introduction Générale

La crise financière récente a particulièrement attiré l'attention des économistes puisqu'elle a mis en cause le fonctionnement du système financier et l'architecture des politiques économiques existantes (notamment les politiques monétaire, prudentielle et budgétaire). Le premier dysfonctionnement observé concerne *la politique monétaire*. La principale préoccupation des banques centrales était, avant la crise, la stabilité des prix. Afin d'accomplir cet objectif, elles utilisaient comme instrument le taux d'intérêt. La stabilité de l'output était considérée comme un objectif secondaire, mais qui découlait de l'objectif principal. La période qui a précédé la crise a été caractérisée par une inflation stable et faible en zone euro¹, en concordance avec l'objectif affiché par la Banque Centrale Européenne (BCE). De plus, à partir des années 1980, la plupart des économies développées ont connu une réduction des fluctuations conjoncturelles. C'est pour cela d'ailleurs que la période d'avant crise est nommée la “Grande modération”. Cela a conduit à penser que la politique monétaire était suffisante pour assurer un environnement macroéconomique stable.

En même temps, les enseignements tirés de la crise précédente, déclenchée par la “bulle Internet”, avaient permis de conclure qu'il n'était pas optimal d'utiliser la politique monétaire pour répondre aux dérapages des prix d'actifs. La meilleure solution dans une telle situation était de réparer les dégâts engendrés par la bulle seulement au moment où celle-ci éclatait (“benign neglect”). Cependant, la crise qui a débuté en 2007 a montré l'échec de cette vision sur plusieurs aspects.

D'abord, l'existence d'un nouveau canal de transmission de la politique monétaire – le canal de la prise de risque (risk taking channel) – mis en évidence par Borio et Zhu en 2008 (Borio and Zhu, 2012), fait preuve d'un impact plus important des actions monétaires sur l'activité réelle. Ainsi, si certaines conditions sont remplies, il est possible qu'une simple modification du taux d'intérêt puisse générer du risque financier dans l'économie. D'ailleurs, les banques centrales qui ont maintenu des taux bas pendant la période de boom économique ont été fortement critiquées et même considérées comme responsables de la gravité de la crise (Giavazzi and Giovannini, 2010, Kannan et al., 2012). Cette prise

¹ Voir le Chapitre 1.

de conscience souligne la nécessité d'un changement, du moins partiel, de stratégie des banques centrales. Ensuite, les événements récents ont rendu évident le fait que la simple stabilité des prix n'est pas suffisante pour assurer aussi la stabilité du secteur financier ou encore la stabilité macroéconomique. La bonne maîtrise de l'inflation n'a pas empêché les perturbations financières et leurs sévères conséquences sur le secteur réel. Enfin, la gravité de la crise a ramené au premier plan la discussion sur les réponses des banques centrales aux bulles financières et immobilières.

Dans un discours récent,² le Gouverneur de la Banque de France, Christian Noyer, résume cette mauvaise compréhension d'avant la crise :

“Avec le recul, nous voyons bien aujourd’hui que cette économie ‘idéale’ n’a sans doute jamais existé. La ‘Grande modération’ a probablement été tout autant le résultat d’une ‘bonne fortune’ (découlant des effets désinflationnistes de la mondialisation) que d’une ‘bonne politique’. Nous savons que la stabilité monétaire est une condition nécessaire, mais pas suffisante, de la stabilité financière, car les marchés de capitaux ne sont pas toujours et pas nécessairement efficaces. L’efficacité de l’instrument du taux d’intérêt peut par ailleurs être rapidement annulée par des spirales financières négatives.”

Étant donné l'impact des décisions des banques centrales sur le risque financier avec les conséquences sur l'activité réelle qui peuvent en découler, on peut s'interroger sur la cohérence et l'efficacité d'un nouvel objectif pour les autorités monétaires : celui de stabilité financière. Plus précisément les discussions se concentrent aujourd'hui sur le volet macroprudentiel et sur la prise en compte du risque systémique.

La crise a également dévoilé des dysfonctionnements dans *la politique prudentielle*. Le rôle de cette réglementation était d'assurer la stabilité financière, un enjeu crucial pour le bon fonctionnement de l'économie dans son ensemble. Pourtant, plusieurs problèmes ont pu être identifiés. D'abord, la réglementation prudentielle ne s'intéressait qu'au risque des institutions prises individuellement – réglementation microprudentielle – ignorant l'aspect macroprudentiel, c'est-à-dire les liens potentiels entre les établissements. L'action principale de la politique prudentielle était d'intervenir afin de corriger les défaillances du marché bancaire issues des problèmes d'asymétrie d'information, de la responsabilité limitée des institutions financières et d'autres imperfections comme les garanties implicites ou explicites offertes par le gouvernement. De plus, cette réglementation s'appliquait seulement au système bancaire et aux institutions d'assurance, laissant des institutions présentant un grand risque, comme les hedge funds, non couvertes.

² Discours prononcé le 26 mars 2012 intitulé “L’orthodoxie des banques centrales à l’épreuve d’une période non orthodoxe”.

En outre, depuis deux décennies, le paysage bancaire n’a pas cessé de changer. Nous faisons référence ici à la dérégulation, à la désintermédiation bancaire et au décloisonnement des marchés – les 3D. L’utilisation accrue des produits et processus innovants et complexes, comme les produits dérivés et la titrisation, a augmenté l’incertitude sur l’évolution réelle du risque. La concurrence accrue dans le secteur financier a été l’une des causes principales du succès de ces produits. Même si ces nombreuses innovations financières étaient difficiles à maîtriser, ces produits ont donné l’occasion aux institutions financières de faire de l’arbitrage réglementaire, c’est-à-dire de contourner les règles imposées par la politique prudentielle. Toutes ces transformations et développements que la réglementation a manqué d’intégrer ont conduit à une montée du risque dans le secteur financier.

Enfin, la défaillance de la réglementation prudentielle porte également sur la procyclicité introduite par cette dernière (voir par exemple, Repullo and Suarez, 2008). En effet, par leur contenu, les règles prudentielles ont contribué à l’amplification des problèmes lors de la crise. En demandant moins de capital en période de boom économique, elles ont poussé les institutions bancaires à accroître excessivement leur activité et à prendre des risques au-delà de leur capacité de gestion. L’arrivée de la crise a marqué un retournement des exigences en fonds propres. Cette fois-ci, les institutions ont dû mobiliser très rapidement plus de fonds propres afin de respecter les contraintes imposées par Bâle II. Cela a inévitablement conduit les banques à adopter des comportements sous-optimaux caractérisés par des ventes massives d’actifs (“asset fire sales”) et des opérations de réduction du levier (“deleveraging”).

Des concepts comme le risque systémique et le “too big to fail” ont resurgi lors de la crise et ont dévoilé l’absence de mesures de risque, ainsi que les failles dans la régulation du système bancaire. Même si ces notions étaient introduites dans la littérature économique bien avant la crise financière récente³, il n’y a pas encore un consensus sur leur définition. Tout comme la stabilité financière, le risque systémique est défini seulement d’une manière très générale. Quant à ses mesures ou quantifications, les choses sont encore moins claires. La récente crise a néanmoins amplifié l’intérêt pour ces concepts et des efforts académiques et professionnels sont déployés pour répondre à ces manques. Une première preuve est fournie par le nouveau Cadre réglementaire international du secteur bancaire, Bâle III, qui intègre désormais un volet macroprudentiel (BIS, 2011).

Toutefois, la notion de risque systémique peut s’appliquer aussi aux pays et non seulement aux institutions financières. De ce point de vue, une dernière politique contestée par la crise est *la politique budgétaire*. Ce qui a commencé comme une crise financière, s’est vite transformée en une crise de la dette souveraine européenne. D’un côté, les gou-

³ En effet, le terme “risque systémique” a été introduit dans le langage économique aux début des années 1980 par l’économiste William Cline, suite au déclenchement de la crise de la dette souveraine en Amérique Latine (Cline, 1984).

vernements de plusieurs pays de la zone euro ont dû intervenir pour sauver leur système bancaire. Vu la sévérité et la durée de la crise, l'action des stabilisateurs automatiques n'a pas été suffisante pour faire face à un choc comme celui qui a perturbé l'équilibre économique en 2007. Dans cette configuration, d'importantes mesures de relance budgétaire et de soutien au secteur bancaire ont été déployées afin de lutter contre la crise. Le niveau élevé des fonds utilisés a fragilisé les finances publiques dans une grande partie des pays de la zone euro. De l'autre côté, le manque de sanction claire pour la violation du Pacte de Stabilité et de Croissance (PSC), a conduit plusieurs pays à dépasser les 60% de dette en pourcentage du PIB autorisés par le traité de Maastricht bien avant le début de la crise. Dans ces conditions, ces pays sont entrés en période de crise déjà avec un niveau très important de dette, dette qui n'a pas cessé d'augmenter ces dernières années.

La montée rapide de la dette publique dans un environnement d'instabilité financière et de faible croissance économique a augmenté la nécessité d'une évaluation de la soutenabilité de la dette, c'est à dire la capacité d'un pays de rembourser l'ensemble de la dette publique accumulée à n'importe quel moment dans le temps. La perte de confiance des investisseurs dans les gouvernements affaiblis par la crise a conduit à une augmentation sans précédent des rendements obligataires et a ouvert la discussion sur les Eurobonds. La situation en zone euro s'est aggravée à tel point que nous pouvons parler maintenant des pays à risque systémique important.

Les trois politiques brièvement présentées ci-dessus représentent le cadre macroéconomique de base dans une économie et doivent être conçues tout en prenant en compte leurs interactions. D'un côté, le policy-mix politique monétaire — politique budgétaire a été amplement et longuement étudié par les économistes⁴. Dans la construction de ces deux politiques, il faut tenir compte de la condition d'indépendance de l'autorité monétaire de la sphère politique, afin d'assurer un fonctionnement efficace de la banque centrale. En outre, des finances publiques saines et crédibles représentent aussi une condition nécessaire à la stabilité financière. Néanmoins, le policy-mix le plus débattu en ce moment reste celui entre la politique monétaire et la réglementation macroprudentielle.

Comme remarqué précédemment, les problèmes identifiés dans le cadre réglementaire actuel soulèvent de nombreuses questions. Certaines de ces questions, ainsi que les solutions envisagées pour améliorer les trois politiques susmentionnées, seront abordées dans le cadre de ce travail. La thèse porte principalement sur le lien qui existe entre le risque financier et la politique monétaire. Cependant, la notion du risque systémique nous conduit aussi aux problématiques liées à la dette souveraine et à la politique budgétaire. Nous nous interrogeons dans un premier temps sur l'existence du canal de la prise de

⁴ Pour des revues de littérature récentes sur ce sujet, voir Kirsanova et al. (2009), Leeper (2010) ou Wren-Lewis (2010).

risque et nous essayons de répondre à la question : est-ce qu'en zone euro, ce canal a joué un rôle dans le déploiement des événements qui ont mené à la crise ? (**Chapitre 1**).

Un premier constat issu de ce questionnement concerne le manque de mesures de risque avant le déclenchement de la crise. Cela représente la raison pour laquelle nous analysons dans un deuxième temps les mesures de risque systémique proposées récemment dans la littérature financière. Après un bref regard sur les mesures appliquées aux institutions financières, nous nous interrogeons sur la possibilité d'adapter ces indicateurs aux pays membres de la zone euro, afin d'identifier les États qui présentent une importance systémique (**Chapitre 2**). Ce sujet présente un intérêt particulier au vu des événements récents, car il est évident maintenant que le maintien de la stabilité financière passe aussi par une politique budgétaire saine.

Un deuxième constat que nous pouvons tirer de l'analyse du canal de la prise de risque concerne le comportement de la banque centrale : Est-ce qu'une banque centrale a intérêt à réagir par son seul instrument — le taux d'intérêt — aux indicateurs d'instabilité financière ? Sachant que la politique monétaire a une influence sur le risque financier, est-ce qu'une stratégie de "leaning against the wind" peut amener des bénéfices en termes de stabilité de l'inflation et de la sphère financière en même temps ? (**Chapitre 3**). La réponse à cette question nous amène à développer en dernier lieu une analyse sur les arbitrages entre objectifs.

Ainsi, dans le dernier chapitre (**Chapitre 4**) nous analysons l'apparition des trade-offs entre les objectifs de stabilité macroéconomique (inflation et output) et l'objectif de stabilité financière. Poursuivre plusieurs objectifs et essayer de les atteindre avec le même instrument peut-il présenter des avantages ? Est-ce qu'en rajoutant un nouvel instrument cette fois-ci de politique macroprudentielle, les résultats peuvent être améliorés ?

Pour répondre à ces problématiques, l'analyse engagée sera à la fois théorique et empirique. Nous détaillons par la suite le contenu de chaque chapitre, en présentant la méthodologie employée et les résultats obtenus.

Le **Chapitre 1** propose d'abord une revue de littérature sur le lien entre la politique monétaire et le risque financier. Un grand nombre d'articles tant théoriques qu'empiriques, a été consacré, dans la période récente, après la crise financière, aux effets de la politique monétaire sur le risque. En s'appuyant sur cette littérature, nous pouvons affirmer que l'existence du canal de la prise de risque peut être résumée par l'impact d'un changement du taux directeur sur la perception et la tolérance au risque des agents économiques. En partant de cette définition, nous essayons de voir tout d'abord quels sont les mécanismes de fonctionnement qui se trouvent à la base de ce nouveau canal. L'analyse est ensuite portée sur les effets de court et long terme de la politique monétaire sur le niveau de risque financier et leurs conséquences pour l'économie réelle. Une con-

clusion importante de cette revue de la littérature est qu'un niveau bas du taux d'intérêt, maintenu pendant une période suffisamment longue, peut engendrer une prise de risque excessive. Effectivement, dans le canal de la prise de risque, c'est le comportement des agents qui est affecté en premier par la politique monétaire. Cette accumulation du risque dans le système financier peut avoir des répercussions graves sur l'économie réelle une fois le risque matérialisé. Toujours dans cette partie, nous dressons un bilan des mesures de risque employées et nous faisons le point sur les modèles utilisés dans cette littérature.

L'analyse théorique est accompagnée dans ce chapitre d'une étude empirique sur la causalité entre la politique monétaire et le risque financier. D'un côté, nous testons l'hypothèse selon laquelle la politique monétaire a une influence sur le niveau du risque dans le système bancaire comme l'indique le canal de la prise de risque. Notre étude nous permet de prouver l'existence de ce canal pendant la période d'avant-crise. D'un autre côté, nous testons aussi l'influence du risque sur la conduite de la politique monétaire. Dans ce cas, l'étude menée nous aide à savoir si les autorités monétaires réagissaient déjà au risque sans pour autant le déclarer ouvertement. Cette analyse nous permet d'ouvrir la discussion sur le rôle des banques centrales dans le maintien de la stabilité financière et leur implication dans la politique macroprudentielle.

La construction d'un modèle VAR (vecteur autorégressif) est nécessaire afin de calculer des mesures de causalité. En vue du délai long de transmission de la politique monétaire sur l'économie réelle et du fait que l'accumulation du risque est un processus long, l'analyse s'effectue en utilisant les mesures de *causalité de long terme* proposées par Dufour and Taamouti (2010). Le modèle VAR porte sur la zone euro et est composé de trois types de variables : (i) une variable représentant la position de la politique monétaire, donnée par le taux d'intérêt de court terme (ii) des variables auxiliaires et (iii) une variable prenant en compte le niveau de risque. Les variables auxiliaires sont choisies en adéquation avec le mécanisme de transmission du canal de la prise de risque. Le choix de l'indicateur de risque s'avère plus difficile, car avant la crise, les mesures de risque existantes n'ont pas montré cette accumulation insidieuse du risque. Notre solution consiste alors dans l'utilisation d'une mesure proposée après le déclenchement de la crise, en l'occurrence le SRisk (Brownlees and Engle, 2012).

Dans les différentes configurations étudiées, nous retrouvons qu'à long terme, la politique monétaire influence effectivement le niveau de risque dans l'économie. De plus, à plusieurs reprises, l'impact sur le court terme n'est pas significatif, soulignant donc l'importance d'une approche de long terme. En outre, nous ne retrouvons pas d'effets significatifs du risque sur la conduite de la politique monétaire. Cela montre que la BCE n'accordait pas beaucoup d'importance dans sa démarche aux prix d'actifs, et de façon plus générale, à la stabilité financière.

Cette première analyse fournit une justification et un point de départ pour les chapitres qui vont suivre. Dans le **Chapitre 2** de la thèse, nous nous tournons vers le concept de risque systémique et sa quantification. Le risque systémique dérive d’une situation où la défaillance d’une ou de plusieurs institutions financières engendre une perturbation des services financiers. Par la suite, cette perturbation peut potentiellement avoir des conséquences graves sur l’économie réelle. Bien qu’il existe plusieurs définitions pour la notion de risque systémique et que cette notion existe dans la littérature depuis plusieurs décennies, la question de sa mesure a été abordée seulement après le déclenchement de la crise récente.

Le **Chapitre 2** débute par une courte revue de littérature sur les mesures et les indicateurs proposés jusqu’à présent par différents auteurs. Ensuite, nous concentrons notre attention sur les trois mesures du risque systémique qui ont attiré le plus d’attention, tant dans la sphère académique, que dans celle professionnelle : la MES (Marginal Expected Shortfall – Brownlees and Engle, 2012), la CES (Component Expected Shortfall – Banulescu and Dumitrescu, 2014) et le SRisk (Brownlees and Engle, 2012). La MES est une mesure économétrique qui se définit comme la perte de valeur attendue pour une firme conditionnellement à une baisse du marché des actions dans son ensemble. Les institutions qui présentent une MES élevée sont celles qui ont une contribution marginale plus importante au risque systémique, et qui donc peuvent causer le plus de pertes en cas de crise. La CES est une dérivée de la MES qui rajoute à cette dernière une dimension “taille”. Finalement, le SRisk est une mesure obtenue à partir de la contrainte en capital imposée aux institutions financières par les Accords de Bâle. Cet indicateur de risque systémique tient compte de la MES et du levier de chaque institution.

Les mesures du risque systémique ont été conçues dans une optique d’évaluation du risque des institutions financières. Notre objectif dans ce chapitre est de transposer ces mesures au risque souverain. Par conséquent, nous essayons de déterminer quels sont les pays européens qui contribuent le plus au risque systémique dans la zone euro. Un État est considéré comme étant systémique lorsqu’il n’est plus capable de rembourser sa dette publique, sachant qu’un possible défaut de paiement peut avoir des conséquences adverses pour l’ensemble des pays avec lesquels il est interconnecté. Un défaut potentiel de paiement apparaît au moment où le taux obligataire proposé par le marché est si élevé qu’il devient impossible pour ce pays de lever les fonds nécessaires pour rembourser ses obligations en cours. En conséquence, la MES peut être définie dans notre analyse comme l’accroissement attendu du taux de rendement appliqué à un certain gouvernement lorsque le marché obligataire européen se trouve en crise. De plus, pour calculer la CES nous utilisons la taille relative de la dette souveraine afin d’obtenir la contribution absolue de chaque pays au risque systémique de la zone.

Finalement, nous proposons une nouvelle mesure du risque systémique d'un pays que l'on va appeler "le besoin de financement attendu" (EFR – Expected Financing Requirements). Inspiré du SRisk, l'EFR est calculé à partir de la contrainte budgétaire d'un État. Cette mesure nous permet de classer les pays par ordre de leur importance systémique (leur contribution au risque de la zone). Elle dépend du niveau de dette publique, du déficit primaire et du taux de croissance, mais aussi de la MES de chaque pays.

Pour le calcul de ces mesures, nous utilisons un modèle DCC (Dynamic Conditional Correlations) bivarié appliqué sur les données du marché obligataire européen. Pour mener notre analyse, nous construisons un indice fictif du marché obligataire calculé comme une moyenne pondérée des rendements. Le poids de chaque pays est donné par le pourcentage de dette publique d'un État dans la dette totale de la zone. Au final, notre mesure, l'EFR, permet de prendre en compte non seulement la taille d'un pays, mais aussi les corrélations existantes entre les rendements du pays en question et le marché. Ces deux ingrédients – taille et corrélations – sont essentiels dans la mesure du risque systémique.

Etant donné que l'objectif de ce chapitre est de vérifier si les mesures appliquées jusque là aux institutions financières peuvent être aussi transposées aux pays, notre analyse est effectuée seulement "in-sample". Cela implique une étude ex-post des faits, sans s'interroger sur le pouvoir explicatif de ces mesures. Les trois indicateurs considérés dans notre analyse nous donnent des informations sur la contribution de chaque pays au risque systémique de la zone. La MES capte principalement un "effet taux", tandis que la CES et l'EFR intègrent un "effet taille" en plus de l'effet taux. Nos résultats montrent que ces mesures identifient effectivement comme pays d'importance systémique, les États ayant eu les plus graves problèmes pendant la crise de la dette. Afin d'affiner ces résultats, nous analysons les indicateurs en tenant aussi compte de la probabilité de chaque pays de connaître un événement systémique.

L'intégration des mesures de risque systémique dans la réglementation macroprudentielle est essentielle pour un meilleur fonctionnement de l'économie dans son ensemble. Dans le chapitre présenté ci-dessus, nous montrons que le risque systémique ne concerne pas seulement les institutions financières, mais que cette notion peut également s'appliquer aux États. Par conséquent, la politique budgétaire peut aussi envisager de prendre en compte ce type de mesures appliquées aux États afin de surveiller et d'imposer des règles plus strictes aux pays les plus systématiquement risqués.

Le **Chapitre 3** propose un modèle théorique d'équilibre général (MEGIS – Modèle d'équilibre général inter temporel et stochastique). Sachant que les décisions de politique monétaire ont un impact non-négligeable sur le niveau de risque, la banque centrale doit, du moins indirectement, veiller à la stabilité financière. C'est la raison pour laquelle

nous nous interrogeons dans ce chapitre sur le comportement d’une banque centrale qui souhaite réagir au risque financier. Ceci implique l’adoption d’une stratégie de “leaning against the wind”. Notre analyse présente deux volets. Dans un premier temps, nous essayons de déterminer si, dans un cadre qui correspond à une situation d’avant-crise⁵, une banque centrale s’intéressant au risque financier aurait pu mieux stabiliser les cycles économiques et réduire la sévérité de la crise. Pour cela, nous considérons une règle de taux augmentée d’un indicateur de stabilité financière. En suivant les recommandations du Comité de Bâle, nous prenons comme indicateur le ratio des crédits sur le PIB. La stabilité financière est ainsi définie comme la volatilité de cet indicateur. Dans un second temps, nous déduisons le comportement optimal de la banque centrale lorsque l’objectif de stabilité financière se rajoute aux objectifs traditionnels de stabilité des prix et de l’output.

Le cadre théorique suppose la modélisation d’une économie dans laquelle plusieurs acteurs interagissent : les ménages, les banques, les entrepreneurs, les producteurs du capital et des détaillants. La structure de l’économie correspond au modèle standard dynamique néo-keynésien, mais notre modèle diffère de ce cadre principalement par l’hypothèse de l’existence des frictions sur le marché du crédit. La présence de ces frictions donne lieu à un mécanisme d’accélérateur financier qui apparaît à deux niveaux : dans la relation entre la banque et l’entrepreneur et dans la relation entre la banque et le ménage représentatif (Badarau, 2009, Badarau and Levieuge, 2011, Bernanke et al., 1999). L’asymétrie d’informations entre ces acteurs donne lieu à deux primes de financement externe, qui dépendent inversement de la situation financière des emprunteurs.

Dans le but de reproduire les événements qui ont précédé la crise financière de 2007, nous introduisons une bulle sur les prix d’actifs comme celle proposée par Bernanke and Gertler (1999). La bulle est exogène dans ce chapitre.⁶ Elle dure quatre périodes et est ensuite suivie de quatre périodes de récession. Cela nous aide à obtenir un cycle économique complet.

Le premier volet de notre analyse nous permet de déduire le fait que répondre à un indicateur financier aurait eu des effets négatifs, car seul l’output aurait été mieux stabilisé. Cette perte de croissance aurait été accompagnée par plus de volatilité dans la sphère financière, mais aussi du côté de l’inflation. Les résultats du deuxième volet de notre analyse mettent en avant la présence des trade-offs entre objectifs, quand seul le taux d’intérêt est utilisé dans le but d’atteindre les trois objectifs de la banque centrale. Nous remarquons aussi que la politique monétaire devrait être plus agressive à l’inflation, ainsi qu’à l’output gap, afin de mieux stabiliser l’économie. Enfin, les avantages obtenus en termes de stabilité financière sont très limités. Par conséquent, ce scénario ne serait

⁵ Nous faisons référence ici à une bulle financière et une politique monétaire accommodante.

⁶ Nous relâchons cette hypothèse dans le dernier chapitre.

pas favorisé par les banques centrales, qui doivent garder comme objectif principal la stabilité des prix.

La mise en évidence des trade-offs nous conduit vers une analyse plus approfondie de cette problématique dans le dernier chapitre de la thèse (**Chapitre 4**). Nous quittons le cadre théorique complexe du modèle DSGE du Chapitre 3, pour étudier les arbitrages entre objectifs dans un modèle toujours néo-keynésien, mais présenté sous une forme réduite. Une première analyse s'intéresse à l'existence des trade-offs dans un scénario de bulle endogène sur les prix d'actifs. En effet, la bulle apparaît suite aux chocs aléatoires et est influencée par la conduite de la politique monétaire. Tout comme dans le modèle proposé par Gali (2014), et contrairement aux croyances existantes, une augmentation du taux directeur a un impact positif sur le niveau de la bulle. En revanche, cette même politique a une influence positive sur la probabilité d'éclatement de la bulle, réduisant potentiellement la durée de la période de boom. La banque centrale est supposée dans cette analyse pratiquer une stratégie de *leaning against the wind*, c'est-à-dire qu'elle réagit à la bulle financière par le taux d'intérêt. L'équation de la bulle est introduite dans un modèle hybride standard, à trois équations : une courbe IS (de demande), une courbe de Phillips et une équation qui gouverne la règle de taux de la banque centrale. Par ailleurs, il est supposé que la bulle d'actifs influence positivement la demande dans cette économie. L'apparition des trade-offs est étudiée pour trois types de chocs : un choc d'offre, un choc de demande (choc sur les prix d'actifs) et une combinaison de ces deux chocs.

Cette première analyse confirme les résultats du chapitre antérieur et nous montre que les trade-offs entre les différents objectifs apparaissent dans toutes les configurations considérées. De fait, rajouter un nouvel objectif aux mandats des banques centrales sans lui donner aussi un nouvel instrument, risque fortement de produire des effets indésirables sur l'économie. Le principe de Tinbergen n'est pas vérifié et nos résultats soulignent la nécessité d'avoir au moins un nouvel instrument afin de répondre à l'objectif de stabilité financière. Cela représente donc le but de notre deuxième analyse.

Avant ce deuxième exercice théorique, nous présentons un bilan des résultats des articles traitant l'interaction entre la politique monétaire et la réglementation macro-prudentielle. Nous développons ensuite le modèle proposé dans la première partie du chapitre afin d'y intégrer un secteur bancaire (Bernanke and Blinder, 1988, Nakornthab and Rungcharoenkitkul, 2010). Cela nous permet par la suite d'ajouter une règle sur le capital bancaire en concordance avec les Accords de Bâle. La bulle financière est elle aussi modifiée, car cette fois-ci, ce n'est pas seulement la politique monétaire qui influence la dynamique de la bulle, mais aussi les crédits. Nous pouvons étudier ainsi l'existence de

trade-offs dans trois configurations : absence de réglementation prudentielle, réglementation fixe et réglementation contracyclique.

Suite à cette analyse, nous pouvons tirer trois principales conclusions. Premièrement, l'introduction d'un deuxième instrument de politique économique, permet de réduire la volatilité des variables macroéconomiques et financières par rapport à une situation où une telle réglementation n'est pas imposée. En outre, la règle contracyclique procure les meilleurs résultats. Deuxièmement, le scénario où la banque centrale intervient aussi dans le maintien de la stabilité financière en pratiquant une stratégie de *leaning against the wind* est préféré au scénario où l'autorité monétaire utilise une règle de taux standard, à la Taylor. Troisièmement, une stratégie impliquant une réponse plus agressive du taux d'intérêt aux variables financières semble avoir des effets déstabilisants sur le secteur financier et sur l'économie réelle. Globalement, même si les trade-offs entre objectifs persistent dans ce deuxième modèle, l'introduction d'une réglementation macroprudentielle aide à la réduction des cycles économiques et financiers.

General Introduction

The recent financial crisis has particularly attracted the attention of economists as it has called into question the functioning of the financial system and the design of existing economic policies (namely, monetary, prudential and fiscal policies). The first flaw identified concerns the conduct of *monetary policy*. Before the crisis, the main concern of central banks was price stability. To accomplish this goal, monetary authorities used as instrument the main refinancing interest rate. Output stability was considered only as a secondary objective, which was nevertheless closely connected to the main objective. The period before the crisis was characterized by a low and stable inflation in the euro area,⁷ consistent with the objective set by the European Central Bank (ECB). In addition, since the 1980s, the most developed economies have experienced a reduction in cyclical fluctuations. It is for this reason that the pre-crisis period has been named the “Great Moderation”. All these facts led us to think that monetary policy was sufficient to ensure a stable macroeconomic environment.

At the same time, the lessons learned from the previous crisis, triggered by the “Internet bubble”, led us to believe that it was not optimal to use monetary policy in response to asset price deviations. Rather, it was believed that the best solution in such a situation was to repair the damage caused by the bubble after its burst (“benign neglect”). However, the crisis that began in 2007 demonstrated that this analysis was biased from several points of view.

First, the existence of a new monetary policy transmission channel – the risk-taking channel – highlighted by Borio and Zhu in 2008 (Borio and Zhu, 2012) indicated that monetary actions might have a greater impact on the real activity than we would have thought. According to this channel, if certain conditions are met, it is possible that a simple change in the interest rate may generate financial risk in the economy. Actually, central banks that kept their interest rates low during the period of economic boom have been heavily criticized and even considered responsible for the severity of the crisis (Giavazzi and Giovannini, 2010, Kannan et al., 2012). The awareness about how this new channel works emphasizes the need for a change in the central banks’ strategy, even if

⁷ See Chapter 1.

the change would be only partial. Additionally, recent events have made it clear that the mere price stability is not sufficient to ensure also the stability of the financial sector or even macroeconomic stability. Good control of inflation has not prevented the financial turmoil and its severe impact on the real sector. Finally, the gravity of the crisis has brought to the forefront the discussion on the responses of central banks to financial and real estate bubbles.

In a recent speech,⁸ the Governor of the Bank of France, Christian Noyer, summarizes this misunderstanding we had before the crisis:

“With hindsight, of course, we can see now that this ‘ideal’ economy may never have existed. The Great Moderation was as much a product of ‘good luck’ (brought by disinflationary effects of globalization) than good policy. Monetary stability is a necessary but not a sufficient condition of financial stability, because capital markets are not always and necessarily efficient. And downward financial spirals may quickly bring our economies to the point where interest rates can no longer be used as effective tools.”

Given the impact of central banks’ decisions on financial risk and the potential consequences on the real activity, one can think of the coherence and the effectiveness of a new objective for the monetary authority: the one of financial stability. More specifically, the discussions now focus on the macroprudential component of policy and on how to account for systemic risk.

The crisis has also revealed flaws in the design of *prudential policy*. The role of this regulation is to ensure financial stability, a crucial condition for the proper functioning of the economy as a whole. However, several problems have been identified. First, prudential regulation was only interested in risk of individual institutions – the microprudential regulation – ignoring the macroprudential side, *i.e.* the potential connections between institutions. The main duty of prudential policy was to intervene to correct the failures of the banking market resulting from asymmetric information problems, limited liability of financial institutions and other imperfections such as implicit or explicit guarantees offered by the government. In addition, this regulation only applied to the banking sector and to insurance institutions, leaving other high risk financial institutions, such as hedge funds, outside these norms.

Moreover, for the last two decades, the banking industry has continuously been changing. We refer here to deregulation, bank disintermediation and to the globalization of financial markets. The increased use of complex and innovative products and processes, such as derivatives and securitization, raised the uncertainty about the actual evolution

⁸ Speech given on the 26th of March 2012 entitled “Re-examining central bank orthodoxy for un-orthodox times”.

of risk. Increased competition in the financial sector has been one of the main reasons for the success of these products. Although financial innovations were difficult to control, these products have provided financial institutions with the opportunity to resort to regulatory arbitrage, that is, to circumvent the rules imposed by prudential policy. All these changes and developments that regulation failed to integrate led to a rise in risk in the financial sector.

Finally, the failure of prudential regulation also relates to the procyclicality introduced by the latter (see for example Repullo and Suarez, 2008). Indeed, by their content, prudential rules contributed to the amplification of problems during the crisis. By requiring less capital in periods of economic boom, they gave a strong incentive to banks to excessively increase their activity and to take risks beyond their risk management capacity. The outbreak of the crisis marked a reversal in capital requirements. Financial institutions had to quickly mobilize more capital to meet the constraints imposed by Basel II. This inevitably led banks to adopt suboptimal behaviors characterized by massive asset sales (the so called “asset fire sales”) and deleveraging.

Interest in concepts such as systemic risk and “too big to fail” resurfaced during the crisis. This revealed the lack of well-performing risk measures, as well as flaws in the regulation of the banking system. Although these concepts were introduced in the economic literature well before the recent financial crisis,⁹ there is not yet a consensus on their definition. As in the case of financial stability, systemic risk is defined only in a very general way. Things are even more ambiguous when it comes to their measurement. However, the recent crisis has amplified academic and professional efforts made to address these gaps. The macroprudential component included in the new international regulatory framework for the banking sector, Basel III (BIS, 2011), is the first evidence of these efforts.

However, the concept of systemic risk, initially developed for financial institutions, may also apply to countries. From this point of view, *fiscal policy* has also been criticized during the recent years. What began as a financial crisis, quickly turned into a sovereign debt crisis in Europe. On the one hand, several countries from the Eurozone needed government interventions in order to save their respective banking system. Given the severity and the length of the crisis, automatic stabilizers had not been sufficient to deal with the shock that disrupted economic activity in 2007. Therefore, to fight against the crisis under these circumstances, significant fiscal stimulus and banking sector support were needed. The important amount of funds used for these operations weakened the public finances in many of the Eurozone countries. On the other hand, the lack of a clear penalty for the violation of the Stability and Growth (SGP), has led several countries

⁹ Indeed, the term “systemic risk” was introduced into the economic language in the early 1980s by the economist William Cline following the outbreak of the sovereign debt crisis in Latin America (Cline, 1984).

to exceed the limit of 60% of debt (as a percentage of GDP) allowed by the Maastricht Treaty well before the beginning of the crisis. Therefore, these countries that infringed the SGP entered the crisis with an already high level of debt that continued rising over the recent years.

The rapid increase of public debt in an environment of financial instability and slow economic growth has increased the need for an assessment of the debt sustainability, *i.e.* the ability of a country to repay all the accumulated public debt at any moment in time. The loss of confidence of investors in governments that were weakened by the crisis led to an unprecedented rise in bond yields and opened the discussion on Eurobonds. The situation in the Eurozone has worsened to the point that we can now speak of systemically important countries.

The three policies briefly depicted above represent the basic macroeconomic framework in an economy and should be designed by taking into account their interactions. On the one hand, the policy mix between monetary policy and fiscal policy has been widely studied by economists.¹⁰ In designing these two policies, one must take into account the condition of independence of the monetary authority from the political sphere, to ensure the effective functioning of the central bank. In addition, sound and credible public finances represent also a necessary condition for safeguarding financial stability. However, the most debated policy mix is currently the one between monetary policy and macroprudential regulation.

As previously noted, the problems identified with the regulatory framework raise many questions. We discuss in this dissertation some of these problems, as well as some of the proposed solutions to improve the three aforementioned policies. This dissertation focuses mainly on the relationship between monetary policy and financial risk. However, the concept of systemic risk allows us to move towards the problems related to sovereign debt and fiscal policy. The first question that we try to answer concerns the existence of a risk-taking channel: Did this channel play a role in the unfolding of events that led to the crisis? (**Chapter 1**).

The first remark issued from the analysis of the risk-taking channel concerns the lack of risk measures before the outbreak of the crisis. This is the reason why in the following chapter, we examine the systemic risk measures that have been recently proposed in the financial literature. After a brief overview of the measures applied to financial institutions, we wonder about the ability to adapt these measures to the Eurozone member states in order to identify the most systemically important countries (**Chapter 2**). In light of recent events, this topic becomes particularly interesting, especially since it is now clear that the preservation of financial stability also requires sound fiscal policy.

¹⁰ For reviews of the recent literature on this topic, see Kirsanova et al. (2009), Leeper (2010) or Wren-Lewis (2010)

The second remark we can make from the analysis of channel risk-taking relates to the behavior of the central bank: Does the monetary authority benefit from responding to financial stability indicators when using only the interest rate? Given that monetary policy has an influence on financial risk, is a “leaning against the wind” strategy able to improve at the same time price stability and financial stability? (**Chapter 3**). The answer to this question brings us to an analysis of trade-offs between objectives.

Consequently, in the last chapter of the dissertation (**Chapter 4**), we analyze the emergence of trade-offs between macroeconomic stability objectives (inflation and output) and the objective of financial stability. Is pursuing several objectives at the same time and trying to achieve them by using the same instrument a good strategy for the central bank? Can results be improved if a macroprudential instrument is added as a policy response to financial imbalances?

To address the abovementioned questions, we employ both empirical and theoretical models. In what follows, we introduce in more detail the contents of each chapter and present the methodology and our main results.

Chapter 1 begins with a literature review on the relation between monetary policy and financial risk. The years following the financial crisis marked the emergence of a large number of both theoretical and empirical articles dealing with this topic. The existence of the risk-taking channel can be summarized by the impact of a change in the policy rate on the risk perception and risk tolerance of economic agents. Based on its definition, we try to see first of all what are the main mechanisms through which this new channel operates. The analysis is then focused on the short and long term effects of monetary policy on the level of financial risk. The impact on the real economy is also studied. The main results in this literature suggest that a low level of interest rates, maintained for a sufficiently long period, can lead to excessive risk-taking. According to this channel agents’ behavior is the first to be affected by monetary policy actions. The resulting financial risk accumulation can have serious repercussions on the real economy once the risk materializes. We provide, in the same section, a review of the risk measures and of the models used to study the risk-taking channel.

The theoretical analysis in this chapter is accompanied by an empirical study on the causal relationship between monetary policy and financial risk. On the one hand, we test the hypothesis according to which monetary policy has an influence on the level of risk as indicated by the risk-taking channel. Our analysis allows us to prove the existence of this channel during the pre-crisis period. On the other hand, we also test the influence of risk on the conduct of monetary policy. In this case, the study helps us reveal whether or not the monetary authorities reacted to risk without openly declaring such a strategy.

This analysis allows us to open the discussion on the role of central banks in maintaining financial stability and their involvement in macroprudential policy.

The construction of a VAR model (Vector AutoRegressive) is required to compute causality measures. Given the lag in the transmission of monetary policy to the real economy and due to the fact that risk accumulation is a long process, the analysis is performed using *long run causality measures* (Dufour and Taamouti, 2010). The VAR model focuses on the euro area and consists of three types of variables: (i) a variable representing the monetary policy position, given by the short term interest rate (ii) auxiliary variables and (iii) a variable taking into account the level of risk. The auxiliary variables are chosen in line with the transmission mechanisms of the risk-taking channel. The choice of the risk indicator is more difficult, because before the crisis, existing measures of risk did not capture its insidious accumulation. Our solution consists in using a measure that has only been proposed after the outbreak of the crisis, namely the SRisk (Brownlees and Engle, 2012).

In the various configurations studied, we find that in the long run, monetary policy influences indeed the level of risk in the economy. In addition, on several occasions, the impact in the short run is not significant, emphasizing thus the importance of a long term approach. In addition, we do not find a significant impact of risk on the conduct of monetary policy. This shows that the ECB did not give much importance to asset prices, and more generally to financial stability before the outbreak of the crisis.

This initial analysis provides a rationale and a starting point for the chapters that follow. In **Chapter 2**, we turn to the concept of systemic risk and its measurement. Systemic risk derives from a situation where the failure of one or more financial institutions creates a disruption in financial services. Subsequently, this disturbance can potentially have serious consequences on the real economy. Although there are several definitions for the concept of systemic risk and that this notion has been introduced in the economic literature a long time ago, the interest in the measurement of this type of risk appeared only after the outbreak of the recent crisis.

Chapter 2 begins with a brief literature review of the measures and indicators proposed so far by different authors working on this topic. We focus afterwards on three systemic risk measures that attracted the most attention, both from academics and professionals: the MES (Marginal Expected Shortfall – Brownlees and Engle, 2012), the CES (Component Expected Shortfall – Banulescu and Dumitrescu, 2014) and the SRisk (Brownlees and Engle, 2012). The MES is an econometric measure defined as the expected loss for a firm conditional on the overall decline of the equity market. The institutions with the highest levels of MES are those that have the highest marginal contribution to systemic risk, and thus may cause important losses to the system during a crisis. The

CES is viewed as an extension of the MES as it adds a “size” dimension to the latter. Finally, SRisk is an index obtained from the capital constraint imposed on financial institutions by the Basel Accords. This systemic risk measure takes into account not only the MES of each institution, but also its leverage level.

Systemic risk measures have been designed for the risk assessment of financial institutions. Our goal in this chapter is to transpose these measures to sovereign risk. Therefore, we try to identify the European countries that contribute the most to systemic risk in the euro area. A country is considered as being systemic when it is no longer able to repay its debt, knowing that its possible default may have adverse consequences for all the countries with which it is connected. A potential payment default occurs when the bond yield proposed by the market is so high that it becomes impossible for the country to raise the necessary funds to repay its outstanding obligations. Therefore, the MES can be defined in our analysis as the expected increase in the yield applied to a government when the European bond market is already experiencing a crisis. Further, to compute the CES we use the relative size of the sovereign debt. We obtain in this way the absolute contribution of each country to the systemic risk of the area.

Finally, we propose a new measure of systemic risk for countries that we entitle “Expected Financing Requirements” (EFR). Inspired by the SRisk, the EFR is calculated from the budget constraint of the government. This new measure allows us to classify countries according to their systemic importance. The level of public debt, the primary deficit and the rate of growth, as well as on the MES of each country are needed to compute the EFR.

To obtain the three aforementioned measures, we use a bivariate DCC model (Dynamic Conditional Correlations) applied on data for the European bond market. To conduct our analysis, we construct a virtual bond market index calculated as a weighted average of the yields. The weight of each country is given by the percentage of public debt in the total debt of the area. In the end, our measure, EFR, takes into account not only the size of a country, but also the existing correlations between the yields of the country and the ones of the market. These two ingredients — size and correlations — are essential in the measurement of systemic risk.

Since the objective of this chapter is to determine whether the measures usually applied to financial institutions can also be transposed at country level, we perform only an “in-sample” analysis. This implies an ex-post study of events, without taking interest in the explanatory power of these measures. The three indicators considered in our analysis give us information on each country’s contribution to the systemic risk of the area. MES captures mainly a “yield effect”, while the CES and the EFR include a “size effect” in addition to the yield effect. Our results show that these measures identify as systemically

important countries, the Eurozone states that actually had the most serious problems during the debt crisis. To refine these results, we analyze our measures by looking at the probability of each country to experience a systemic event.

Taking into account systemic risk measures when designing macroprudential regulation is essential for a better functioning of the economy as a whole. In the chapter described above, we show that systemic risk is not only characteristic to financial institutions, but can also apply to countries. Therefore, fiscal policy can also be improved by integrating such measures in order to monitor systemically risky countries and to impose them stricter rules.

Chapter 3 proposes a Dynamic Stochastic General Equilibrium model (DSGE). Knowing that monetary policy decisions have a non-negligible impact on the level of risk, the central bank should, at least indirectly, take interest in the financial stability objective. For this reason, in this chapter, we try to understand the effects of a monetary policy strategy that responds to financial risk *i.e.* the adoption of a “leaning against the wind” strategy. We perform two analyzes. First of all, we try to determine whether, in a setting that corresponds to a pre-crisis situation,¹¹ a central bank which takes interest in financial risk could have better stabilized economic cycles and reduce the severity of the crisis. For this, we consider an augmented interest rate rule that includes a financial stability indicator. In compliance with the recommendations of the Basel Committee, we use the ratio of credit to GDP as an indicator of financial distress. Furthermore, we define financial stability as the volatility of this ratio. Second, we derive the optimal behavior of the monetary authority when the central bank adds the financial stability objective to its traditional objectives of price and output stability.

The theoretical framework involves modeling an economy in which several actors interact: households, banks, entrepreneurs, capital producers and retailers. The structure of the economy is similar to the standard New Keynesian model. However, what differentiates our model from this framework is the assumption that credit markets are subject to financial frictions. These frictions give rise to a financial accelerator mechanism that appears at two levels: in the relationship between the bank and the entrepreneur and in the relationship between the bank and the representative household (Badarau, 2009, Badarau and Levieuge, 2011, Bernanke et al., 1999). The asymmetric information problems between these agents justify the existence of two external finance premiums, which depend inversely on the financial condition of the borrowers.

In order to reproduce the events that preceded the financial crisis of 2007, we introduce an asset price bubble as the one proposed by Bernanke and Gertler (1999). The bubble

¹¹ We refer here to a scenario where a financial bubble is present and where monetary policy is accommodative.

is exogenous in this chapter,¹² it lasts four periods and its burst triggers four periods of downturn. This allows us to obtain a complete economic cycle.

From the first analysis, we deduce that responding to a financial indicator would have overall had negative effects, because only the output would have been better stabilized. This loss of growth would have been accompanied by increased volatility in the financial sphere, but also by more volatile inflation. The results of the second analysis evidence the emergence of trade-offs between objectives, when the interest rate is the only instrument at the disposal of the central bank. We also note that monetary policy should be more aggressive to inflation and to the output gap, as this would better stabilize the economy. Finally, the benefits obtained in terms of financial stability are very limited. Given our results, we argue that central banks would not resort to a leaning against the wind strategy if no macroprudential regulation is enforced. Therefore, monetary authorities should rather concentrate on their primary objective of price stability.

The identification of trade-offs in the above framework determines us to undertake a more thorough analysis of this issue in the last chapter of the dissertation (**Chapter 4**). We leave aside the complex theoretical framework of Chapter 3 to study the trade-offs between objectives in a reduced form New Keynesian model. We first examine whether trade-offs still emerge in a scenario where asset price bubbles are endogenous. More precisely, the bubble appears as a result of random shocks and is influenced by monetary policy. Similar to the assumptions made by Gali (2014), and contrary to existing beliefs, an increase in the interest rate has a positive impact on the level of the bubble. However, the same policy has a positive influence on the probability of bubble burst, potentially reducing the length of the boom period. The central bank is assumed in this analysis to pursue a strategy of leaning against the wind, that is, it reacts to the financial bubble when establishing the level of the interest rate. The equation of the bubble is introduced into a hybrid three equation model composed of: an IS curve (demand), a Phillips curve and an equation that governs the interest rate rule of the central bank. Furthermore, it is assumed that the asset bubble positively influences the demand in this economy. The emergence of trade-offs is studied for three types of shocks: a supply shock, a demand shock (shock on asset prices) and a combination of these two shocks.

This first investigation confirms the results of the previous chapter and proves that trade-offs between objectives appear in all the configurations considered. More precisely, adding a new objective to the mandates of central banks without providing them also with a new instrument increases the chances of a negative outcome for the economy. The Tinbergen principle is not verified and our results highlight the need to have at least one

¹² We relax this assumption in the last chapter.

new instrument to address the financial stability objective. This represents the aim of our second analysis.

Before this second theoretical exercise, we present a summary of the results on the interaction between monetary policy and macroprudential regulation. We then develop the framework proposed in the first part of the chapter to include a banking sector (Bernanke and Blinder, 1988, Nakornthab and Rungcharoenkitkul, 2010). This allows us to add a rule on bank capital requirements in accordance with the Basel III Accords. The bubble is also altered because, this time, it is not only the monetary policy that influences the dynamics of the bubble, but also the evolution of credit. With this extended model we study the existence of trade-offs in three configurations: no prudential regulation, fixed capital rules and countercyclical regulation.

Three main conclusions can be drawn from this last analysis. First, the introduction of a new economic policy instrument reduces the volatility of macroeconomic and financial variables relative to a situation where no such regulation is imposed. Additionally, the countercyclical rule provides the best results. Second, the scenario where the central bank is also involved in maintaining financial stability by practicing a policy of leaning against the wind is preferred to the scenario where the monetary authority uses only a standard Taylor rule. Third, a strategy involving a more aggressive response of interest rates to financial variables seems to have a destabilizing effect on the financial sector and on the real economy. Overall, even if the trade-offs between objectives persist in this second model, the introduction of macroprudential regulation helps to reduce economic and financial cycles.

Chapter 1

Monetary Policy and Risk-Taking

“Important central banks, such as the Bank of England and the United States Federal Reserve kept their key interest rates too low for too long (...). To be sure, the fall of the risk premium on financial markets, the development of all kinds of exotic derivatives, and these derivatives’ subsequent misuse sowed the seeds for this crisis, but those factors could not have caused the crisis without the plentiful rainfall that allowed those seeds to grow.” (Eijffinger, 2010)

The accumulation of risk in the years leading to the crisis went without notice. An extremely favorable environment with low interest rates for a protracted period of time (2002 – 2006) and low inflation, accompanied by an abundance of global liquidity,¹ led economic agents to behave in a riskier way in their search for yield. Financial innovations – new products (credit derivatives) and new practices (securitization) – have been especially created to meet this risk appetite. Like any innovation, this generated a general enthusiasm in the financial sector, but it also misguided people with respect to the risk accompanying these products and processes. All financial institutions – banks, pension and investment funds, as well as insurance companies – relied on leverage, by using off-balance-sheet transactions, to finance their investments. Under these circumstances, their indebtedness levels have quickly increased. At the same time, banks relying on securitization eased their credit standards and even agreed to extend credit to the poorest households (Ioannidou et al., 2009; Jimenez et al., 2009; Maddaloni and Peydro, 2011). Certainly, this phenomenon was more pronounced in the United States (US), however different studies show that, before the outbreak of the crisis, this practice had a global dimension. A few examples are Ioannidou et al. (2009) who perform an analysis of the increase in risk on Bolivian data or Jimenez et al. (2009) who confirm the presence of this phenomenon in Spain. Contrary to what we might expect, risk premiums remained at very low levels and therefore the accumulation of risks went undetected until the summer

¹ See, for example, Bracke and Fidora (2008).

of 2007, when both in the US and in Europe, the first signs of financial distress appeared. Even though a few warning signals were highlighted before this date, financial institutions ignored all evidence of increasing risk and preferred to concentrate on their returns. It was hardly at the outbreak of the crisis that the danger posed by this increased risk was acknowledged.

The crisis represented both the failure of prudential regulation and monetary policy, the latter being seen by some authors as one of the main factors of the crisis (Acharya and Richardson, 2009; Allen and Carletti, 2009; Diamond and Rajan, 2009). If the responsibility for financial stability is directly attributed to prudential regulation, monetary authorities can also, in an indirect way, have an interest in ensuring financial stability. The explanation comes from the fact that the monetary policy stance can influence the level of risk in the financial sector and that this risk may subsequently affect the real economy. However, before the crisis, monetary authorities were oriented only towards keeping a low and stable inflation rate and neglected the accumulation of other imbalances in the economy.

To understand better the importance of monetary policy in an economy, one must analyze the transmission channels of this policy to the real economy. Before the crisis, four main channels were acknowledged and amply documented in the literature – the interest rate channel, the credit channel, the equity price channel and the exchange rate channel.² However, the crisis revealed that the transmission of monetary policy exceeds these dimensions. To explain the drivers of the recent crisis, Borio and Zhu (2012)³ gave the definition of a new monetary policy transmission mechanism – the risk-taking channel. They define it as *“the impact of changes in policy rates on either risk perceptions or risk-tolerance and hence on the degree of risk in the portfolios, on the pricing of assets, and on the price and non-price terms of the extension of funding”*. This new concept drew the attention of researchers and many empirical and theoretical studies took thenceforth interest in the relationship between monetary policy and risk.

Box 2.1 Monetary Policy Transmission Channels

Interest rate channel: It represents the traditional channel of monetary policy transmission, commonly found in IS-LM and new Keynesian models. According to this mechanism, a change in the monetary policy interest rate has a direct effect on investment and consumption decisions. Given price stickiness in the short run, a decline in the policy rate will translate into a decrease in the real interest rate in the

² For a survey on traditional monetary policy transmission channels see “Symposium: The Monetary Transmission Mechanism” (1995) or Mishkin (1996). See also Box 2.1 of this thesis for a brief overview of monetary policy transmission channels.

³ First version: 2008.

short run. Moreover, consistent with the theory on the term structure of interest rates, long term real interest rates will diminish as well. As a consequence, firms will face a lower cost of capital and thus will invest more, whereas households will consume more durable goods and invest in housing. The ultimate result of these decisions will be an increase in inflation and in output.

Two other monetary policy transmission channels can be related to this conventional mechanism. First, as expectations play an important role in the functioning of the interest rate channel, *the expectations channel* became more relevant, especially with the introduction of the inflation targeting regime. When the central bank changes its policy stance, economic agents' expectations concerning inflation, future values of interest rates and other macroeconomic variables are affected. These expectations have an influence on people's decisions about consumption and investment. The signals sent by the monetary authority need to be as clear as possible if the central bank intends to use this transmission mechanism in order to anchor inflation expectations.

The cost channel is the second mechanism that can be related to the interest rate channel. If in the latter, the interest rate influences entrepreneurs' medium and long term investment decisions (demand side effects), according to the cost channel, policy rates also have an impact on firms' financing costs in the short run (supply side effects). A decrease in the policy rate, diminishes the marginal cost of production (working capital to finance wages, suppliers etc.). In this case, firms will either adjust their offer or their price, both actions resulting in a lower inflation rate. Nevertheless, in the long term, demand effects prevail. This channel is considered as one of the factors explaining the "price puzzle".⁴

Credit channel: Generally, this channel relies on credit market imperfections that affect the amount of credit offered by banks. The credit channel can actually be decomposed into three monetary policy transmission mechanisms. First, *the balance sheet channel* which, as its name states, is based on changes in the balance sheet of firms when the monetary policy stance is adjusted. For example, a decrease in the policy rate improves the net worth of borrowers. They can offer higher collateral to banks in exchange of credit, which implies a lower external finance premium. Borrowers will therefore increase their investments, which in turn will contribute to the increase in aggregate demand and inflation. This channel is also known as *the "financial accelerator mechanism"*. Furthermore, the same reasoning can be applied to households' balance sheet. An additional mechanism related to asymmetric information problems is *the credit rationing process* (Stiglitz and Weiss, 1981). This phenomenon appears in times when monetary policy is tight as this increases adverse selection problems. Banks

become reluctant to granting loans, even when the borrowers are willing to pay high interest rates. The explanation is that these borrowers have the highest default risk and this is precisely why they accept higher interest rates. The reduction in credit supply pushes down investment and subsequently lowers output and inflation.

The second component of the credit channel is *the bank lending channel*. When the central bank decides to accommodate its policy, bank reserves and deposits increase. Since these represent the main sources of financing for banks, loan supply increases. Households and firms obtain more credit, hence output and inflation increase.

The bank capital channel is the third component of the credit channel. The mechanisms through which monetary policy influences credit supply in this case is similar to the one in the balance sheet channel, but this time, it is the balance sheet of the financial intermediary that improves when the short term rate decreases. Financial frictions between the bank and its creditors are lower as the bank possesses more capital and the external finance premium, which is negatively related to the financial position of the bank, decreases. As banks pass on this premium to their borrowers, credit increases, along with output and inflation.

Equity price channel: The effects of monetary policy on the real economy also pass through the price of equity. Given the negative relationship between interest rates and discounted future cash flows, expansionary monetary policy entails an increase in equity prices, making economic agents more wealthy. Note that the same reasoning can be applied to housing and land prices. From this, it follows an increase in consumption, and finally in aggregate demand and inflation. Moreover, higher asset prices also increase the market value of firms. According to Tobin's Q theory, investment observes an increase, stimulating aggregate demand and creating inflation.

Exchange rate channel: In an open economy, the exchange rate channel also explains the transmission of monetary policy to the real economy. When domestic interest rates fall, the national currency becomes less attractive. The subsequent depreciation of the currency increases the competitiveness of the country, leading to an increase in exports. Output and inflation rise. However, the depreciation may also have inflationary effects, if the trade deficit is high. Indeed, imports become more expensive when a currency depreciation occurs. Therefore, depending on the firm's dependence on imports, production costs may increase, leading to higher prices.

⁴ Tightening monetary policy leads to an increase and not a decrease in inflation in the short-run.

The objective of this chapter is twofold. Firstly, we begin with a literature review aimed at summarizing the main results obtained thus far in the risk-taking channel literature. To this end, we expose the transmission mechanisms from monetary policy to risk, the effects of this policy on the level of risk and its long-term consequences. We also present the risk measures and the methodologies that have been employed to demonstrate the existence of this channel. Secondly, we perform our own empirical analysis in order to test the presence of the risk-taking channel in the Eurozone. For this purpose, we rely on the long term causality measures recently proposed by Dufour and Taamouti (2010). We also aim through this methodology to show that the risk-taking channel is closely related to other monetary policy transmission mechanisms, more precisely, the financial accelerator and the bank capital channel.

1.1 The Risk Taking Channel of Monetary Policy: A Literature Review

If the concept of risk has been considered in the economic literature for a long time, the strand that takes interest in the relationship between monetary policy and risk is rather recent.⁵ A decade ago, the main concern was whether or not monetary policy should take into account asset prices (Bernanke and Gertler, 1999; Bernanke and Gertler, 2001; Cecchetti et al., 2000). Nowadays, the question has slightly changed and does not concentrate on asset prices exclusively, but on the general concept of risk – understood, for example, as the default probability of credit institutions (Altunbas et al., 2009; Altunbas et al., 2010) or of borrowers (Jimenez et al., 2009), or alternatively, as the leverage used in credit operations (Angeloni and Faia, 2009; Angeloni et al., 2013; Ioannidou et al., 2009).

1.1.1 Monetary policy transmission mechanisms via risk

As we have seen in the definition of the risk-taking channel, the interest is focused on the effect of changes in monetary policy on *the risk perception and the risk tolerance* of economic agents – financial institutions and households.

We find in the literature several mechanisms that explain how this new transmission channel works. First, the change in interest rates affects the risk perception and the risk tolerance of *banks and other financial institutions*. Since a decline in interest rates

⁵ We think here, strictly speaking, at the influence of monetary policy on risk. Few attempts to study this relationship have been made before the crisis, the most notable one being the contribution of Hyman Minsky to the literature on financial crisis and their unfolding. Minsky’s famous “financial fragility hypothesis” is based on the idea that a period of economic stability fosters an accumulation of financial fragility. To him, one of the possible causes of a boom is a change in monetary policy. Moreover, what he describes as “manias” and “euphoria” are concepts closely linked to the risk perception and risk tolerance of economic agents. Other economists who analyzed this relationship between easy monetary policy and financial imbalances are Fisher (1933), Hayek (1939) and Kindleberger (2000).

results in an increase in the net asset value of the bank (Adrian and Shin, 2009; Adrian and Shin, 2010; Borio and Zhu, 2012; Fostel and Geanakoplos, 2008; Geanakoplos, 2009; Shin, 2009), a decrease in the probability of bank run (Diamond and Rajan, 2006) and a reduction in adverse selection (Dell’Ariccia and Marquez, 2006), credit institutions will issue more debt in order to grant riskier loans (Angeloni et al., 2013; Jimenez et al., 2009).⁶ The decrease in adverse selection leads in turn to an increase in banking competition (Dell’Ariccia and Marquez, 2006), which will also encourage risk-taking. The risk-taking channel also operates via decisions on bank leverage (Adrian et al., 2010) and the composition of the balance sheet in terms of maturity: banks accumulate more debt⁷ and grant loans at longer horizons when interest rates are low (Angeloni et al., 2013).

On the borrowers’ side, low interest rates have an effect on risk through asset valuation, cash flows and income. The increase in the borrowers’ net worth leads to a decline in their risk aversion (Altunbas et al., 2009; Borio and Zhu, 2012). Furthermore, Dubecq et al. (2009) speak of a “myopia” of economic agents, because to them the monetary policy stance reflects the level of risk in the economy. Therefore, if the central bank chooses to maintain the interest rate at a low level, this can be misleadingly interpreted as a decline in risk premia. Under these circumstances, economic agents will take more risks without requiring the adequate adjustment for risk. In the same line of thought, during periods when interest rates are low and the economy is expanding, economic agents become more risk-tolerant as they can consume more compared to the status-quo level (Campbell and Cochrane, 1999).⁸

Second, Rajan (2006) explains excessive risk-taking by profitability constraints imposed on financial institutions. If we take the example of banks when interest rates are low, the banking margin and implicitly profitability decrease, so to achieve the required level of profit, banks are encouraged to seek higher returns by investing in riskier assets. The bonus scheme and the lack of supervision and regulation reinforce this mechanism. For other types of financial institutions, such as pension funds or insurance companies, the effect is even more visible because they have target rates of return established in nominal terms which they have to achieve for a given date. To cope with these commitments, these institutions are basically forced to accept more risk.

Third, the level of transparency and the commitment of the central bank to its communication and its reaction function also play a role in this transmission mechanism. If the actions of the monetary authorities are predictable, uncertainty about the future is reduced. This has an influence on the behavior of agents by encouraging them to reduce

⁶ Jimenez et al. (2009) show that new credits are indeed riskier, otherwise we would only speak of the credit channel. More details on this idea are provided hereafter.

⁷ Securitization is a factor that promotes leverage growth. Moreover, Keys et al. (2010) and Mian and Sufi (2008) show that the use of securitization has indeed augmented risk-taking for banks.

⁸ According to the idea that the richer the person is, the more risk tolerant he becomes.

their risk premium (Altunbas et al., 2009; Borio and Zhu, 2012; Montes and Peixoto, 2014). This last argument joins the idea of a “paradox of credibility” of monetary policy, put forward by Borio (2005). More exactly, the fact that the central bank is successful in meeting its main objective may conceal the risks facing the economy.

Moral hazard is the fourth mechanism through which banks are encouraged to take more risks. Knowing that, if necessary, monetary authorities will intervene to bail out the “too big to fail” banks, these institutions have less incentives to monitor the risks they take. Evidence on this is provided by Farhi and Tirole (2009), Keister (2010) and Wilson and Wu (2010). As low interest rates are also associated with an excess of liquidity (Allen and Carletti, 2009; Allen and Gale, 2000. Allen and Gale, 2009), because of moral hazard, these surplus resources are redirected to projects with negative net worth (Maddaloni and Peydro, 2011).

All the mechanisms presented above support the existence of the risk-taking channel, but one should bear in mind that monetary policy was not the only factor that contributed to the accumulation of risks before the burst of the housing bubble. Acharya and Richardson (2009), Allen and Carletti (2009) and Diamond and Rajan (2009) find that easy credit standards have three causes, namely very low levels of short and long rates, the widespread use of financial innovations and low banking supervision.

1.1.2 Short-term and long-term effects of monetary policy on risk

We analyze in this subsection the effects of a change in interest rates on the level of risk in the economy. The results obtained in the literature converge towards the same idea: risk increases when interest rates are low.⁹ Nevertheless, there are two nuances to this result. First, it is necessary that policy rates stay low for an extended period of time and second, we must make a distinction between the short and the medium term.

Several authors define *low interest rates for a long period of time* as rates that stay below the levels recommended by the Taylor-type rules for several consecutive quarters (Altunbas et al., 2010; Hofmann and Bogdanova, 2012; Jimenez et al., 2009; Maddaloni and Peydro, 2011).¹⁰ This represents an important condition for the increase in risk. Indeed results obtained thus far in this literature show that in the short run risk actually decreases, and only in the medium term the economy is confronted with higher risk levels. The explanation lies in the fact that lower rates will firstly reduce the probability of default on outstanding loans (Altunbas et al., 2010; Jimenez et al., 2009) because the interest burden will be smaller on borrowers. However, if rates continue to stay low,

⁹ For example, Altunbas et al. (2010), Angeloni and Faia (2009), Angeloni et al. (2013), Delis and Kouretas (2011), Ioannidou et al. (2009), Jimenez et al. (2009) and Rajan (2006).

¹⁰ These authors consider several specifications for the policy rule: with or without smoothing, including or not a response to asset prices, a more or less important parameter for inflation.

banks start granting riskier loans and shortly the overall risk of their portfolio increases (Altunbas et al., 2010; Ioannidou et al., 2009; Jimenez et al., 2009).¹¹ Ioannidou et al. (2009) and Jimenez et al. (2009) demonstrate that in a low interest rate environment banks are more prone to extend credit to borrowers who have experienced incidents in the past or to borrowers who apply for the first time for a credit.¹² They postulate that during a monetary expansion, not only the amount of credit increase, but also their default rate, proving thus that banks increase their appetite for risk.

These results are confirmed only for short-term rates, whereas long rates do not have a significant impact on risk-taking (Altunbas et al., 2009; Jimenez et al., 2009; Maddaloni and Peydro, 2011). The explanation relies on the fact that banks use short-term debt to refinance themselves (Jimenez et al., 2009). However, the only configuration where long rates are meaningful in the analysis is when credits for house purchasing are taken into account — knowing that this type of loan is contracted for a long period of time (Maddaloni and Peydro, 2011).

1.1.3 Risk-taking and lending standards

To demonstrate that banks actually take more risk, Ioannidou et al. (2009) use the following reasoning: if banks face a risky borrower, they will adjust the conditions of the loan, such as the rate, the amount, the duration, the collateral or the type of credit, in order to offset risk. If this were the case, then monetary policy should not interfere significantly in explaining the risk level. Their results suggest that banks adjust lending standards when the risk of the borrower is high, however, during periods when interest rates are low the adjustment does not cover the entire risk.

Another study which supports this idea is the one by Maddaloni and Peydro (2011). Using data from bank lending surveys,¹³ they show that, during periods of monetary expansion, lending standards are relaxed. The softening is even more pronounced, if rates remain low for a protracted period. However, the most important conclusion of their study is that the softening of standards goes beyond the improvement in the creditworthiness of borrowers¹⁴ and that all lending standards are relaxed implying that indeed banks' appetite for risk increases. Besides low interest rates, other factors that could explain why banks choose to soften lending standards are: an improvement in bank capital, easier access to capital markets and increased liquidity, as well as higher competition.¹⁵

¹¹ As banks provide new riskier loans and as outstanding credits arrive at maturity, their portfolio becomes riskier.

¹² These borrowers are considered riskier because there is more uncertainty about the reimbursement of the credit.

¹³ The bank lending survey is a quarterly questionnaire sent to all banks by the central bank of each country in the Euro Zone. The survey contains 18 questions with qualitative responses regarding credit standards applied to businesses and households (business, mortgage and consumer loans). This survey reveals if, how and why credit standards have changed during the last quarter. The same type of survey exists for the US and has also been used in Maddaloni and Peydro (2011).

¹⁴ Softening lending standards due to an improved creditworthiness of borrowers does not necessarily mean more risk.

¹⁵ However, these factors can also be seen as the direct consequence of lower interest rates.

1.1.4 Implications of the risk-taking channel

Several observations need to be made at this point of the presentation of the risk-taking channel. First, we can remark that the financial crisis started when interest rates rose after a long period of monetary accommodation. The explanation given by Ioannidou et al. (2009) and Jimenez et al. (2009) is that credits with an initial high default rate, granted by banks during the period 2002 – 2006, were exposed to higher interest rates as outstanding loans. Knowing that their probability of default was already high before the increase in the interest rate, the default was almost imminent.¹⁶ As a consequence, the accumulated risk reached a peak and proved fatal to the financial system. It is not only the borrowers' net worth that declines once the interest rates rise, but also the banks' balance sheets that are revised downwards.¹⁷ The increase in interest rates can also be harmful for the financial system (Jimenez et al., 2009). Even when interest rates are high, a sharp decrease in the net value of the bank may represent an incentive to taking risk as the only way to survive ("gambling for resurrection" – Kane, 1989; Hellmann et al., 2000). The same thing – large risk-taking when rates are high – can occur if monetary authorities intervene to help banks cope with liquidity problems. Such action may comfort banks and incite them to continue with the risky behavior (Jimenez et al., 2009). In addition, rising interest rates increase the opportunity cost of cash holding by banks, forcing them to invest in assets with higher yields and thus higher risk.

Second, the gross domestic product (GDP) and inflation can also influence risk-taking. Angeloni and Faia (2009) and Ioannidou et al. (2009) note that the effects of the risk-taking channel depend on the position of the business cycle: an expansionary monetary policy when the GDP growth rate is high, encourages banks to take more risk in comparison to periods when the economy is slowing down. This result is also confirmed by Maddaloni and Peydro (2011) who find that credit standards are procyclical, and more precisely, that an increase in GDP leads to a softening of lending standards. Nevertheless, a distinction needs to be made between risk-taking and risk perception. Altunbas et al. (2010) posit that favorable economic conditions reduce risk perceptions. Borio et al. (2001) reach the same conclusion. Several explanations are provided to support this idea: myopic agents refuse to see risks and behave in a mimetic way (Brunnermeier, 2009; Minsky, 1976), the practice of compensation schemes for managers triggers higher risk-taking (Rajan, 2006) and the use of Value-at-Risk (Danielsson et al., 2001) and of financial leverage (Adrian and Shin, 2008), both procyclical indicators, cover the true risk. Altunbas et al. (2010) and Jimenez et al. (2009) agree on the fact that a high growth rate of GDP, coupled with low interest rates, increase the number of profitable projects

¹⁶ We refer here mainly to variable rate loans granted to households for the purchase of a house where this good also represents the collateral for the credit.

¹⁷ Because banks use mark-to-market accounting.

which translate into a reduction of risk for new and outstanding loans.

Depending on whether the loan is outstanding or newly-extended, the effects of inflation are different. In the first case, high inflation reduces the default rate. As inflation reduces the real value of debt, risks associated to outstanding debt will be smaller (Allen and Gale, 2000; Diamond and Rajan, 2006). In the second case, high inflation generates an increase in risk-taking (Jimenez et al., 2009).

Third, as mentioned earlier, the link between monetary policy and risk is enhanced by a high level of securitization and by weak banking supervision standards (Altunbas et al., 2010; Maddaloni and Peydro, 2011). The replacement of the traditional banking model “originate and hold” by the “originate and distribute” model without an adequate regulatory framework allowed banks to take more risk during periods of low interest rates. However, these results should be carefully interpreted because accounting for the regulatory framework is not straightforward, given that more stringent regulation is not necessarily better (Allen and Carletti, 2009; Rajan, 2009).

In what follows, we look at how banks’ characteristics can influence risk-taking. Financial institutions decide on the amount of money they lend by taking into account their characteristics, such as the size of their balance sheet, their liquidity, their capital or the amount of non-performing loans. Accordingly, more liquid banks, that possess a low capital, take more risk (Altunbas et al., 2010; Ioannidou et al., 2009). However, banks that have a low risk level are the ones that grant more credit and that have a greater capacity to respond to monetary policy shocks (Altunbas et al., 2009). Moreover, if banks have more funds involved in the loan, they will be more concerned about risk (Keeley, 1990).

When considering the balance sheet size, measured as the logarithm of total assets, Altunbas et al. (2010) and Jimenez et al. (2009) find that small banks are riskier because of their lower net worth and their inability to diversify risks, but also because of difficult access to liquidity (Diamond and Rajan, 2006). On the contrary, Ioannidou et al. (2009) show that because big banks offer more loans, they also take more risks.

Banks that have more non-performing loans on their balance sheets have a greater likelihood of engaging in risky projects (Ioannidou et al., 2009; Jimenez et al., 2009). Additionally, it appears that, during periods of monetary expansion, banks agree to grant loans to borrowers who have experienced payment incidents in the past (Ioannidou et al., 2009). Competition also affects risk-taking. A more competitive environment during a monetary expansion discourages the monitoring of new loans and generates an easing of credit standards (Dell’Ariccia and Marquez, 2006).

1.1.5 Risk measures and methodology

This literature particularly focuses on credit risk. One possible explanation is the fact that the banking system assumes a key importance in the economy and it is mainly through this sector that financial risk propagates. This is especially true in the Eurozone, where banks remain the main source of financing as opposed to the US where financial market operations are more common as financing choice.

Risk measures are directly related to the methodology and databases used. For theoretical models, like DSGE models, measures include the probability of default on the risky asset (bad state of nature) (Angeloni and Faia, 2009; Dubecq et al., 2009), and leverage (Angeloni and Faia, 2009) computed as the ratio between deposits and loans. We also find in this type of models capital constraints, such as those imposed on banks by the Basel II Agreement. The purpose of these constraints was precisely to reduce excessive risk-taking, but they proved insufficient.

Most of the papers on this topic treat the subject from an empirical point of view. The econometric methodology used to study the risk-taking channel covers several types of models – VAR, dynamic panel, duration models, discrete choice models and also probit models. These methodologies allow the use of more diversified – ex ante or ex post – risk measures. Therefore, in these models the measures considered include the probability of default of banks and of borrowers (Altunbas et al., 2009; Altunbas et al., 2010; Ioannidou et al., 2009; Jimenez et al., 2009), leverage, loan loss provisions as a percentage of total credit (Altunbas et al., 2010), the time to default or the hazard rate (Ioannidou et al., 2009; Jimenez et al., 2009). Moreover, data from the internal rating of borrowers or from credit standards has been exploited to construct dummy variables in order to account for risk (Ioannidou et al., 2009). Ratios that reflect the risk profile of the bank, such as the ratio of household loans to total assets¹⁸ (Angeloni et al., 2013) or the ratio of financial income to average assets (Jimenez et al., 2009) were also used. Market risk is given very little attention in the literature. An example is the use of an index of stock market volatility. Angeloni et al. (2013) considers this indicator in a VAR model, while Bloom et al. (2012) use the index in a DSGE model.

1.1.6 Risk taking and the credit channel

From the above analysis of the risk-taking channel we can remark that this new transmission mechanism is closest in spirit to the credit channel, and for some authors, like Jimenez et al. (2009), it is actually a part of it. Nevertheless, there are elements that help us to distinguish these two channels and make us believe that the effect of interest

¹⁸ Given that, in the recent crisis, loans to households were considered as the riskiest.

rates goes beyond the credit channel. First, within the credit channel, monetary policy influences the volume of loans (supply).¹⁹ Within the risk-taking channel, monetary policy influences not only the volume of credit, but also the composition of the loan portfolio (Jimenez et al., 2009) and leverage of financial firms (Dubecq et al., 2009). Second, on the credit channel side, low interest rates lead to an improvement in the net worth of borrowers and influence banks to extend credit to people who used to be riskier (Bernanke et al., 1996) or owned less collateral (Matsuyama, 2007). On the risk-taking channel side, low interest rates lead bankers to give loans to borrowers who are riskier at present (Borio and Zhu, 2012; Jimenez et al., 2009). The fact that banks are willing to accept more risk materializes as either liquidity risk, for long term loans, or as credit risk, if borrowers have a higher probability of default per unit time (Jimenez et al., 2009).

We can conclude that, even though similar to the financial accelerator mechanism and the bank capital channel, the risk-taking channel goes one step further and looks at what happens to the level of risk in the economy, which was not the case for either component of the credit channel. The following section consists of an analysis of the risk-taking channel in which elements related to the financial accelerator mechanism and the bank capital channel are included to prove that indeed these three mechanisms are closely connected.

1.2 An Evaluation of the Risk Taking Channel: Evidence from Long-Run Causality Measures

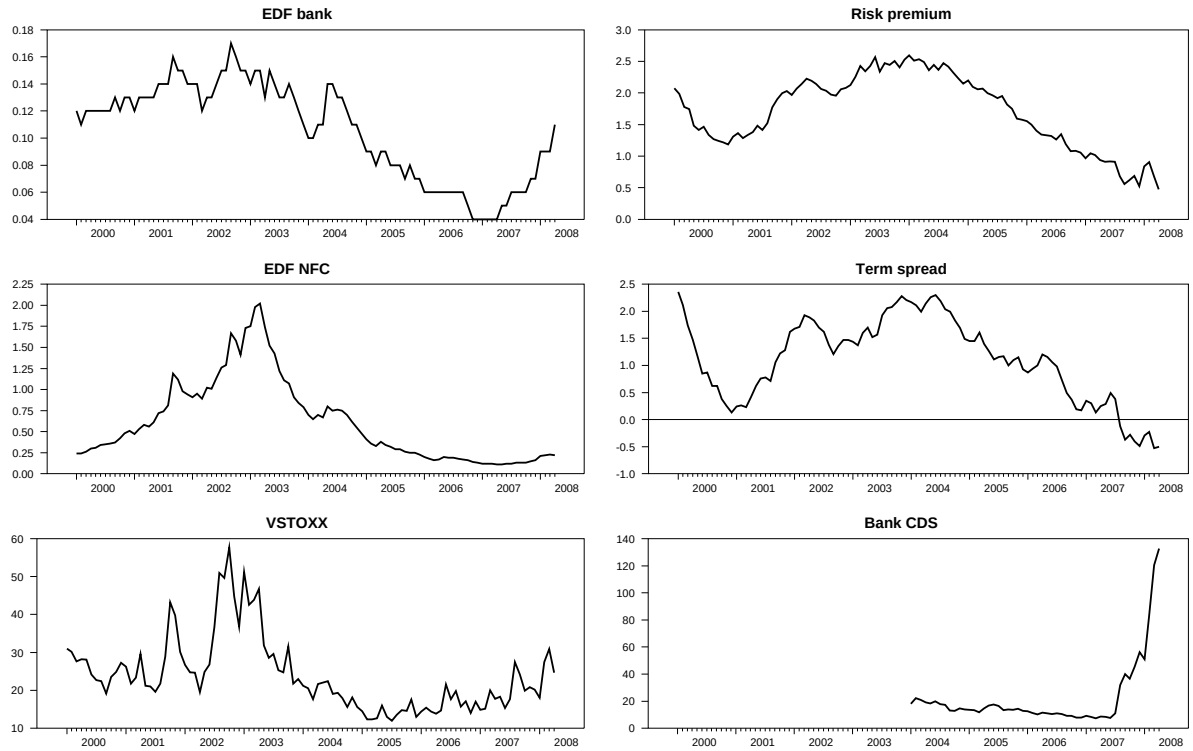
We aim in this section to provide an empirical analysis of the risk-taking channel, meant to test whether or not easy monetary policy influences the risk level in the economy. Moreover, we wish to see if credit channel variables help explaining the existence of the risk-taking channel. Three remarks have to be made before engaging in this analysis.

First, finding the appropriate risk measure is not straightforward as most of the existing measures do not account for the latent accumulation of risk during the period of easy monetary policy. It is precisely one of the criticisms made to the regulatory framework which failed to provide a good risk indicator before the burst of the financial crisis. Figure 1.1 presents the evolution of several commonly used risk measures, over the period 2000 – 2008. We can clearly see that none of the six measures showed the pattern described by the theory of the risk-taking channel. According to these indicators, during the time span 2002 – 2006, when monetary policy was expansionary, risk was rather

¹⁹ The risk level of a credit institution can also influence the volume of loans offered by banks (Altunbas et al., 2010). To assess credit supply, Altunbas et al. (2010) use two risk indicators in their econometric regression: the probability of default of banks and the percentage of non-performing loans in the balance sheet of each bank. They show in this way that banks which have a smaller probability of default have the possibility to offer more loans and they are better protected from the impact of changes in monetary policy.

descending. Using these measures as a risk indicator in empirical analyses will therefore not correspond to the true evolution of risk and will lead to inaccurate results. While true risk increased during the period of monetary policy expansion, risk aversions and risk perception decreased. These measures could thus be more appropriate if they were used as a proxy for risk perception, rather than risk itself.

Figure 1.1: The risk measures considered in the literature



Note: This figure presents several risk measures over the period 2000 – 2008, at a monthly frequency. Data concerns the euro area. *EDF Bank* and *EDF NFC* represent the expected default frequencies for banks and non-financial corporations, respectively. *VSTOXX* is the implied volatility index for the euro zone, computed on option prices. The *risk premium* is computed as the bank lending rate minus the short term interest rate, whereas the *term spread* is the difference between the long and the short term interest rates. *Bank CDS* stands for credit default swaps. Due to a lack of availability, data for CDS starts only in 2004. Source: Datastream.

Second, as noted earlier, the risk-taking channel functions only when maintaining the policy rate at low levels *for an extended period of time*. Therefore, the relationship between risk and the monetary policy stance should be studied mainly from a long-run perspective. Altunbas et al. (2009) acknowledge this feature of the risk-taking channel and include in their analysis the number of consecutive quarters of easy monetary policy.²⁰ Luo et al. (2011) propose a measure for monetary policy that takes into account the duration of the policy stance. Conversely, several studies employing VAR modeling techniques do not account for this condition and only rely on the study of IRFs (impulse response functions) (Angeloni et al., 2013; Bekaert et al., 2013; Buch et al., 2014). Look-

²⁰ Altunbas et al. (2009) define “easy monetary policy” as the period in which the short term interest rate stayed below the level given by the Taylor rule.

ing at the response to a one-time shock in monetary policy does not allow for capturing the effect of monetary policy on the risk perception or risk tolerance of agents. It might even be the case that the response of risk measures to this type of shock be insignificant, which by any means does not exclude the hypothesis of an effect if the shock persists for several periods.²¹

In connection to this last remark, one question may arise concerning the type of monetary policy in the Eurozone from the beginning of 2000 and up to the first signs of crisis: *Was monetary policy too accommodating for too long in the Eurozone?* To answer this question, we plot in Figure 1.2 the evolution of inflation and the output gap, as well as the dynamics of the short term interest rate with respect to the rate implied by a classic Taylor rule (Taylor, 1993).

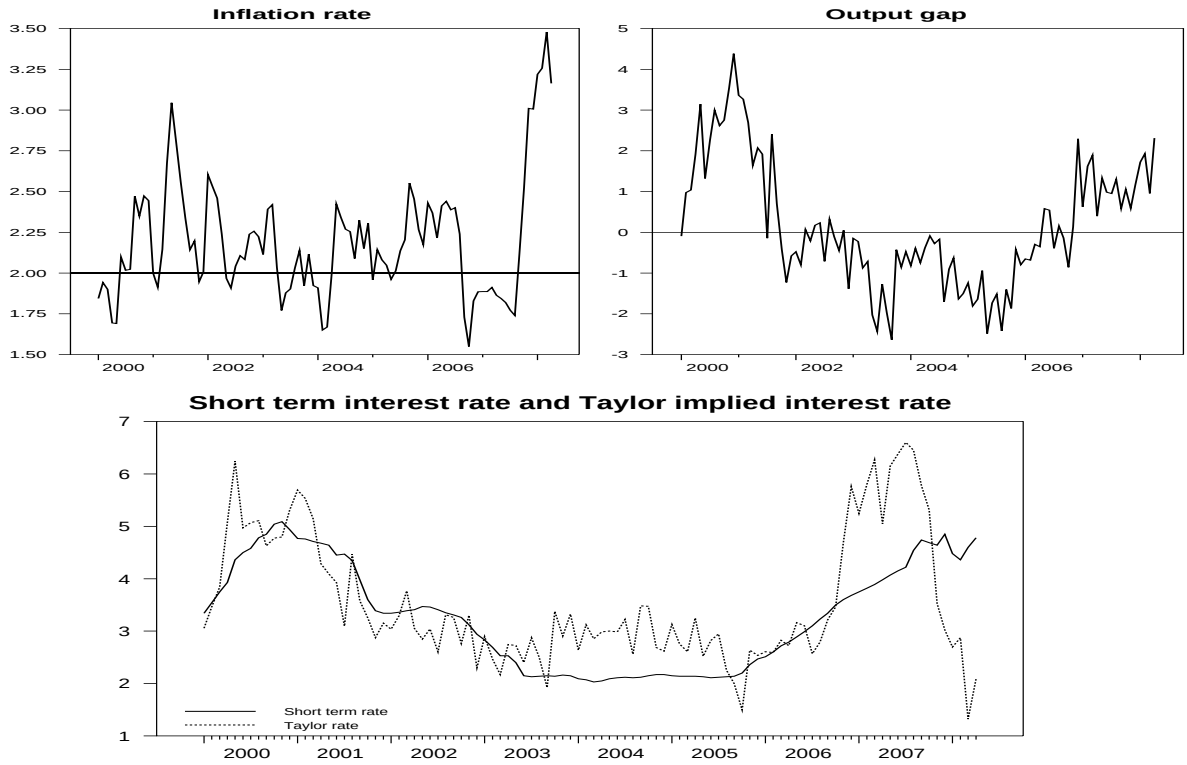
To understand the changes in the interest rate, we first analyze inflation and the output gap. Over this period, the inflation rate was rather stable, fluctuating around 2%, the ECB's established upper limit for inflation,²² with a mean value of 2.2% and a standard deviation of only 0.37. Only at the end of 2007, inflation rocketed to reach its highest level since the beginning of 2000. To see the monthly evolution of the output gap, a secondary stabilization objective of the ECB, we rely on the industrial production index, since data on GDP is not available at this frequency. We compute the output gap as the difference between the industrial production index and its trend obtained with a Hodrick-Prescott filter (Hodrick and Prescott, 1997). According to the figure, the time span can be divided in three sub-periods. The first one, between 2000 and 2001, corresponds to the peak, crash and contraction of the European economy triggered by the Dot-com Bubble. Between 2002 and 2006, the second sub-period, the output gap was almost exclusively negative, meaning that the economy did not run at full capacity. However, this can be interpreted as a signal that inflation would not rise in the following periods, because production and labor costs would maintain their levels. At the end of 2006 and up until the outbreak of the crisis, the output gap became positive, signaling an overheat of the economy.

As inflation was stable and the output gap negative during the middle sub-period, we have reasons to believe that the monetary authority was not required to be more reactive than it was. Indeed, decisions about the main refinancing rate of the central bank are mainly based on these two macroeconomic indicators. Looking at the lower panel of Figure 1.2, we can notice that the short term rate (solid line) was mostly consistent with the evolution of both inflation and output. In late 2000, the burst of the Dot-Com

²¹ Bekaert et al. (2013) and Luo et al. (2011) use a Blanchard-Quah decomposition (Blanchard and Quah, 1989) to separate short run and long run effects. However, using this methodology implies that the long term effects of monetary policy on risk are permanent which is far from being evident.

²² Price stability is defined by the ECB as a year-on-year increase in the harmonised index of consumer prices for the euro area of below 2%.

Figure 1.2: The evolution of inflation, output gap and interest rates



Note: The upper left panel of the figure presents inflation in the euro area computed based on the harmonized consumer price index. The horizontal line corresponds to the upper inflation threshold established for the euro area. The upper right panel represents the output gap, computed as the industrialized production index minus its long term trend given by the HP filter. The lower panel plots the short term interest rate (solid line) and the Taylor rate (dashed line). The Taylor rule is computed as: $i_t = r^* + 1.5\pi_t + 0.5(y_t - \bar{y})$, where i_t is the short term interest rate, r^* is the long term real interest rate and $y_t - \bar{y}$ gives the output gap. The time span is 2000M1 – 2008M4. Source: Datastream.

Bubble generated a gradual decrease in the short term interest rate, from 5% in 2000M11 to approximately 2.15% in 2003M6. When the economy started to recover from the crisis, interest rates remained low for a protracted period, between 2003 and 2006. This period corresponds exactly to the one when the central bank was blamed of being “too accommodating, keeping the interest rates too low for too long”. This can better be seen if we compare the short term interest rate to the rate obtained by applying the Taylor rule. The rate implied by the Taylor rule is almost everywhere – between April 2003 and September 2005 – superior to the level of the short term rate. This would indeed indicate that monetary policy was too easy for approximately 30 months. However, the gap between these two rates is not always very important, the mean value being equal to -0.46 and the standard deviation to 0.52 . All in all, these are signs indicating that the underlying assumptions of the risk-taking channel are fulfilled and testing its existence in the Eurozone is a relevant research question.²³

²³ The accommodating policy stance was more pronounced in the US than in the euro area. However, we consider that, given the intensification of international transactions between financial institutions, the fact that interest rates in the US

To address the last issue – of easy monetary policy for a protracted period – we propose to study the risk-taking channel through an innovative approach. In a VAR model for the euro area, we are going to use *long run causality measures* to assess the impact of monetary policy on risk. As regards the risk measure, we rely on the recent literature on systemic risk measurement and choose the SRisk (Brownlees and Engle, 2012) for our analysis as it represents one of the few measures capturing the real risk accumulation before the outbreak of the financial crisis.

1.2.1 The Concept of Long-Run Causality

The definitions for Granger causality and for causality measures, as proposed by Granger (1969) and Geweke (1982), are applied only for one-step ahead forecasting. This means that we are in a short run perspective. When only two variables are considered in the analysis, if one of them Granger causes the other, this can always be seen at horizon one. Moreover, if at horizon one there is no evidence of Granger causality, then we can certainly assert that no causal relations will be found at higher forecast horizons.

In order to study causality beyond horizon one, several authors (Dufour and Renault, 1998; Lutkepohl and Muller, 1994) defined *long run causality* or *multi-step causality*. x causes y at horizon h if the past of a variable x improves the prediction of y for period $t + h$, where t is the present. This concept is useful when studying dynamic relations in a VAR with more than 2 variables. In this configuration, causality between two variables, from x to y for example, may appear at higher horizons, even if at horizon one, x does not cause y . This happens because causality can transit through some auxiliary variable(s), z . To understand better the intuition behind this concept, consider the following simple example of a VAR(1) with only 3 variables:²⁴

$$\begin{pmatrix} x_{t+1} \\ y_{t+1} \\ z_{t+1} \end{pmatrix} = \begin{bmatrix} 0.60 & 0.00 & 0.80 \\ 0.00 & 0.40 & 0.00 \\ 0.00 & 0.60 & 0.10 \end{bmatrix} \begin{pmatrix} x_t \\ y_t \\ z_t \end{pmatrix} + \begin{pmatrix} \varepsilon_{x,t+1} \\ \varepsilon_{y,t+1} \\ \varepsilon_{z,t+1} \end{pmatrix}. \quad (1.1)$$

Notice that in this specification y does not cause x at horizon one, as its coefficient in the equation of x_{t+1} is zero. However, z is caused by y , and z helps predict x at horizon one. Writing the system at time $t + 2$ will inform us about causal relations between the

were kept low for a protracted period, also had an influence on the risk-taking behavior in the euro area. Therefore, the increase in risk can be explained not only by the policy stance of the ECB, but also by the policy decisions outside the Eurozone. In the following econometric analysis, we do not take into account this negative spillover, but future extensions might include a role for the fed funds rate, for example.

²⁴ Example taken from Dufour and Taamouti (2010).

three variables at horizon two.

$$\begin{pmatrix} x_{t+2} \\ y_{t+2} \\ z_{t+2} \end{pmatrix} = \begin{bmatrix} 0.36 & 0.48 & 0.56 \\ 0.00 & 0.16 & 0.00 \\ 0.00 & 0.30 & 0.01 \end{bmatrix} \begin{pmatrix} x_t \\ y_t \\ z_t \end{pmatrix} + \begin{bmatrix} 0.60 & 0.00 & 0.80 \\ 0.00 & 0.40 & 0.00 \\ 0.00 & 0.60 & 0.10 \end{bmatrix} \begin{pmatrix} \varepsilon_{x,t+1} \\ \varepsilon_{y,t+1} \\ \varepsilon_{z,t+1} \end{pmatrix} + \begin{pmatrix} \varepsilon_{x,t+2} \\ \varepsilon_{y,t+2} \\ \varepsilon_{z,t+2} \end{pmatrix}. \quad (1.2)$$

At horizon two, we find that y causes x , as the coefficient in front of y_{t+1} in the first equation is different from zero (0.48). This indirect causality would not have been identified by short run causality measures.

Long run causality is particularly interesting in our analysis, as we know that monetary policy takes time to impact the real economy and that according the risk-taking channel, low interest rates increase risk especially in the long run. Much of the work on long run causality has focused on testing these relationships (Breitung and Candelon, 2006; Breitung and Candelon, 2007; Bruneau and Jondeau, 1999; Dufour and Tessier, 2006; Lutkepohl and Burda, 1997). However, being able to quantify causality is more interesting for policy making. Measures of long run causality have been recently proposed by Dufour and Taamouti (2010). In our analysis, we apply these measures to evaluate long term causal effects between monetary policy and risk.

1.2.2 Methodology

Computing long run causality measures implies defining and estimating a VAR model with at least three variables, determining the forecast errors for different horizons h and computing their covariance matrix. The methodology used to estimate these measures and to compute corresponding confidence intervals can be summarized by the following five steps.²⁵

Step 1. Specification of the model. We define a VAR(p) model with 3 types of variables: x , y and z . The system defined in this way corresponds to the *unconstrained model*. In our analysis, x represents the proxy for the monetary policy stance, y is a measure quantifying risk in the financial sector and z includes all auxiliary variables through which monetary policy may transit before influencing risk. Let k be the number of variables in the VAR, with $k = kx + ky + kz$. x and y are variables, so their dimension is one ($kx = ky = 1$), while kz , the number of auxiliary variables, may be greater or equal to one. Let $W = (x', y', z')'$. The VAR model takes the following form:

$$W_t = \sum_{j=1}^p \Phi_j W_{t-j} + \varepsilon_t, \quad (1.3)$$

²⁵ A review of VAR models and short run causality measures is provided in the Appendix A of this chapter.

where Φ_j represent the coefficient matrices and ε_t are independent and identically distributed with $E(\varepsilon_t) = 0$, $E(\varepsilon_t \varepsilon_t') = \Sigma_\varepsilon$, a nonsingular covariance matrix and $E(\varepsilon_t \varepsilon_s') = 0$, for all $t \neq s$. The identification of the optimal lag, p , is made with the Akaike information criterion (AIC) (Ivanov and Kilian, 2005; Kilian, 2001). To compute causality measures, we also need to define the *constrained models*, meaning a model where only x and z are included and a model with only y and z . With the former specification, we aim at studying causality from y to x , whereas the latter is used to measure causality from x to y . Given that causality measures are based on determinants of the covariance matrices of the constrained and unconstrained forecast errors, for comparison reasons, we use the same lag order, p , for the three defined models.

Step 2. Model estimation. Depending on the combination of variables, x , y and z ,²⁶ the obtained model is either stationary, stationary in first difference or cointegrated. To avoid employing different types of estimation methodologies, we follow Sims et al. (1990) and estimate the model in levels by applying the ordinary least squares estimators for Φ_i and for the covariance matrix of the residuals, Σ_ε . Indeed, Sims et al. (1990) prove that even when there are some unit roots in the VAR system or there is possible cointegration between variables, the estimation of the system in first difference or in a vector error correction form (VECM) is unnecessary as OLS estimators for the model in levels remain consistent. Moreover, using a VECM would prevent us from computing long run causality between variables, as this would lead to several technical problems that could only be solved by making ad-hoc hypothesis and that would imply an increase in the sources of potential bias.²⁷ An additional advantage of estimating the model in levels is the ease of interpretation of results. The same estimation procedure is applied for the two constrained models in order to determine parameters and covariance matrices of residuals.

Step 3. Estimation of the forecast errors' covariance matrix at horizon h . Causality measures are computed based on the moving average representation and more precisely, on the covariance matrix of the forecast error of W_{t+h} , obtained from the unconstrained and the constrained models. Our aim is first to determine the forecast errors at horizon h , and then to estimate their covariance matrix. For that, the Wold representation theorem is used to transform the VAR(p) in a VMA(∞):

$$W_t = \sum_{i=0}^{\infty} \Psi_i \varepsilon_{t-i}, \quad (1.4)$$

²⁶ In the analysis subsection, we will consider several associations of these variables. Mainly, the auxiliary variables, z will represent different quantities. For robustness purposes, we will also consider several proxies for the monetary policy stance and risk indicators (variables x and y , respectively).

²⁷ We refer here, for example, to the fact that the unconstrained model could present one cointegration relation, that can very well disappear when one of the variables is removed from the analysis (constrained model). Other example would concern the bootstrap of confidence intervals that would become even more complex (see Step 5 further on).

where Ψ_i represent the response of the endogenous variables, at each horizon i , to a shock to the system. These matrices can be recursively computed using Φ_j :²⁸

$$\Psi_i = \Phi_j^{(i)} \quad \text{and} \quad \Phi_j^{(i+1)} = \Phi_{j+1}^{(i)} + \Phi_1^{(i)} \Phi_j, \quad \Phi_j^{(1)} = \Phi_j, \quad \Phi_1^{(0)} = I_k, \quad (1.5)$$

where I_k represents the identity matrix of size k and $i \geq 1$. The forecast error at horizon h is given by:

$$W_{t+h} - E_t(W_{t+h}) = \sum_{i=0}^{h-1} \Psi_i \varepsilon_{t+h-i}. \quad (1.6)$$

An estimator of the variance covariance matrix of these forecast errors for the unconstrained model is:

$$\hat{\Sigma}(h) = \sum_{i=0}^{h-1} \hat{\Psi}_i \hat{\Sigma}_\varepsilon \hat{\Psi}_i', \quad (1.7)$$

where $\hat{\Sigma}_\varepsilon$ is the estimated covariance matrix from *Step 2* and where $\hat{\Psi}_i$ are computed base on the relations in equation (1.5) in which we replace Φ_j by $\hat{\Phi}_j$. As defined in *Step 1*, the disturbances, ε_t , are not serially correlated, but may be contemporaneously correlated. If this is the case, the forecast errors' covariance matrix can also be obtained by applying a Cholesky decomposition. Let P be a lower triangular matrix such that $PP' = \Sigma_\varepsilon$ and let $u_t = P^{-1}\varepsilon_t$, where u_t are orthogonal residuals with Σ_u equal to I , the identity matrix. Equation (1.6) becomes:

$$W_{t+h} - E_t(W_{t+h}) = \sum_{i=0}^{h-1} \Psi_i P u_{t+h-i} = \sum_{i=0}^{h-1} \gamma_i u_{t+h-i}, \quad (1.8)$$

where $\gamma_i = \Psi_i P$. Given that u_t are orthogonal, the covariance matrix of the forecast errors is given by:

$$\hat{\Sigma}(h) = \sum_{i=0}^{h-1} \hat{\gamma}_i \hat{\gamma}_i'. \quad (1.9)$$

An alternative solution to this estimation technique is obtained by writing the system in its companion form. More precisely, any VAR of order p can be written as a VAR(1). In our case, (1.3) becomes:

$$\begin{pmatrix} W_t \\ W_{t-1} \\ \vdots \\ W_{t-p+1} \end{pmatrix}_{[k \times p]} = \begin{bmatrix} \Phi_1 & \Phi_2 & \cdots & \Phi_p \\ I_k & 0 & \cdots & 0 \\ 0 & \ddots & 0 & 0 \\ 0 & 0 & I_k & 0 \end{bmatrix}_{[kp \times kp]} \begin{pmatrix} W_{t-1} \\ W_{t-2} \\ \cdots \\ W_{t-p} \end{pmatrix}_{[k \times p]} + \begin{pmatrix} \varepsilon_t \\ 0 \\ \cdots \\ 0 \end{pmatrix}_{[k \times p]}. \quad (1.10)$$

²⁸ See Dufour and Renault (1998) for more details.

or, in a compact form:

$$\widetilde{W}_t = A\widetilde{W}_{t-1} + \widetilde{\varepsilon}_t. \quad (1.11)$$

Repeatedly substituting for $\widetilde{W}$ leads to an equation where $\widetilde{W}$ depends on current and past shocks in the following way:

$$\widetilde{W}_t = \widetilde{\varepsilon}_t + A\widetilde{\varepsilon}_{t-1} + A^2\widetilde{\varepsilon}_{t-2} + \dots + A^h\widetilde{\varepsilon}_{t-h} + A^{h+1}\widetilde{W}_{t-h-1}. \quad (1.12)$$

The first k rows of each matrix A^i , with $i = 1, \dots, h$, give the impulse response of the variables at horizons 1 to h . These elements will be used in equations (1.4)-(1.7) instead of Ψ_i . Moreover, when orthogonal residuals are used, equation (1.12) is written as:

$$\widetilde{W}_t = \widetilde{u}_t + AP\widetilde{u}_{t-1} + A^2P\widetilde{u}_{t-2} + \dots + A^hP\widetilde{u}_{t-h} + A^{h+1}P\widetilde{W}_{t-h-1}. \quad (1.13)$$

where $\widetilde{u}$ is the orthogonal residual obtained from a Cholesky decomposition, $\widetilde{u}_t = P^{-1}\widetilde{\varepsilon}_t$ and $PP' = \Sigma_{\widetilde{\varepsilon}}$. *Step 3* is repeated for both constrained models defined above.

Step 4. Computing causality measures. Long run causality measures are interpreted in the same way as the measures of short run causality defined by Geweke (1982): y causes x at horizon $h \geq 1$ if the past of variable y , in addition to the past of x and z , is helpful in forecasting x_{t+h} . Causality measures for horizon h are based on the covariance matrices of the forecast errors from the unconstrained and the constrained models. Having estimated these elements in *Step 3*, we can proceed with the computation of long run causality measures. As defined by Dufour and Taamouti (2010), causality from y to x is given by:

$$\hat{C}(y \xrightarrow{h} x|F) = \ln \left[\frac{\det[J_0\hat{\Sigma}_0(h)J_0']}{\det[J_1\hat{\Sigma}(h)J_1']} \right], \quad (1.14)$$

where $J_0 = [I_{kx} \ 0]$ and $J_1 = [I_{kx} \ 0 \ 0]$ and where F defines the information set. $\hat{\Sigma}(h)$ is the covariance matrix in the unconstrained model, whereas $\hat{\Sigma}_0(h)$ is the covariance matrix from the constrained model, where y has been withdrawn from the system. J_0 and J_1 actually serve to identify the block of the covariance matrices that corresponds to x . The numerator is based on the constrained model and the denominator on the unconstrained one. As the constrained model has less explanatory variables (only x and z) than the unconstrained one, the covariance of the forecast errors at horizon h from the former model should be higher than (equal to) the covariance corresponding to the latter if y causes (does not cause) x . Consequently, the measure is by construction either equal to zero, if there is no causality from y to x , or greater than zero if y causes x at horizon h .

The measure for causality from x to y can be defined in a similar manner:

$$\hat{C}(x \xrightarrow{h} y|F) = \ln \left[\frac{\det[J_0^* \hat{\Sigma}_0^*(h) J_0^{*'}]}{\det[J_1^* \hat{\Sigma}(h) J_1^{*'}]} \right], \quad (1.15)$$

with $\hat{\Sigma}_0^*$ the covariance matrix of the forecast errors at horizon h obtained from the constrained model with y and z as variables. This time $J_0^* = [I_{ky} \ 0]$ and $J_1^* = [0 \ I_{ky} \ 0]$ are used to recuperate the blocks corresponding to the variable y in the covariance matrices $\hat{\Sigma}_0^*$ and $\hat{\Sigma}(h)$. Instantaneous causality at horizon h is quantified by the following formula:

$$\hat{C}(x \overset{h}{\dashv} y|F) = \ln \left[\frac{\det[J_1 \hat{\Sigma}(h) J_1'] \det[J_1^* \hat{\Sigma}(h) J_1^{*'}]}{\det[G \hat{\Sigma}(h) G]} \right], \quad (1.16)$$

with $G = \begin{bmatrix} I_{kx} & 0 & 0 \\ 0 & I_{ky} & 0 \end{bmatrix}$. As in the case of short run measures of causality, no direction can be established for this type of connection. Finally, the sum of the three long run causality measures (1.14), (1.15) and (1.16), gives the dependence measure at horizon h :

$$\hat{C}(x, y|F) = \hat{C}(y \xrightarrow{h} x|F) + \hat{C}(x \xrightarrow{h} y|F) + \hat{C}(x \overset{h}{\dashv} y|F). \quad (1.17)$$

Under certain regularity assumptions that can be found in Lewis and Reinsel (1985) or Dufour and Taamouti (2010), the above estimators are weakly consistent.²⁹

Step 5. Confidence intervals. The last step of our methodology consists in building confidence intervals for our causality measures. We proceed by bootstrap-after-bootstrap as proposed by Kilian (1998),³⁰ which allows us to correct for small-sample bias and skewness. Not applying this correction may lead to changes in the interval width and location, even if the bias is small. Additionally, this method can successfully be applied not only to stationary VARs, but also to random walk processes and cointegrated processes estimated in levels, as is our case.

In the first round of bootstrap, the purpose is to compute the bias in the VAR coefficients. For this, we generate, based on the residuals obtained in *Step 1*, new bootstrap data for the dependent variable of the unconstrained model:

$$W_t^* = \sum_{j=1}^p \hat{\Phi}_j W_{t-j}^* + \varepsilon_t^*, \quad (1.18)$$

²⁹ A point estimator $\hat{\Phi}$ of Φ is said to be weakly consistent if $\hat{\Phi}$ converges in probability to Φ .

³⁰ Kilian (1998) provides all the details of the bootstrap-after-bootstrap methodology. An empirical application is also included in this paper, which proves that among four considered methodologies – bootstrap-after-bootstrap, delta method, standard bootstrap and Monte Carlo – the bootstrap-after-bootstrap is the best technique to estimate confidence intervals.

where ε_t^* is a random draw with replacement from $\{\hat{\varepsilon}_t\}_{t=p+1}^T$, with T the sample size. OLS estimates are used to determine bootstrap coefficients, $\hat{\Phi}^*$. We repeat this procedure B times, where B , the number of bootstrap samples, is chosen such that $\frac{1}{2}\alpha(B+1)$ is an integer (Davidson and MacKinnon, 2004), with $1 - \alpha$ the confidence level.³¹ The bias of the VAR coefficients is given by $Bias^* = E^*[\hat{\Phi}^* - \hat{\Phi}]$, where E^* represents the expectation term. The bias estimate is $\widehat{Bias}^* = \frac{1}{B} \sum_{j=1}^B \hat{\Phi}^{*(j)} - \hat{\Phi}$. At this stage, one should determine whether the VAR model is stationary or not. This can be done based on the absolute value of the largest root of the companion matrix associated with $\hat{\Phi}$. If this value is larger than one, no correction is needed for coefficients. If the value is less than one, bias-corrected coefficients, $\hat{\Phi} - \widehat{Bias}^*$, should be used from this point on.

The second round of bootstrap concerns the computation of confidence intervals based on bootstrapped causality measures. Firstly, the bias-corrected coefficients are imposed in equation (1.18) and B new bootstrap replications of $\hat{\Phi}$ are generated. Afterwards, the obtained model is estimated through OLS. The same bias from the first round of bootstrap is used to correct the estimated coefficients. The residuals from this model are used to determine the covariance matrix based on which long-run causality measures are computed. Using the same bootstrap sample, the two constrained models are also estimated through OLS regressions, where coefficients also need to be bias-corrected (the two rounds of bootstrap are applied to the constrained models). Causality measures as defined by equations (1.14), (1.15), (1.16) and (1.17) are next computed. Finally, α and $1 - \alpha$ percentile intervals are calculated for each of the four types of long run causality.³²

1.2.3 Data description

To analyze long run causality between monetary policy and risk, we apply the methodology described above to Eurozone monthly data over the period 2000M1 – 2008M4 (100 observations). Data is retrieved from Datastream and from the ECB Statistical Data Warehouse. The time span is chosen so that a complete economic cycle is covered in the analysis, from peak to peak. As argued in the literature review, the functioning of the risk-taking channel can mainly be seen in calm periods because this is when financial markets become euphoric and economic agents are more prone to risk-taking. Nevertheless, studying the risk-taking channel during crisis times has also its importance. The reaction of financial institutions to expansionary monetary policy is indeed not the same in periods of crisis, but there are still reasons to believe that, even then, risk is increasing. The actions of the central bank aimed to reduce the consequences of a crisis, like

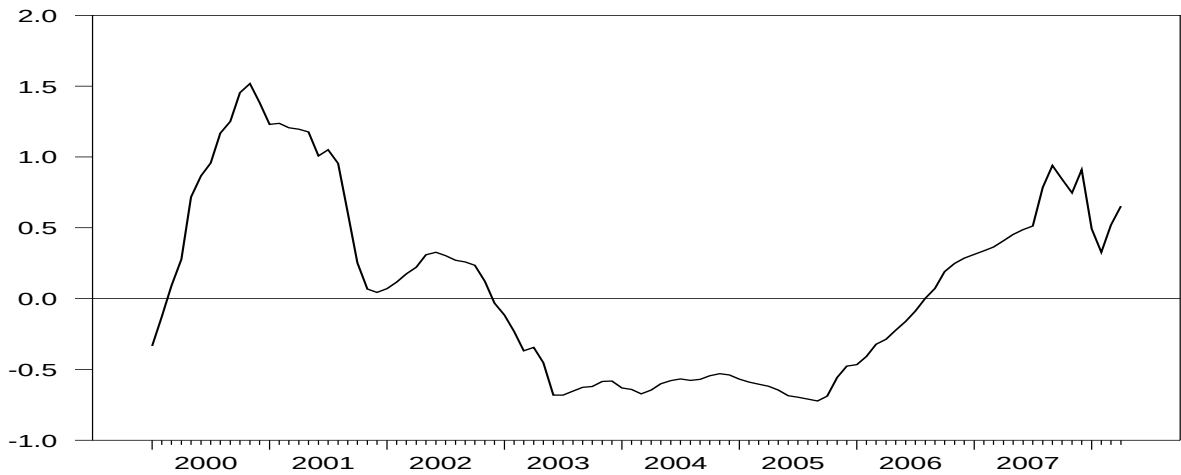
³¹ The vector of p initial observations is kept the same for each of the B simulations. This is meant to avoid any bias arising when data is non stationary. More precisely, changing initial values would lead to different density functions of the coefficients Φ^* .

³² A final correction is applied directly on the causality measures. For details, see Dufour and Taamouti (2010).

lowering the refinancing rate or employing unconventional policy measures, represent for financial firms an important source of moral hazard which may incite them to continue their risk-taking. Moreover, institutions that have a lot at stake and that are close to a default, will try to improve their returns by accepting high amounts of risk. This is why we decide to include in our study the period 2000 – 2002, which corresponds to the Dot-Com crisis. However, we do not consider the period after the breakout of the subprime crisis. We argue that the recent financial crisis, the most severe since the one in 1929, has been characterized by a sudden break in the trends of all macroeconomic variables. Therefore, taking into account this period may bias our results.

The variable chosen to account for the monetary policy stance in our analysis (corresponding to x in the above methodology) is constructed as the difference between the short term interest rate and its HP trend (variable denoted by $igap$). We consider the gap and not the level of this money market rate because a key point of the risk-taking channel is the duration of easy monetary policy. Consequently, as long as the gap is negative, the monetary policy stance is considered to be expansionary. Conversely, if the gap is positive, the monetary policy is said to be tight. Figure 1.3 shows the dynamics of the gap during our analyzed period.

Figure 1.3: The short term interest rate gap

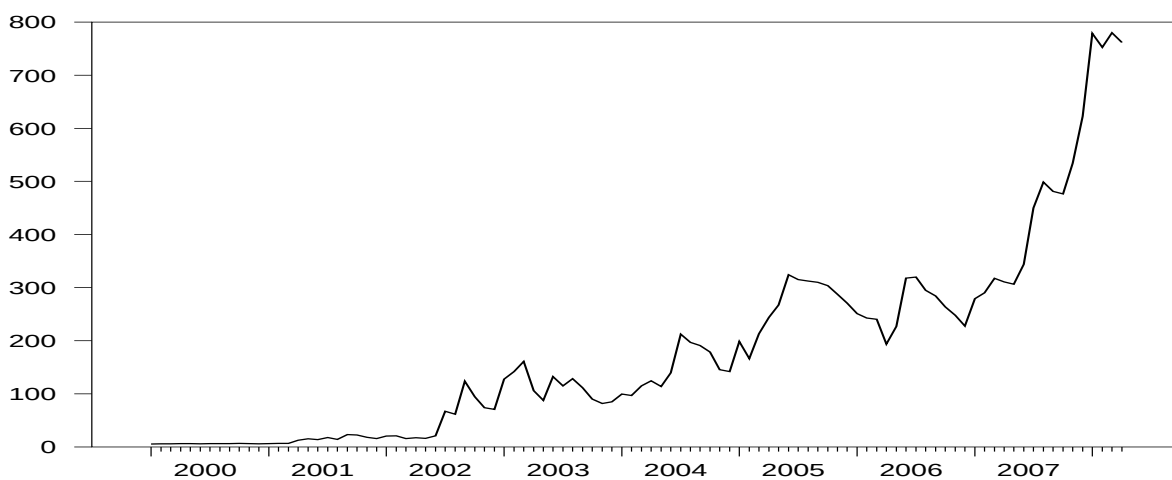


Note: This figure presents the short term interest rate gap over the period 2000M1 – 2008M4. This variable is computed as the difference between the short term rate and its HP trend. Source: Datastream and author's calculations.

The variable representing the risk indicator (y in the methodology presentation) is the SRisk of Engle et al. (2014). Initially proposed by Brownlees and Engle (2012), this indicator is used in the literature to measure the systemic risk of financial firms. Engle et al. (2014) transposed it to the European case in order to determine systemically important financial institutions. To compute the SRisk, they use data on the market capitalization of firms, their financial leverage, but also data related to the sensitivity of the equity

return to market shocks.³³ Consequently, this measure accounts not only for the size of the institution and its individual risk, but also for the correlations between the market and the firm's returns, hence the two main components of systemic risk. The *SRisk* we use in our analysis represents an aggregate of systemic risk at the European level and is computed for four types of financial firms: banking institutions, insurance companies, financial services and real estate firms. As we can remark in Figure 1.4, this indicator started increasing in 2002, after a short period of stability. This measure is therefore particularly suitable for our analysis of the risk-taking channel, as it gives a truer view of how risk accumulation evolved during the period of easy monetary policy.

Figure 1.4: *SRisk* in Europe (in bln euros)



Note: This figure presents the *SRisk* over the period 2000M1 – 2008M4. Source: Engle et al. (2014)

For the z variable(s), we consider several options.³⁴ In the risk-taking channel literature it is argued that lax monetary policy increases risk because low interest rates have first an influence on the risk perception and the risk tolerance of economic agents. Accordingly, the first group of variables used in our analysis is one strictly related to this channel. We consider in this group the volatility index for the Eurozone (*VSTOXX*) which captures risk aversion and uncertainty (Bekaert et al., 2013) and a Global Risk Aversion Indicator (*GRAI*). We also include the BBB Euro Non Financial Index (*BBB*). This variable is meant to provide the evolution of risk in the non financial sector, thus it is a good indicator of risk perception.

The risk-taking channel can also be associated to the financial accelerator mechanism and to the bank capital channel. As a matter of fact, the effects of these three trans-

³³ More details about this measure are provided in the second chapter of this dissertation, where an analysis of systemic risk measures is undertaken.

³⁴ Recall that z represents all variables through which the effects of monetary policy may transit before influencing risk. The names of the variables that we include in our analysis are provided in parentheses.

mission mechanisms are overlapping and difficult to disentangle. For this reason, we also include in our analysis variables related to these two channels. Regarding the financial accelerator mechanism, we argue that an increase in collateral value (captured by a stock market index – *stock* – or a housing price index – *hprice*) leads to lower risk premia (*rprem*) and financing costs (*cost_eq_firms*) and lower expected default frequency for non financial institutions (*edf_nfc*), more credit and potentially more risk. Monetary policy can also influence risk through the bank capital channel in the following way: expansionary monetary policy improves the liquidity (*liq*) and capital position (*cap*) of banks which leads to better financing conditions – lower cost of equity (*cost_eq_bk*) and lower expected default frequency (*edf_bk*). These developments translate eventually in higher risk. The two expected default frequencies (of firms and banks) can also be seen as proxies for risk perception.³⁵

1.2.4 Results

Our main objective in this econometric analysis is to test and measure the causality from monetary policy to risk. Nevertheless, causality from y to x (Risk $\rightarrow$ Policy) is as interesting to study as causality from x to y (Policy $\rightarrow$ Risk). While the latter can be viewed as a confirmation or a rejection of the risk-taking channel theory, the former helps us to see whether or not monetary policy reacted to increasing risk before the financial crisis.

The first analysis is performed with three variables in the VAR system, therefore $kz = 1$. The order of the VAR is selected by AIC. We include a time trend in all models and compute the measures for a horizon h of 24 periods. Throughout this section x is the monetary policy stance variable and y – the risk variable.

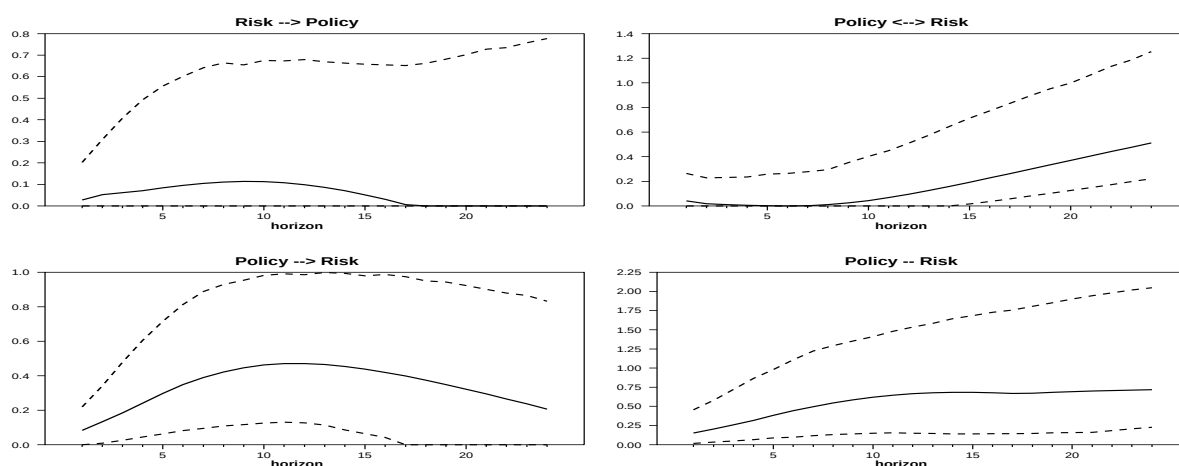
Figure 1.5 presents causality measures (solid lines) from y to x (Risk $\rightarrow$ Policy, upper left panel), from x to y (Policy $\rightarrow$ Risk, lower left panel), instantaneous causality between x and y (Policy $\leftrightarrow$ Risk, upper right panel) as well as total linear dependence (Policy – Risk, lower right panel). Dashed lines represent confidence intervals. The auxiliary variable is the volatility index, *VSTOXX*. As volatility was low in financial markets during the period of accommodating monetary policy, this index could have contributed to the misperception of risk and encouraged investors to take more risk. In this framework, the level of risk in the economy does not seem to cause at any horizon the monetary policy stance. This is consistent with the fact that financial stability did not represent an objective for central banks before the global financial crisis. Turning to the causality from Policy to Risk, we remark that starting with horizon two, the measure becomes significant. Moreover, the measure increases until horizon 12, and remains significant up

³⁵ Table 1.1 in the Appendix B gives more details about the auxiliary variables.

to horizon 16. This results implies that the actions of the central bank have indeed an impact on the risk-taking behavior of economic agents. What is also interesting in this configuration is that at horizon one causality does not appear to be significant, underlying the importance of conducting this study in a long run perspective. Indeed, using only short run causality measures, would have led, in this case, to the wrong conclusion of no causality.

In accordance to the theory of the risk-taking channel, our result suggests that the policy stance does not have an immediate influence on risk. Additionally, instantaneous causality appears only starting with horizon 15 and has an increasing pace. The lower right panel shows the linear dependence between risk and monetary policy, computed as the sum of the three types of causality measures.

Figure 1.5: Causality measures for $z=VSTOXX$

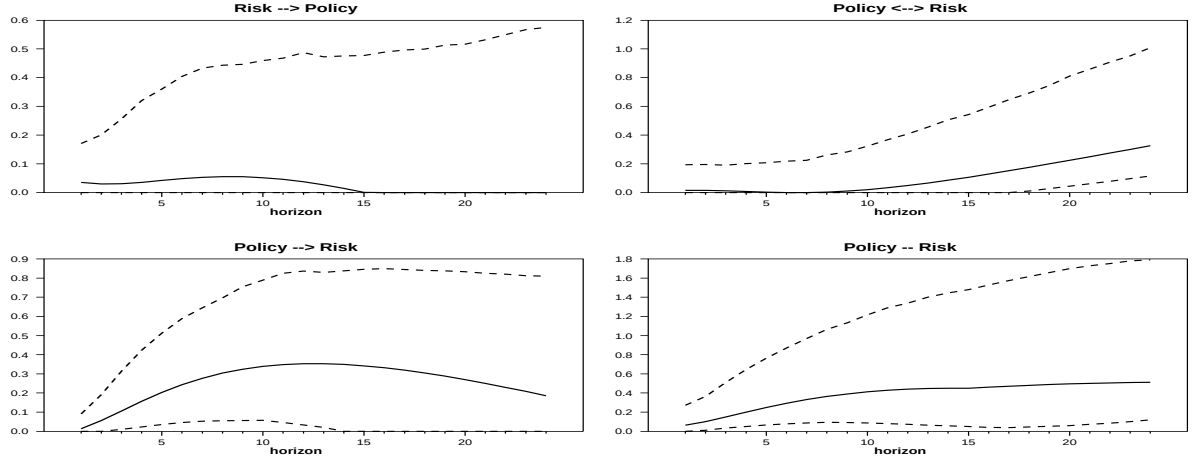


Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = igap$ and $y = SRisk$. The auxiliary variable is $VSTOXX$. The order of the VAR, selected by AIC, is 3. Confidence intervals at 95% are represented by the dashed lines.

When changing the auxiliary variable to $GRAI$, the risk aversion indicator, results do not change much. In Figure 1.6, the monetary policy stance influences risk only starting with horizon 3, confirming that interests rates have to be kept low for a longer period of time in order to have an impact on risk.

Figure 1.7 presents causality measures when the auxiliary variable is the BBB Euro Non Financial Index. This index was at its low during the period of expansionary policy, implying that firms with a triple B investment grade were perceived as less risky at that time. In this scenario, the policy stance is an evident predictor of risk. Starting with period 6, the causality measure Policy $\rightarrow$ Risk becomes significant and increases, proving, as in the other cases that monetary policy needs to be accommodating for a longer time

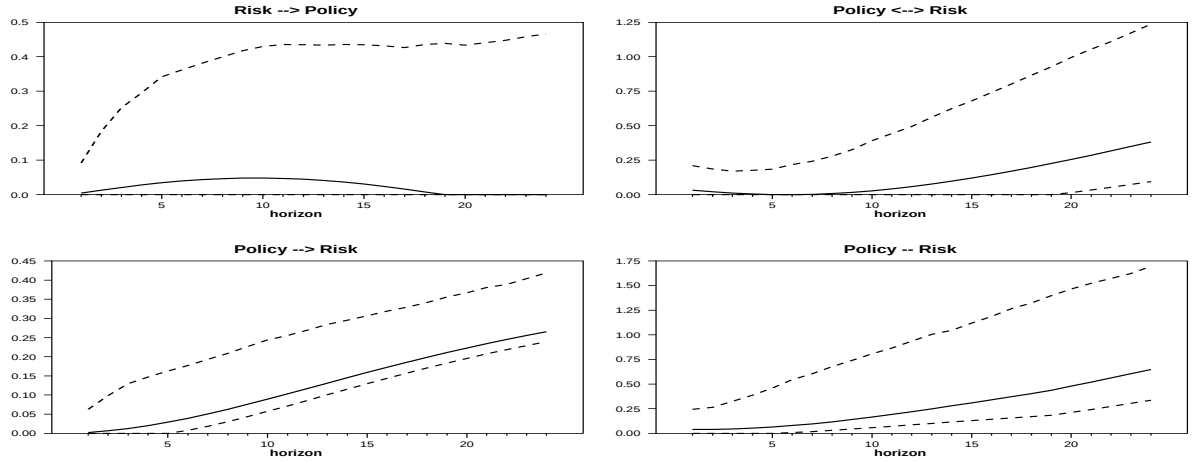
Figure 1.6: Causality measures for $z=GRAI$



Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = igap$ and $y = SRisk$. The auxiliary variable is $GRAI$. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

period in order for the risk-taking channel to become active.

Figure 1.7: Causality measures for $z=BBB$

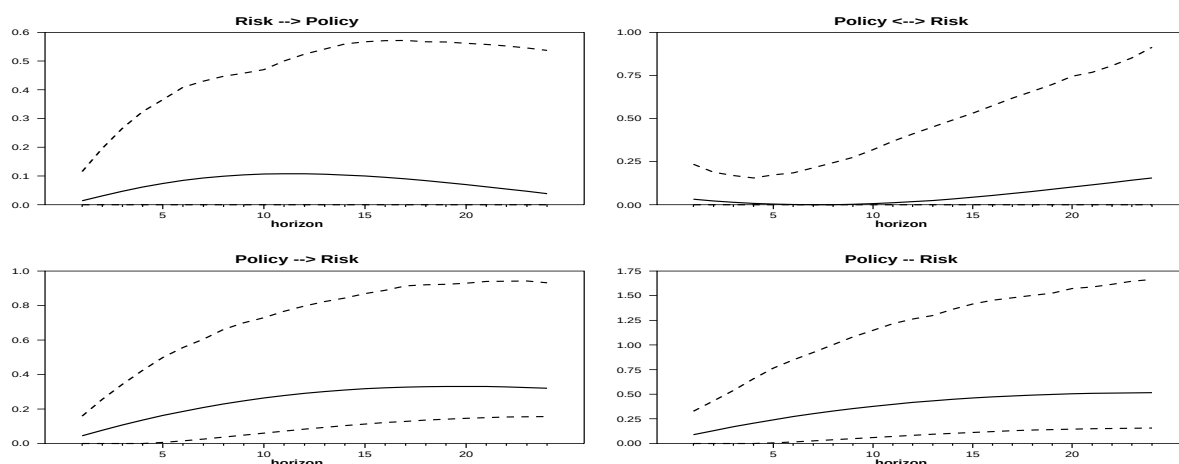


Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = igap$ and $y = SRisk$. The auxiliary variable is BBB . The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

For all the three cases considered thus far, we find no causality from our risk variable to the conduct of monetary policy. We continue the study of the risk-taking channel with variables that can also be connected to other monetary policy transmission mechanisms, *i.e.* the financial accelerator or the bank capital channel. In Figure 1.8, we present causality measures for the case where the auxiliary variable is the expected default frequency of non financial corporations. A decrease in this probability implies a reduction in perceived risk and a decrease in the external finance premium. If the risk-taking channel is

in place, financial institutions should lower their lending standards and agree to finance riskier projects from these entrepreneurs. Results in Figure 1.8 seem to confirm this fact, as the causality measure from Policy to Risk is significant and increasing starting with period 5.

Figure 1.8: Causality measures for $z=edf_nfc$

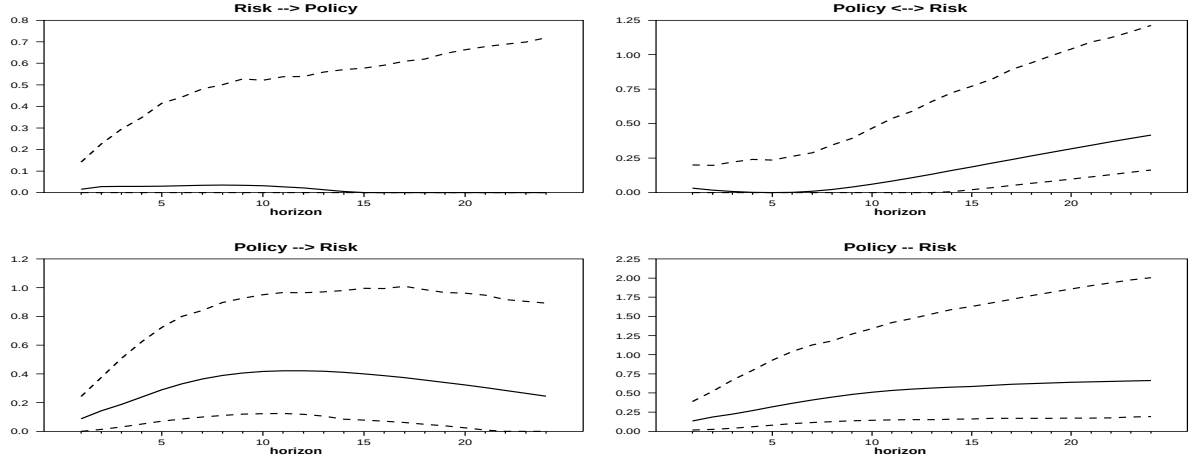


Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = igap$ and $y = SRisk$. The auxiliary variable is edf_nfc . The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Considering as an auxiliary variable the capital to assets ratio of banks confirms further our results. This ratio was rather stable during the period 2003 to 2007, implying no particular problems for the banking sector. The impact of the policy stance on risk is present in this configuration, starting with period 2 and until period 22. The last two figures validate our intuition about the connections between the three monetary policy transmission channels: the risk-taking channel, the financial accelerator mechanism and the bank capital channel. The graphs for all the other auxiliary variables are provided in the Appendix C of this chapter. No causality (neither from Risk to Policy, nor from Policy to Risk) is found when the auxiliary variable is the risk premium, the stock market index or the liquidity to assets ratio. The result is rather surprising for the risk premium, a key element in the financial accelerator mechanism. The evolution of this premium over the sample period shows a decrease from 2004 to the end of our sample period, which implies a decline in perceived risk. This should have normally contributed to the accumulation of risk.

Overall, most of the auxiliary variables provide evidence of a causal relation from monetary policy to risk. The fact that these variables are not only related to the risk perception and risk tolerance of economic agents, but can also be connected to the credit channel, proves the strong relation between these three monetary policy transmission

Figure 1.9: Causality measures for $z=cap$



Note: This figure presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = igap$ and $y = SRisk$. The auxiliary variable is cap . The order of the VAR, selected by AIC, is 3. Confidence intervals at 95% are represented by the dashed lines.

channels. Furthermore, our results seem to confirm the fact that central banks were not concerned with financial risk in the period preceding the crisis. The results of this baseline analysis are further checked in the next subsection, where robustness tests are conducted.

1.2.5 Sensitivity analysis

To verify the robustness of our results, we explore several alternative specifications of the VAR model. First, we replace the monetary policy indicator with the gap between the short term interest rate and the rate obtained with the traditional Taylor rule (*gapTaylor*). The results are shown in the Appendix D. For the auxiliary variables strictly connected to the risk-taking channel – *VSTOXX*, *GRAI* and *BBB* – the causality from the policy stance to the level of risk appears significant only after several periods. Moreover, the measure of causality is increasing, suggesting that when the central bank keeps its rates too low for a protracted period of time, financial agents will be more and more incited to take risk. Instantaneous causality between these two variables is also present in the case of *VSTOXX* and *BBB*. Just as in the main analysis, there seems to be no causality from Risk to Policy. For variables related to the financial accelerator mechanism, the risk-taking channel theory seems verified only for two out of the five considered auxiliary variables. When the auxiliary variable relates to the bank capital channel, results are similar to the ones obtained in the baseline analysis. The difference comes from the shape of causality measures. Whereas before the measure was at first increasing and then declining, in our robustness analysis, the measure is zero for several periods, and increases afterwards.

The second sensitivity analysis concerns the y variable. We consider two alternative risk measure: the SRisk computed only for the banking sector ($SRisk_bk$) and the credit-to-GDP ratio. For $SRisk_bk$, the risk-taking channel seems to be confirmed in most of the cases, the only two variables for which there is no causality from Policy to Risk being *stock* and *edf_bk*.³⁶ After the subprime crisis, the Basel III committee underlined the importance of adopting a macroprudential framework. One of the indicators they proposed for risk monitoring is the credit-to-GDP ratio. We therefore include in our model this variable, instead of $SRisk$. Results are reported in the Appendix D. Once more, the results for most of the z variables considered indicate the existence of causality from Policy to Risk, but not from Risk to Policy. As in the main analysis, *liq* and *stock* do not represent variables through which the policy stance may impact risk in the medium run. A final robustness analysis consisted on applying BIC instead of AIC when selecting the lag order of the VAR. Results for this specification are close to the ones obtained in the main analysis, with causality measures becoming significant even for the variables *rprem* and *liq*.

1.3 Concluding Remarks

This study provides new evidence on the risk-taking channel by employing long run causality measures. This recently proposed monetary policy transmission mechanism has gained a lot of attention since the outbreak of the financial crisis, as it represents a way of explaining why the crisis was so severe and why risk accumulation went unnoticed. The first part of this chapter presents a review of the literature on this subject. The different studies conducted thus far on distinct data sets seem all in favor of the influence of the monetary policy stance on risk. To extend the existing literature, we propose a different methodology and study the causal relationships between monetary policy and risk.

Several aspects of the risk-taking channel are addressed in this chapter. First, given that the duration of expansionary monetary policy represents a key element in the functioning of this channel, we adopt a long run perspective, and compute causality measures over several horizons. We find that in most cases, causality from the monetary policy stance to risk becomes significant only after several periods.

We also estimate causality from risk to the monetary policy stance. Once more, the long term perspective is important, as the central bank may choose not to react at first, when, even if risk is increasing, it remains at a low acceptable level, but decide to react latter on, when risk becomes a danger to the economy. Interestingly, our results show no such causal relation in this direction. This finding is not so surprising if we recall

³⁶ Results are not presented in this work due to space constraints, but they are available upon request.

that the ECB's mandate concerns only inflation and that before 2008 no worries were raised in this respect. However, as part of the two pillar strategy adopted by the ECB, financial indicators were supposed to be monitored as they may give information about future inflation. If evidence provided here proves that this was not the case, the explanation may come not from a lack of vigilance of the central bank, but most probably from an absence of good risk measures. We address this second issue by employing in our analysis a recently proposed systemic risk measure, that reproduces the slow and long risk accumulation that preceded the crisis.

Finally, the third aspect deals with the possible connections between the credit channel and the risk-taking channel. The question is here of whether or not the risk-taking channel is a new monetary policy transmission mechanism or merely an extension of existing channels. To account for these relations, we consider in our VAR model, not only variables strictly related to risk aversion and risk perception, but also information that is usually associated to the financial accelerator mechanism and to the bank capital channel. Long run causality measures suggest that the risk-taking channel can also be seen as a component of the credit channel, as its functioning transits mostly through the same variables.

The existence of the risk-taking channel relies on behavioral biases like myopia, herding or excessive euphoria. We have seen with the crisis that the element which triggers this behavior is expansionary monetary policy. This implies that excessive risk-taking becomes a negative externality of the central bank's behavior and should be treated as such. More attention needs to be paid to periods when interest rates are very low, especially if they are accompanied by signs of increased risk-taking. At these times, central banks should avoid sudden changes in policy from an expansionary stance to an overly restrictive policy, but also avoid maintaining low interest rates for a long time. Recognizing the risk-taking channel as a negative externality is just a first step to finding a solution to this problem. Several questions need to be answered before coming to a conclusion: Should monetary policy respond to risk and would that be enough to internalize this externality? Should other instruments, besides the interest rate, be used? And, as important, are there trade-offs that arise between the main objective of the central bank and the financial stability objective? These are the questions that we address in Chapters 3 and 4.

Another problem underlined by our study is the lack of good risk indicators. Every measure of risk available before the outbreak of the crisis was misleading. It was only after the crisis that the systemic risk concept gained a lot of attention and much research was conducted on this topic. Having the right tools to measure risk is crucial in guiding the behavior of financial market participants and could lead in the future to a diminution

of risk in times of expansionary monetary policy. The next chapter of this work deals with systemic risk measurement and applies this concept to the Eurozone debt crisis.

1.4 Appendix

A. Stationary Vector Autoregressive Models and Short Run Causality

We propose here a brief reminder on stationary VAR models and causality measures. For more details regarding VAR processes, see Hamilton (1994), Hatanaka (1996), Johansen (1995) or Lutkepohl (2005).

Linear vector autoregressive models have been proposed by Sims (1980) as an alternative to multivariate simultaneous equations models. Sims criticized the latter for the ad-hoc hypothesis of exogeneity imposed to some of the variables in these models. VAR models correct this issue by treating all variables entering the process as potentially endogenous. These models are based on a dynamic representation of variables. The general form of a VAR(p) system is:

$$Y_t = A_0 + \sum_{i=1}^p A_i Y_{t-i} + \varepsilon_t, \quad (1.19)$$

where Y_t is a k -dimensional vector of variables y_{it} , for $i = 1, \dots, k$. A_0 is a vector of k constants and A_i are k -by- k coefficient matrices. ε_t is an independently and identically distributed (iid) error term satisfying $E(\varepsilon_t) = 0$, $E(\varepsilon_t \varepsilon'_t) = \Sigma_\varepsilon$, a nonsingular covariance matrix and $E(\varepsilon_t \varepsilon'_s) = 0$, for all $t \neq s$. Finally, p represents the order of the VAR process. Each variable depends linearly on its own past and also on the past values of all other variables. Deterministic trends can be added to this specification.

VAR models have attracted a lot of attention since their introduction and have been broadly used. One reason for that is the specification and the estimation simplicity. Usual stationary test are applied to see if the system is stable. These include Augmented Dickey-Fuller (ADF, Dickey and Fuller, 1981), Phillips-Perron (PP, Phillips and Perron, 1988) or Kwiatkowski-Phillips-Schmidt-Shin (KPSS, Kwiatkowski et al., 1992) tests, among others. To choose the order of the VAR, model selection criteria, like the Akaike information criteria (AIC, Akaike, 1973; Akaike, 1974), Schwarz criterion (BIC, Schwarz, 1978) or Hannan-Quinn criterion (HQ, Hannan and Quinn, 1979) can be use. Stationary VAR models — in level or in first difference — are efficiently estimated by ordinary least squares (OLS), applied to each equation of the system. Other possibilities are by maximum likelihood or Bayesian estimation.

Another reason for their wide use, is the large array of applications: forecasting, impulse response analysis, forecast error variance decomposition or causality between the VAR's variables. As our focus in the empirical analysis is on causality measures, we only present here this concept.

A variable y_1 is said to *Granger cause* (Granger, 1969) another variable y_2 if the past values of y_1 , in addition to past values of all other variables in the system, including y_2 , can improve the one-step ahead prediction of y_2 . Conversely, if adding the past values of y_1 in the equation of y_2 does not improve the forecast of y_2 at horizon 1, then y_1 is said to be Granger noncausal for y_2 . Moreover, an equivalent definition for Granger causality can be given in terms of the variance of the forecast errors. It is obvious that, if y_1 is Granger causal for y_2 , then the variance of forecast errors in the non constrained model (the one including the past information on all variables) is lower than the variance in the constrained model (the model from which we excluded the past information of y_2). To test for causality, the Wald or Fisher tests can be used. Non causality between two variables implies that some of the parameters in the model be 0, therefore both of these tests are suitable. The use of the Wald test is appealing as it involves only the estimation of the non constrained model. The null hypothesis is always the absence of causality between two variables. For small samples, the Fisher test is recommended.

Geweke (1982) proposed a way to quantify causality between variables. Short run causality measures between two variables or two blocks of variables, y_1 and y_2 , rely on covariance matrices of marginal autoregressions (y_1 is only explained by its past, idem for y_2), joint autoregressions (y_1 is explained by its past, but also by the past of y_2 , idem for y_2) and VAR processes (including both y_1 and y_2). Let us consider these processes for two variables, y_1 and y_2 :

Marginal autoregressions:

$$y_{1t} = a_1 y_{1,t-1} + a_2 y_{1,t-2} + \dots + a_p y_{1,t-p} + u_{1t}$$

$$y_{2t} = b_1 y_{2,t-1} + b_2 y_{2,t-2} + \dots + b_p y_{2,t-p} + u_{2t}$$

where u_{1t} and u_{2t} are white noises, with σ_{u1} and σ_{u2} their variances.

Joint autoregressions:

$$y_{1t} = c_1 y_{1,t-1} + c_2 y_{1,t-2} + \dots + c_p y_{1,t-p} + d_1 y_{2,t-1} + d_2 y_{2,t-2} + \dots + d_p y_{2,t-p} + u_{12t}$$

$$y_{2t} = e_1 y_{2,t-1} + e_2 y_{2,t-2} + \dots + e_p y_{2,t-p} + f_1 y_{1,t-1} + f_2 y_{1,t-2} + \dots + f_p y_{1,t-p} + u_{21t}$$

where u_{12t} and u_{21t} are white noises, with σ_{u12} and σ_{u21} their variances.

VAR process:

$$Y_t = \sum_{i=1}^p A_i Y_{t-i} + u_t$$

where $Y_t = (y_1, y_2)'$ and u_t is a vector of two white noises, with Σ_u their covariance matrix.

Based on comparisons of determinants of these covariance matrices, Geweke (1982) gives analytical forms for causality measures from y_1 to y_2 , from y_2 to y_1 and for instantaneous causality between the two variables. In the above example, where only two variables are considered, these measures become:

Causality from y_1 to y_2 :

$$C_{y1 \rightarrow y2} = \log \frac{|\sigma_{u2}|}{|\sigma_{u21}|}$$

Causality from y_2 to y_1 :

$$C_{y2 \rightarrow y1} = \log \frac{|\sigma_{u1}|}{|\sigma_{u12}|}$$

Instantaneous causality between y_1 and y_2 :

$$C_{y2 \leftrightarrow y1} = \log \frac{|\sigma_{u21}| |\sigma_{u12}|}{|\Sigma_u|}$$

Moreover, Geweke defines total causality as the sum of these three components:

$$C_{y1, y2} = C_{y1 \rightarrow y2} + C_{y2 \rightarrow y1} + C_{y2 \leftrightarrow y1}$$

Instantaneous causality depends on the covariance between innovations, but no direction can be given to this relation. One interesting feature of causality measures is that if there is no causality between two variables, the measure is equal to zero, whereas the measure increases as causality becomes stronger. Log-likelihood ratio tests (LRT) are used to test the nullity of causality measures.

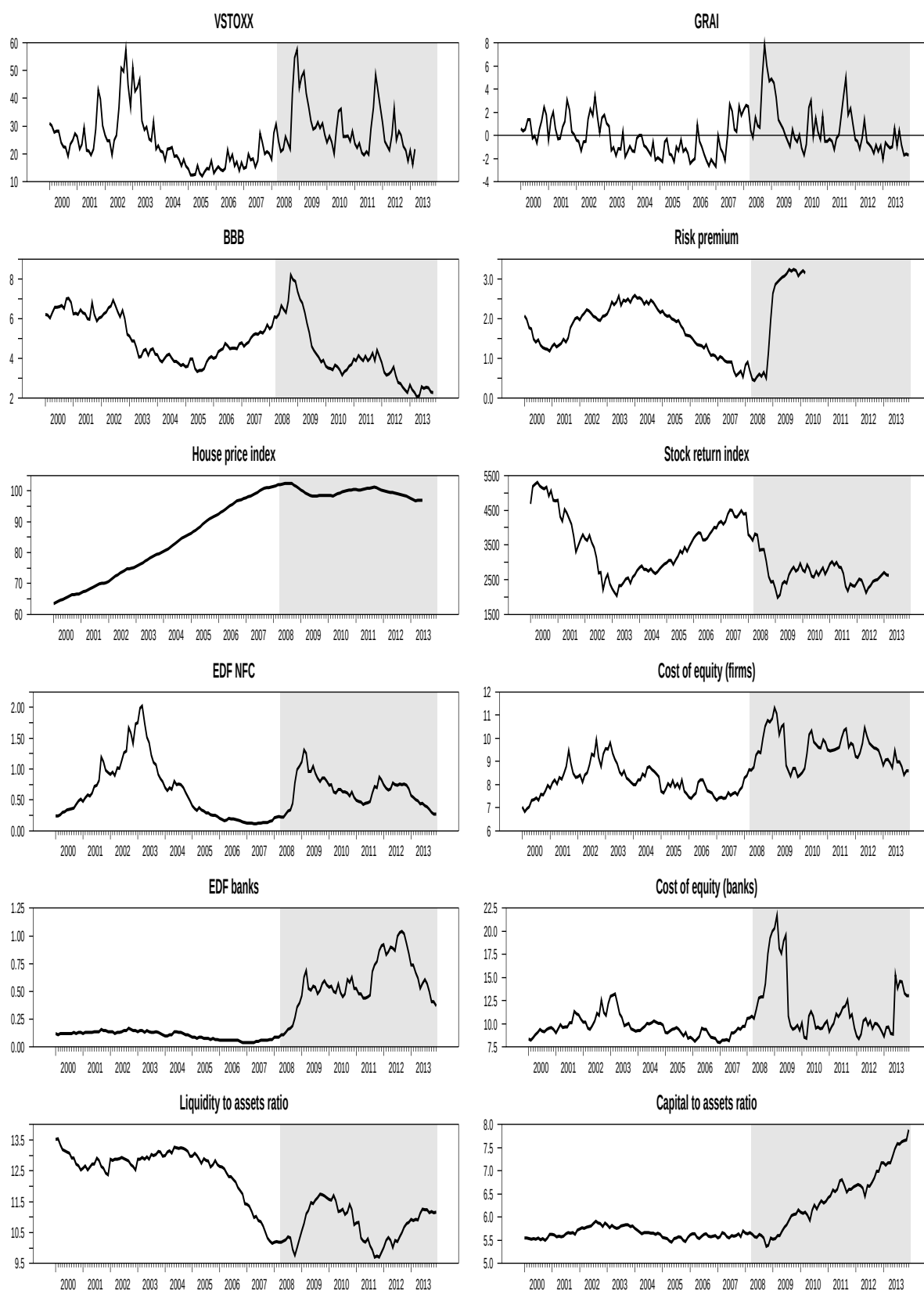
The measures proposed by Geweke are used to quantify causality at horizon one (one period ahead). The long run causality measures that we consider in the main text represent a generalization of these measures to any horizon h .

B. Data description

Table 1.1: Auxiliary variables, z

Group	Variable	Description	Source
RTC	<i>VSTOXX</i>	The VSTOXX Index is based on EURO STOXX 50 real time options prices and is designed to reflect market expectations of volatility.	Datastream
	<i>GRAI</i>	Global Risk Aversion Indicator	ECB Data Warehouse
	<i>BBB1</i>	The BofA Merrill Lynch BBB Euro Non-Financial Index. The index is computed based on the cost of bonds issued by firms with an investment grade BBB.	Datastream
Financial Accelerator	<i>rprem</i>	The risk premium computed as the difference between the bank lending rate and the short term interest rate.	Datastream and author's calculations
	<i>hprice</i>	Housing price index for the Eurozone. Quarterly data transformed by linear extrapolation into monthly data.	ECB Data Warehouse
	<i>stock</i>	Stock market index for the Eurozone	Datastream
	<i>edf_nfc</i>	Expected default frequency of non financial corporations	Moody's
	<i>cost_eq_firms</i>	The cost of equity for firms	ECB Data Warehouse
Bank Capital Channel	<i>edf_bk</i>	Expected default frequency for banks	Moody's
	<i>cost_eq_bk</i>	Cost of equity for banks	ECB Data Warehouse
	<i>cap</i>	Capital to assets ratio	ECB Data Warehouse
	<i>liq</i>	Liquidity to assets ratio	ECB Data Warehouse

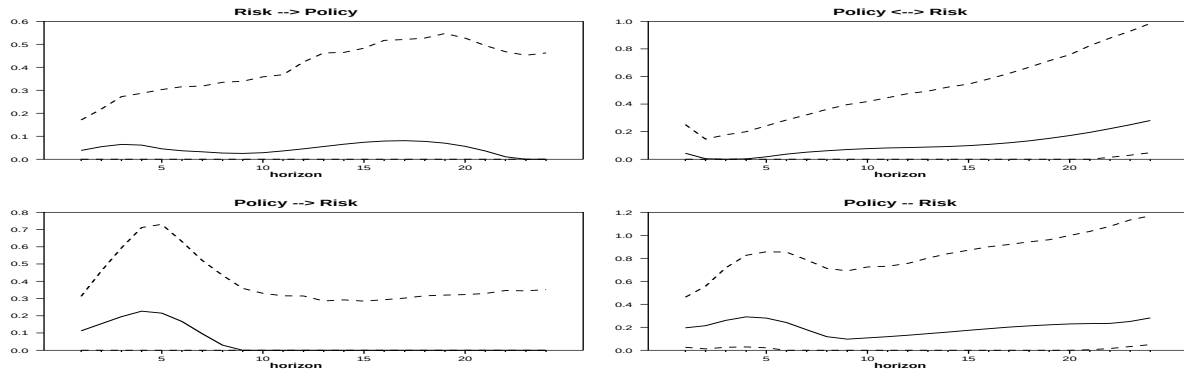
Note: All variables have a monthly frequency.

Figure 1.10: All z variables

Note: This figure presents the evolution of all auxiliary variables employed in the main analysis, over the period 2000 – 2013. The shaded area corresponds to the subprime crisis and it is not included in the analysis, but is presented here in order to give a global view for the dynamics of these variables. Source: see Table 1.1.

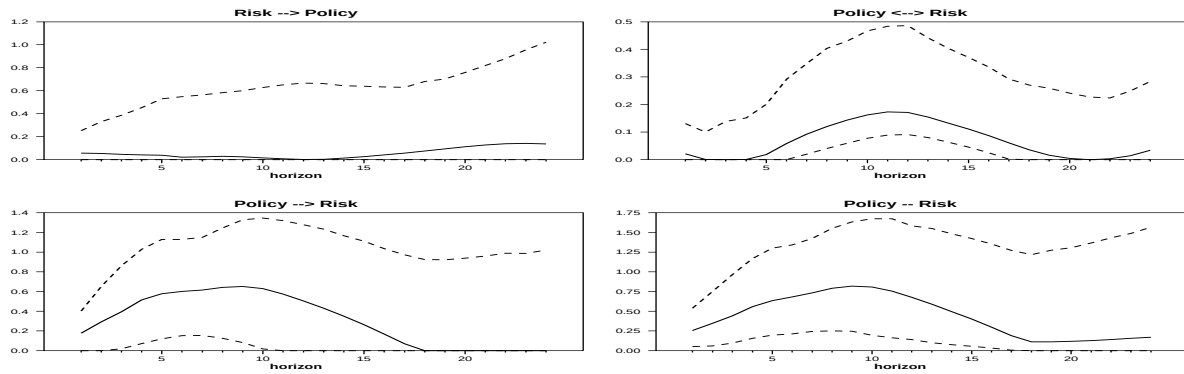
C. Results - Figures

Figure 1.11: Causality measures for $z=rprem$



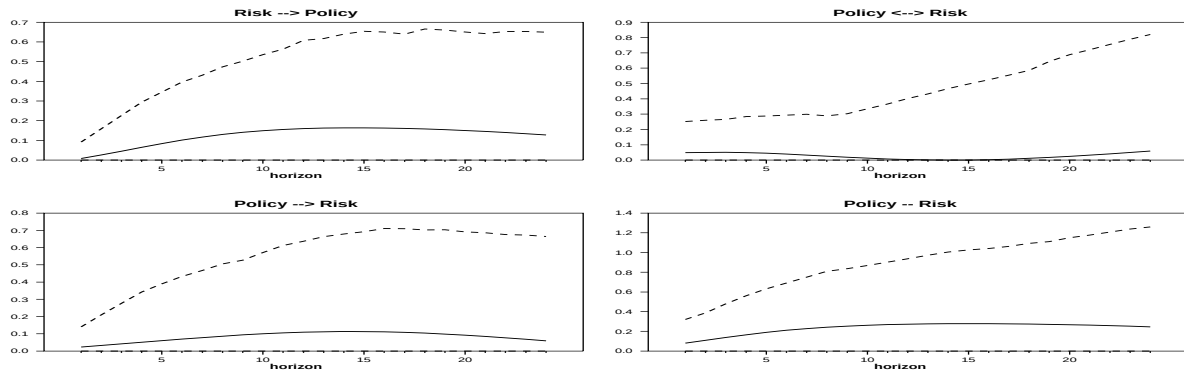
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = igap$ and $y = SRisk$. The auxiliary variable is $rprem$. The order of the VAR, selected by AIC, is 4. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.12: Causality measures for $z=hprice$

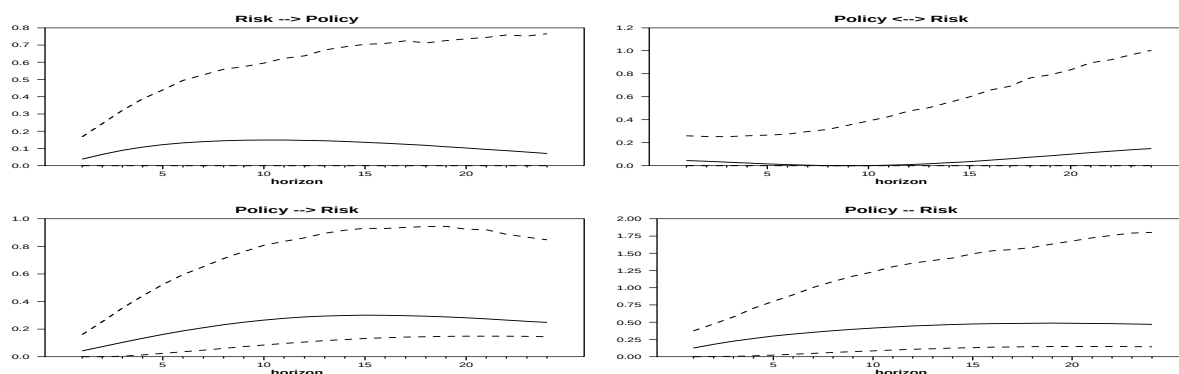


Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = igap$ and $y = SRisk$. The auxiliary variable is $hprice$. The order of the VAR, selected by AIC, is 7. Confidence intervals at 95% are represented by the dashed lines.

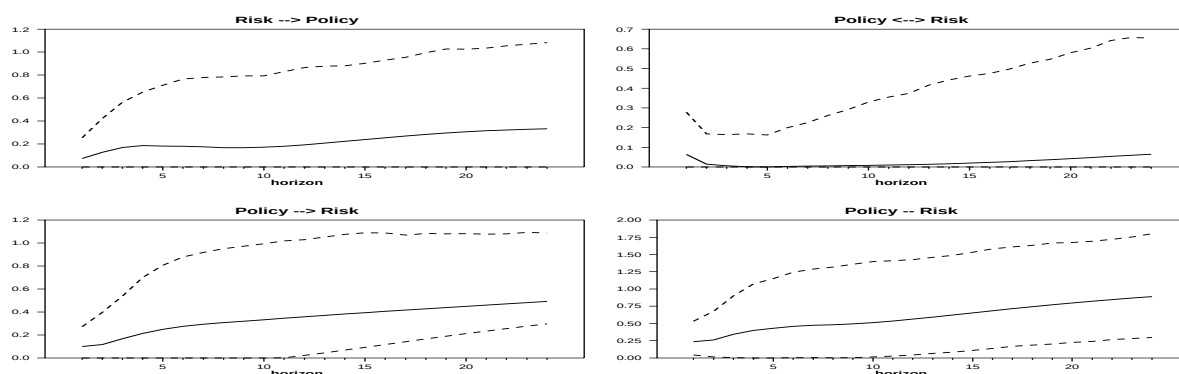
Figure 1.13: Causality measures for $z=stock$



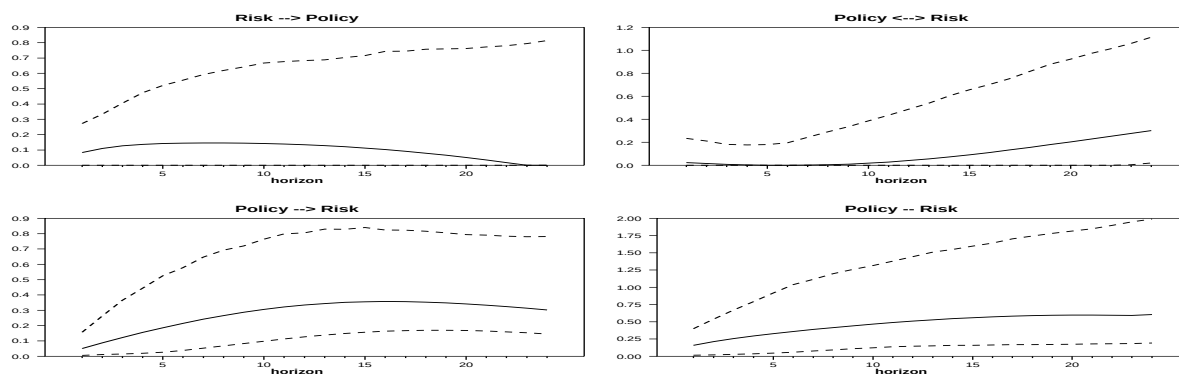
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = igap$ and $y = SRisk$. The auxiliary variable is $stock$. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.14: Causality measures for $z=cost_eq_firms$ 

Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = igap$ and $y = SRisk$. The auxiliary variable is $cost_eq_firms$. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

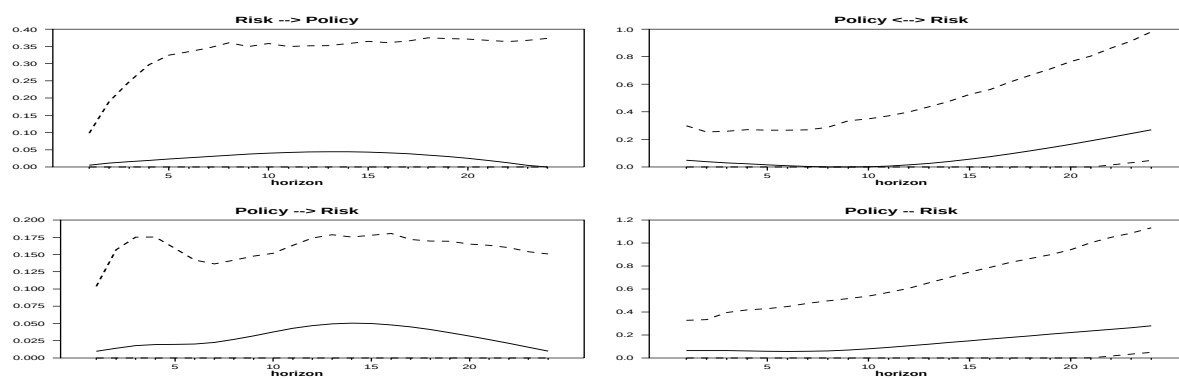
Figure 1.15: Causality measures for $z=edf_bk$ 

Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = igap$ and $y = SRisk$. The auxiliary variable is edf_bk . The order of the VAR, selected by AIC, is 4. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.16: Causality measures for $z=cost_eq_bk$ 

Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = igap$ and $y = SRisk$. The auxiliary variable is $cost_eq_bk$. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

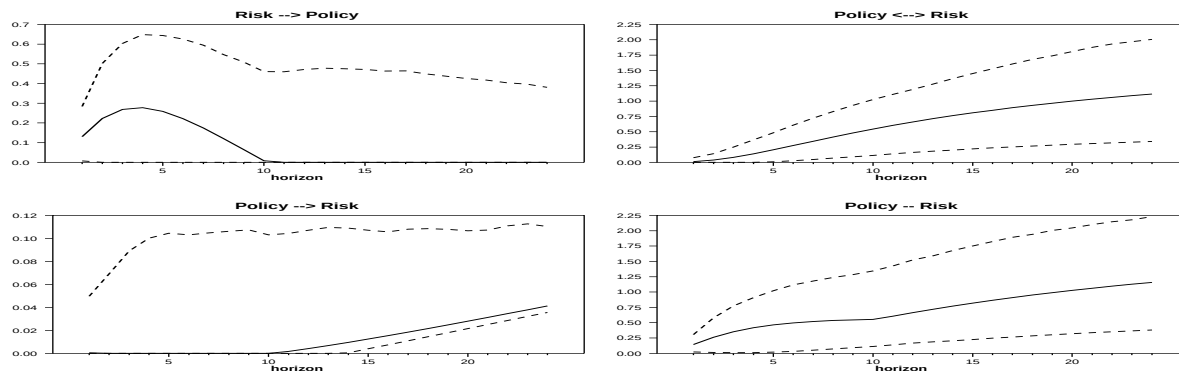
Figure 1.17: Causality measures for $z=liq$



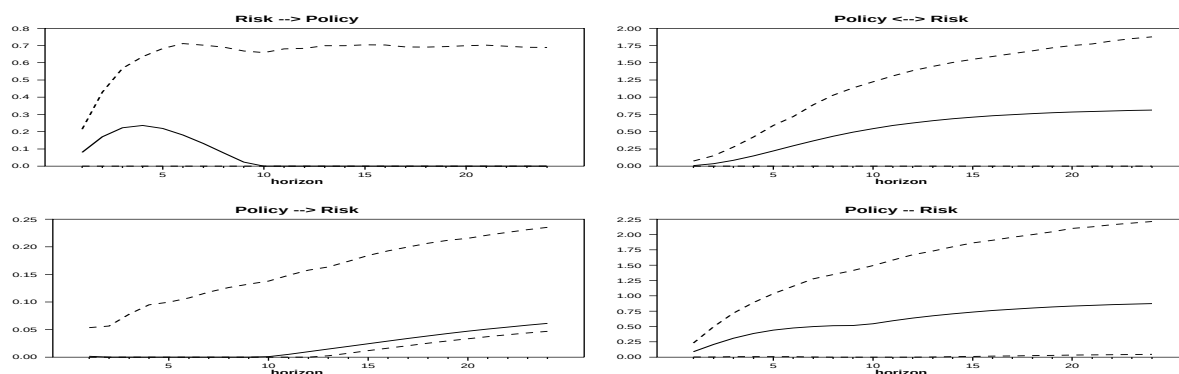
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = igap$ and $y = SRisk$. The auxiliary variable is liq . The order of the VAR, selected by AIC, is 2. Confidence intervals at 95% are represented by the dashed lines.

D. Robustness - Figures

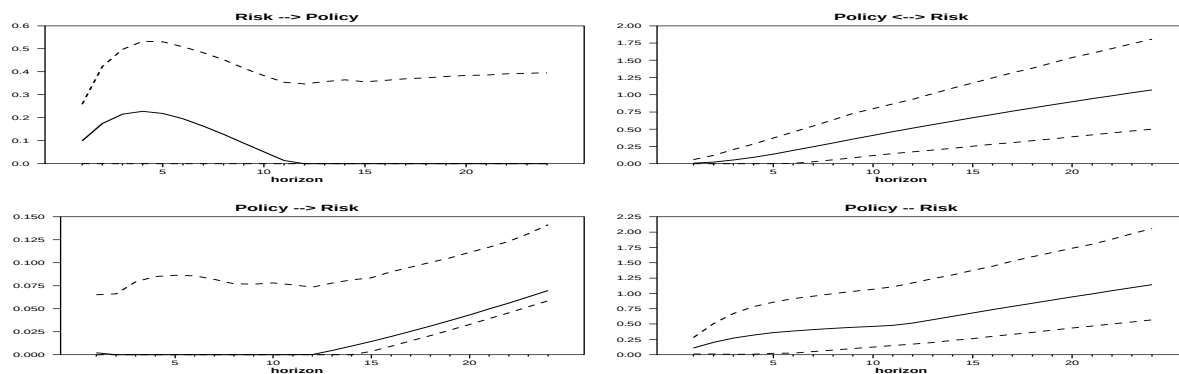
Robustness to x

Figure 1.18: Robustness to x (1)

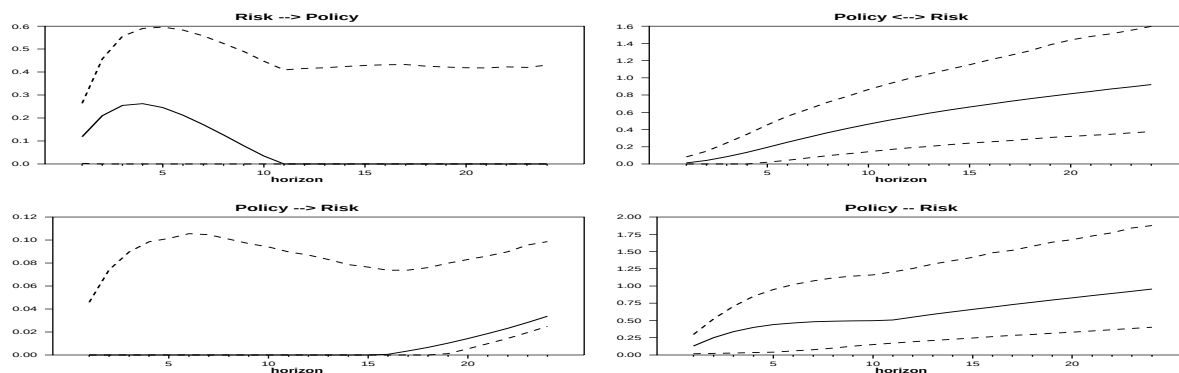
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = SRisk$. The auxiliary variable is $VSTOXX$. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.19: Robustness to x (2)

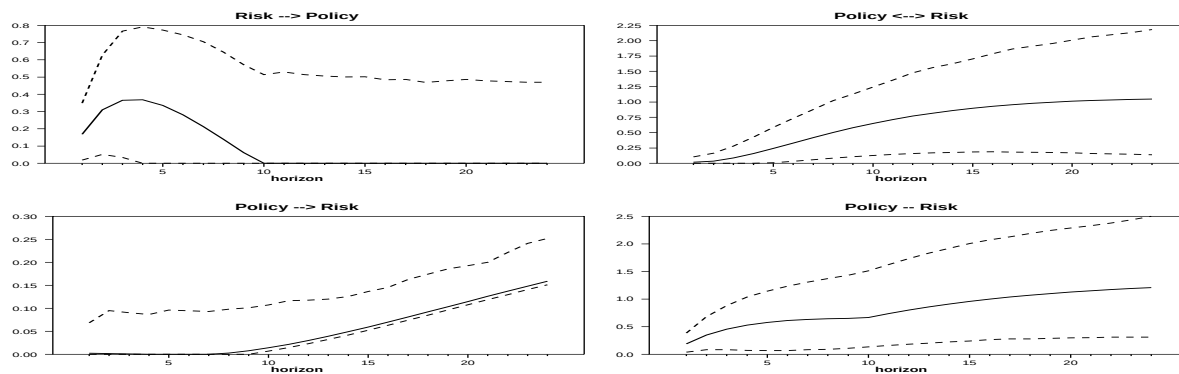
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = SRisk$. The auxiliary variable is $GRAI$. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.20: Robustness to x (3)


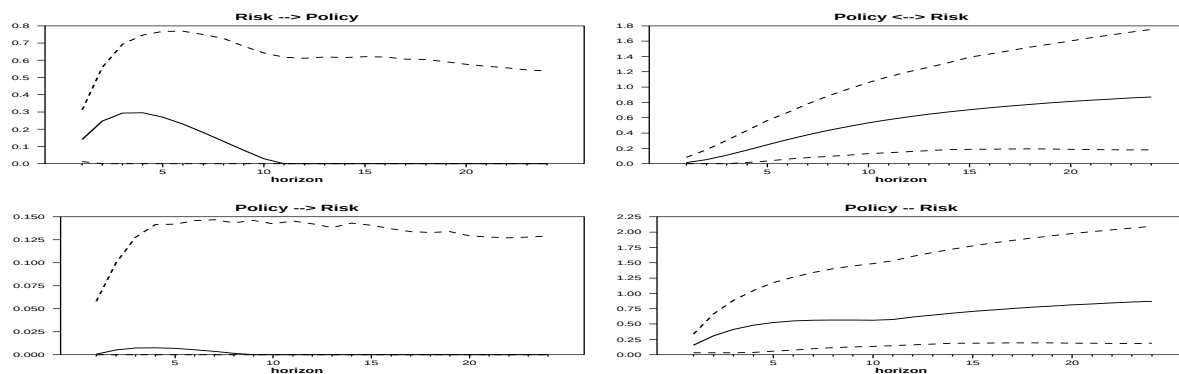
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = SRisk$. The auxiliary variable is BBB . The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.21: Robustness to x (4)


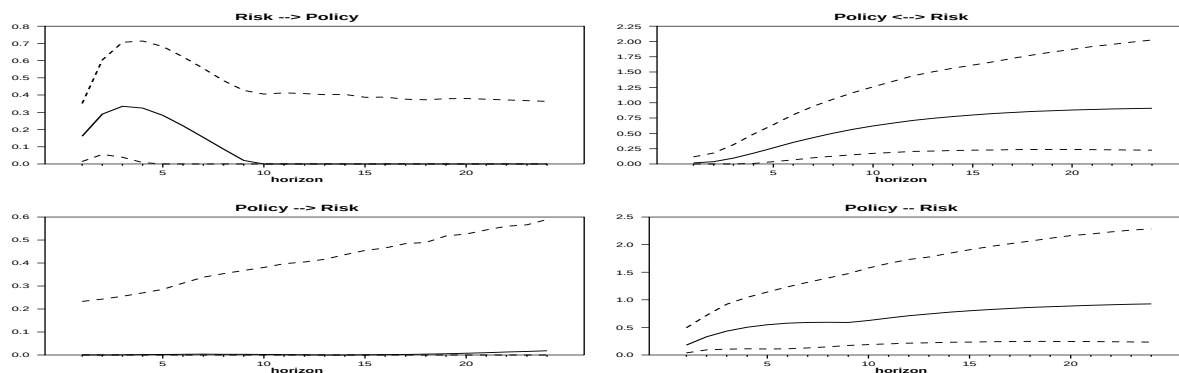
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = SRisk$. The auxiliary variable is $rprem$. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.22: Robustness to x (5)


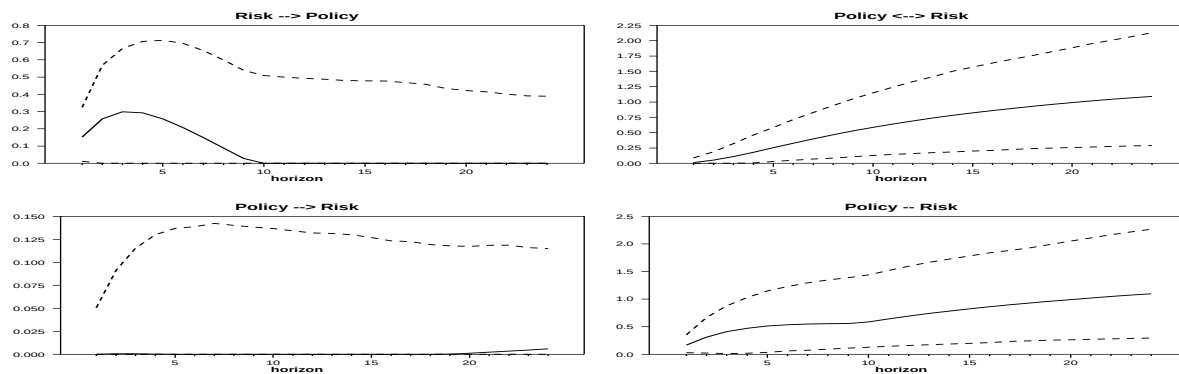
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = SRisk$. The auxiliary variable is $hprice$. The order of the VAR, selected by AIC, is 2. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.23: Robustness to x (6)

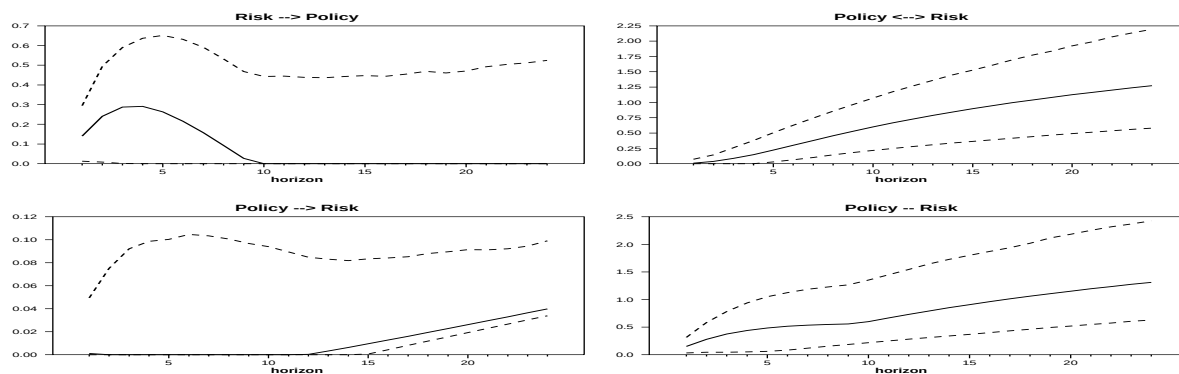
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = SRisk$. The auxiliary variable is *stock*. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.24: Robustness to x (7)

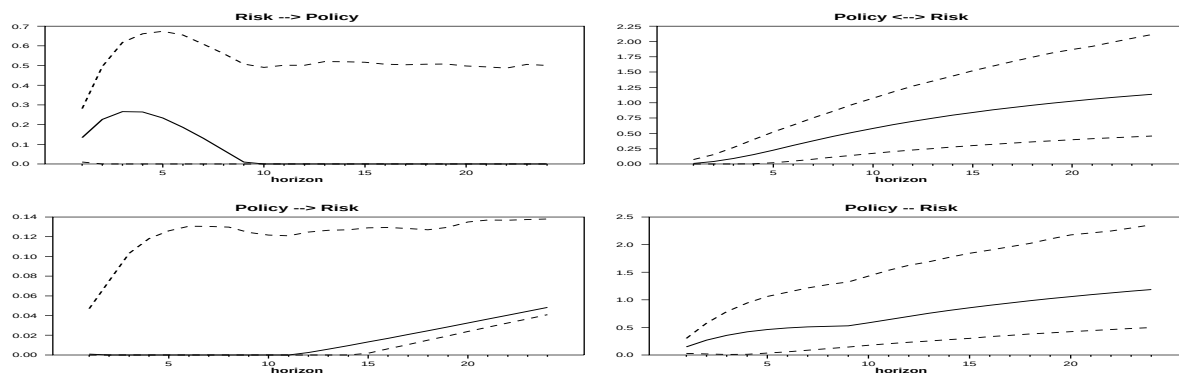
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = SRisk$. The auxiliary variable is *edf_nfc*. The order of the VAR, selected by AIC, is 2. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.25: Robustness to x (8)

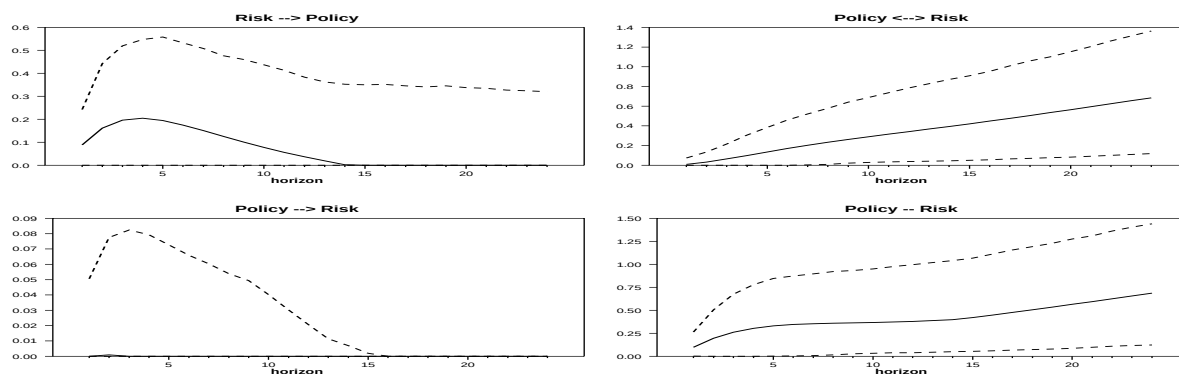
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = SRisk$. The auxiliary variable is *cost_eq_firms*. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.26: Robustness to x (9)


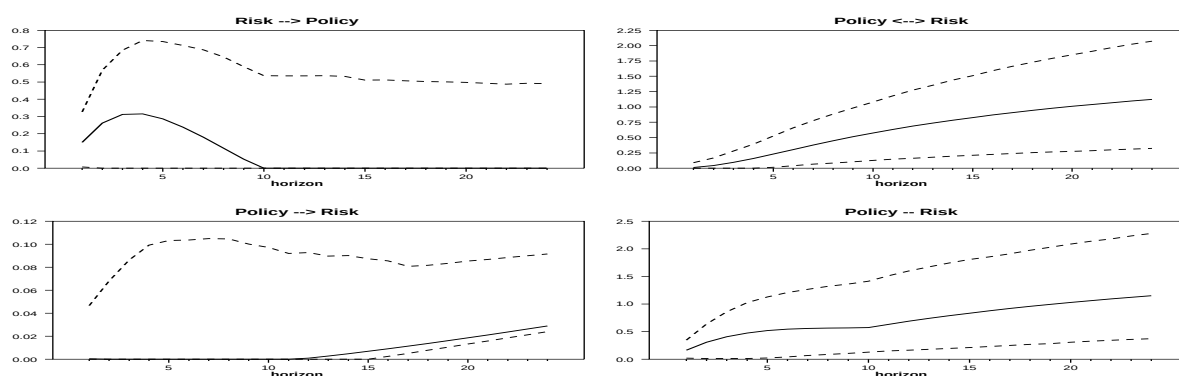
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = SRisk$. The auxiliary variable is edf_bk . The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.27: Robustness to x (10)


Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = SRisk$. The auxiliary variable is $cost_eq_bk$. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

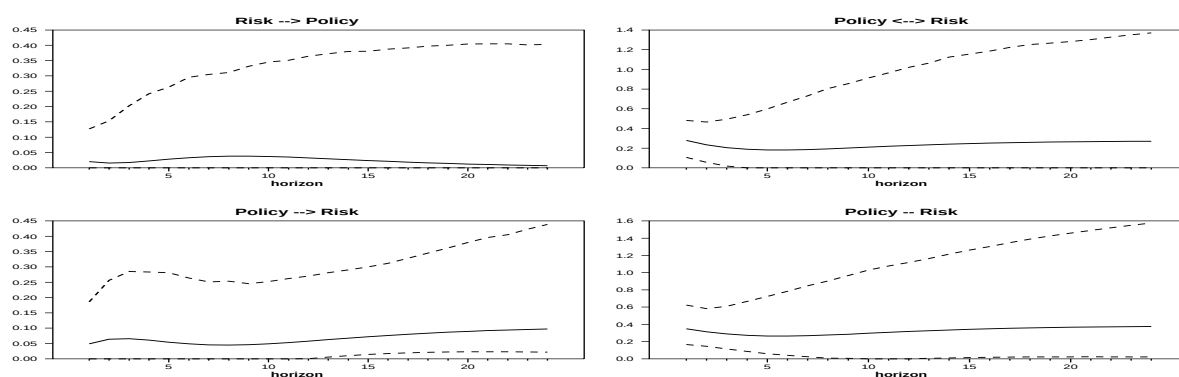
Figure 1.28: Robustness to x (11)


Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = SRisk$. The auxiliary variable is liq . The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

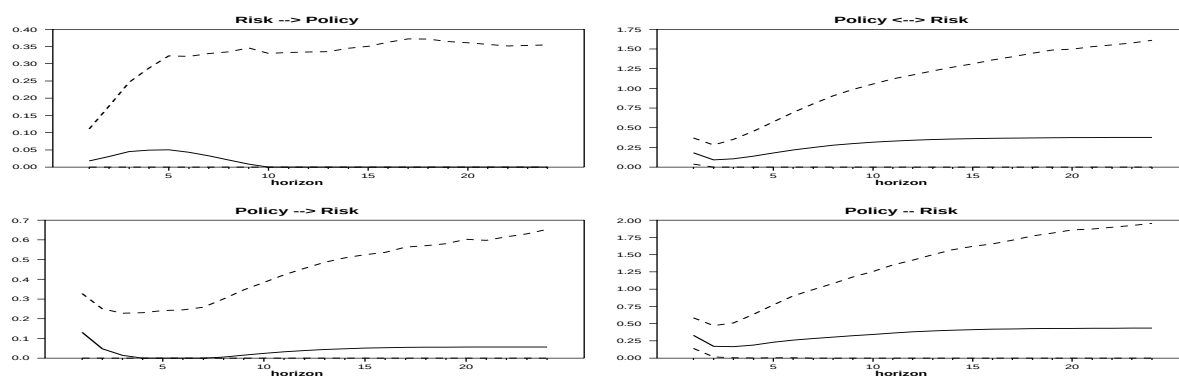
Figure 1.29: Robustness to x (12)

Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = SRisk$. The auxiliary variable is cap . The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

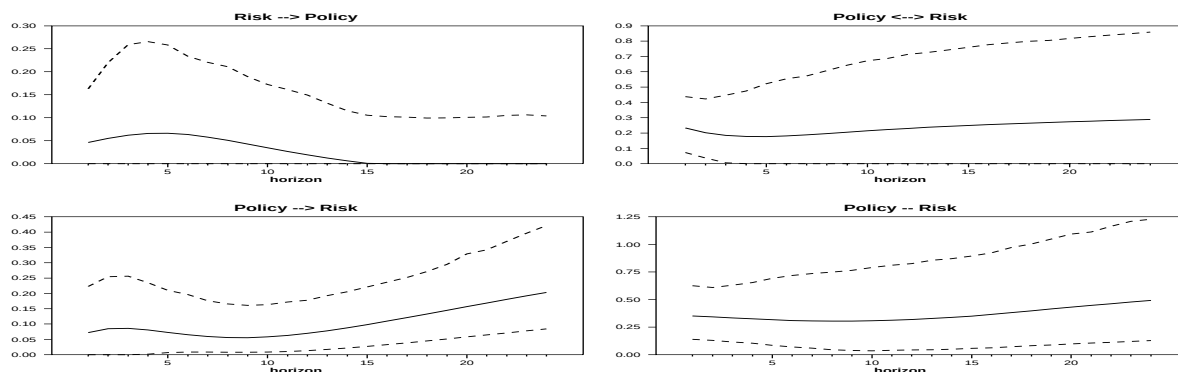
Robustness to y

Figure 1.30: Robustness to y (1)

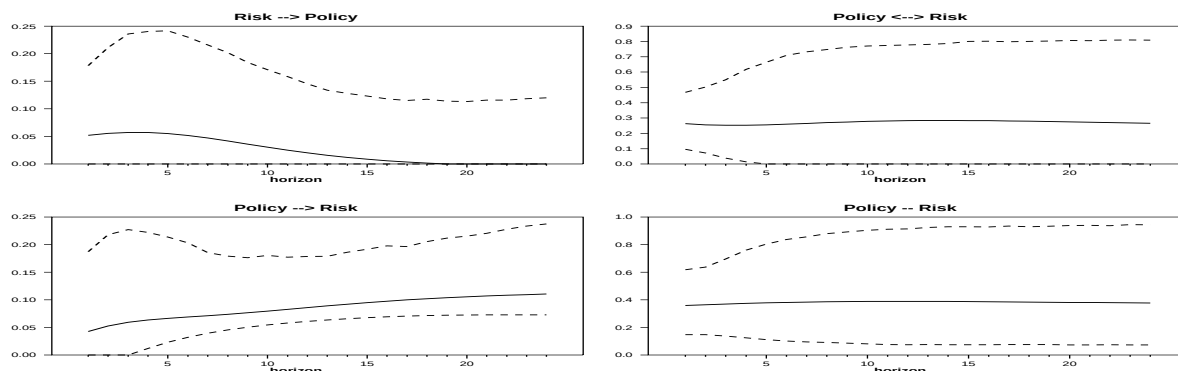
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = credit_to_gdp$. The auxiliary variable is $VSTOXX$. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.31: Robustness to y (2)

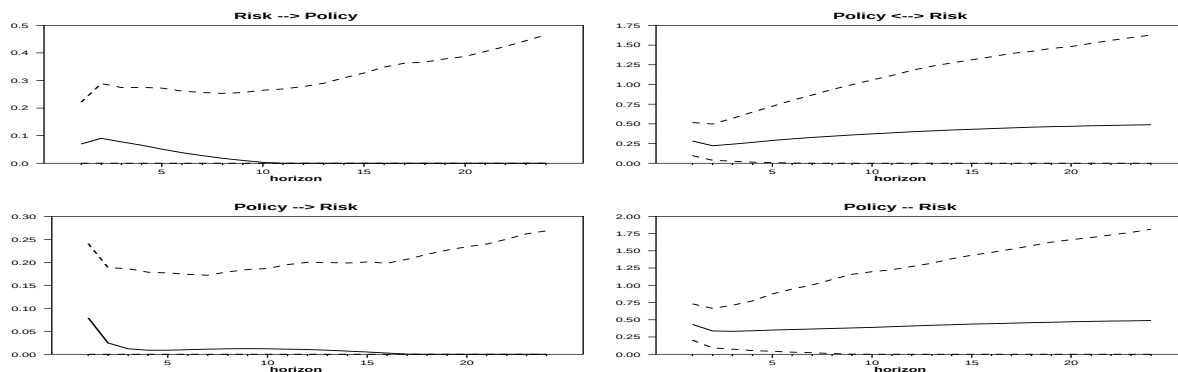
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = credit_to_gdp$. The auxiliary variable is $GRAI$. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.32: Robustness to y (3)


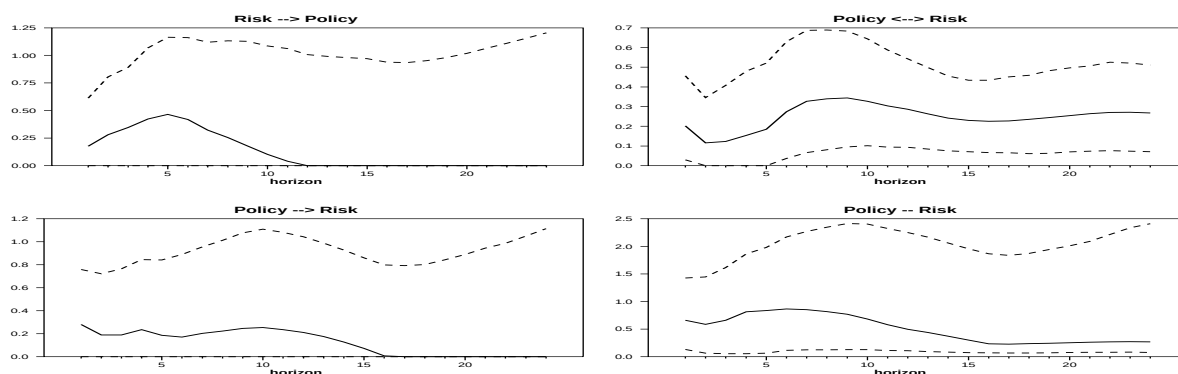
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = credit_to_gdp$. The auxiliary variable is BBB . The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.33: Robustness to y (4)


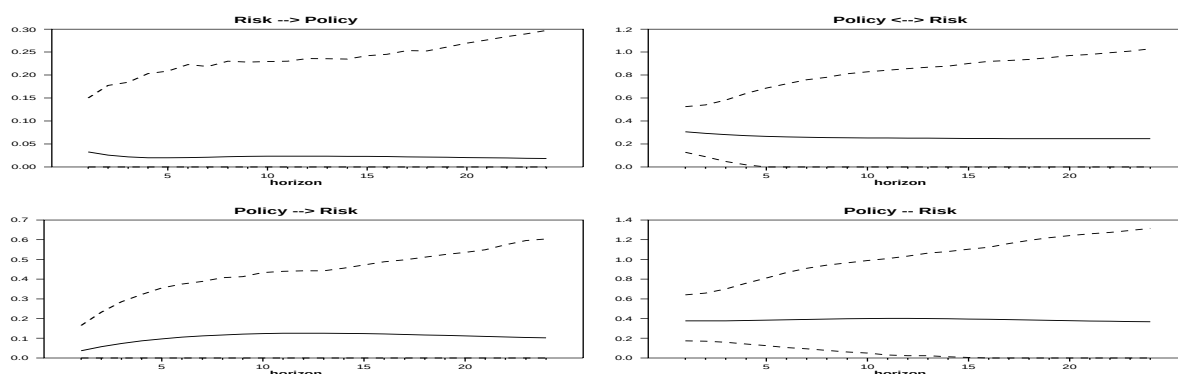
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = credit_to_gdp$. The auxiliary variable is $rprem$. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.34: Robustness to y (5)


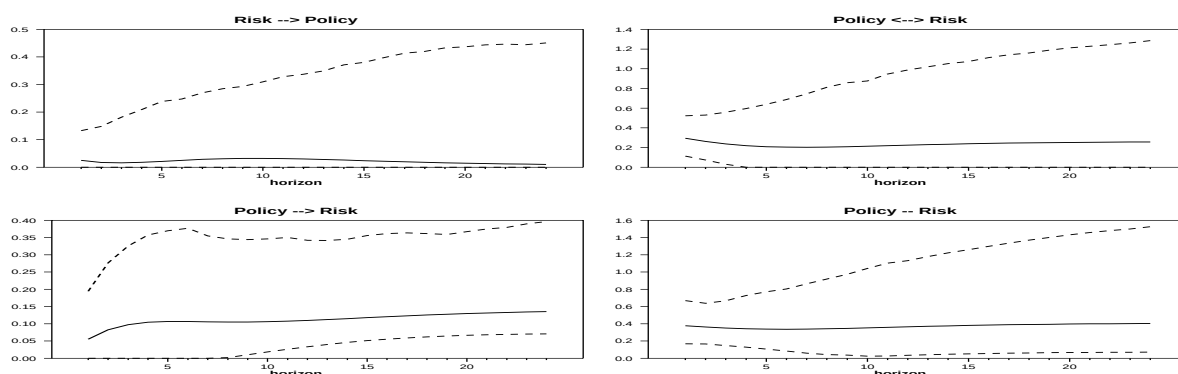
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = credit_to_gdp$. The auxiliary variable is $hprice$. The order of the VAR, selected by AIC, is 2. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.35: Robustness to y (6)

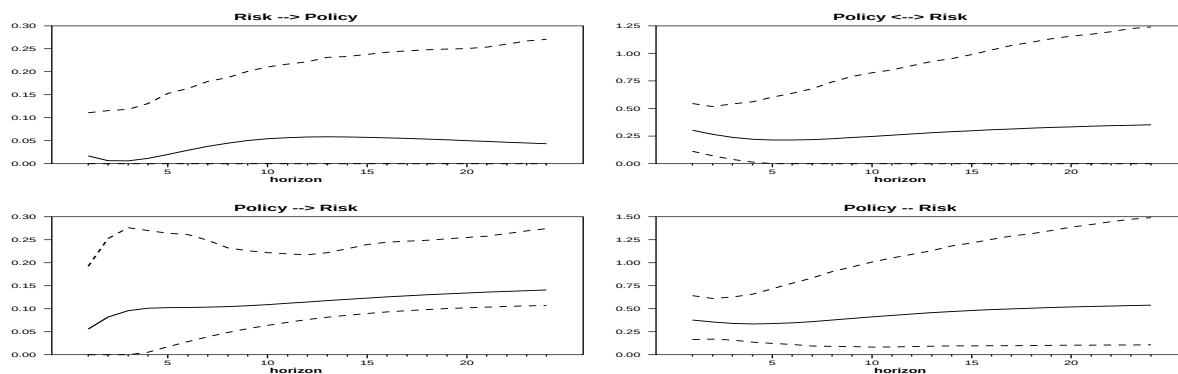
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = credit_to_gdp$. The auxiliary variable is *stock*. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.36: Robustness to y (7)

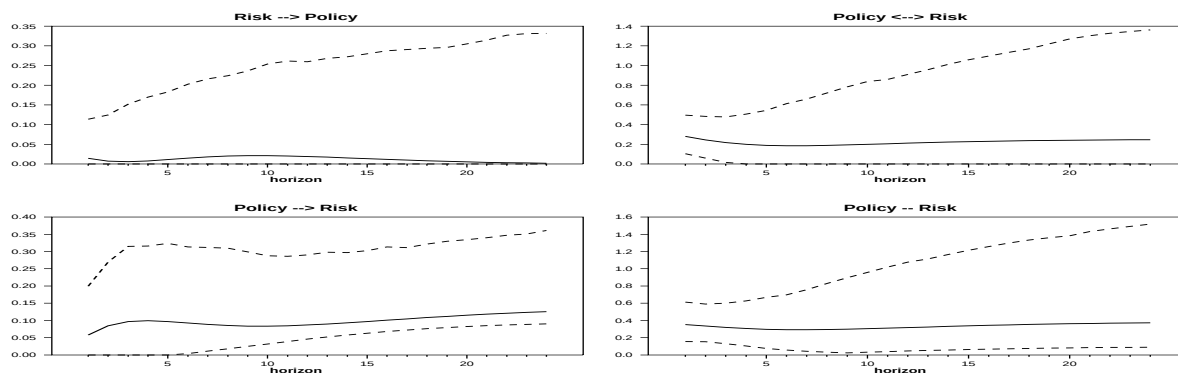
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = credit_to_gdp$. The auxiliary variable is *edf_nfc*. The order of the VAR, selected by AIC, is 2. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.37: Robustness to y (8)

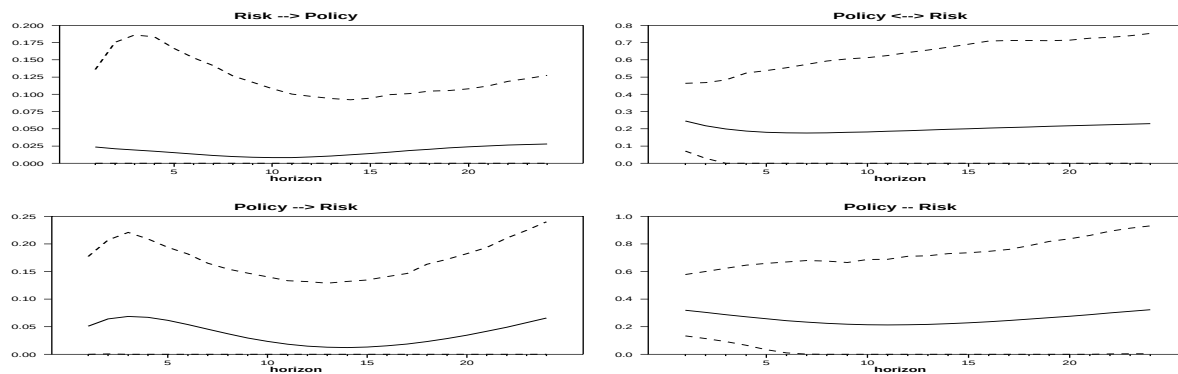
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = credit_to_gdp$. The auxiliary variable is *cost_eq_firms*. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.38: Robustness to y (9)


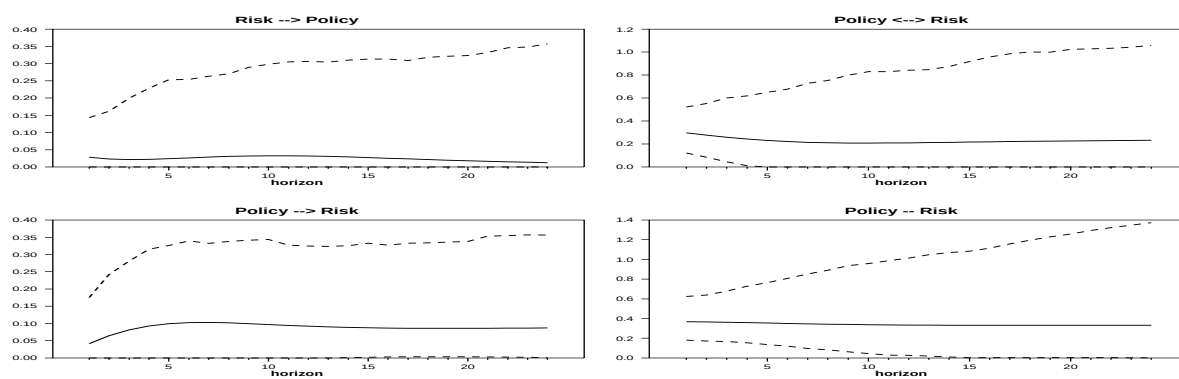
Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = credit_to_gdp$. The auxiliary variable is edf_bk . The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.39: Robustness to y (10)


Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = credit_to_gdp$. The auxiliary variable is $cost_eq_bk$. The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.40: Robustness to y (11)


Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = credit_to_gdp$. The auxiliary variable is liq . The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Figure 1.41: Robustness to y (12)

Note: This figures presents causality measures for the variables x (Policy) and y (Risk). More precisely, $x = gapTaylor$ and $y = credit_to_gdp$. The auxiliary variable is cap . The order of the VAR, selected by AIC, is 1. Confidence intervals at 95% are represented by the dashed lines.

Chapter 2

Systemic Risk Measures and the Sovereign Debt Crisis

Recognizing the existence of a risk-taking channel of monetary policy brings us to the question of how to measure risk. The concept of risk is at the core of this new transmission channel and represented the main driver of the crisis. However, the period preceding the financial crisis deceived by its lack of good risk indicators. The measures that existed at that time and that everyone trusted in, like the Value-at-Risk (VaR) or the Expected Default Frequency (EDF) computed by Moody's, underestimated real risk and showed a much better risk profile of financial institutions than it was the case. When the first signs of concern appeared in the second half of 2007, awareness of true risk led to panic and frozen markets. To avoid this type of events in the future, both practitioners and academics struggle to propose new risk measures capable of capturing the latent accumulation of risk occurring in calm periods. Since the outbreak of the crisis, the focus was mainly on systemic risk indicators.

The concept of systemic risk is very elusive in nature and therefore difficult to apprehend. Although there is no official definition for this term, the existing ones assent that systemic risk is set off by a triggering event that generates significant adverse consequences for the financial system and ultimately for the entire economy.¹ The triggering event itself may be very general, from the failure of a large financial institution to a shock affecting several firms at the same time. A consensus is reached on the fact that systemic risk concerns the whole financial sector and not individual institutions. Before the crisis, it was believed that safeguarding the financial stability of each particular institution, by imposing microprudential regulation, would be enough to ensure the stability of the whole system. Ex post, the macroprudential dimension has become indispensable in the design

¹ Borio and Drehmann (2009) and Eijffinger (2010) analyze and compare various definitions of systemic risk.

of prudential regulation. To propose such regulation, one must first measure systemic risk.

When speaking about systemic risk, two other concepts are usually evoked: “Too Big to Fail” (TBTF) and “Too Interconnected to Fail” (TITF). The first notion refers to the size of financial firms, whereas the second one to their linkages with the rest of the financial system.² Either one of these statuses for an institution normally insures its rescue by the government from any type of problems, because allowing it to default would cause even more damage to the entire system. Certainly, these mechanisms reinforce moral hazard and can incite big and interconnected firms to take more risk. This only represents an additional reason for which systemic risk needs to be assessed. Taking into account these two dimensions – size and interconnectedness – when quantifying systemic risk seems therefore crucial.

Interest in measuring systemic risk has risen since the outbreak of the subprime crisis. Measures proposed until now are generally designed to evaluate systemic risk *in the financial system*. More exactly, they assess individual institutions’ contribution to systemic risk with the purpose of imposing special rules for the most systemically risky ones.³

One way in which we can classify systemic risk measures is based on data used to compute them. We distinguish between measures which are market based and measures which involve confidential information related to the balance sheet and to the financial position of each institution. While the latter are only available to regulators, the former have the advantage of being accessible to all interested parties, be that academics, practitioners or regulators. Lately, the measures based on publicly available data gained more attention. This can be explained by their success in identifying, using a simpler and more time effective methodology, the same systemically risky institutions as the ones proposed by the Financial Stability Board. For this reason, in this chapter, we concentrate on market based indicators and more precisely, we choose among the existing ones, three connected systemic risk measures: the marginal expected shortfall (MES, Brownlees and Engle, 2012), the component expected shortfall (CES, Banulescu and Dumitrescu, 2014) and the SRisk index (Brownlees and Engle, 2012).

These measures have been largely studied by now in the financial literature, but have never been applied to other types of crises. Given the unfolding of events in the Eurozone, we wonder whether systemic risk measures developed for financial institutions should also be applied at countries’ level. As Tabellini (2011) recently underlined, “the sovereign debt crisis in the Eurozone has become systemic”, justifying the need for more careful analysis. In this context, we consider that identifying countries that are more fragile to

² Contagion effects in the financial system are more important if an institution is highly interconnected.

³ For example, the Basel III Agreement has a section entirely dedicated to regulation for globally systemically important institutions (G-SIFIs).

risk and that might default is crucial. We intend in this chapter to answer questions such as: What would be the consequences of a Eurozone crisis on the ability of its member states to finance their debt? Which are the economies that contribute the most to the systemic risk of the area? Although important, these subjects have not been treated before in the literature, as in the recent past no major crisis emerged at the European level. However, the current sovereign debt crisis underlined the necessity to assess the systemic risk contribution of European countries and to provide a ranking of these states based on their riskiness.

In the analysis undertaken in this chapter, answering these questions implies first identifying countries' contribution to sovereign systemic risk, and then establishing a ranking able to reveal the systemically important Eurozone members. To this end, we transpose and adapt the econometric methodology used to compute the MES, the CES and the SRisk for the financial system to countries. Our baseline assumption is that, an initial crisis emerging at the area level, on the bonds market, due for example to a loss of confidence of investors or a rating downgrade of some euro area members, would create high pressure on the economic situation of individual countries. This might further lead to high bond yields and thus to an amplification of the original systemic crisis. It therefore represents a negative externality on the system. Our research is performed on data concerning 11 Eurozone countries, among which the ones most affected by the crisis.

The results can have some interesting implications in terms of fiscal policy making because they would allow authorities to detect the members whose debt might not be sustainable and whose eventual payment default might impose even more problems to the stability of the region. Moreover, the ranking could be a useful tool for regulators if the Stability and Growth Pact were to be further revised. It could also help to establish a better surveillance mechanism and eventually to impose penalties on countries that infringe regulation.

The rest of this chapter is structured as follows. We first provide a short description of events from the establishment of the Eurozone to the present date, underlying the causes of the debt crisis. Then, we present the systemic risk measures usually used in the financial literature to determine systemically important financial institutions (SIFIs). We proceed next with the empirical analysis and transpose first the MES and the CES to Eurozone countries. These two systemic risk indicators are exclusively based on bond yields and public debt weights of countries. The MES allows us to identify the periphery countries as the ones imposing the higher risk on the system. When the relative size of public debt is taken into account (CES), countries like Italy and Germany appear as the most systemically risky in calm periods. From this study, we conclude that although these measures are informative, the analysis of systemic risk could benefit from including other

macroeconomic factors into the model. A more comprehensive measure of systemic risk proposed in the literature is the SRisk index. Therefore, our second analysis consists in adapting this measure to Eurozone countries. We propose a new systemic risk measure, the expected financing requirements (EFR) of a country, which is constructed based on the MES and the government budget constraint. Besides bond yields and public debt levels, the measure takes into account the inflation rate, the growth rate and the primary deficit of each country. Results obtained with this measure are similar to the ones obtained with the CES indicator.

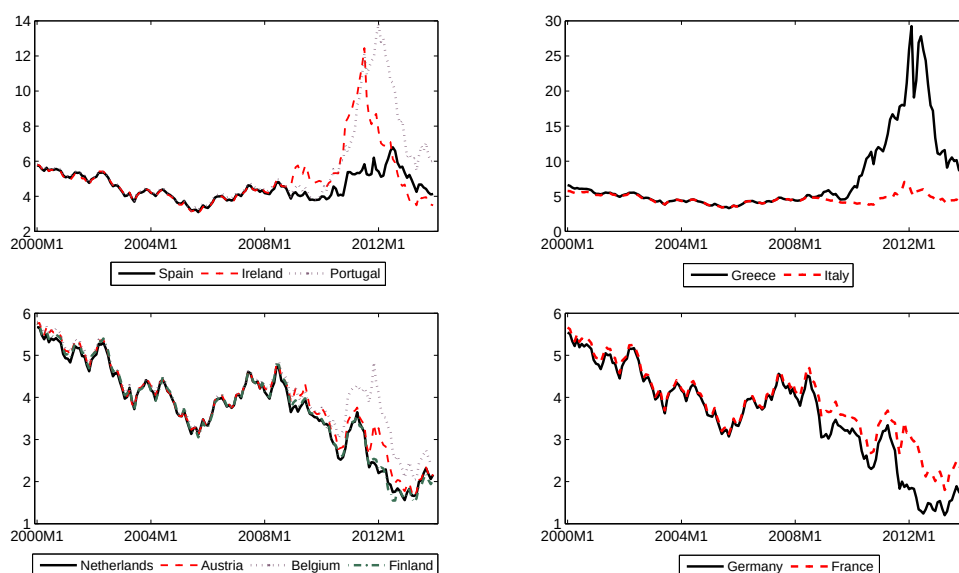
2.1 The Eurozone Debt Crisis: Causes and Unfolding of Events

The Eurozone regroups countries in Europe that have as official currency the euro and that share a common central bank, the ECB. The euro came into existence in 1999, when 10 countries joined the currency union: France, Germany, Italy, Belgium, Luxembourg, Spain, Ireland, the Netherlands, Austria, Portugal and Finland. Greece joined in 2001, before the introduction of common coins and banknotes. Nowadays, the Eurozone counts 18 members. To be accepted in the European Monetary Union (EMU), countries must meet several criteria established by the Maastricht treaty. These criteria concern budget deficits, debt, inflation, interest rates and other monetary requirements and are meant to insure the convergence of countries before joining the area. Homogeneity among countries is a necessary condition for successful monetary policy implementation. Moreover, countries belonging to the European Union and, therefore, all countries in the euro area, must comply with the rules established by the Stability and Growth Pact (SGP). This regulation aims at ensuring that member states conduct their national fiscal policies in a sustainable manner over the cycle. The two main rules to which countries must obey are: *(i)* a deficit inferior to 3% of their GDP and *(ii)* a public debt-to-GDP ratio of less than 60%. Corrective action is taken in case these rules are breached.

With the set-up of the EMU, all member countries benefited from similar borrowing rates as their bonds were considered to be equally risky (see Figure 2.1, the period up to 2009). As a result, capital flows from the Eurozone core to the periphery had become more important. This apparent convergence in interest rates went along with a competitiveness divergence. In Southern-European countries, as the cost of borrowing diminished, capital inflows led essentially to consumption and housing booms, making these countries less competitive. On the contrary, Germany experienced an increase in competitiveness, exporting its products to the periphery and undertaking reforms to restructure its economy after the reunification (Battistini et al., 2013).

In this context, the financial crisis has further deepened the differences in competitiveness between countries. Moreover, as banks holding risky assets were highly affected by the financial turmoil and threatened the stability of the whole system, governments were obliged to increase public spending in order to support their respective banking sectors. Under these conditions, some Eurozone members encountered difficulties to raise the funds needed to finance their increasing debt. As a consequence, the risk premia went up and borrowing cost increased considerably for countries like Greece, Ireland, Spain, Portugal or Italy (Figure 2.1). However, important levels of public debt-to-GDP did not necessarily translate in high yields. Germany, although exceeded the Maastricht criteria throughout the crisis period (reaching a debt-to-GDP ratio of 81.9% in 2012), is still viewed as a safe haven and enjoys the smallest yields in the euro area.

Figure 2.1: Government bond yields

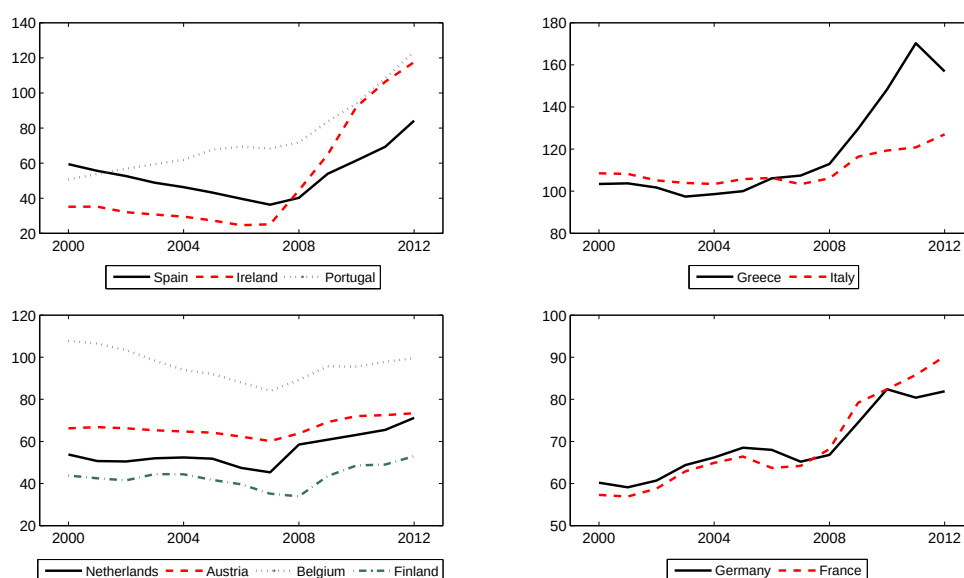


Note: This figure presents the evolution of the government bond yields with a 10-year maturity over the time span 2000 – 2013 for 11 Eurozone countries. The scale changes from panel to panel. Data has a monthly frequency. Source: Eurostat.

The financial crisis, associated to public financing difficulties and to country-specific factors, led to a sovereign debt crisis in Europe. Looking at the troubled and heavily-indebted governments, we can distinguish several country-specific factors that contributed to the worsening of their situation. Countries like Ireland and Spain were rather disciplined regarding their fiscal policies and had low levels of public debt before 2007 (25.1% and 36.3% of GDP, respectively, see Figure 2.2). These two countries enjoyed the benefit of sufficient “fiscal space” (Blanchard et al., 2010). However, both countries had high levels of private debt (households and firms) and, as a consequence, their financial sector was severely affected by the subprime crisis. Additionally, their economic growth was mainly based on the real estate sector that took a major downturn during the crisis.

Actions taken by the government led to rocketing public debt levels, which made them very vulnerable from the point of view of debt sustainability. For Greece and Italy, public debt has always been a matter of concern, as their debt-to-GDP ratio was close to or exceeded 100% at all times since the creation of the EMU. The advent of the crisis only worsened the situation for these two countries in terms of sovereign debt levels. The situation in Portugal was different, as its debt-to-GDP ratio has continuously increased since 2001 and exceeded the Maastricht criterion in 2004 (*i.e.* 60% of its GDP). However, the problems in Portugal were mainly due to large public spending on economic stimuli during the financial crisis.

Figure 2.2: Government debt as a proportion of GDP

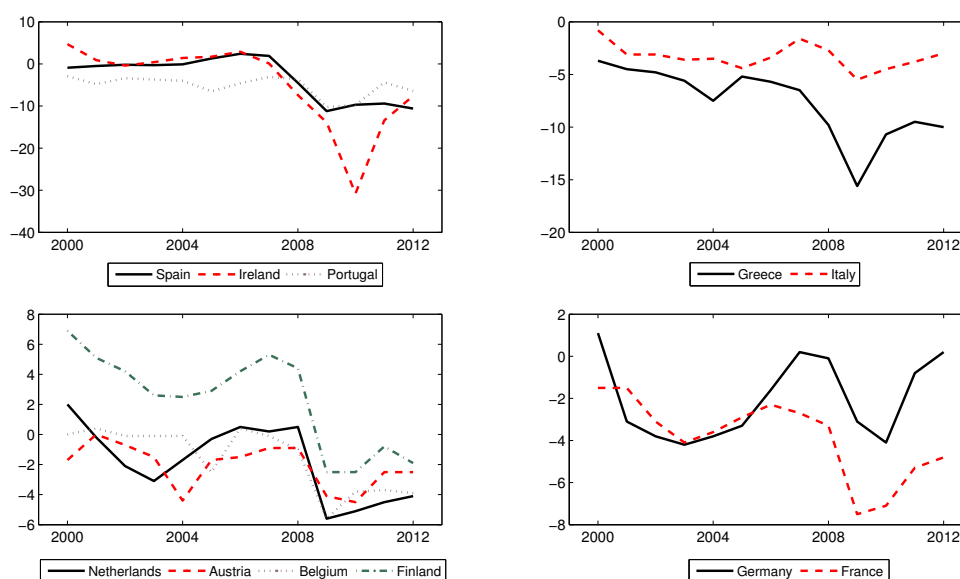


Note: This figure presents the evolution of the government debt-to-GDP ratio over the time span 2000 – 2012 for 11 Eurozone countries. The scale changes from panel to panel. Data has an annual frequency. Source: Eurostat.

Concerning deficits, most of the 11 countries studied here were in compliance with the rules of the SGP (Figure 2.3). The only exceptions were Greece and Portugal, but their high deficits before the crisis are justified by an important interest burden of public debt. However, in 2009, due to unprecedented measures taken to safeguard the financial system, all countries but Finland found themselves exceeding the ratio imposed by regulation.

The first signs announcing the sovereign debt crisis appeared at the end of 2009 when Greece admitted to having a debt-to-GDP ratio of 113% - nearly the double of the threshold fixed by regulation. Problems for Greece worsened at the beginning of 2010, when it revealed severe irregularities in its national accounting. The country passed at that time through a series of downgrades from rating agencies and saw its borrowing costs reach a record high. In May, Eurozone members and the International Monetary Fund (IMF) agreed to a bailout package of 110 billion euros to rescue Greece. In the

Figure 2.3: Government surplus or deficit as a proportion of GDP



Note: This figure presents the evolution of the government deficit-to-GDP ratio over the time span 2000 – 2012 for 11 Eurozone countries. The scale changes from panel to panel. Data has an annual frequency. Source: Eurostat.

meantime, concerns about other heavily indebted countries appeared. At the end of the year, these concerns materialized for the Irish Republic, which was the the second country to receive a bailout package (amounting to 85 billion euros). Economic growth perspective worsened for countries in trouble, as austerity measures aimed at reducing deficits were imposed in return of these bailout packages. During 2010, the gravity of the situation and the rapid pace at which events unfolded, demanded urgent attention at the area level. In May, Euro member states decided to create a new structure – the European Financial Stability Facility (EFSF) – that had as mission to safeguard financial stability in Europe. To meet its objectives, the EFSF was empowered to issue bonds on the financial markets and to lend the capital obtained in this way to countries taking part in its programmes. Moreover, the EFSF had also the right to intervene in bond markets, to provide precautionary financial assistance or to finance the recapitalization of financial institutions through loans to their respective governments.

The next country to receive bailout funds was Portugal, in 2011, with a package of 78 billion euros. In order to prevent contagion to other European countries, a second bailout package was given to Greece (109 billion euros). By August 2011, Spain and Italy were also confronted with problems related to their public debt. Their bond yields rose sharply and the ECB agreed to buying their bonds in order to stop the crisis from spreading. Under these circumstances, economic growth was heavily affected, contributing to the reinforcement of the crisis. Financial markets have also been affected by the debt crisis, as every news concerning troubled countries translated into higher volatility of share prices.

In September, Standard and Poor's downgraded Italy from A+ to A and in October, the ECB agreed to extending emergency loans to banks affected by the sovereign crisis.

The beginning of 2012 brought about a series of ratings downgrades among which France lost its triple A. In Greece, new austerity measures were taken in order to allow the country to access bailout funds. The year was marked by a high increase in unemployment in the Eurozone and low economic growth. During the first half of 2012, Italy and Spain were once again sanctioned by high yields for their debt problems. At the same time, another country – Cyprus – demanded bailout funds in order to rescue its failing banking sector and to reimburse its public debt. However, mid 2012 represented a turning point when the debt crisis slowed down as a result of measures taken at the national and area level. The European Stability Mechanism (ESM) replaced the temporary rescue facility, EFSF and become the permanent crisis resolution mechanism in Europe. Moreover, the support from the ECB during the crisis – cheap loans to banks, low interest rates and unlimited bond-buying programs – was also essential to lowering the degree of market uncertainty. Consequently, borrowing costs started decreasing for periphery countries.

In 2013, bailout programs and support from the ECB resulted in a further reduction of borrowing costs for problem countries. Although at present the debt crisis seems under control, the euro area is still confronted with low economic growth and high unemployment, problems that are still to be tackled. Undoubtedly, important structural reforms are needed to reduce public debt levels and, at the same time, sustain recovery. However, what is most important is that the crisis emphasized the fragility of the Eurozone. During the worst times of the debt crisis, default fears appeared and the question of a possible exit of countries from the EMU emerged. The problems raised by the crisis concerning regulation at the area level were numerous. We address in this chapter one of these matters: identifying systemically important countries.

2.2 Systemic Risk Measures in the Financial Literature: A Brief Overview

As our aim is to transpose systemic risk measures to the sovereign case, we start by presenting the existing measures used in the financial literature to identify SIFIs. Within the vast literature on systemic risk, the measures constructed on *market data* that capture the relation between institutions and the market are of particular interest to us.⁴ In this literature, systemic risk measures have already been proposed (Acharya et al., 2012a; Acharya et al., 2012b; Adrian and Brunnermeier, 2011; Banulescu and Dumitrescu, 2014; Brownlees and Engle, 2012; Tarashev et al., 2010), analyzed (Bandt et al., 2013;

⁴ For a complete survey on systemic risk measures, refer to Bisias et al. (2012).

Drehmann and Tarashev, 2011) and compared (Benoit et al., 2013; Gauthier et al., 2012; Rodriguez-Moreno and Pena, 2013). These papers are summarized hereafter.

Systemic risk measures have been defined in different ways. A popular measure that is computed based on financial returns and that received notable attention is the Marginal Expected Shortfall (MES). Acharya et al. (2012b) introduced the MES as a measure of how a firm's risk-taking adds to the system's overall risk, where the latter is measured by the Expected Shortfall (ES) of the market. According to their methodology, the MES corresponds to the average return of a firm on days when the market return is in its tail. Their analysis of systemic risk goes further as they propose a more comprehensive measure – the Systemic Expected Shortfall (SES) – that also captures a financial institution's contribution to systemic risk. The SES depends on the MES, on the institution's leverage and on its market capitalization.

Using the MES developed by Acharya et al. (2012b), Brownlees and Engle (2012) implement a multi-step econometric model to determine the marginal contribution of financial firms to systemic risk.⁵ They define the MES as the equity loss that should be expected by an investor in a financial firm, if the market were to be confronted with a substantial decline (*i.e.* a crisis). A systemic risk index (SRisk, also used by Acharya et al., 2012a) is also proposed in their paper. SRisk is defined as the expected capital shortage of a firm when the market is in distress. The index depends on the MES, the leverage and the size of each financial institution.⁶

The MES is also employed in the construction of the Component Expected Shortfall (CES) proposed by Banulescu and Dumitrescu (2014). This systemic risk measure is obtained by calibrating the MES with the market capitalization of each financial institution. The CES provides complementary information with respect to the MES, as it captures the absolute contribution of financial institutions to systemic risk.

A different measure, relying on the Value-at-Risk (VaR) approach, was proposed by Adrian and Brunnermeier (2011). This measure, labeled CoVaR, is also computed using financial returns and captures the system's losses when a particular financial institution is in distress. Remark that in this case the conditioning event is reversed with respect to the MES: it is not the market that is in distress, but a particular firm. To determine the contribution of an institution to systemic risk, Adrian and Brunnermeier (2011) define the ΔCoVaR , as the difference in the CoVaR of the system when an institution defaults and the CoVaR computed when no default occurs.⁷

⁵ This measure initially developed for the US, has been expanded by Engle et al. (2014) to European financial institutions. They find that the riskiest financial companies are located in France and UK.

⁶ As a matter of fact, SRisk is the equivalent of SES.

⁷ Adrian and Brunnermeier (2011) underline that fact that the CoVaR can also be used to compute the loss of an institution when another institution is in distress. Moreover, reversing the conditioning event is also possible with their measure.

Chan-Lau et al. (2009) propose a measure which is similar to the CoVaR, but is computed on CDS spreads of financial institutions. Co-Risk examines the CDS spread of one firm, conditional on the CDS spread of another firm, each at the respective 95th percentile of its empirical distribution.

The Shapley value has also been used to measure systemic risk (Tarashev et al., 2010). This measure decomposes the risk of the system (given either by the VaR or the expected shortfall – ES) and allocates it across financial institutions. According to this methodology, the contribution of a financial firm i to the risk of the system is equal to the difference between the risk of the system and the risk of the system when i is excluded from it.

According to Drehmann and Tarashev (2011), these measures can be classified either as top-down or bottom-up. The top-down measures “start with the risk of the system and allocate it to individual institutions”. The MES, the CES and the Shapley value belong to this group. The bottom-up measures “start with distress at a particular institution and then compute the associated level of system-wide distress”. This category includes the CoVaR and the Co-Risk.

A different classification of systemic risk measures is provided by Bandt et al. (2013). They distinguish between indicators focusing on institutions, among which we find the MES, and indicators related to interconnectedness and to financial infrastructures and sectors.

In order to check the validity of systemic risk measures, several articles compare these measures or their performances. Benoit et al. (2013) compute the MES, the SRisk and the CoVaR using a common estimation framework, and compare the three indicators both theoretically and empirically. They find that these measures identify different financial firms as being systemically important. Moreover, they reveal that using market risk measures or the level of liabilities would lead to the same rankings as the ones provided by these systemic risk measures, proving their incapability to capture the complex nature of systemic risk.

Gauthier et al. (2012) compare bank capital requirements issued from five systemic risk measures (component and incremental VaR, Shapley values, the Δ CoVaR and the MES) with two benchmarks based on Basel II requirements. They find that a macroprudential approach to financial regulation, based on systemic risk measures, diminishes the default probabilities of banks. A direct comparison of systemic risk measures is performed by Rodriguez-Moreno and Pena (2013). In their paper, market-based high-frequency macro and micro measures⁸ are compared using three criteria: causality, the Gonzalo and Granger metric and correlation with an index of systemic events. Their re-

⁸ These measures are: the LIBOR spreads, the principal component analysis (PCA) of portfolios of CDS spreads, the systemic factor extracted from the CDS indexes (CDX and iTraxx) and their tranches, the systemic risk index (SI) based on structural credit risk models, the multivariate densities and the aggregate of individual co-risk measures.

sults show that the measures based on credit default swaps are the most reliable systemic risk indicators. Although they consider a large panel of systemic risk measures, they do not analyze measures like the MES or the CES.

In what follows, we analyze systemic risk at country level by focusing on two of the top-down measures, the MES and the CES. We choose these measures as they provide several advantages. First, they can be computed by using only publicly available data. Second, these indicators are complementary and can thus provide a thorough analysis of systemic risk in Europe. Finally, they are intuitive and simple to compute, accounting at the same time for the risk profile of the country and its interconnection with the system. To complete our analysis, we also transpose the SRisk measure to the case of sovereigns.

2.3 Sovereign Systemic Risk in Europe: An MES and CES Approach

The first analysis we engage in concerns the MES and the CES. The aim is to determine whether or not, these systemic risk indicators used for financial firms can also be successfully applied to countries. We start by defining some of the key concepts employed throughout this chapter.

2.3.1 Definitions

In our analysis, we focus on the systemic risk caused by sovereign debt problems. We define systemic sovereign risk as the failure of countries, during crisis periods, to meet their obligations to creditors, failure that would have significant adverse consequences for the financial system – the bond market in particular – and subsequently for the rest of the economy. Moreover, a country is considered to be systemically important in our analysis if it needs to raise a large amount of funds and/or faces high bond yields at a time when the system is already under stress.

The first risk measure we consider, the MES,⁹ is defined as the expected increase in a particular government bond yield when the overall (European) government bonds' market is under stress. The measure captures the marginal contribution of countries to the system's distress: the higher the MES of a country, the greater its contribution to systemic risk.

To determine the formula for the MES, we follow the steps of Brownlees and Engle (2012) and make the necessary adjustments to transpose this measure to sovereigns.

⁹ For comparison reasons, we choose to keep the expression “Marginal Expected *Shortfall*” when talking about sovereigns, although this concept is specifically suited for financial firms. However, one should bare in mind that in our framework, the MES does not represent a measure of expected loss for an investor if the overall market declined substantially, but a measure of the expected financing conditions (bond yields) for a country in crisis times.

Consequently, we replace financial returns with nominal government bond yields for a 10-year maturity for each country in our sample. The first step in deriving an expression for the MES is to construct a bond index. To this end, a weighting scheme should be defined. The second step requires specifying a measure for the aggregate risk of the system. The bond index allows us to define a crisis event taking place at the area level. We build the virtual Eurobonds index as a weighted average of each member state bond yield:

$$r_{mt} = \sum_{i=1}^N w_{it} r_{it}, \quad \text{with} \quad w_{it} = \frac{B_{i,t-1}}{\sum_{i=1}^N B_{i,t-1}}, \quad (2.1)$$

where r_{mt} stands for the market index, r_{it} represents the bond yield of country i at time t , w_{it} the weight of country i in the market index and N the number of countries in the sample. The weights used in the construction of the index are calculated as the public debt of country i , $B_{i,t-1}$, divided by the total public debt of the eleven Eurozone countries considered in the analysis. We suppose that at each date t the only information available on public debt is the one from date $t - 1$. This implies that weights for date t are known in $t - 1$, *i.e.* $E_{t-1}(w_{it}) = w_{it}$. This index can be viewed as the yield that would apply to Eurozone bonds if such an instrument existed. The idea underlying its construction is that the interest paid on the mutualized debt of all countries should be equal to the sum of interest paid on the N individual debts, that is: $r_{mt} \sum_{i=1}^N B_{i,t-1} = \sum_{i=1}^N r_{it} B_{i,t-1}$.

The choice of the weights is essential to our analysis as they have two major roles: they are included in the construction of the bond index (equation 2.1) and they are also used to construct the CES measure (equation 2.8). By analogy with the literature devoted to backtesting and to risk model validation, two strategies can be employed in the selection of countries' weights. First, the weights can be defined as the historical relative share of a country in the total debt. This type of weighting scheme implies calculating the weights at specific moments in time (*i.e.* quarterly in our case). This approach is also employed by Brownlees and Engle (2012), Acharya et al. (2012b) and Banulescu and Dumitrescu (2014) to measure the systemic risk of financial institutions. The second strategy, derived from the financial literature on risk management analysis, consists in keeping the weights constant during the analyzed period. We choose to adopt the former approach in our empirical analysis and to consider the latter for robustness check only.

Another important issue is the choice of the macroeconomic variable used in the weighting scheme. Given that we analyze sovereign systemic risk, public debt seems the more intuitive variable for the construction of weights. Additionally, the weights based on pub-

lic debt verify the condition $\sum_{i=1}^N w_{it} = 1$, fundamental for the coherence of our index.¹⁰

Expected Shortfall (ES)

We consider that aggregate risk is measured by the conditional Expected Shortfall (ES),¹¹ defined as the expected market bond yield conditional on this yield exceeding a given threshold, C . The main change with respect to the traditional ES, constructed on financial returns, is the nature of the distribution. We are no longer in a profit and loss distribution, where extreme losses in the financial market represent the systemic event. The conditioning event is, in the case of sovereigns, a situation where the whole area faces a difficulty to raise funds, (*i.e.* high bond rates), needed to finance the mutualized debt. The ES is defined by the following relation:

$$ES_{m,t-1}(C) = E_{t-1}(r_{mt} | r_{mt} > C). \quad (2.2)$$

Due to the fact that systemic events are situated in the right tail of the bond yield distribution, the value we choose for the threshold, C , is the historical Value-at-Risk at a 10% confidence level computed for the yields of the market. We consider the realization of the condition $r_{mt} > C$ as being the systemic event, or more exactly, an area-wide event that influences all countries at the same time. Consequently, high bond yields for a single country are not seen in our study as a systemic event *per se*. This might only be the case if the yields for this country and its public debt are so high that they generate an increase in the market index as well. We argue that during the Eurozone debt crisis, it was not a single country that imposed the systemic character to the crisis. Rather, several countries showed concurrently signs of weakness coming from various sources.

Marginal Expected Shortfall (MES)

The MES is defined as the partial derivative¹² of the system's ES with respect to the weight of country i in the Eurozone.¹³

¹⁰ Another good candidate for the construction of weights would have been the debt-to-GDP ratio, because its value may bear useful information about the difficulties that countries encounter in repaying their debt. Unfortunately, this variable does not respect the condition for coherence.

¹¹ This choice is based on risk measures properties. According to the criteria defined by Artzner et al. (1999), the ES is a coherent risk measure as opposed to the Value-at-Risk, for example.

¹² Details are provided in Appendix A.

¹³ To simplify notations, we use MES_{it} instead of $MES_{it|t-1}$, but it should be understood as the MES computed at time t given the information available at time $t - 1$.

$$MES_{it}(C) = \frac{\partial ES_{m,t-1}(C)}{\partial w_{it}} = \frac{\partial \sum_i w_{it} E_{t-1}(r_{it}|r_{mt} > C)}{\partial w_{it}} = E_{t-1}(r_{it}|r_{mt} > C). \quad (2.3)$$

Two interpretations can be given to the MES at this stage. First, if we consider the partial derivative expression, we can define the MES as the change in the ES (risk) of the system when the weight of a given country, i , increases by one unit. In other words, the MES shows how the risk of the whole area evolves when a country increases its public debt. Second, the MES can also be viewed as the bond yield that would be applied to country i when the system is under stress, *i.e.* the bond yield index exceeds the threshold value. In particular, the MES gives the rate that would be demanded for country's i bonds if the Eurozone experienced a systemic event.

To compute this measure, we use a bivariate process of bond yields for each country i and the system. This allows us to consider not only individual volatility of bond yields, but also the correlations of each bond yield with the market. These correlations are particularly important when studying systemic risk, as they account for the interconnections between countries' yields. Stationarity tests for our data reveal that all series are integrated of order 1,¹⁴ therefore data is modeled by a random walk process:

$$r_{jt} = r_{j,t-1} + z_{jt}, \quad \text{with } j = \{i, m\}, \quad (2.4)$$

where z_{jt} is an error term such that $\mathbb{E}_{t-1}(z_{jt}|z_{j,t-1}) = 0$ and $\mathbb{E}(z_{jt}) = 0$. The bivariate Garch (Generalized AutoRegressive Conditional Heteroskedasticity) takes the form:

$$\begin{aligned} z_{it} &= \sigma_{it}\varepsilon_{it} \\ z_{mt} &= \sigma_{mt}\varepsilon_{mt}, \end{aligned} \quad (2.5)$$

where σ_{it} and σ_{mt} represent the volatility of z_{it} and z_{mt} , respectively. For the computation of the MES, we express the innovation as in Brownlees and Engle, 2012:¹⁵

$$\varepsilon_{it} = (\rho_{imt}\varepsilon_{mt} + \sqrt{1 - \rho_{imt}^2}\xi_{it}). \quad (2.6)$$

where $\varepsilon_{jt} = (\varepsilon_{mt} \quad \xi_{it})'$ is a vector of shocks for the market, ε_{mt} and the particular country i , ξ_{it} . Moreover, ρ_{imt} represents the conditional correlation of the bond yield index with country i . Taken individually they are independently and identically distributed with zero mean and identity covariance matrix. However, they are not assumed to be

¹⁴ We performed the Augmented Dickey Fuller test to all series, including the market index. We found that all of them had a unit root and that they become stationary once we take the first difference.

¹⁵ For more details on this writing, refer to Appendix B.

independent from one another. Indeed, extreme values of these disturbances could occur at the same time for systemically risky countries. When the market is in its tail, the country's disturbances may be even further in the tail if there is a serious risk of default. The MES is hence computed as:

$$\begin{aligned}
 MES_{it}(C) &= E_{t-1}(r_{it} \mid r_{mt} > C) \\
 &= r_{i,t-1} + E_{t-1}(z_{it} \mid z_{mt} > C - r_{m,t-1}) \\
 &= r_{i,t-1} + \sigma_{it}\rho_{imt}E_{t-1}\left(\varepsilon_{mt} \mid \varepsilon_{mt} > \frac{C-r_{m,t-1}}{\sigma_{mt}}\right) + \sigma_{it}\sqrt{1-\rho_{imt}^2}E_{t-1}\left(\xi_{it} \mid \varepsilon_{mt} > \frac{C-r_{m,t-1}}{\sigma_{mt}}\right).
 \end{aligned} \tag{2.7}$$

Component Expected Shortfall (CES)

The second systemic risk measure used in our study is the percentage Component Expected Shortfall (CES%) recently proposed by Banulescu and Dumitrescu (2014). We use this measure to evaluate the absolute contribution of each country (in percentage) to the overall risk at time t and compute it as follows:

$$CES\%_{it}(C) = \frac{\partial ES_{t-1}(C)}{\partial w_{it}} \frac{w_{it}}{ES_{t-1}(C)} = \frac{w_{it}MES_{it}(C)}{\sum_{i=1}^N w_{it}MES_{it}(C)}. \tag{2.8}$$

One attractive feature of this measure is that the sum of CES% of all countries in the sample adds up to 100%. This facilitates the interpretation of results. The larger the CES% of a country, the more systemically important this country is. The CES% actually represents a decomposition of the system's risk (measured by the ES) while taking into account the debt weight of each country, thus to some extent, the country's size. The higher the public debt of a country, the higher the impact on the system if the country is left to default: the "Too Big To Fail" concept used for financial institutions can therefore be easily transposed to countries. All together, the CES% captures both size (TBTF) and correlation (TITF) effects.

2.3.2 Estimation framework

A bivariate DCC is used to model the volatility and the correlations between the innovations of the bond yield index, z_{mt} , and of the yields of each country, z_{it} . According to this model, the conditional covariance matrix is decomposed as follows:

$$H_t = D_t R_t D_t, \tag{2.9}$$

where $D_t = \begin{pmatrix} \sigma_{it} & 0 \\ 0 & \sigma_{mt} \end{pmatrix}$ represents a 2-by-2 diagonal matrix of volatilities and $R_t = \begin{pmatrix} 1 & \rho_{imt} \\ \rho_{imt} & 1 \end{pmatrix}$ denotes the time-varying correlation matrix. As it is common practice in this literature, a two step approach is used to estimate this model.

In the first stage, a univariate asymmetric Garch, namely the GJR-Garch(1,1), is considered for each of the eleven countries and for the market index. The asymmetric model allows us to take into account the leverage effect, *i.e.* an increase in yields, due for example to macroeconomic announcements about employment or inflation levels, tends to increase yields volatility more than a drop of the same magnitude. Our choice of an asymmetric Garch model is also motivated by the recent literature underlying that bond returns are characterized by asymmetric volatility (Goeij and Marquering, 2006). The conditional variance is given by:

$$\sigma_{it}^2 = \omega_i + \alpha_i z_{i,t-1}^2 + \gamma_i z_{i,t-1}^2 \mathbb{I}_{(z_{i,t-1} > 0)} + \beta_i \sigma_{i,t-1}^2, \quad (2.10)$$

$$\sigma_{mt}^2 = \omega_m + \alpha_m z_{m,t-1}^2 + \gamma_m z_{m,t-1}^2 \mathbb{I}_{(z_{m,t-1} > 0)} + \beta_m \sigma_{m,t-1}^2, \quad (2.11)$$

where $\mathbb{I}_{(\cdot)}$ denotes the indicator function. For simplicity, in the estimation process, we suppose that the constant term, ω_i is equal to $(1 - \alpha_i - \beta_i - 0.5\gamma_i)\bar{\sigma}_{it}^2$, with $\bar{\sigma}_{it}^2$ the non conditional variance of the series.¹⁶ The model parameters, α , γ and β , are estimated using the Quasi Maximum Likelihood approach (QML).

In the second stage, we express the dynamic conditional correlation matrix as:

$$R_t = \text{diag}(Q_t)^{-1/2} Q_t \text{diag}(Q_t)^{-1/2}, \quad (2.12)$$

where Q_t is the pseudo conditional correlation matrix of the innovations standardized by their conditional standard deviation obtained previously, $\varepsilon_t^* = \frac{z_{it}}{\sigma_{it}}$. To compute Q_t , we introduce these standardized innovations into a DCC(1,1) model:

$$Q_t = (1 - \alpha_C - \beta_C)S + \alpha_C \varepsilon_{t-1}^* \varepsilon_{t-1}^{*'} + \beta_C Q_{t-1}, \quad (2.13)$$

where ε_t^* is the vector of standardized innovations, S is the unconditional covariance matrix of ε_t^* and α_C and β_C the DCC parameters to be estimated by QML. The conditions for the positive definiteness of H_t can be found in Engle and Sheppard (2001). Consistency

¹⁶ Symmetrically, we impose the same specification for the market, that is, $\omega_m = (1 - \alpha_m - \beta_m - 0.5\gamma_m)\bar{\sigma}_{mt}^2$, where $\bar{\sigma}_{mt}^2$ represents the non conditional variance.

and asymptotic normality conditions based on the work of Newey and McFadden (1994) can also be found in Engle and Sheppard (2001). To obtain robust standard errors, the covariance matrix is computed as $A^{-1}BA^{-1}T^{-1}$, where A represents the analytic hessian and B the covariance of the scores.

The final elements needed to compute the MES are tail expectations. For this, we use a non parametric kernel estimation. The methodology that we apply follows Scaillet (2005), with two notable differences. First, in our case, the conditioning with respect to past information is not necessary since we apply the formula on standardized residuals that are independent and identically distributed. Second, the sign in the conditioning event is reversed. Therefore, the tail expectations are:

$$\hat{E}_h(\varepsilon_{mt}|\varepsilon_{mt} > \kappa) = \frac{\sum_{t=1}^T \varepsilon_{mt} \left(1 - \Phi\left(\frac{\kappa - \varepsilon_{mt}}{h}\right)\right)}{\sum_{t=1}^T \left(1 - \Phi\left(\frac{\kappa - \varepsilon_{mt}}{h}\right)\right)}, \quad (2.14)$$

$$\hat{E}_h(\xi_{it}|\varepsilon_{mt} > \kappa) = \frac{\sum_{t=1}^T \xi_{it} \left(1 - \Phi\left(\frac{\kappa - \varepsilon_{mt}}{h}\right)\right)}{\sum_{t=1}^T \left(1 - \Phi\left(\frac{\kappa - \varepsilon_{mt}}{h}\right)\right)}, \quad (2.15)$$

with $\Phi(x)$, the normal cumulative distribution function (Gaussian Kernel function) and h , a positive bandwidth. κ is the cutoff point given by $(C - r_{m,t-1})/\sigma_{mt}$.¹⁷ For the determination of the bandwidth, we follow Scaillet (2005) and fix its value at $T^{-1/5}$ times the empirical standard deviation, equal to 1 in our case.

Conditional variances and correlations from the DCC model together with tail expectations are inserted in equation (2.7) to compute the MES. The latter is used in the construction of the CES. The results obtained using this methodology applied on European data, are presented and analyzed in the next section.

2.3.3 Data and Results

In this subsection, we first provide the descriptive statistics related to our data, then we analyze the estimation results of the DCC model and finally, we study the systemic risk of countries as measured by the MES and the CES.

2.3.3.1 Descriptive statistics and estimation results

Our empirical analysis is conducted using daily data on 10-year nominal sovereign bond yields for the period January, 2001 – December, 2013 (closing prices)¹⁸ and quarterly

¹⁷ For more details on the formulas, see Appendix C.

¹⁸ The main source for the data is the Macrobond database.

data on public debt for the same time span. Eleven Eurozone countries¹⁹ are analyzed in order to determine the evolution in time of their systemic risk contribution.

Table 2.1 summarizes the descriptive statistics of the market index, countries' bond yields and countries' weights. When comparing the minimum, maximum or average yields of all countries, we remark that the Greek yields are always the highest. Looking at the series of yields actually reveals not only that the market sanctioned heavily Greece for the irregularities and problems with its public debt during the crisis, but also that this country had historically the highest yields in the Eurozone.²⁰ The average yield for the market index is equal to 4.14%. Furthermore, there is a rather small volatility²¹ in the series of yields, Greece being the most volatile in the panel. At the beginning of the analyzed period and until the outbreak of the debt crisis, all countries' bond yields were extremely close, around 5%, proving that a European convergence of the long-term government bond yields was achieved, encouraged by the EMU creation. At the end of 2009, divergences appeared as the sovereign yields of several periphery countries soared. Countries responded to the financial crisis by taking strict budgetary measures and offering rescue funds to the financial sector, measures that had the downside of increasing public debt. In addition, the problems at the euro area level, related to the balance of payment and to competitiveness divergences, aggravated the overall situation. As investors lost confidence in some countries' ability to repay their debt, high levels of debt were sanctioned by higher yields. For example, during the debt crisis, the bond yield applied to Greece reached a maximum of 34.33%, whereas for Portugal and Ireland the maximum yield attained 16.21% and 14.10%, respectively.

The last row of Table 2.1 shows the weight of each country in the market index as of 2013Q3.²² Germany, France and Italy, the three biggest Eurozone countries,²³ stand for almost 70% of the total debt of the zone, while periphery countries – Portugal, Ireland, Greece and Spain – account for less than 20% (*i.e.* less than the weights of the three biggest countries taken individually). For example, Italy has almost a quarter of the Eurozone debt, whereas Greece less than 5% of the total debt. Looking at the weights of these two countries seems to indicate that Greece does not have the size to be considered a major threat for the other economies, whereas Italy should be viewed as a TBTF country. Moreover, we can also conclude that the funds needed to rescue Italy would

¹⁹ The countries considered are: Germany, France, Italy, Spain, Ireland, Greece, Portugal, Belgium, Netherlands, Austria and Finland. These countries correspond to ten out of the eleven countries that initially formed the Eurozone. The eleventh country, Luxembourg, was omitted from our sample due to missing data. Greece, who joined the area in January 2001, before the introduction of notes and coins, was added to the sample.

²⁰ Indeed, we find Greece to have the highest yields 2869 times out of 3392, which represents the total number of observations in our database.

²¹ The volatility is computed here as the standard deviation of each series.

²² Recall that we use a time-varying weighting scheme. For the evolution in time of these weights, refer to Figure A1 in Appendix D.

²³ As measured by their GDP in 2013.

be a lot greater than the rescue package already offered to Greece. Nevertheless, this preliminary inference should be further refined and improved by examining the results of systemic risk measures.

Table 2.1: Descriptive statistics of the series

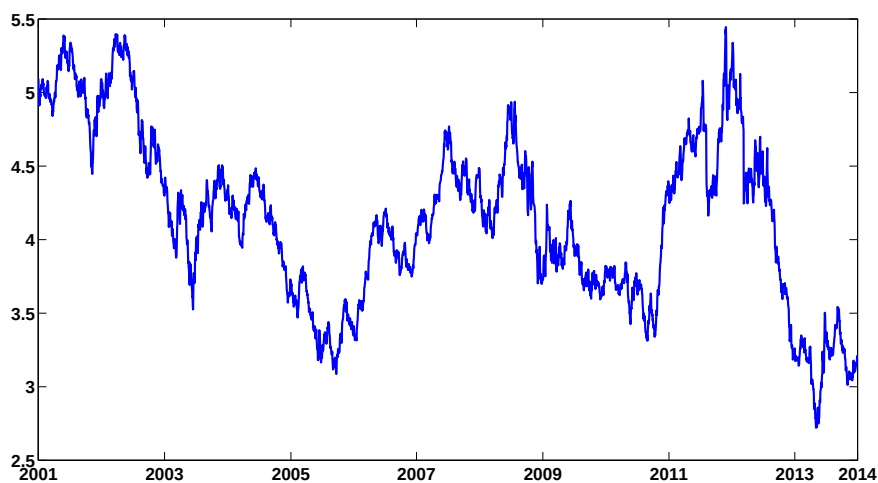
	Market index	Belgium	Germany	Ireland	Greece	Spain	France	Italy	Netherlands	Austria	Portugal	Finland
Avg Yield	4.14	3.96	3.43	4.98	7.60	4.48	3.74	4.55	3.64	3.77	5.50	3.65
Max	5.45	5.80	5.27	14.10	34.33	7.49	5.34	7.64	5.39	5.47	16.21	5.47
Min	2.72	1.91	1.02	2.98	3.21	3.02	1.67	3.20	1.49	1.51	3.10	1.38
Vol	0.58	0.78	1.07	1.68	5.78	0.74	0.83	0.66	0.97	0.91	2.38	1.01
Corr	-	0.86	0.57	0.45	0.12	0.59	0.73	0.75	0.62	0.71	0.29	0.63
Skw	0.08	-0.43	-0.57	2.10	2.08	0.74	-0.35	1.01	-0.49	-0.49	1.95	-0.49
Kur	2.36	2.98	2.35	7.80	6.84	3.54	2.56	4.85	2.44	2.72	6.09	2.49
Weights 2013	-	4.44	23.70	2.28	3.53	10.63	21.28	23.02	4.92	2.68	2.35	1.17

Note: The table presents descriptive statistics for the bond yield index and for each country in our sample. The results are based on daily data on bond yields over the period January, 2001 - December, 2013. The last row of the table presents the weights of each country in the market index, in 2013, 3rd quarter. These weights are computed as the debt of each country divided by the total debt of all countries. Source: Eurostat.

Figure 2.4 provides the evolution of the market index. The bond yield for the Eurozone started increasing only in the second half of 2010 and reached a peak at the end of 2011. This captures the economic turmoil at that time, when uncertainty about a Greek and Italian default was fostering and Ireland and Portugal were downgraded to junk by Moody's rating agency. During 2012 problems still persisted but the situation on the bond market started to improve since and the index reached in 2013 a historical low. We explain this decline by the fact that core countries, among which Germany and France, experienced an important reduction in their bond yields. Indeed, investors reacted to the crisis by turning to the bonds that presented the lowest risk. This increase in demand translated into small bond yields for "safe haven" countries. At the same time, the measures taken at the national and area level, improved investors' confidence which generated a decline in the bond yields of periphery countries. At the end of our sample period, *i.e.* end of 2013, Germany had a bond yield of only 1.92%, whereas five other countries had their bond yields between 2 and 3%. Greece was the country with the highest yield at that time, its borrowing rate being of 8.41%.

We proceed now with the estimation of our econometric model. Volatilities and correlations are estimated using the methodology outlined in Section 3.2.2. Table 2.2 reports the results of the GJR-Garch and DCC models. The α parameter, which gives the impact of new information on the volatility of the series, and β , which determines the degree of memory of the process, are always significant. The asymmetric effect given by γ is significant for 7 out of the 11 countries considered, proving therefore the need to account for such an impact on the conditional variance. The DCC parameters are also always significant and have the expected values.

Figure 2.4: Government Bond Yield Index



Note: This figure presents the bond index computed as a weighted average of government bond yields with a 10-Year maturity for eleven Eurozone countries. Weights are given by the part of each country's public debt in the total debt of the area. Source: Macrobonds.

Table 2.2: GJR-Garch and DCC estimated parameters

Parameters	α	γ	β	α_C	β_C
Market Index	0.028***	0.012***	0.961***	-	-
Belgium	0.051***	0.011***	0.930***	0.046***	0.949***
Germany	0.038***	0.000	0.954***	0.043***	0.955***
Ireland	0.150***	0.134***	0.715***	0.007***	0.993***
Greece	0.038***	0.077***	0.923***	0.026***	0.974***
Spain	0.050***	0.061***	0.914***	0.062***	0.933***
France	0.032***	0.000	0.960***	0.016***	0.982***
Italy	0.036***	0.061***	0.928***	0.039***	0.960***
Netherlands	0.033***	0.000	0.957***	0.022***	0.975***
Austria	0.128***	0.000	0.819***	0.021***	0.978***
Portugal	0.047***	0.042***	0.931***	0.023***	0.975***
Finland	0.048***	0.000	0.938***	0.048***	0.947***

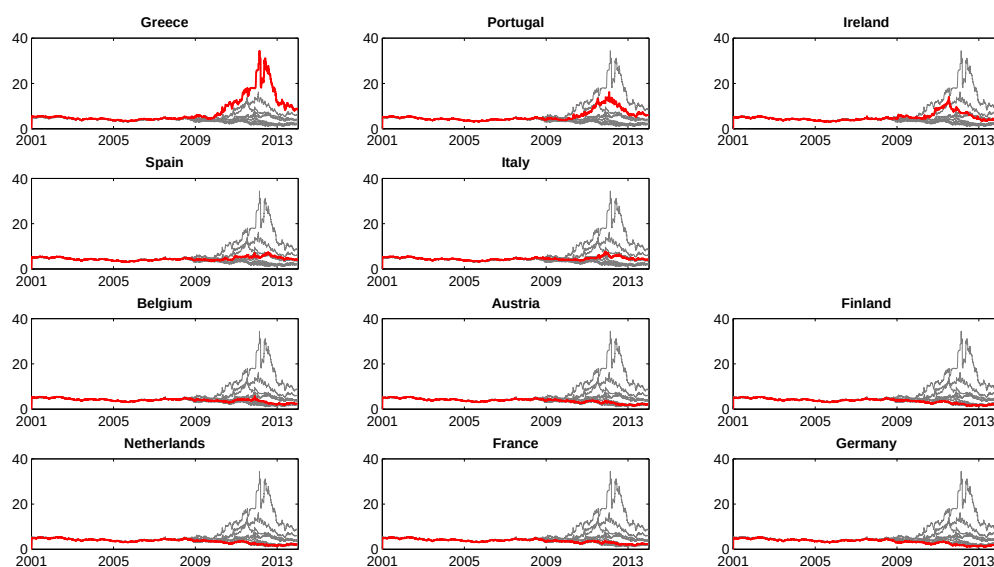
Note: This table presents the estimated parameters of the GJR-Garch and DCC models. *** denotes significance at the 99% level.

2.3.3.2 Systemic risk analysis

The evolution of the MES for each country is plotted in Figure 2.5. The MES shows what the bond yields would be for a particular country, if the entire area was facing a crisis. At the same time, the MES allows us to identify the systemic riskiness of the analyzed countries. The upper panel of the figure shows the most systemically important countries according to this measure. These countries are the periphery countries, the ones that experienced the biggest problems during the crisis. By contrast, the lower panel shows the Eurozone members that have not been at the core of the debt crisis.

Overall, while the marginal contribution to systemic risk of periphery countries increased in crisis times with respect to calm periods, the one of each core country, except Belgium, had a declining trend over the whole period. Greece proves to be the most systemically risky country on the analyzed time span, with a sharp increase in 2011. Recall that, during this year, financial markets became increasingly worried about a possible exit of Greece from the Eurozone, the Greek parliament voted drastic austerity measures and the European Union (EU) agreed on helping the country with several billion euros. In the same year, Greece was downgraded several times by credit rating agencies and reached the lowest investment-grade rating. All these events contributed to an abrupt increase in Greek yields and consequently to a raise in its marginal contribution to systemic risk. The following two MES values are the ones of Portugal and Ireland, countries that also required bailout funds in order to keep their commitments towards repaying their public debt. Not surprisingly, the smallest MES value is associated to Germany, country whose bonds have been seen as a refuge value in Europe and have always displayed the lowest long-term yields.

Figure 2.5: Marginal Expected Shortfall (MES) by country



Note: This figure presents the evolution of the MES for each country in our sample. For comparison reasons, in each panel the main series is presented in red, whereas the other series are shaded. The scale is kept the same for all countries.

Table 2.3 displays the value of the MES for all countries in the sample at two selected dates: June 2006 (corresponding to a pre-crisis period) and June 2012 (considered as a crisis period). In 2006, the MES already highlights three of the periphery countries, Greece, Italy and Portugal, as being the most systemically important countries. However, we do not notice an important difference between the periphery and the core countries,

as the MES values are clustered together. It is important to notice that the MES is able to identify even in 2006 the countries that had problems in terms of public debt. For the three abovementioned countries, their sovereign debt position was at the source of the crisis and are therefore in top 3, whereas Spain and Ireland experienced only private debt problems at that time, that the MES cannot capture. Consequently, Spain and Ireland are mixed with core countries and find themselves towards the bottom of the classification. In 2012, the rankings differ for some of the countries, the most notable change being for Ireland and Spain that find themselves at the top of the classification, due to the increase in their marginal contribution to systemic risk. At this date there is a strong difference between the MES of core and periphery countries. The average MES of the latter (12,01) is more than 5 times higher than the average of the former countries (2,27). At the two considered dates, Greece has the highest marginal contribution to systemic risk and Germany has the lowest one. We interpret the Greek MES of 29.04% (June 2012) as follows: if the Greek weight in the market index increases by 1%, than the Expected Shortfall (overall risk) of the market is expected to increase by 29.04%. We can also interpret this result as the average bond yield that would apply to new bonds issued by the Greek government, if the Eurozone was subject to a systemic event. Finally, we can remark that the marginal contribution to systemic risk for all core countries declined between the two dates and increased for periphery countries (for Greece, Ireland and Portugal, the marginal contribution more than doubled). Divergences between these countries deepened with the crisis.

Table 2.3: MES based ranking

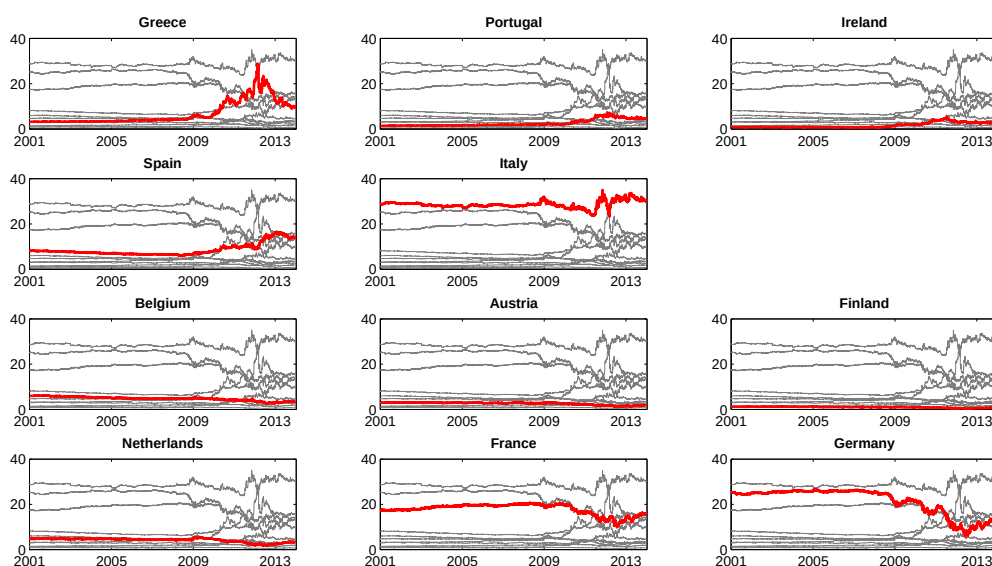
15/06/2006		15/06/2012	
Greece	4.19	Greece	29.04
Italy	4.18	Portugal	10.62
Portugal	4.00	Ireland	7.27
Finland	3.92	Spain	6.91
Austria	3.92	Italy	6.21
Belgium	3.91	Belgium	3.34
France	3.91	France	2.69
Spain	3.87	Austria	2.36
Ireland	3.87	Netherlands	2.01
Netherlands	3.87	Finland	1.84
Germany	3.84	Germany	1.37

Note: This table provides the countries' rankings based on the MES measure at two different dates. The figures are expressed in percentages.

Based on the MES and countries' weights, we compute the CES. We evaluate the absolute contribution of each country to systemic risk using the percentage form of the CES. While the MES captures mainly a bond yield effect, the CES% combines the MES and a size effect. The larger the CES%, the greater the contribution of the country to systemic risk, with all the countries CES% summing up to 100%.

Figure 2.6 shows the dynamics of this measure from the beginning of 2001 until the end of 2013. For comparison reasons, the scale for the subplots is kept the same. Before 2010, the evolution of the CES was on average stable for all the countries, the top 3 countries, Germany, Italy and France, being distanced from the others. The period 2010 – 2012 represented a turning point, when contributions to systemic risk changed. Sharp increases have been registered for risky countries (Greece, Italy, Spain, Ireland and Portugal), whereas the other Eurozone members have experienced a decrease in their absolute contribution to systemic risk. This is in line with our previous findings related to the MES. If in calm periods, the CES% captures mainly the size effect, in crisis times this measure is able to account for the combination of the two effects: yield and debt weight.

Figure 2.6: Percentage Component Expected Shortfall (CES%) by country



Note: This figure presents the evolution of the CES% for each country in our sample. For comparison reasons, in each panel the main series is presented in red, whereas the other series are shaded. The scale is kept the same for all countries.

Table 2.4 confirms the above results. The rankings obtained based on the CES% identify the countries that effectively suffered major transformations and became the most systemically important. More precisely, Greece, Spain, Portugal, Italy and Ireland experienced increases in their contribution to systemic risk. If in calm periods, their

contribution to systemic risk was about 42%, in crisis times it raises to approximately 75%. This is an interesting result because it shows that countries that registered an increase in their absolute contribution to systemic risk (in other words, a rise in their CES%) are the same as the ones identified by the MES.

In general, according to this measure, risk is concentrated: the top three countries (Italy, Germany and France in 2006 and Italy, Greece and Spain in 2012) account for around 65 – 70% of the global risk.

Greece is the country that experienced the highest increase in its percentage contribution to systemic risk (from 3.87% in 2006 to 20.63% in 2012), mainly to the detriment of Germany whose contribution to systemic risk was divided by more than three. Italy has the highest CES% both before and during the debt crisis. This result can be explained by the fact that in 2006 the size effect has certainly dominated, also justifying the presence of Germany and France in the top-3 systemically important countries, whereas with the outbreak of the debt crisis, the yield effect added to the first one (and thus pushed Greece and Spain into the top-3).²⁴

Table 2.4: CES% based ranking

15/06/2006		15/06/2012	
Italy	28.37	Italy	30.76
Germany	25.69	Greece	20.63
France	19.62	Spain	13.59
Spain	6.59	France	12.25
Belgium	4.95	Germany	7.37
Netherlands	4.45	Portugal	5.14
Greece	3.87	Belgium	3.24
Austria	2.83	Ireland	3.21
Portugal	1.83	Netherlands	2.04
Finland	1.03	Austria	1.34
Ireland	0.78	Finland	0.43

Note: This table provides the countries' rankings based on the CES measure at two different dates.

To consolidate our results, we perform different robustness check studies. First, we compare our bond yield index with the S&P Eurozone Sovereign Bond Index 7 – 10Y proposed by McGraw Hill Financial. The S&P Index is, as in our case, a market-value-weighted index. However, the weights are based on outstanding par amounts for bonds.²⁵ We observe the same dynamics and levels for both indexes. A comparison of the two indices is provided in Appendix D – Figure A3. Furthermore, the results obtained with

²⁴ For a more general view of our results in terms of CES% at different moments in time, refer to Figure A2 in Appendix D.

²⁵ For more information, see <http://us.spindices.com/indices/fixed-income/sp-eurozone-sovereign-bond-index>.

the S&P index are similar to the ones obtained in this section. Second, we also performed an analysis using constant weights (as of 2012Q4) in the construction of our index and for the CES% measure. The results do not change. Finally, we estimate an econometric model using a Garch(1,1) and find that the countries' ranking remain the same. We used this model because there might be a low level of asymmetry in some of the series as underlined by several of the GJR-Garch(1,1) coefficients.

To summarize, the MES provides helpful information about what would be the rate at which a country could issue new bonds if a crisis were to emerge. The CES shows the percentage contribution of countries to systemic risk when not only yields, but also the relative size of a country's public debt is taken into account. The results obtained in this section prove that in a pre-crisis period, the MES can identify some of the countries that might experience difficulties when the whole system would be in distress, whereas the CES captures mostly the size effect at these times. In crisis periods, the two measures identify periphery countries as the ones contributing the most to systemic risk.

Overall, these measures perform fine in real-time identification of systemic risk. They provide information about which countries need more monitoring and can therefore represent a useful tool for authorities. However, their forecasting power is limited and the measures would benefit from including into the analysis other macroeconomic factors. We intend in what follows to extend the study of systemic risk so that it integrates country specific factors such as inflation, growth rates and public deficits. This would bring further insights to the measurement of systemic sovereign risk.

2.4 Systemic Risk in a Macroeconomic Framework

The analysis developed in this section is based on the concept of SRisk (Acharya et al., 2012a; Brownlees and Engle, 2012). Conceived for financial institutions, the SRisk measures the part of the total expected system capital shortfall in a crisis that is due to a particular financial institution. It is assumed that the institutions confronted with a large capital shortfall during a crisis contribute the most to the turmoil (as it will be difficult for them to find funds to cope with the shortfall) and are thus considered as the most systemically risky. The SRisk is based on two elements: (i) the Marginal Expected Shortfall (MES) and (ii) the leverage of the firm. As it relies on more information, we consider this measure to be more comprehensive than the MES and the CES.

The objective in this section is to transpose this systemic risk measure to the sovereign debt risk and to determine which are the countries that contribute the most to systemic risk in the euro area, given their economic characteristics. The results obtained using

this measure should be more accurate than the ones obtained with the MES or the CES, as the measure takes into account the macroeconomic situation of each country.

Consequently, we propose a new measure based on the SRisk, that we call EFR – *Expected Financing Requirements*. The EFR gives a country’s expected increase in debt during a crisis and is built in a stress test logic, *i.e.* conditional on a particular negative event. For coherence, we keep the same event as in the first analysis of systemic risk, meaning an increase in the government bond index. However, any type of economic crisis in the area could also be considered as a systemic event. Derived from the government budget constraint, the EFR depends on: (i) the expected bond yields of a country (thus, the MES) and (ii) on its macroeconomic situation given by its public debt, primary deficit, growth rate and inflation. Therefore, as the CES, the EFR accounts for both a yield and a size effect. We present in what follows the methodology used to derive this measure.

2.4.1 Expected Financing Requirements

Recall that we assumed a country to be systemically risky if it faces large financing requirements at a time when the whole system is already under stress, that is, when it becomes difficult to raise the necessary funds to repay outstanding obligations.²⁶ Important financing needs may come either from the bond yield imposed by the market or from a deteriorated economic situation of the country (its primary deficit, its debt level etc.). Therefore, the largest contributors to systemic sovereign risk are the countries that need to raise the highest amount of funds, as the difficulties encountered by these economies will only deepen the crisis for the whole system.

To identify and measure the financing requirements of a country, we start from the standard budgetary constraint equation.²⁷ Let Y_{it} be the real GDP of country i at time t and let B_{it} be the real value of public debt. The government budget constraint combines the nominal interest rate r_{it} , net inflation π_{it} , net growth in real GDP g_{it} (between $t - 1$ and t), and the primary deficit def_{it} in order to obtain the evolution of the government debt to GDP ratio:

$$\frac{B_{it}}{Y_{it}} = (r_{it} - \pi_{it} - g_{it}) \frac{B_{i,t-1}}{Y_{i,t-1}} + \frac{def_{it}}{Y_{it}} + \frac{B_{i,t-1}}{Y_{i,t-1}}. \quad (2.16)$$

The nominal return r_{it} and the real stock of debt B_{it} in equation (2.16) are averages across terms to maturity.²⁸ The increase in the real debt stock at time t for country i can be expressed as follows:

²⁶ To deal with a need of funding, the government will have to issue new debt at a yield rate imposed by the market. We suppose that the country is unable to raise funds in any other way (*i.e.* seigniorage, increase in taxes, reduction of public investment).

²⁷ In the case of financial institutions, the risk measure is derived from a Basel-type regulatory constraint.

²⁸ Hall and Sargent (2010) use different maturity structures of debt. This can represent a future extension for our analysis.

$$B_{it} - B_{i,t-1} = \left((g_{it} + 1) (1 + r_{it} - \pi_{it} - g_{it}) - 1 \right) \times B_{i,t-1} + def_{it}. \quad (2.17)$$

From this standard budgetary constraint, we derive the formal definition of the Expected Financing Requirements.

Definition. *The expected financing requirements of a country i at time t , EFR_{it} , represents the expected change in the public debt of the country conditional on the emergence of a crisis:*

$$EFR_{i,t-1} = \mathbb{E}_{t-1} (B_{it} - B_{i,t-1} | Crisis). \quad (2.18)$$

Considering the above definition and the result in equation (2.17), we obtain:

$$EFR_{i,t-1} = \mathbb{E}_{t-1} \left(\left((g_{it} + 1) (1 + r_{it} - \pi_{it} - g_{it}) - 1 \right) \times B_{i,t-1} + def_{it} \middle| Crisis \right). \quad (2.19)$$

A positive EFR represents an increase in the financing requirements of a country during stress times.²⁹ Further, we use the assumptions made in the analysis of the MES to find the final expression of the EFR. More precisely, we keep the same conditioning event and use the same market index as before. Moreover, bond yields are modeled as random walk processes. The threshold, C , is also the same, meaning the VaR on the bond index at a 10% confidence level. Assuming that g_{it} and def_{it} are predetermined, we can derive from equation (4.3) the final expression for the expected financing requirements of a country:

$$EFR_{i,t-1} = \left((g_{it} + 1) (1 + r_{i,t-1} + \mathbb{E}_{t-1} (z_{it} | r_{mt} > C) - \mathbb{E}_{t-1} (\pi_{it} | r_{mt} > C) - g_{it}) - 1 \right) \times B_{i,t-1} + def_{it}. \quad (2.20)$$

From (2.20), we can remark that the financing requirements depend both on the structural factors of each country – primary deficit, public debt level, inflation and growth rate – and on the spillover effects captured by the expectation term on yields. We recognize here the marginal expected shortfall computed in the previous section. The countries with the highest expected financing requirements are the greatest contributors to systemic risk, thus are the countries considered as most systemically risky. Hence, large expected expected financing requirements in a generalized debt crisis does not capture only individual country vulnerability, but also systemic risk. We further propose a percentage version of the EFR that will help us to classify countries by their systemic importance:

²⁹ The concept of expected financing requirements is similar to that of an institution's capital shortfall used by Brownlees and Engle (2012), *i.e.* the capital that a financial firm would need to raise if another financial crisis developed.

$$EFR\%_{it} = EFR_{it} / \sum_{i=1}^N EFR_{it}. \quad (2.21)$$

The $EFR\%$ measures the part of the total expected system's financing requirements in a crisis that is due to government i . Our key assumption is that, during a period of distress for the whole system, funding requirements for a given country impose external costs on the other countries as they induce even more stress on the system. These costs can be viewed as externalities that are particularly severe when the entire area faces difficulties to issue debt. Therefore, high expected financing requirements are dangerous not only for the country in question, but also for its bondholders, hence for the global system. This is particularly true if the increase in financial requirements occurs when the other economies in the area also need funds to repay outstanding debt.

2.4.1.1 The historic approach

The second expectation term in equation (2.20) concerns the value of inflation given the occurrence of the systemic event. As inflation series do not present Arch effects (*i.e.*, volatility seems to be constant over time), the dynamic estimation is not appropriate. Hence, a historic approach is preferred when computing this conditional expectation. This methodology was first proposed by Acharya et al. (2012b), and reconsidered afterwards by Brownlees and Engle (2012), in their computation of the MES. The historical rolling MES, as defined by the latter in a financial approach, is the average loss for a firm when the market returns are lower than a certain negative threshold, C , over a given period of time. We adapt this measure to our case, using the following formula:

$$E_{t-1}(\pi_{it} \mid r_{mt} > C) = \frac{\sum_{\tau=t-W}^T \pi_{i\tau} \mathbb{I}_{(r_{m\tau} > C)}}{\sum_{\tau=t-W}^T \mathbb{I}_{(r_{m\tau} > C)}}, \quad (2.22)$$

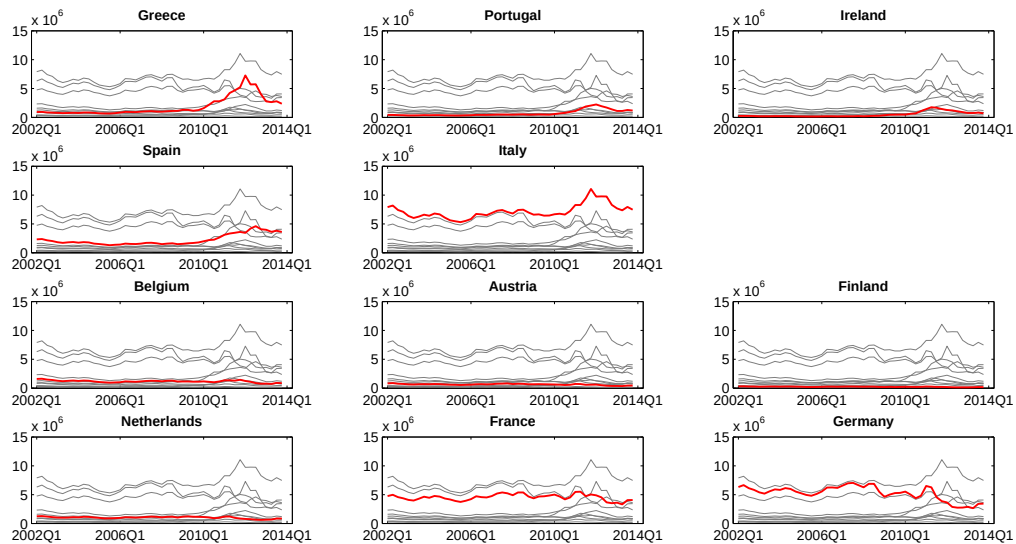
where W is the length of the rolling window and $\mathbb{I}$ is an indicator function. Notice that the systemic event is the same as in the previous analysis.

The formulas and definitions given until now correspond to the *short-run* or *one-period ahead* MES of Brownlees and Engle (2012) and an in-sample analysis is sufficient to compute this measure. In this study, we do not engage in this study in an out-of-sample approach as our goal is to determine whether or not systemic risk measures defined for financial institutions can also be applied to countries. The out-of-sample estimation would be useful to determine the forecast power of these measures, but this application is left for future research.

2.4.2 Results

To illustrate the evolution in time of our systemic sovereign risk measure, we first present the time series of EFR for each of the 11 countries in our sample over the period 2002Q1 – 2013Q4. As macroeconomic data is available at a lower frequency than bond yields or inflation rates, we decided to compute the EFR measure on a quarterly basis, by aggregating the results for the two expectation terms – the MES on bond yields and the historic MES on inflation. Data on primary deficit, public debt and growth rates were retrieved from Eurostat directly at a quarterly frequency. The GDP deflator was used to transform nominal data into real values. Figure 2.7 reveals that, during calm periods, the size effect prevails, as countries like Italy, Germany and France have the highest expected financing requirements in case a crisis were to emerge. Before 2010, the evolution of contributions to systemic risk was relatively steady for all considered countries. However, in stress periods the situation changes. We can remark that Italy is the country that has the highest expected financing requirements, thus the highest need to get financed during crisis times. This makes Italy a systemically important country. Greece is the next euro area state to have high financing needs over the last period of our sample. Thus, even if Greek debt accounts for less than 5% of the total Eurozone debt, the figure shows that this country is certainly systemically risky, showing a sharp increase of its systemic risk during 2010 – 2012.

Figure 2.7: Expected Financing Requirements (EFR) by country



Note: This figure presents the evolution of the Expected Financing Requirements of the countries in our sample. For comparison reasons, in each panel the main series is presented in red, whereas the other series are shaded. The scale is kept the same for all countries.

These results also reveal the importance of our measure: if we choose to analyze only the data based on the deficit of countries,³⁰ we get a ranking that always places Spain and France on the top positions. Therefore, the riskiness of countries such as Italy and Greece will only be partially captured.

Table 2.5 presents the percentage version of the EFR and gives the contribution of sovereigns to systemic risk at two different dates – a calm period, 2006Q2 and a crisis period, 2012Q2. In calm periods, the size effect that we have seen before is confirmed in the rankings of countries, with the three biggest countries of the Eurozone holding the first three positions in this classification. Before the financial and debt crises, risk was concentrated and Italy, Germany and France accounted for almost 75% of this risk. The country with the highest contribution to systemic risk in both calm and stress periods, is Italy. France, Spain and Germany are also among the largest contributors to systemic risk in both periods.

Table 2.5: *EFR* based ranking

2006Q2		2012Q2	
Italy	28.01	Italy	29.86
Germany	25.95	Greece	17.43
France	19.68	France	13.84
Spain	6.60	Spain	12.84
Belgium	4.84	Germany	8.73
Netherlands	4.47	Portugal	5.95
Greece	3.98	Ireland	3.70
Austria	2.81	Belgium	3.36
Portugal	1.79	Netherlands	2.29
Finland	1.08	Austria	1.54
Ireland	0.79	Finland	0.48

Note: This table provides the countries' rankings based on the EFR measure at two different dates.

Between these two dates, several changes took place. All periphery countries experienced increases in their percentage contribution to systemic risk. The most significant increase is the one of Greece, who was not in top 6 in 2006 (or before), but attained the second position in 2012. High expected financing requirements for a country in stress times represent a negative externality for the entire system and are more dangerous than high EFR in calm times. The reason is that if a single country has problems when there is no major crisis at the euro area level, the necessary funds needed to save this country are more easily raised than in a period when all countries have difficulties to cope with

³⁰ This would be the unconditional equivalent of our measure, *i.e.* where no conditioning event is considered.

the reimbursement of their own debt. This qualifies Greece as a systemically important country.

The purpose of computing the EFR measure was to add new information to our initial analysis and thus to identify better systemic risk before and during the sovereign debt crisis. However, taking into account macroeconomic data and looking at the specific situation of each country has limited benefits over the results obtained with the CES. Given that the CES already accounted for not only a yield effect, but also a size effect, the results of the EFR and CES are relatively similar. The ranking in calm periods is the same for the two measures, whereas in stress times, rankings vary very little. Moreover, the numerical values are also similar. This confirms the results of our first analysis and validates these measures as systemic risk indicators for countries.

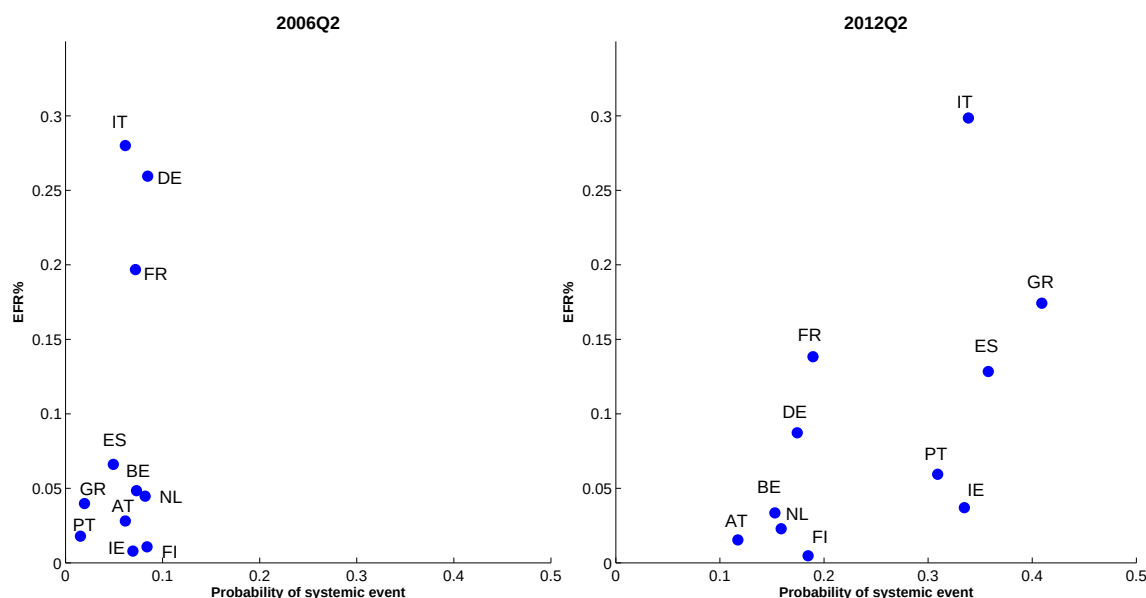
We take our analysis one step further and consider not only the contribution of the country to systemic risk, but also its probability of default. The reason for doing this is that some countries might have high EFR, however their probability of defaulting on their debt might be extremely low. In this situation, the country, although systemically important according to the EFR, should not be viewed as imposing a major threat to the system (an example of such a country is Germany). Figure 2.8 plots the EFR measure against the probability of default of each country, that is the probability of experiencing a systemic event.³¹

In the left panel, countries are clustered together (they have low funding needs) except for Italy, Germany and France. However, all countries present a low probability of systemic event (lower than 0.1). In the second quarter of 2012 (right panel), Italy, Greece and Spain distinguish themselves from the other countries as they have the highest probabilities of systemic event and the most important levels of EFR. This underlines, for the three countries, the danger of not only being confronted with a default, but also needing an important amount of funds in order to be rescued. Countries with high probabilities of systemic event, but lower EFR are Ireland and Portugal. Although France and Germany have relatively high EFR, their probabilities of experiencing a high increase in their bond yields are very low, disqualifying them from the systemically important countries.

When we analyze two countries in particular, Greece and Germany in our example, we can easily see from Figure 2.9 that there is a smaller volatility in the probability of default and the EFR of Germany (at different moments in time, right panel) compared to Greece (left panel). For the latter, both the EFR and the probability increased sharply between 2002 and 2012, making this country systemically risky. We can identify the peak of the sovereign debt crisis in 2012, when Greece had the highest probability of experiencing a

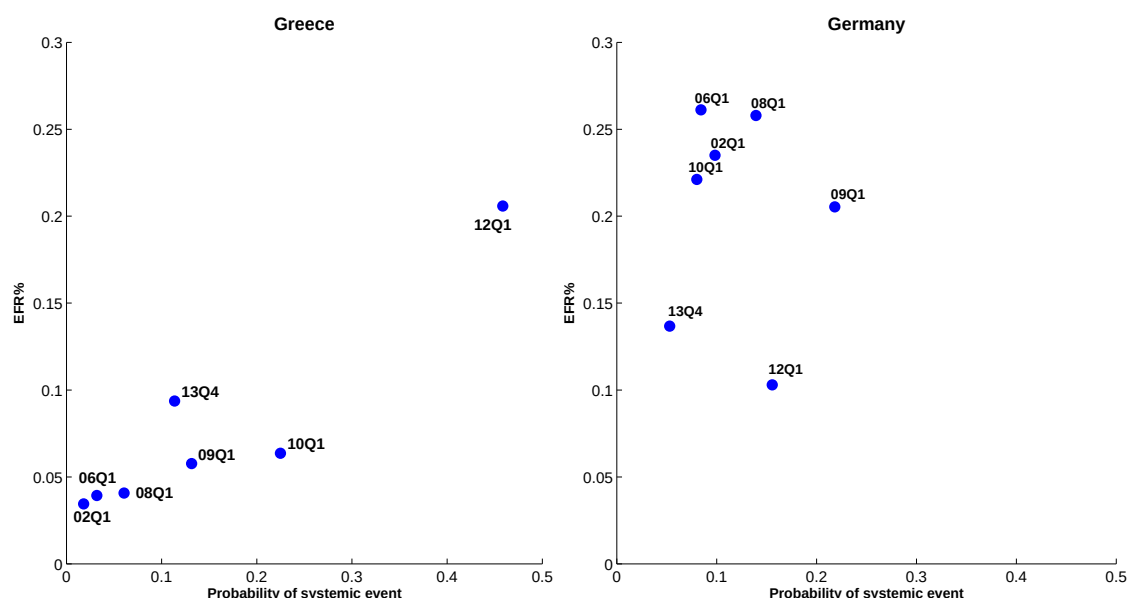
³¹ The systemic event is given by a high increase in bond yields for the respective country. We assume here that such an increase may prevent the country from raising funds to repay its outstanding obligations, which may lead to an eventual default.

Figure 2.8: Expected Financing Requirements (EFR%) at two different dates



Note: This figure presents the Expected Financing Requirements in percentage version at two dates representing a calm period (2006Q2) and a crisis period (2012Q2). On the x-axis, we represent the probabilities of countries to be confronted with a systemic event, defined as an increase in its respective bond yield. The scale on the two axes is kept the same for comparison reasons.

Figure 2.9: A country comparison based on EFR% - Germany versus Greece



Note: This figure presents the Expected Financing Requirements of Greece and Germany. On the x-axis, we represent the probabilities of countries to be confronted with a systemic event, defined as an increase in its respective bond yield. The scale on the two axes is kept the same for comparison reasons.

systemic event and the most important EFR over the whole period. At the same time, due to a flight to quality, Germany experienced a low systemic event probability and the lowest EFR it has ever known since 2002. In 2013, the crisis slowed down, bringing

better financing conditions for all periphery countries including Greece. Consequently, the Greek probability of systemic event reached the levels it had before the crisis.

2.5 Conclusions

The question of identifying systemically risky financial institutions has caught a lot of attention over the recent years. The reason is that countries became aware of the damage that SIFIs can provoke to the entire financial system if they are left to default. The costs are also very high if governments decide to save these institutions and thus to protect the financial system. In the Eurozone, deficits and public debts skyrocket after the outbreak of the financial crisis, situation which eventually lead to a sovereign debt crisis. Another reason for this increased interest in systemic risk measures comes from the lack of good risk indicators. The analysis in the first chapter allowed us to compare several measures that were very popular before the crisis. However, none of them accurately estimated the real risk accumulation that preceded the burst of the house price bubble. In the aftermath of the crisis, the work of Brownlees and Engle (2012) attracted a lot of attentions and their measures, the MES and the SRisk index, proved to be better risk indicators than the measures used before.

In this chapter, we transpose three of the most popular systemic risk measures – the MES, the CES and the SRisk – to the case of Eurozone member states. We do so by working with 10-year government bond yields and public debt, instead of financial returns and market capitalization. To properly transpose the measures developed for financial institutions, several adjustments are made. First, we construct a market index like an weighted average of government bond yields. The weights are given by the relative size of public debt in the total debt of Eurozone members. Although constructed differently, the index obtained is very similar to the S&P Eurozone Sovereign Bond Index 7 – 10Y, comforting us in our methodological approach. The index gives an idea about what would be the yield on Eurobonds if euro area members mutualized their debt. In our analysis, we use the index to impose the systemic event. We define this event as a situation where the market yields increase beyond their VaR level. This has the advantage of allowing us to consider the ES as the risk measure of the system, like in Brownlees and Engle (2012). The second adjustment concerns bond yields, that, unlike financial returns, are not stationary. We therefore consider them as random walk processes in our model. The first derivative of the ES with respect to the weight of the country in the system represents the MES, our first systemic sovereign risk measure. The MES gives the expected financing rate of a country provided that a crisis emerges at the area level. The second measure we compute is the CES which besides the bond yields, takes into account the public debt

of each country. Finally, based on the SRisk index, we propose a new systemic sovereign risk measure, the EFR. This measure is meant to be more comprehensive as it integrates information on the macroeconomic situation of each country.

The objective of the analysis conducted in this chapter is to see if these measures, that were proposed for financial markets, can also be successfully applied to countries in order to identify the largest contributors to systemic risk in the Eurozone. All three measures give information about the *contribution* of countries to systemic risk. Therefore, we analyze their evolution in time, comparing calm and stress periods and the rankings of countries obtained based on the three measures. The MES capture mostly a yield effect, whereas the CES and the EFR integrate both a yield and a size effect. Accordingly, results are similar for the CES and the EFR. Our findings confirm the fact that countries with deteriorated public finances, sanctioned by investors with high yields, have experienced in recent years an important increase in their (marginal and absolute) contribution to systemic risk. This results imply that the measures proposed for financial institutions can easily be adapted to identify systemically important countries. Italy seems to impose the largest risk on the system as not only its contribution to systemic risk is high, but also its probability of having a high yield rate on its sovereign bonds increased in the recent period. Big countries, like Germany and France, also present high expected financing requirements in case of crisis, however, their probabilities of systemic event are considerably lower than the ones of periphery countries.

To sum up, the measures seem to identify well the countries that went through major transformations during the financial and sovereign debt crises. However, a feature that should not be neglected is the fact that our analysis is performed in-sample, meaning it provides real-time estimates of systemic risk contribution. Taking into account macroeconomic aspects of each country does not seem to be enough to deal with this problem. Of course, in order to apply regulation based on these measures, a forecast exercise needs to be undertaken to identify in a timely manner the countries that contribute the most to systemic risk. Brownlees and Engle (2012) engage in such an exercise when computing the Long Run MES (LRMES). However, as financial institutions and countries do not function in the same way, some further adjustments have to be made before computing a LRMES for countries. This is beyond the scope of our chapter, but can represent an interesting topic for future research. Only afterwards could these measures be entirely used for regulation purposes.

Based on these measures, the Eurozone authorities can identify which countries need more monitoring. With the debt crisis, this has become an important matter. The ranking of systemically important countries relative to their probability of default can also be a useful tool. As the Stability and Growth Pact is currently being revised, these types

of tools could very well fit into this framework. More precisely, the EFR can represent a complementary measure to the already established ratios of debt and deficit. A limit on the systemic risk contribution can be imposed to systemically important countries, that would in this way prevent them from accumulating too much debt, for example. A contribution to a rescue fund can also be envisaged based on the EFR, with countries imposing the highest risk being the ones that provide the most money to the fund. A countercyclical contribution could also be conceived, in the spirit of the countercyclical buffer imposed on financial institutions. Of course, given the critical levels of public debt attained by several Eurozone countries, this measure will need more time before being enforced.

Moreover, the debt crisis and all the fiscal problems that it brought along underlined the importance of undertaking a more careful screening process when further enlarging the Eurozone. If in calm periods, the heterogeneity among countries does not seem to be a major problem from the point of view of bond yields levels, in crisis times macroeconomic divergences are growing and worsen the already critical situation of problem countries. Eurozone enlargement criteria should be therefore strictly observed in order to prevent future problems.

Much research has been conducted on the topic of systemic risk measurement since the outbreak of the crisis. Although several years have passed since, there is still no consensus on which measure is best and how regulation should use it. The results of these studies are nevertheless interesting and promising for the future. The implementation of systemic risk measures into regulation remains therefore just a question of time.

2.6 Appendix

A. Details on the calculation of MES (1)³²

We use as a starting point the expression of the expected shortfall of the Eurozone system at time t ,

$$ES_{m,t-1}(C) = E_{t-1}(r_{mt} | r_{mt} > C). \quad (2.23)$$

Then, following Scaillet (2004), we intend to prove that the first order derivative with respect to the weight of the i^{th} country, *i.e.* MES, is given by:

$$\frac{\partial ES_{m,t-1}(C)}{\partial w_{it}} = E_{t-1}(r_{it} | r_m > C). \quad (2.24)$$

In order to prove this, we denote by $\check{r}_{mt}$ the yield applied to the system except for the contribution of the i^{th} country, where $\check{r}_{mt} = \sum_{j=1, j \neq i}^n w_{jt} r_{jt}$ and $r_{mt} = \check{r}_{mt} + w_{it} r_{it}$. In our proof, the threshold C is not restricted to a scalar. Rather, C is assumed to depend on the distribution of the market yield and hence on the weights and the probability p to be in the distribution tale, as in the case of the *VaR*. We therefore provide a general proof for equation (2.24). First, the ES is expressed as follows:

$$\begin{aligned} ES_{m,t-1}(C) &= E_{t-1}(\check{r}_{mt} + w_{it} r_{it} | \check{r}_{mt} + w_{it} r_{it} > C(w_{it}, p)) \\ &= \frac{1}{p} \int_{-\infty}^{\infty} \left(\int_{C(w_{it}, p) - w_{it} r_{it}}^{\infty} (\check{r}_{mt} + w_{it} r_{it}) f(\check{r}_{mt}, r_{it}) d\check{r}_{mt} \right) dr_{it}, \end{aligned} \quad (2.25)$$

where $f(\check{r}_{mt}, r_{it})$ is the joint probability density function of the two series of yields. Second, the first order derivative with respect to the weight of country i is:

$$\begin{aligned} \frac{\partial ES_{m,t-1}(C)}{\partial w_{it}} &= \frac{1}{p} \int_{-\infty}^{\infty} \left(\int_{C(w_{it}, p) - w_{it} r_{it}}^{\infty} (r_{it}) f(\check{r}_{mt}, r_{it}) d\check{r}_{mt} \right) dr_{it} \\ &\quad - \frac{1}{p} \int_{-\infty}^{\infty} \left(\frac{\partial C(w_{it}, p)}{\partial w_{it}} - r_{it} \right) C(w_{it}, p) f(C(w_{it}, p) - w_{it} r_{it}, r_{it}) dr_{it}. \end{aligned} \quad (2.26)$$

However, the probability of being in the right tail of the distribution of the market yields is constant, *i.e.* $\Pr(\check{r}_{mt} + w_{it} r_{it} > C) = p$. Consequently, the first order derivative of this probability is null. It follows that:

$$\left(\frac{\partial C(w_{it}, p)}{\partial w_{it}} - r_{it} \right) f(C(w_{it}, p) - w_{it} r_{it}, r_{it}) = 0. \quad (2.27)$$

³² The proof provided here is similar to the one found in Banulescu and Dumitrescu (2014). However, the conditioning event is reversed in our case, therefore results are different.

Hence, equation (2.26) becomes:

$$\begin{aligned}
\frac{\partial ES_{m,t-1}(C)}{\partial w_{it}} &= \frac{1}{p} \int_{-\infty}^{\infty} \left(\int_{C(w_{it},p)-w_{it}r_{it}}^{\infty} (r_{it}) f(\check{r}_{mt}, r_{it}) d\check{r}_{mt} \right) dr_{it} \\
&= E_{t-1}(r_{it} | \check{r}_{mt} + w_{it}r_{it} > C(w_{it}, p)) \\
&= E_{t-1}(r_{it} | r_{mt} > C).
\end{aligned} \tag{2.28}$$

We proved thus that the MES is given by equation (2.28).

B. Details on the calculation of MES (2)

When computing the marginal expected shortfall, we make use of a detailed expression for z_{it} . The innovations for the bond yield of country i and for the yield of the market can be written as Garch processes:

$$\begin{aligned}
z_{it} &= \sigma_{it} \varepsilon_{it} \\
z_{mt} &= \sigma_{mt} \varepsilon_{mt}
\end{aligned} \tag{2.29}$$

To unfold this expression, we use some standard results of the Capital Asset Pricing Model (CAPM), written for the innovations, as our data is not stationary. Mainly, the yields for country i are such that:

$$z_{it} = \beta_i z_{mt} + \mu_{it}, \tag{2.30}$$

with μ_{it} an error term and β_i estimated as in any linear regression:

$$\beta_i = \frac{\text{cov}(z_i, z_m)}{\text{var}(z_m)} = \frac{\sigma_{imt}}{\sigma_{mt}^2}. \tag{2.31}$$

Moreover, the conditional correlation between the innovations for the yield of country i and the market index is given by:

$$\rho_{imt} = \frac{\sigma_{imt}}{\sigma_{it}\sigma_{mt}}, \tag{2.32}$$

which allows us to rewrite the equation of z_{it} as:

$$\begin{aligned}
z_{it} &= \frac{\sigma_{imt}}{\sigma_{mt}^2} \sigma_{mt} \varepsilon_{mt} + \mu_{it} \\
&= \frac{\sigma_{imt}}{\sigma_{mt}} \varepsilon_{mt} + \mu_{it} \\
&= \frac{\sigma_{imt}}{\sigma_{mt}\sigma_{it}} \sigma_{it} \varepsilon_{mt} + \mu_{it} \\
&= \rho_{imt} \sigma_{it} \varepsilon_{mt} + \sigma_{\mu it} \xi_{it},
\end{aligned} \tag{2.33}$$

where μ_{it} is the residual of the linear regression and ξ_{it} is the standardized residual. Furthermore, the variance of z_{it} , $\sigma_{it}^2 = \rho_{imt}^2 \sigma_{it}^2 + \sigma_{\mu_{it}}^2$, gives us an expression for the variance of the residuals, μ :

$$\sigma_{\mu_{it}}^2 = \sigma_{it}^2(1 - \rho_{imt}^2), \quad (2.34)$$

and thus, their standard error:

$$\sigma_{\mu_{it}} = \sigma_{it} \sqrt{(1 - \rho_{imt}^2)}. \quad (2.35)$$

Finally, putting all these results together, we obtain the formula for the yield of country i :

$$\begin{aligned} z_{it} &= \rho_{imt} \sigma_{it} \varepsilon_{mt} + \sigma_{it} \sqrt{(1 - \rho_{imt}^2)} \xi_{it} \\ &= \sigma_{it} \underbrace{(\rho_{imt} \varepsilon_{mt} + \sqrt{(1 - \rho_{imt}^2)} \xi_{it})}_{\varepsilon_{it}} \end{aligned} \quad (2.36)$$

C. Tail Expectations³³

We use a non-parametric kernel framework to estimate the tail expectations $E_{t-1}(\varepsilon_{mt} | \varepsilon_{mt} > (C - r_{m,t-1})/\sigma_{mt})$ and $E_{t-1}(\xi_{it} | \varepsilon_{mt} > (C - r_{m,t-1})/\sigma_{mt})$ as in Scaillet (2005).

For simplicity, let us denote the systemic risk event $(C - r_{m,t-1})/\sigma_{mt}$ by κ . Consequently, the tail expectation on market yields becomes:

$$E_{t-1}(\varepsilon_{mt} | \varepsilon_{mt} > (C - r_{m,t-1})/\sigma_{mt}) = E_{t-1}(\varepsilon_{mt} | \varepsilon_{mt} > \kappa). \quad (2.37)$$

Based on the definition of the conditional mean, we can express equation (2.37), as a function of the probability density function f :

$$\begin{aligned} E_{t-1}(\varepsilon_{mt} | \varepsilon_{mt} > \kappa) &= \int_{\kappa}^{\infty} \varepsilon_{mt} f(u | u > \kappa) du \\ &= \int_{-\infty}^{\infty} \varepsilon_{mt} f(u | u > \kappa) du - \int_{-\infty}^{\kappa} \varepsilon_{mt} f(u | u > \kappa) du, \end{aligned} \quad (2.38)$$

where the conditional density $f(u | u > \kappa)$ can be written as:

$$\frac{f(u)}{Pr(u > \kappa)}. \quad (2.39)$$

³³ The proof provided here is similar to the one found in Banulescu and Dumitrescu (2014). However, the conditioning event is reversed in our case, therefore results are different.

Next, we need to compute $f(u)$ and $Pr(u > \kappa)$. For this, we first consider the standard kernel density estimator of the density f at point u given by:

$$\hat{f}(u) = \frac{1}{Th} \sum_1^T \phi\left(\frac{u - \varepsilon_{mt}}{h}\right),$$

where h stands for the bandwidth parameter, and T is the sample size (Silverman, 1986; Wand and Jones, 1995; Simonoff, 1996). Second, the probability to be in the tail of the distribution can be defined as the integral of the probability density function over the domain of definition of the variable u , *i.e.* $p = Pr(u > \kappa) = \int_{\kappa}^{\infty} f(u) du$. Thus, we can replace $\hat{f}(u)$ with the kernel estimator and obtain:

$$\hat{p} = \frac{1}{Th} \sum_{t=1}^T \left(1 - \Phi\left(\frac{\kappa - \varepsilon_{mt}}{h}\right)\right).$$

Consequently, equation (2.37) becomes:

$$\hat{E}_{t-1}(\varepsilon_{mt} | \varepsilon_{mt} > \kappa) = \frac{\sum_{t=1}^T \varepsilon_{mt} \left(1 - \Phi\left(\frac{\kappa - \varepsilon_{mt}}{h}\right)\right)}{\sum_{t=1}^T \left(1 - \Phi\left(\frac{\kappa - \varepsilon_{mt}}{h}\right)\right)}. \quad (2.40)$$

Similarly, it can be shown that:

$$\hat{E}_{t-1}(\xi_{it} | \varepsilon_{mt} > \kappa) = \frac{\sum_{t=1}^T \xi_{it} \left(1 - \Phi\left(\frac{\kappa - \varepsilon_{mt}}{h}\right)\right)}{\sum_{t=1}^T \left(1 - \Phi\left(\frac{\kappa - \varepsilon_{mt}}{h}\right)\right)}. \quad (2.41)$$

D. Supplementary figures

Figure A1: Debt weights by country over the period 2000Q4 – 2013Q4

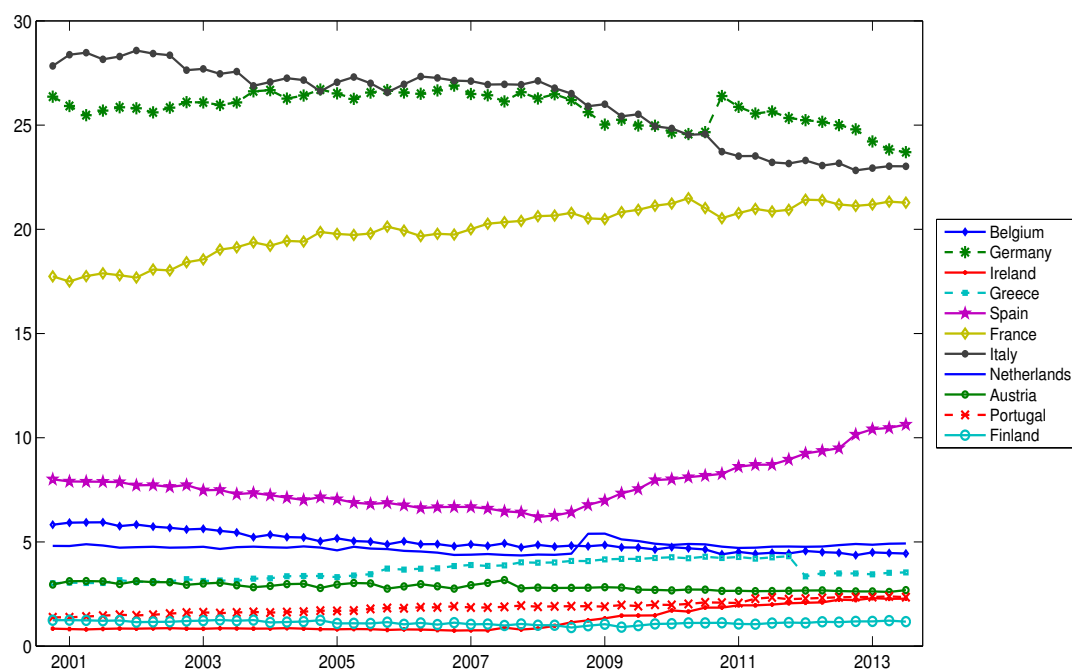


Figure A2: Percentage Component Expected Shortfall by country at different dates

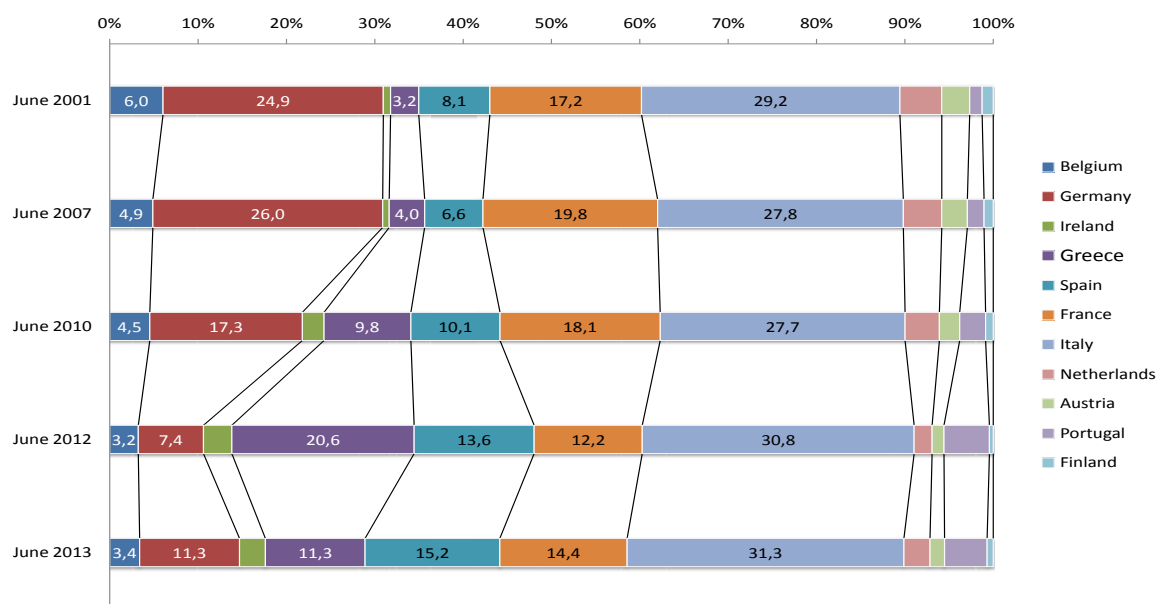
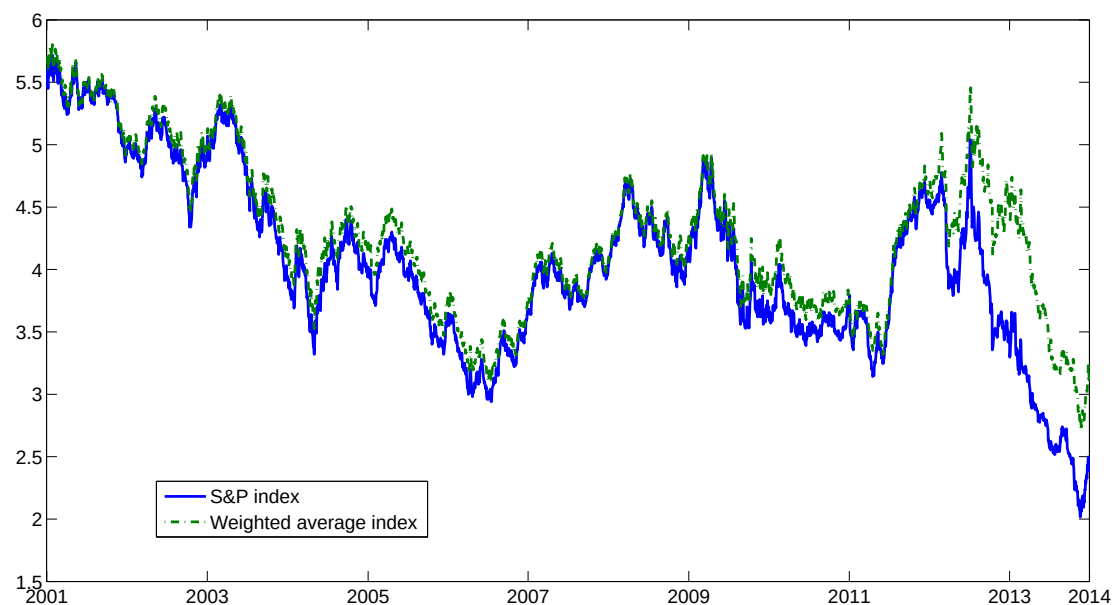


Figure A3: A comparison between the S&P bond index and the weighted average index



Note: This figure presents two bond indices: the S&P Eurozone Sovereign Bond Index 7 – 10Y and the index used in the main analysis, computed as a weighted average of government bond yields 10Y. The two indices have the same dynamics.

Chapter 3

Monetary Policy and Financial Stability: Is Leaning Against the Wind the Answer?¹

“Of course, the global financial crisis has done great damage, and this has understandably led to questions as to whether the disaster might have been avoided, or its severity reduced, had policies been different. The aspects of policy that have most obviously been called into question have to do with the regulation of the financial system. But it is also worth asking whether alternative monetary policies might have made a difference.”

(Woodford, 2012)

In this chapter, we intend to tackle another problem raised by the risk-taking channel of monetary policy. As we have seen from the analysis of the first chapter, the decisions of the monetary authority can have a significant influence on the level of risk and implicitly on the dynamics of the economy. Although the crisis was not a direct result of loose monetary policy, it is obvious that the policy stance was an important factor in the unfolding of events. In view of these results, it is natural to wonder what should be the appropriate behavior of monetary authorities in this situation. Does the central bank need to take into account the consequences of its decisions on financial stability? What are the potential benefits and/or disadvantages of a central bank’s response to an increase in financial imbalances? We analyze these questions in a theoretical framework in which we assume a pre-crisis scenario. More precisely, we consider a financial bubble meant to replicate risk accumulation and we assume that the central bank is the only authority that can intervene in the economy to smooth cycles.

We propose two ex-post analyses. The first one allows us to see if the monetary authority could have improved the dynamics of the economy, had it chosen to lean against

¹ This chapter is based on Badarau and Popescu (2014), *Economic Modelling*, 42 (2014), pp. 301-312.

the wind during the asset price bubble. This implies two types of comparisons. On the one hand, we compare the results obtained under an optimal policy rule with the ones where the central bank is conducting expansionary monetary policy, to prove that this latter strategy induced a higher increase in credits, thus more risk accumulation. On the other hand, we compare the dynamics of the economy under two rules – a standard Taylor-type rule and an augmented one. The augmented policy rule takes into account a financial variable – credit to GDP – which defines in our model financial stability. In the second analysis, we study the optimal behavior of a central bank responsible not only for price stability, but also for maintaining financial stability. Different scenarios are compared to determine which strategy is the most efficient and what are the problems that might arise.

The leaning against the wind strategy is central to our analysis. Until 2007, the debate, both inside and outside central banks, was somewhat focused on whether or not monetary policy should respond to financial imbalances (the “clean” versus “lean” debate). According to the “cleaning” approach, central banks should not play an active role in preventing financial bubbles, but rather just clean up after they burst (the so-called “Greenspan put”). The arguments claim that bubbles are hard to detect, the short term interest rate may be ineffective or too blunt to target a particular asset price bubble, and more importantly, the costs associated to the cleaning policy may be much lower than those related to a policy of leaning against the wind. Conversely, proponents of active monetary policy, designed to prevent or dampen financial risks (the “leaning” view), argue that central banks should carefully scrutinize developments in the financial sector and respond adequately to rising financial imbalances such as asset price bubbles. According to this view, the main monetary policy instrument, the short term interest rate, can slow the bubble’s growth, thereby preventing its burst or resulting in less damaging effects for the economy once the bubble bursts. Moreover, if the central bank doesn’t act preventively, once the risk materializes, the policy rate can become inefficient because of the zero lower bound constraint.

The cleaning approach seemed to prevail before the crisis. The latter has however underlined two major limits of this strategy. First, the 2007 crash of the housing price bubble has shown that the economic costs of a financial crisis can be very high and persistent. As pointed out by Woodford (2012), in spite of unprecedented measures undertaken by number of central banks in the aftermath of the global financial crisis, authorities were unable to avoid the sharp contraction of the global economic activity. Years after the subprime crisis, many economies are still struggling with its harmful effects. Second, the pre-crisis period showed that a trade-off can emerge between macroeconomic stability and financial stability. Despite the central banks’ success in maintaining a low and

stable inflation since the early 2000s, financial risks accumulated during this period and culminated in the crash of the house price bubble. Certainly, the problem of trade-offs between objectives is not to be neglected. Having several objectives, but only one instrument to address them, is against the Tinbergen principle (Tinbergen, 1952). De Grauwe and Gros (2009) prove that, in the presence of bubbles, the economy can indeed be confronted with a trade-off between price stability and financial stability. According to these authors, a central bank favoring price stability will allow excessive credit creation endangering thereby financial stability. Therefore, we will take particular interest in trade-offs between objectives, both in this chapter and in the following one.

The leaning against the wind view, as a way to keep the financial sector safe, has gained importance since the outbreak of the financial crisis. The debate has moved from the question of whether to act, to the issue of how to act. Raising the interest rate would help dampen excessive risk-taking. As stated by Rudebusch (2005), ideally, a moderate adjustment of the interest rate could constrain the bubble and reduce the risk of an important macroeconomic disturbance. Therefore, the advent of the crisis determined many authors to take interest in financial stability indicators that could become part of the leaning against the wind strategy. The prevailing indicators include credit growth (Agenor et al., 2013, Schularick and Taylor, 2012) or credit over GDP, but leverage (Angeloni and Faia, 2009) and interest rate spreads (Curdia and Woodford, 2010, Gilchrist and Zakrajsek, 2012) are also considered as potential candidates integrating important information for the central bank. Drehmann et al. (2010) compare several indicators and find the ratio of credit to GDP as the best one for predicting crises. Moreover, the latest Basel agreement (BIS, 2011) on financial stability also establishes credit growth with respect to GDP as a reference measure capturing excessive risk accumulation. Generally, these indicators are directly integrated in models that combine monetary policy with macroprudential regulation.²

Although several authors find a blame for the central bank as regards the development of events that led to the crisis (Giavazzi and Giovannini, 2010, Kannan et al., 2012), the scenario where the monetary authority would have been interested in financial stability before the crisis – when macroprudential regulation was not yet implemented – is mainly overlooked in this literature. One example where the central bank is the sole responsible for price and financial stability at the same time and uses a single instrument to deal with both is Bauducco et al. (2011). They consider the case of a central bank who wants to foster financial stability by using an augmented Taylor rule. The indicator used in their analysis is the default probability of entrepreneurs and, according to their results,

² A few examples of papers treating this matter are Agenor et al. (2013), Angelini et al. (2011), Beau et al. (2013), Christensen et al. (2011), Dib (2010), Lambertini et al. (2013) or Paries et al. (2011). We analyze the interaction between monetary policy and macroprudential policy in the next chapter, where details about these papers can be found.

the augmented rule proves useful only when the financial stability is menaced. However, the central bank is confronted with a temporary trade-off between objectives. Beau et al. (2013) also study the case where only a credit growth augmented interest rate is used, without any macroprudential regulation, but the central bank is not interested in maintaining financial stability. The effects of the augmented rule turn out to be destabilizing for inflation when compared to the standard Taylor rule, even in the case of financial shocks. Our analysis belongs to this strand of literature and intends to add some insight about the effects of an augmented Taylor rule on the dynamics of the economy when both price stability and financial stability are considered.

However, from a theoretical point of view, giving a macroprudential objective to the central bank is not straightforward. Contrary to price stability, financial stability is difficult to define and measure because of its wide range of application. Usually, authors prefer defining financial instability instead of financial stability. Such definitions can be found, for example, in Borio and Lowe (2002), Ferguson (2002) and Kindleberger (2000). The ECB gives a definition for financial stability, but it remains too vague to come to a conclusion on its appropriate measure: “financial stability is a condition in which the financial system (...) is capable of withstanding shocks and unraveling of financial imbalances” (ECB, 2008, p. 117). In the present chapter, we choose the credit to GDP ratio as an indicator of financial (in)stability and restrict the concept of financial stability to limiting credit variability.

To perform our analysis, we develop a New-Keynesian Dynamic Stochastic General Equilibrium (DSGE) model which has as a starting point the standard financial accelerator model of Bernanke et al. (1999). The financial accelerator mechanism is compulsory because it allows for rapid risk accumulation during good times and it amplifies the downturn once the situation reverses. However, in order to study financial stability, several elements are added to this framework. As banks are the major actors of financial stability, the financial accelerator is modeled not only through the firm balance sheet channel (Bernanke et al., 1999), but also through the bank capital channel as in Badarau and Levieuge (2011). Next, to obtain a complete business cycle, we introduce a boom-bust process inspired by the one of Bernanke and Gertler (1999). The positive bubble triggers the risk and favors its accumulation, whereas the burst of the bubble induces the crisis as risk materializes, which is exactly how recent crises developed.³ Finally, to be closer to reality, we allow for speculative behavior when investment decisions are made.

The rest of the chapter is organized as follows. We proceed by describing the DSGE model. More precisely, we present one by one the main blocks of the model and describe

³ More precisely, we refer to the Internet bubble and the housing bubble. Moreover, these crises highlighted the presence of a financial accelerator mechanism, as booms that preceded them were more intense and busts more drastic than previous crises.

the key mechanisms through which shocks are transmitted. Details on the resolution of the model are afterwards given – computation of the steady state, log-linear form of the model and its calibration. Further, in the results section, we interpret our impulse response functions obtained following a financial shock and we compare them according to the different monetary policy rules used. Optimization results are then presented together with a comparison of variances issued from this optimal behavior. Results allow us not only to judge if the monetary authority would have been capable of changing the outcome of the bubble’s burst, but also to see whether or not monetary policy should play a role in maintaining financial stability.

3.1 The Model

For the development of the model, we use a simplified framework including representative agents. We consider an economy populated by households, entrepreneurs and capital producers, banks, a government and a monetary authority. In order to facilitate aggregation and to introduce nominal price rigidities and monopolistic competition, we also add retailers, but their role remains secondary in the model. Households save money in the form of bank deposits, work for entrepreneurs and consume retail goods. The government has a passive role in the model, as it only collects taxes from households and uses them to consume final goods. Retailers differentiate wholesale goods produced by entrepreneurs and distribute them to the economy. Entrepreneurs produce homogeneous wholesale goods using a constant returns to scale production function. In the production process, they use capital bought from capital producers and labor supplied by households and by entrepreneurs themselves. To finance investments in capital, entrepreneurs use their net worth, but this is never fully sufficient, so, they are always obliged to resort to external finance. Banks have the role of supplying credits to entrepreneurs. Likewise, banks have two sources of funding, bank capital and deposits collected from households. Debt contracts are renewed at the end of each period (Bernanke et al., 1999, Carlstrom and Fuerst, 1997). We suppose that banks do not have a fully diversified portfolio so they have a non null probability of default. The same goes for entrepreneurs, who may fail on their investments project. In the default case, of either the entrepreneur, or the bank, a costly state verification procedure is started.

Financial frictions due to asymmetric information and agency problems appear at two levels. On the one hand, entrepreneurs face an external finance premium on the money borrowed from the bank. On the other hand, financial frictions appear between banks and households, as the former also have to pay a finance premium when rising funds from households. These external finance premiums depend inversely on the financial

condition of the borrowers. For example, a borrowing firm with a high financial leverage – calculated as the amount of assets over internal capital – will face a higher external finance premium. This premium influences the cost of capital, thus, it has a negative impact on investment decisions which in turn influence the output in the economy. This mechanism corresponds to the financial accelerator mechanism of Bernanke et al. (1999). Moreover, the same reasoning applies to banks with the difference that banks pass on their premium to entrepreneurs. This will induce a supplementary impact on aggregate investment and output.

In the remainder of this section, we will present the building blocks of the model with an accent on the banking sector and on the boom-bust process. To model the banking sector, we follow the steps proposed by Badarau (2009). For the bubble process, we retain the framework employed by Bernanke and Gertler (1999).

3.1.1 The Banking Sector:

In the production process entrepreneurs need capital. At the end of each period, t , the representative firm will buy K_{t+1} units of physical capital at price Q_t . To finance this purchase, the firm uses its own net worth, N_{t+1}^f . We suppose that internal funds are never enough to entirely finance new capital, so the firm has to obtain a credit from the bank, B_{t+1} , to cover the remainder of the sum:⁴

$$B_{t+1} = Q_t K_{t+1} - N_{t+1}^f. \quad (3.1)$$

In order to supply credit to firms, banks finance themselves not only with their own net worth (bank capital), N_{t+1}^b , but also with external funds. They collect deposits from households amounting to A_{t+1} :

$$A_{t+1} = B_{t+1} - N_{t+1}^b = Q_t K_{t+1} - N_{t+1}^f - N_{t+1}^b. \quad (3.2)$$

Interest rates for credits (R^B) and deposits (R^A) are determined from two constrained optimization programs, one for the firm and another one for the bank. The optimization program for the entrepreneur consists in the maximization of its expected profit subject to the participation of the bank to the credit contract. However, the bank will agree to the loan only if it is able to raise funds from households, thus, a second participation constraint appears in the entrepreneur's optimization program. Similarly, the representative bank maximizes the expected profit subject to the participation of the household to the funding contract.

⁴ As investment decisions take place at the end of period t , going into period $t + 1$, the entrepreneur is capable of estimating in t the capital needed in the production process for the following period, K_{t+1} , as well as the resources necessary to finance this capital, N_{t+1}^f and B_{t+1} . Therefore, all these variables are predetermined in the model.

3.1.1.1 Firm's Maximization Program

The return on capital is affected by both aggregate and idiosyncratic risk. Aggregate risk, R^K , affects all firms in the economy in the same way and its value is revealed to everyone in period $t+1$, whereas the idiosyncratic risk, ω , is firm specific and is known only by the entrepreneur.⁵ Thus, the ex post gross return on capital is $\omega_{t+1}R_{t+1}^K Q_t K_{t+1}$. Moreover, there exists a threshold value, $\bar{\omega}^f$, below which the result of the firm is not enough to repay bank debt, case in which the entrepreneur declares default. This threshold is obtained in a situation where the ex post gross return of the entrepreneur is only enough to repay the credit from the bank:

$$\bar{\omega}_{t+1}^f R_{t+1}^K Q_t K_{t+1} = R_{t+1}^B B_{t+1}. \quad (3.3)$$

The presence of idiosyncratic risk gives rise to asymmetric information problems between the borrower and the bank regarding the outcome of the investment project. The bank proceeds to a costly state verification (Townsend, 1979) only if the entrepreneur fails on his project, that is, when $\omega < \bar{\omega}^f$. Monitoring costs, μ^b , are proportional to the gross expected return, $\mu^b \omega_{t+1} R_{t+1}^K Q_t K_{t+1}$. Table 3.1 summarizes the gross revenues of the entrepreneur and of the bank in each state of nature – default or success – of the investment project.⁶

Table 3.1: Gross revenues from the investment project and the lending operation

	<i>Default</i> ($\omega < \bar{\omega}^f$)	<i>Success</i> ($\omega \geq \bar{\omega}^f$)
<i>Entrepreneur</i>	0	$\omega_{t+1} R_{t+1}^K Q_t K_{t+1}$
<i>Bank</i>	$(1 - \mu^b) \omega_{t+1} R_{t+1}^K Q_t K_{t+1}$	$R_{t+1}^B B_{t+1}$

Note: Under the default hypothesis, the entrepreneur does not have enough money to reimburse its debt towards the bank, thus, all revenues go to the bank and the entrepreneur gets nothing. In this case, the bank starts an audit procedure and recovers the revenue from the project net of these monitoring costs, $(1 - \mu^b) \omega_{t+1} R_{t+1}^K Q_t K_{t+1}$. When $\omega \geq \bar{\omega}^f$, the entrepreneur has enough money to repay the lender the promised amount, $R_{t+1}^B B_{t+1}$. Revenues for the entrepreneurs before debt repayment are $\omega_{t+1} R_{t+1}^K Q_t K_{t+1}$.

The expected profit of the entrepreneur, $\Pi_{f,t+1}^e$, is given by the revenue obtained from the investment project minus the amount of the bank debt repayment:

$$\Pi_{f,t+1}^e = E_t \left\{ \int_{\bar{\omega}_{t+1}^f}^{\infty} [\omega_{t+1} R_{t+1}^K Q_t K_{t+1} - R_{t+1}^B B_{t+1}] f(\omega_{t+1}) d\omega_{t+1} \right\}. \quad (3.4)$$

⁵ ω is a random variable issued from a log-normal distribution, with mean $\left(-\frac{\sigma^2}{2}\right)$ and variance equal to σ^2 , *i.i.d.* across firms and over time.

⁶ By gross revenues, we mean revenues obtained before any repayment of debt.

Given that the bank portfolio is not sufficiently diversified, the bank has a non null probability of default. The financial intermediary defaults if (i) the entrepreneur defaults and (ii) the revenues recovered from the entrepreneur are not enough to repay the household. The default threshold, $\bar{\omega}^b$, is obtained, as in the case of entrepreneurs, from the condition that revenues recovered from the firm are only enough to repay households:

$$(1 - \mu^B)\bar{\omega}_{t+1}^b R_{t+1}^K Q_t K_{t+1} = R_{t+1}^A A_{t+1}, \quad (3.5)$$

where R^A is the rate of return of the household (the deposit rate), as anticipated by the bank. Obviously, the entrepreneur's default threshold is superior to the one of the bank, $\bar{\omega}^f > \bar{\omega}^b$.⁷ If the financial intermediary defaults, the household is obliged to engage in a costly audit procedure. The monitoring costs for the household are denoted μ^a and are proportional to the revenue of the bank when the entrepreneur defaults, $\mu^a(1 - \mu^b)\omega_{t+1} R_{t+1}^K Q_t K_{t+1}$. Table 3.2 summarizes gross revenues obtained by banks and households depending on the state of nature, *i.e.* default or success, of the bank.

Table 3.2: Gross revenues from lending and borrowing operations computed from the perspective of the bank

	<i>Default of the bank and of the firm</i> ($\omega < \bar{\omega}^b$)	<i>Default of the firm</i> ($\bar{\omega}^b < \omega < \bar{\omega}^f$)	<i>Success</i> ($\omega \geq \bar{\omega}^f$)
<i>Bank</i>	0	$(1 - \mu^b)\omega_{t+1} R_{t+1}^K Q_t K_{t+1}$	$R_{t+1}^B B_{t+1}$
<i>Household</i>	$(1 - \mu^a)(1 - \mu^b)\omega_{t+1} R_{t+1}^K Q_t K_{t+1}$	$R_{t+1}^A A_{t+1}$	$R_{t+1}^A A_{t+1}$

Note: When the bank goes bankrupt, it gets nothing and all that it recovers from the firm goes to the household after the latter pays the auditing costs, $(1 - \mu^a)(1 - \mu^b)\omega_{t+1} R_{t+1}^K Q_t K_{t+1}$. When the entrepreneur defaults, but the bank has enough resources to pay the household, the household gets the whole amount established in the deposit contract, $R_{t+1}^A A_{t+1}$, whereas the bank gets as gross revenue what it remains after paying the audit costs, $(1 - \mu^b)\omega_{t+1} R_{t+1}^K Q_t K_{t+1}$. In the good state of nature, when neither the entrepreneur, nor the bank default, the bank gets the agreed sum for the credit, $R_{t+1}^B B_{t+1}$, and the household, the agreed sum for the deposit, $R_{t+1}^A A_{t+1}$.

Using the results from Table 3.2, we can aggregate and obtain profits for the bank and firm, respectively. The bank's profit is computed as its revenue from the credit relation with the entrepreneur minus the payment made to the household:⁸

$$\Pi_{b1,t+1}^e = E_t \left\{ \int_{\bar{\omega}_{t+1}^b}^{\bar{\omega}_{t+1}^f} [(1 - \mu^b)\omega_{t+1} R_{t+1}^K Q_t K_{t+1} - R_{t+1}^A A_{t+1}] f(\omega_{t+1}) d\omega_{t+1} + [1 - F(\bar{\omega}_{t+1}^f)] [R_{t+1}^B B_{t+1} - R_{t+1}^A A_{t+1}] \right\}, \quad (3.6)$$

⁷ Sunirand (2002) provides a formal demonstration for this relation.

⁸ The '1' that appears as a subscript for profits reminds us that we are dealing with the first optimization program and that profits for the bank and household are computed from the perspective of the bank.

with $[1 - F(\bar{\omega}_{t+1}^f)]$ the probability of success for the entrepreneur's investment project. Note that the household's revenue also represents its profit.⁹

$$\Pi_{a1,t+1}^e = E_t \left\{ \int_0^{\bar{\omega}_{t+1}^b} (1 - \mu^a)(1 - \mu^b) \omega_{t+1} R_{t+1}^K Q_t K_{t+1} f(\omega_{t+1}) d\omega_{t+1} + (1 - F(\bar{\omega}_{t+1}^b)) R_{t+1}^A A_{t+1} \right\}. \quad (3.7)$$

In deciding whether or not to grant the loan to the entrepreneur, the bank compares the profit it would obtain from the lending operation with the revenue it would get if it had invested the money at a predetermined risk free rate, r_{t+1} .¹⁰ The bank agrees to the contract only if the expected return from lending is at least equal to this opportunity cost:

$$\Pi_{b1,t+1}^e = N_{t+1}^b R_{t+1}, \quad (3.8)$$

where N^b represents the net worth of banks. Likewise, from the point of view of the bank, the household will agree to lend funds to the bank only if its expected profit is at least equal to the opportunity cost for these funds:

$$\Pi_{a1,t+1}^e = A_{t+1} R_{t+1}. \quad (3.9)$$

Equations (3.8) and (3.9) represent the participation constraints of the bank and household to the financing of the entrepreneur. Finally, the expected profit maximization under these two constraints yields the external finance premium of the firm defined as $S_t^f = E_t \left\{ \frac{R_{t+1}^K}{R_{t+1}} \right\}$:

$$S_t^f = \Psi^f \left(\frac{Q_t K_{t+1}}{N_{t+1}^f + N_{t+1}^b} \right), \text{ with } \Psi^{f'}(\cdot) > 0. \quad (3.10)$$

Note that the external finance premium of the entrepreneur does not depend only on its own financial situation, but also on the financial soundness of the bank. Thus, the entrepreneur bears a higher interest rate that also covers the financing cost of the bank. We recognize here the bank capital channel that acts like a financial accelerator.

3.1.1.2 Bank's Maximization Program

The second maximization program allows us to determine the bank's external finance premium. This time the analysis is done from the point of view of the household who

⁹ The household does not have any debt to repay.

¹⁰ $R_{t+1} = 1 + r_{t+1}$.

does not know the bank's balance sheet composition, but the reasoning is very much the same as in the case of the entrepreneur. The household judges the relationship with the bank by looking at the aggregate return on banking assets, R^B . Households are aware that the realization of R^B is subject to an idiosyncratic risk, ε .¹¹ The threshold below which the bank defaults on its commitments towards the household is given by the following equation:

$$\bar{\varepsilon}_{t+1} R_{t+1}^B B_{t+1} = R_{t+1}^A A_{t+1}. \quad (3.11)$$

Gross revenues of the bank and of the household are summarized in Table 3.3.

Table 3.3: Revenues from the lending and borrowing operations computed by the household

	<i>Default</i> ($\varepsilon < \bar{\varepsilon}$)	<i>Success</i> ($\varepsilon \geq \bar{\varepsilon}$)
<i>Bank</i>	0	$\varepsilon_{t+1} R_{t+1}^B B_{t+1}$
<i>Household</i>	$(1 - \mu^a) \varepsilon_{t+1} R_{t+1}^B B_{t+1}$	$R_{t+1}^A A_{t+1}$

Note: In the default scenario, the household proceeds to a costly audit and gets to keep the revenues of the bank net of these audit costs, $(1 - \mu^a) \varepsilon_{t+1} R_{t+1}^B B_{t+1}$, whereas the bank gets nothing. In case of success, the bank has enough money to repay the household the agreed amount, $R_{t+1}^A A_{t+1}$. Revenues for the bank before debt repayment are $\varepsilon_{t+1} R_{t+1}^B B_{t+1}$.

Therefore, the profit for the bank is:

$$\Pi_{b2,t+1}^e = E_t \left\{ \int_{\bar{\varepsilon}_{t+1}}^{\infty} [\varepsilon_{t+1} R_{t+1}^B B_{t+1} - R_{t+1}^A A_{t+1}] f(\varepsilon_{t+1}) d\varepsilon_{t+1} \right\}, \quad (3.12)$$

whereas the profit for the household is given by:

$$\Pi_{a2,t+1}^e = E_t \left\{ \int_0^{\bar{\varepsilon}_{t+1}} (1 - \mu^a) \varepsilon_{t+1} R_{t+1}^B B_{t+1} f(\varepsilon_{t+1}) d\varepsilon_{t+1} + (1 - F(\bar{\varepsilon}_{t+1})) R_{t+1}^A A_{t+1} \right\}, \quad (3.13)$$

where $(1 - F(\bar{\varepsilon}_{t+1}))$ represents the probability of success for the bank. Similarly to the firm's situation, the participation constraint for the household to the financing of the bank is given by the condition that expected profits are at least equal to the opportunity cost:

$$\Pi_{a2,t+1}^e = R_{t+1} A_{t+1}. \quad (3.14)$$

The optimizing behavior of the bank yields the following external finance premium, $S_t^b = \frac{R_{t+1}^B}{R_{t+1}}$:

¹¹ This risk is given by a random variable, ε , following a distribution that presents the same characteristics as the one of ω .

$$S_t^b = \Psi^b \left(\frac{B_{t+1}}{N_{t+1}^b} \right), \text{ with } \Psi^{b'}(\cdot) > 0. \quad (3.15)$$

As expected, the external finance premium depends only on the bank's financial leverage. We provide in Appendix A all the details for the derivation of the two external finance premiums (for entrepreneurs and banks).

The description of the banking sector is completed by the evolution of entrepreneurial net worth and bank capital. In the case of entrepreneurs, net worth is composed of accumulated profits, V_t^f , and entrepreneurial wages, W_t^f :

$$\begin{aligned} N_{t+1}^f &= \gamma^f (V_t^f + W_t^f) \\ &= \gamma^f (Q_{t-1} R_t^K K_t - \\ &\quad - \left[R_t + \frac{\mu^b \int_0^{\bar{\omega}_t^f} \omega_{t+1} f(\omega_t) d\omega_t + \mu^a (1 - \mu^b) \int_0^{\bar{\omega}_t^b} \omega_t f(\omega_t) d\omega_t}{Q_{t-1} K_t - N_{t-1}^f} Q_{t-1} R_t^K K_t \right] (Q_{t-1} K_t - N_{t-1}^f) + \\ &\quad + W_t^f), \end{aligned} \quad (3.16)$$

where γ^f represents the part of entrepreneurs that stays in business at time t . Accumulated profits are equal to the return on capital minus the repayment of borrowings. The ratio of default costs to quantity borrowed reflects the external finance premium of the entrepreneur. The entrepreneurs who default in period t exit the business and consume their residual equity:

$$C_t^f = (1 - \gamma^f) V_t^f. \quad (3.17)$$

The same reasoning applies to bank capital. However, this time, the banks that exit the market (with a probability $1 - \gamma^b$) transfer a part (t^b) of their equity to new or existing banks on the market. Thus, their net worth and consumption are:

$$\begin{aligned}
 N_{t+1}^b &= \gamma^b V_t^b + (1 - \gamma^b) t^b V_t^b \\
 &= [\gamma^b + (1 - \gamma^b) t^b] \{ R_t^K B_{t-1} - \\
 &\quad - \left[R_t + \frac{\mu^a (1 - \mu^b) \int_0^{\bar{\omega}_t^b} \omega_t f(\omega_t) d\omega_t}{Q_{t-1} K_t - N_{t-1}^f - N_{t-1}^b} Q_{t-1} R_t^K K_t \right] (Q_{t-1} K_t - N_{t-1}^f - N_{t-1}^b) \}
 \end{aligned} \tag{3.18}$$

and

$$C_t^b = (1 - \gamma^b)(1 - t^b) V_t^b. \tag{3.19}$$

Having the expressions for the two external finance premiums, as well as the evolution of net worth and consumption for both banks and entrepreneurs, we can move on to integrating this banking sector into the dynamic general equilibrium framework. The rest of the model being fairly standard, we give, in what follows, only the main intuitions related to the functioning of the economy.

3.1.2 General Equilibrium

Households are infinitely-lived agents who decide on their consumption, savings and work-time so as to maximize their intertemporal utility function:

$$E_t \sum_{k=0}^{\infty} \beta^k \left[\frac{\sigma_c}{\sigma_c - 1} C_{t+k}^{\frac{\sigma_c-1}{\sigma_c}} - \frac{\sigma_h}{\sigma_h + 1} H_{t+k}^{\frac{\sigma_h+1}{\sigma_h}} \right], \tag{3.20}$$

where β represents the subjective discount rate of the representative household, C is the consumption and H is the number of hours worked. σ_c represents the intertemporal elasticity of substitution, whereas σ_h is the elasticity of the disutility associated with labor. The household is subject to the following budgetary constraint:

$$P_t C_t + D_t + A_t \leq W_t H_t + A_{t-1} R_t^A + D_{t-1} R_t - T_t + \Delta_t. \tag{3.21}$$

Households' resources come from wages (W), remunerated deposits at the bank (A), savings (D) remunerated at the risk free rate and profits from the retail activity (Δ).¹² Their revenue is consumed by paying taxes (T), buying retailer goods (C) at price P and investing their savings. Maximizing the utility of the representative household subject to its budgetary constraint with respect to C_t , D_t , A_t and H_t yields standard first order conditions.

¹² Households are the owners of retail firms.

$$\lambda_t = \frac{1}{P_t} C_t^{-\frac{1}{\sigma_c}} \quad (3.22)$$

$$0 = \lambda_t - \beta R_{t+1} E_t[\lambda_{t+1}] \quad (3.23)$$

$$0 = \lambda_t - \beta R_{t+1}^A E_t[\lambda_{t+1}] \quad (3.24)$$

$$H_t = (\lambda_t W_t)^{\sigma_h} \quad (3.25)$$

These conditions imply that at the optimum the household is indifferent between consumption and saving and that there is no arbitrage between the different types of investments (deposits or safe assets). Moreover, relation (3.25) gives the supply of labor.

Capital producers differentiate their goods according to the needs of entrepreneurs. This process demands an adjustment cost which permits a variable price of capital. The adjustment cost function is modeled as in Badarau and Levieuge (2011):

$$\Phi(I_t, K_t) = \frac{\phi}{2} \left(\frac{I_t}{K_t} - \delta \right)^2 K_t, \quad (3.26)$$

with $\phi > 0$. I_t denotes aggregate investment expenditures, K_t the aggregate capital stock and δ the depreciation rate of capital. Then, the evolution of the capital stock is given by:

$$K_{t+1} = (1 - \delta)K_t + I_t. \quad (3.27)$$

Entrepreneurs produce wholesale goods by combining capital (K) bought from capital producers and labor supplied by households (H) and by entrepreneurs themselves (H^f , constant and normalized to one). The production technology is a Cobb-Douglas function with constant returns to scale:

$$Y_t = O_t K_t^\alpha [H_t^\Omega (H^f)^{1-\Omega}]^{1-\alpha}, \quad (3.28)$$

where $1 - \Omega$ represents the share of income going to entrepreneurial labor and O is an exogenous technology parameter (total factor productivity).

Entrepreneurs' optimization program consists in maximizing profits subject to the capital accumulation constraint. The profits for entrepreneurs are computed as the revenues from the production process minus production costs like wages, capital adjustment costs and capital investment. Note that entrepreneurs internalize the adjustment costs of capital producers. Profits for the entrepreneur are therefore given by:

$$\Pi_t^E = E_t \sum_{k=0}^{\infty} \left(\frac{1}{R_{t+k}^K} \right)^k \left\{ \rho_{t+k} Y_{t+k} - W_{t+k} H_{t+k} - W_{t+k}^f H_{t+k}^f - (I_{t+k} + \Phi(I_{t+k}, K_{t+k})) \right\}, \quad (3.29)$$

where ρ represents the relative price at which entrepreneurs sell their output.

First order conditions with respect to H_t , H_t^f , I_t and $K_t + 1$ give the classic result of production factors being paid according to their marginal productivity, but also equations for the Tobin Q-ratio and for the expected return on capital. Denoting by Q the Lagrange multiplier associated to the capital accumulation constraint, we obtain:

$$\rho_t \Omega (1 - \alpha) \frac{Y_t}{H_t} = W_t \quad (3.30)$$

$$\rho_t (1 - \Omega) (1 - \alpha) \frac{Y_t^f}{H_t^f} = W_t^f \quad (3.31)$$

$$Q_t = 1 + \frac{\partial \Phi(\cdot)}{\partial I_t} \quad (3.32)$$

$$E_t[R_{t+1}^K] = E_t \left[\frac{\rho_{t+1} \alpha \frac{Y_{t+1}}{K_{t+1}} - \frac{\phi}{2} \left[\delta^2 - \left(\frac{I_{t+1}}{K_{t+1}} \right)^2 \right] + (1 - \delta) Q_{t+1}}{Q_t} \right]. \quad (3.33)$$

Equations (3.30) and (3.31) give the demand for labor from households and entrepreneurs, respectively. Equation (3.32) defines Tobin's Q ratio, where Q_t represents the cost of capital. Finally, the expected return on capital (equation (3.33)) is equal to the expected marginal productivity of capital after deduction of adjustment costs plus the residual value of capital.¹³

Retailers are introduced in the model only to motivate sticky prices. They buy wholesale goods from entrepreneurs at price $\rho = \frac{1}{\mu_t}$ per unit, differentiate them at no costs and sell them in a monopolistic competition market at price P_t . Therefore, the production cost is equal to the price at which the goods have been bought from entrepreneurs. As in Calvo (1983), only a part of the retailers, θ , can change prices in a given period, independent of history. The optimizing behavior of retailers involves the maximization of the present value of future dividends subject to a constraint of expected demand for retail goods. The equilibrium solution allows us to obtain the New Keynesian Phillips curve:

$$\pi_t = \beta E_t[\pi_{t+1}] + \kappa \rho_t, \quad (3.34)$$

¹³ Given that credit contracts last only one period, the entrepreneur is required to sell its capital at the end of this period in order to reimburse his debt to the bank.

with π the log-deviation of inflation relative to its steady-state, κ a parameter depending on θ and β , and ρ the real marginal cost of a representative retailer.¹⁴

The central bank in charge with monetary policy uses a Taylor-type rule which takes the general form:

$$r_t^n = \beta_0 r_{t-1}^n + (1 - \beta_0)(\beta_\pi \pi_t + \beta_y y_t) \quad (3.35)$$

where r^n represents the deviation of the nominal interest rate from steady state, y is the output gap (log-deviation of output from steady state). Later on, we will see that this rule can be modified to include other variables besides inflation and output.

The government plays a secondary role in the model, therefore we do not introduce fiscal policy explicitly. Recall that the government only collects taxes from households (T) and uses them to make public investments (G).

Market clearing conditions

On the goods and services market, the demand must satisfy the supply such that at equilibrium the following relation holds:

$$Y_t = C_t + C_t^f + C_t^b + I_t + G_t. \quad (3.36)$$

The equilibrium on the labor market is obtained by equalizing labor demand and supply:

$$H_t^{\frac{\sigma_h+1}{\sigma_h}} = (C_t)^{-\frac{1}{\sigma_c}} \rho_t \Omega (1 - \alpha) Y_t \quad (3.37)$$

The scenario in which we are interested is the one where a financial shock occurs. We present hereafter the boom-bust process that permits the inclusion of the financial shock in the model.

3.1.3 The Boom and Bust Process

Not only the recent experience, but also crises before 2007, tend to reveal the fact that asset prices are prone to bubbles that have a potential damaging effect on the economy. We argue that such bubbles actually hide the build-up of risk in the economy and that this risk materializes once the bubble bursts.¹⁵ To introduce the bubble in our model, we build on the work of Bernanke and Gertler (1999) and Tetlow (2005). The bust that appears immediately after the bubble's collapse is intended to help obtain a complete

¹⁴As retailers are modeled in a fairly standard way, we do not provide all the details of their maximizing program. For their complete maximization program, refer to Appendix B.

¹⁵We do not explicitly model the risk-taking channel here, but we assume that the bubble in asset prices is accompanied by an increase in risk which could be seen as a consequence of this channel.

economic cycle. Therefore, in the analysis part, this will allow us to see how the central bank could have intervened to reduce the fluctuations in economic variables resulting from this boom and bust process. Keep in mind however that the mechanism introduced here is completely *exogenous*, so, the monetary authority can affect neither its amplitude, nor its duration.¹⁶ Hence, results will be analyzed for all other variables, but not for the boom-bust process.

Booms and busts occur whenever the market price of capital, denoted Z , varies from its fundamental value, Q . The boom-bust is summarized by the difference between these two prices: $u_t = Z_t - Q_t$. Bubbles exist because a *positive shock* makes market prices superior to the fundamental value, $Z_t > Q_t$. If the bubble exists, it persists with probability p and grows at a rate $\frac{aR^K}{p}$. The bubble crashes with probability $(1 - p)$. Investors only know the probabilities and growth rates attached to the bubble which permits them to compute the expected value of the process. The bubble is summarized by the following formula:

$$u_{t+1} = \begin{cases} \frac{aR^K}{p}u_t + \varepsilon_t^b & \text{if the bubble persists, } (p) \\ 0 & \text{otherwise, } (1-p) \end{cases} \quad (3.38)$$

with $p < a < 1$. In calibrating the model, we establish the number of boom periods to four and set $p = 0.6$. To be as close as possible to a rational bubble we fix $a = 0.98$ as in Bernanke and Gertler (1999) or Leveigne (2003). Knowing that, after a bubble, the economy does not recover immediately, we deliberately introduce a sequence of *negative shocks* to obtain the bust phase, when $Z_t < Q_t$. The collapse of the bubble generates panic between investors, so financial markets derive from fundamentals in the opposite direction relative to the boom phase. For symmetry reasons, the bust lasts as long as the bubble. Figure 3.1 shows the boom-bust process obtained for an initial shock equal to 1% of the steady-state fundamental price.¹⁷

We also introduce in our model speculative behavior by imposing that investment decisions are taken based on speculative prices, which seems a reasonable assumption with respect to recent market events. The boom-bust process also influences the balance sheet of the entrepreneur as assets are evaluated at market value. Thus, when a bubble occurs, the financial position of the firm improves artificially, therefore, the premium for external finance is affected. The bank's net worth is influenced by the bubble in a

¹⁶ It would be equally interesting to study the capacity of the monetary authority to prick the bubble. This can be achieved by considering an endogenous bubble. This is not the object of this chapter, but can be developed in future research.

¹⁷ We use the same hypotheses as in Bernanke and Gertler (1999), *i.e.* the bubble is close to being a rational one, the boom and bust scenarios are symmetrical and the initial shock is equal to 1%.

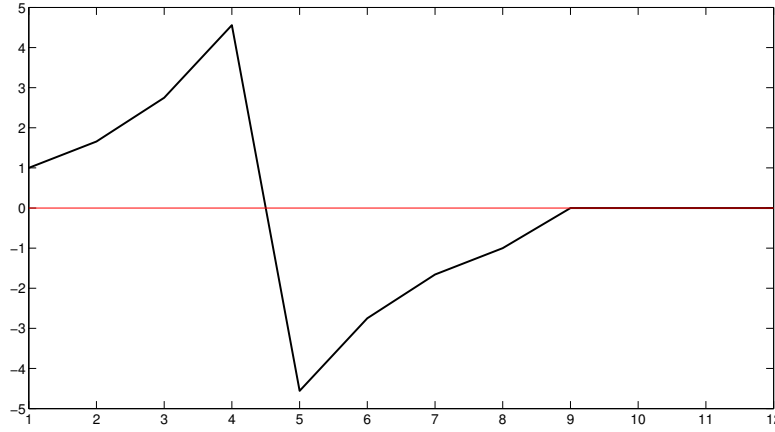


Figure 3.1: The boom and bust process
% deviation from the steady-state

similar way. The opposite effect is obtained during the bust phase. Note also that the bubble-bust process supposes a speculative return on capital, R^Z , that is related to R^K in the following manner:¹⁸

$$R_{t+1}^Z = R_{t+1}^K [b + (1-b) \frac{Q_t}{Z_t}], \quad (3.39)$$

with $b = a(1-\delta)$. Remark that, if there is no bubble, *i.e.* $Q_t = Z_t$, the speculative return is equal to the fundamental return on capital.

3.1.4 Steady state

To study the behavior of the economy in response to financial shocks, we use the log-linear version of the DSGE model presented above. The log-linearization of the model around the steady state implies first determining the steady state. This is the purpose of this subsection. In what follows, X denotes the steady state of a variable X_t , where X_t may be any variable from the model.

From the first order conditions of the household, we can obtain the steady state level of the risk-free interest rate, $R = \frac{1}{\beta}$. The capital accumulation constraint allows us to determine the steady state of the investments to capital ratio, $\frac{I}{K} = \delta$, which also implies that the steady state price of capital is $Q = 1$ (from equation (3.32)). From the first order conditions of the entrepreneur, more precisely equation (3.33), we derive the steady state of the return on capital, $R^K = 1 + r^K = \rho\alpha \frac{Y}{K} + 1 - \delta$. Consequently, we can obtain the ratio of output to capital $\frac{Y}{K} = \frac{R^K - (1-\delta)}{\rho\alpha}$, but also the investment to output ratio, $\frac{I}{Y} = \frac{I}{K} \frac{K}{Y} = \frac{\delta\alpha\rho}{r^K + \delta}$.

¹⁸ Appendix C provides the proof for this relation.

Relation (3.17) is used to determine the equilibrium ratio of firm consumption to output, $\frac{C^f}{Y} = \frac{1-\gamma^f}{\gamma^f} \frac{N^f}{K} \frac{K}{Y}$. In a similar way, from relation (3.19), we obtain the ratio of bank consumption to output, $\frac{C^b}{Y} = \frac{(1-\gamma^b)(1-t^b)}{\gamma^b(1-t^b)+t^b} \frac{N^b}{K} \frac{K}{Y}$. To compute these two ratios, we use the fact that $\frac{N^b}{K} = \frac{N^b}{B} \left(1 - \frac{N^f}{K}\right)$, where $\frac{N^f}{K}$ and $\frac{N^b}{B}$ are exogenous (see the calibration section, hereafter). The part of the household consumption in GDP can also be computed at this stage, from the market clearing condition. Therefore, $\frac{C}{Y} = 1 - \frac{I}{Y} - \frac{C^f}{Y} - \frac{C^b}{Y} - \frac{G}{Y}$, where the ratio of public expenditures, $\frac{G}{Y}$, is exogenously fixed to match euro area data.

To determine the equilibrium on the credit market, we first need to fix the values of the self-financing ratio of entrepreneurs, $\frac{N^f}{K}$, the bank capital ratio, $\frac{N^b}{B}$, the probability of default of firms and of banks, $F(\bar{\omega}^f)$ and $F(\bar{\omega}^b)$ and the external finance premium for entrepreneurs, $R^K - R$. All these quantities are calibrated to match the values found in the existing literature on this subject. To determine the main financial ratios (needed for the calibration of the model), we take into account the fact that in equilibrium the participation constraints to the debt contract must be satisfied. Given that $QK = N^f + N^b + A$ and that $Q = 1$, these relations become:¹⁹

$$\left[\Gamma(\bar{\omega}^f) - (1 - \mu^b)(\Gamma(\bar{\omega}^b) - \mu^b G(\bar{\omega}^f))\right] R^K - R \frac{N^b}{K} = 0 \quad (3.40)$$

$$(1 - \mu^b) \left[\Gamma(\bar{\omega}^b) - \mu^a G(\bar{\omega}^b)\right] R^K - R \left(1 - \frac{N^f}{K} - \frac{N^b}{K}\right) = 0. \quad (3.41)$$

Moreover, the steady state values for firm's and bank's net worth become:

$$\begin{aligned} \frac{N^f}{K} &= \gamma^f \left\{ \left[1 - \Gamma(\bar{\omega}^f)\right] R^K + \rho(1 - \alpha)(1 - \Omega) \frac{Y}{K} \right\} \\ &= \gamma^f \left\{ \left[R^K K - R^K B\right] + \rho(1 - \alpha)(1 - \Omega) \frac{Y}{K} \right\} \end{aligned} \quad (3.42)$$

$$\frac{N^b}{K} = \left[\gamma^b(1 - t^b) + t^b\right] \left\{ \Gamma(\bar{\omega}^f) - (1 - \mu^b) \Gamma(\bar{\omega}^b) - \mu^b G(\bar{\omega}^f) \right\} R^K. \quad (3.43)$$

To obtain relation (3.42), we used the steady state value of W^f , issued from equation (3.31). Moreover, we find that at the steady state, the return on capital is equal to the interest rate on loans ($R^K = R^B$). Using this result and equation (3.49) from Appendix A, we obtain:

$$\Gamma(\bar{\omega}^f) = 1 - \frac{N^f}{K}. \quad (3.44)$$

¹⁹ From this point on, to determine the steady state on the credit market, we use the notations introduced in Appendix A.

Furthermore, using the properties of the log-normal distribution, we can express $F(\bar{\omega}^f)$ (exogenous) as a function of $\bar{\omega}^f$ and σ . $\Gamma(\bar{\omega}^f)$ – that we can compute from relation (3.44) – can also be expressed as a function of $\bar{\omega}^f$ and σ . We therefore obtain a system of two equations and two unknowns which allows us to find the steady state values of $\bar{\omega}^f$ and σ . Finally, to determine $\bar{\omega}^b$, we use the expression of $F(\bar{\omega}^b)$.

Next, to compute γ^B , we use relations (3.40) and (3.43). From relations (3.42), (3.40) and (3.41), we can determine the values of γ^f , μ^b and μ^a . These values are:

$$\begin{aligned}\gamma^b &= \frac{1 - Rt^b}{(1 - t^b)R} \\ \gamma^f &= \frac{\frac{N^f}{K}}{R^K[1 - \Gamma(\bar{\omega}^f)] + \rho(1 - \alpha)(1 - \Omega)\frac{Y}{K}} \\ \mu^b &= \frac{\frac{N^b}{K}\frac{R}{R^K} - [\Gamma(\bar{\omega}^f) - \Gamma(\bar{\omega}^b)]}{\Gamma(\bar{\omega}^b) - G(\bar{\omega}^f)} \\ \mu^a &= \frac{\Gamma(\bar{\omega}^b) - \left(1 - \frac{N^f}{K} - \frac{N^b}{K}\right)\frac{R}{R^K(1 - \mu^b)}}{G(\bar{\omega}^b)}.\end{aligned}$$

Finally, from these relations we can obtain all the necessary ratios for the calibration of the entire log-linear model.²⁰

3.1.5 The log-linear model

Once we have computed the steady state for all interest variables, we proceed to the log-linearization of the model around the steady state. We denote by x the log-deviation of the variable X_t from its steady state: $x = \log(X_t) - \log(X)$. For the log-linearization procedure, refer to Appendix D. Capital letters represent steady state values. We obtain the following relations:

- Production function (cf. equation (3.28))

$$h_t = \frac{1}{\Omega(1 - \alpha)}(y_t - \alpha k_t - o_t)$$

- Capital accumulation (cf. equation (3.27))

$$k_{t+1} = (1 - \delta)k_t + \delta i_t$$

²⁰ For a detailed proof of all the relations that give the steady state, please refer to Badarau (2009).

- Firms' net worth (cf. equation (3.16))

$$n_{t+1}^f = \gamma^f R^K \left(\frac{K}{N} (r_{t+1}^z - r_t) + r_t + n_t - \left(\frac{K}{N} - 1 \right) s_t^f \right) + \gamma^f (1 - \alpha) (1 - \Omega) \rho \frac{Y}{K} \frac{K}{N} (\rho_{t+1} + y_{t+1})$$

- Firms' consumption (cf. equation (3.17))

$$c_t^f = n_t^f$$

- Banks' net worth (cf. equation (3.18))

$$n_t^b = \left(\gamma^b (1 - t^b) + t^b \right) R^K \left(\frac{1}{\frac{NB}{B}} (r_t^z - r_{t-1}) + r_{t-1} + n_{t-1}^b - \left(\frac{1}{\frac{NB}{B}} - 1 \right) s_{t-1}^b \right)$$

- Banks' consumption (cf. equation (3.19))

$$c_t^b = n_t^b$$

- Firms's external finance premium (cf. equation (3.10))

$$r_{t+1}^z = r_t + \psi^f \left(- \left(1 - \frac{1}{1 + \frac{N}{NB}} \right) n_t^f - \frac{1}{1 + \frac{N}{NB}} n_t^b + z_t + k_{t+1} \right)$$

where we compute the external finance premium as the difference between the speculative return and the risk free rate, $s_t^f = r_{t+1}^z - r_t$. Note that to compute s_t^f we use the speculative price of capital as well as the speculative return, which means that the external finance premium takes into account the market value of assets rather than the fundamental one. This is how the bubble influences financing conditions in the model. In periods where no bubbles are present, $z_t = q_t$ and we find the conventional relation for the entrepreneur's external finance premium. $\psi^f = \frac{\Psi_f'(k^f)}{\Psi_f(k^f)} k^f$ is the elasticity of the function $\Psi^f(k^f)$ in equation (3.10), with $k^f = \frac{QK}{N^f + N^b}$.

- Banks' external finance premium (cf. equation (3.15))

$$r_{t+1}^b = r_t + \psi^b \left(- \frac{N}{NB} \frac{NB}{B} n_t^f - n_t^b + \frac{K}{NB} \frac{NB}{B} (z_t + k_{t+1}) \right)$$

where the external finance premium is computed as $s_t^b = r_{t+1}^b - r_t$. Moreover, $\psi^b = \frac{\Psi_b'(k^b)}{\Psi_b(k^b)} k^b$ represents the sensibility of the bank's external finance premium to the financial position of the bank, $k^b = \frac{B}{N^b}$. Note that, banks also benefit from the bubble, as their external finance premium is also computed based on the market price of assets.

- Speculative return on capital (cf. equation (3.39))

$$r_t^z = r_t^k - (1 - b)u_{t-1}$$

- Firms' fundamental return on capital (cf. equation (3.33))

$$r_t^k = (1 - \epsilon)(\rho_t + y_t - k_t) + \epsilon q_t - q_{t-1}$$

$$\text{with } \epsilon = \frac{1-\delta}{\bar{\rho}\alpha\frac{Y}{K}+1-\delta}.$$

- Firms' investment (cf. equation (3.32))

$$z_t = \chi(i_t - k_t)$$

with $\chi = \delta\phi$ the elasticity of the price of capital to investment.

- Households' consumption/Euler equation (cf. equations (3.22) and (3.23))

$$c_t = c_{t+1} - \sigma_c r_t$$

- The bubble

$$u_t = d \frac{aR^k}{p} u_{t-1} + d\epsilon_t^b \quad \text{with } d = \begin{cases} 1 & \text{if bubble} \\ 0 & \text{otherwise} \end{cases}$$

with $u_t = z_t - q_t$ the difference between the market price and the fundamental value.

- Credits (cf. equation (3.1))

$$bb_t = \frac{1}{1 - \frac{N}{K}}(z_t + k_{t+1}) - \frac{1}{\frac{K}{N} - 1}n_t$$

- Credit over GDP

$$by_t = bb_t - y_t$$

- Goods and services market equilibrium (cf. equation (3.36))

$$y_t = \frac{C}{Y}c_t + \frac{I}{Y}i_t + \frac{G}{Y}g_t + \frac{CF}{Y}c_t^f + \frac{CB}{Y}c_t^b$$

- Labor market equilibrium (cf. equation (3.37))

$$\rho_t = -y_t + \left(\frac{\sigma_h + 1}{\sigma_h}\right)h_t + \frac{1}{\sigma_c}c_t$$

- Phillips curve (equation (3.34) of the model, already in a log-linear form)

$$\pi_t = \beta\pi_{t+1} + \kappa\rho_t,$$

$$\text{where } \kappa = \frac{(1-\theta)(1-\theta\beta)}{\theta}.$$

- Monetary policy rule (equation (3.35), already in a linear form)

$$r_t^n = \beta_0 r_{t-1}^n + (1 - \beta_0)(\beta_\pi \pi_t + \beta_y y_t + \beta_b b y_t)$$

- Short term real interest rate

$$r_t = r_t^n - \pi_{t+1}$$

3.1.6 Calibration

The calibration of the parameters and ratios is made in accordance to the values found in the literature for the euro area. As our framework is similar to the one developed by Badarau and Leveuge (2011), we draw on their work for the calibration of some of the parameters. A list of values is provided in Appendix E. Some of the values are actually standard in the literature and we decide therefore to use them in our calibration. Consequently, the subjective discount factor is equal to 0.99, the intertemporal elasticity of substitution σ_c is fixed at 0.75 and the elasticity of labor disutility is 0.32. We also fix the part of capital in the value added, α to a standard value, 0.35. The part of entrepreneurial labor in total labor is negligible, and as Bernanke et al. (1996) or Badarau and Leveuge (2011), we set $(1 - \Omega)$ to 0.01.

Further, we consider that the transfer of banks who exit the business to new banks is equal to 0.001 as in Badarau and Leveuge (2011). Following the same study, we set the parameter giving the sensibility of the external finance premium of firms to a change in the financial situation of both firms and banks (ψ^f) to 0.025, whereas the corresponding parameter for banks, ψ^b is equal to 0.005. Given that banks pass on their premium to the one of entrepreneurs is normal for banks to be less sensible to a change in their financial position than entrepreneurs.

In order to calibrate the rest of the parameters, we used recent studies for the euro area. The depreciation rate of capital is fixed to 0.04 based on the estimations of the OECD (2011). We employ an average value for the elasticity of the price of capital with respect to the investment capital ratio, χ , as in the literature this parameter varies between 0.25 and 2. For the Calvo parameter, we use the results of Dixon and Le Bihan (2012) and set the part of the retails that do not change prices, $1 - \theta$, to 0.6.

At steady state some of the ratios and parameters are considered as given. The real marginal cost is set to $\frac{1}{1.1}$. This corresponds to a markup for retailers of 10%. Moreover, the steady state value for the bank capital to loans ratio, $\frac{N^b}{B}$, and the ratio of net worth to capital, $\frac{N^f}{K}$, are set to the values proposed by Badarau (2009). For the probabilities of default of banks and firms, we assume that $F(\bar{\omega}^b) < F(\bar{\omega}^f)$, meaning that banks have a lower probability of default than the one of entrepreneurs. We consider these values to be 0.007 and 0.03, respectively. Finally, the external finance premium (interest rate spread) is set to 0.02.

Steady state ratios are computed in accordance to the results of section 4.1.4. Therefore, the probability for a bank to exit the market is equal to 0.01, whereas for the firm is 0.017. The threshold $\bar{\omega}^b$ is 0.52 and $\bar{\omega}^f$ is 0.6016. The fact that $\bar{\omega}^f > \bar{\omega}^b$ confirms that the default threshold of firms is higher than the one of banks. Monitoring costs are also obtained from the steady state computation. We obtain $\mu^b = 0.077$ and $\mu^a = 0.545$, therefore the costly state verification is more onerous for households than for banks, justifying a role for the intermediary in the model.

Finally, the macroeconomic ratios are computed using the formulas derived in the preceding section. Investment to GDP is found to be 0.24, a value that is close to the one obtained by Fagan et al. (2005) for the euro area. Banks' consumption to GDP is 0.006, whereas the consumption of firms as a part of GDP is 0.035. These values are close to the ones employed in other models integrating a financial accelerator mechanism. Lastly, the part of total consumption in GDP is 0.6.

The next section presents the dynamics of the model when considering different monetary policy rules and policy objectives.

3.2 Results and Policy Implications

We comparatively examine different scenarios for the monetary policy rule and for the loss function specification and analyze, for all these cases, the reaction of the model economy to financial shocks. The purpose of this analysis is twofold. First, we try to see what the improvements would have been if the central bank had monitored and reacted to a financial risk indicator, the credit-to-GDP ratio, before the crisis. This scenario is analyzed under the assumption that the loss function of the central bank integrates only output and inflation variability, as was the case before the crisis. We conduct our analysis by comparing the dynamics of the economy under a standard Taylor rule and an augmented one. Second, we ask ourselves whether a central bank, endowed with an additional financial stability objective (besides the traditional output and inflation objectives), can succeed in complying with all its objectives. In order to achieve our goal,

we analyze optimal simple rules and discuss the variances of economic variables obtained under different loss functions. In what follows, we develop and analyze progressively all these scenarios, but before all else, we study the reaction of our model to the financial shocks that hit the economy.

3.2.1 Reactions to Baseline Rules

The financial shock concerns capital prices and triggers the boom-bust process. As mentioned above, this process is completely exogenous, so the central bank cannot influence it. To illustrate the functioning of the model, we start with a standard Taylor rule that we label *Rule 1*:

$$r_t^n = \beta_0 r_{t-1}^n + (1 - \beta_0)(\beta_\pi \pi_t + \beta_y y_t) \quad (\text{Rule 1})$$

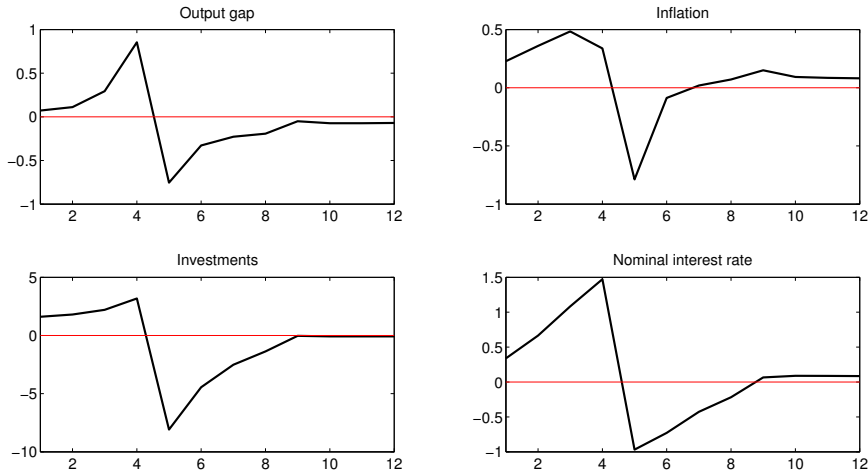
The beta coefficients are chosen so as to match the optimum of a central bank that has as objectives inflation and output stabilization.²¹ The impulse response functions are shown in Figure 2. Panel (a) gives the dynamics of the main aggregate macroeconomic variables, whereas in panel (b) we can see the reaction of the credit market to the boom-bust process.

For the first four periods that correspond to the bubble, we observe an accumulated increase in the output gap, mainly brought about by investments. Because investment decisions are made based on speculative asset prices, the bubble process triggers the increase in aggregate investment over this period. The difference in dynamics between output and investment is justified by the consumption behavior of agents. Actually, as real interest rates are superior to their steady state value, the substitution and wealth effects overweight the income effect. Thus, the consumption level is below the steady state, but increasing during the boom period. This result is also justified by speculative investments, which induce an increase in prices. The higher inflation contributes to the reduction of consumption.²² As expected, inflation raises as the economy overheats and the central bank's response to these economic developments is an increase in its nominal interest rate. However, even if the value of the interest rate is above steady state, this increase is not sufficient to limit speculative behavior and restrict risk-taking.

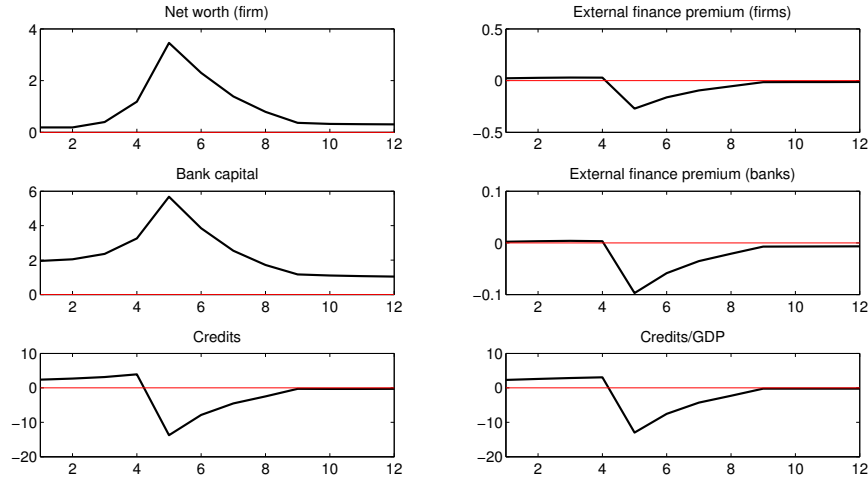
Once the negative shock hits the economy, all these variables plunge. During all this period the monetary authority maintains a low interest rate, trying to fight the decline in inflation and output. The asymmetric behavior of the output gap is again determined by consumption. Investments are drastically reduced, as the market value of capital

²¹ Optimization results are: $\beta_0 = 0.39$, $\beta_\pi = 2.06$ and $\beta_y = 1.20$.

²² Results are not reported here, but consumption stays below the steady state during the boom phase and passes above this value during the bust.



(a)



(b)

Figure 3.2: Dynamics under Rule 1 with optimum coefficients
% deviation from the steady-state

declines in the bust giving agents no incentive to invest despite the small external finance premium.

Turning to credit markets, we notice an overall increase in entrepreneur's net worth during the bubble phase. This is justified by the fact that net worth comes mostly from the accumulation of profits, so the more the entrepreneur advances through the boom phase, the more profits he will gain. Notice also that, because net worth is determined based on results of the previous period, the entrepreneurial net worth reaches its maximum in the fifth period when the negative financial shock occurs.²³ The reaction during the bubble

²³ Net worth is a predetermined variable in the model.

phase is even more pronounced for the bank's net worth. This happens because banks take advantage of the bubble in two ways. First, their credit activity increases, lending more than in normal times. Second, they benefit from a better recovery rate of loans, as entrepreneurs have a higher ability to repay their debt. Moving on to external finance premiums, we see that they initially have a rather constant dynamic. Recall that the external finance premium is a function of the financial position — assets over capital — of both the firm and the bank. Thus, an improvement in net worth should diminish the cost of external finance. However, as investments are now made on market value, their increase basically offsets the positive effect of net worth. Although financial conditions for credits do not improve during the first four periods, there is an increase in credits and in credits over GDP, due to the speculative behavior that generates a more than normal demand for funds. In the fifth quarter the value of assets reduces drastically and, at the same time, the net worth of both banks and entrepreneurs stays high. This determines the decline in external finance premiums.

During the bust phase, net worth starts diminishing and premiums increase slowly from their “floor” values. Despite the low premium (below steady-state value) on external finance, the demand for credits during the bust remains below the steady-state. This is justified by the entrepreneur's lack of incentives to invest. Recall that, even during the bust phase, investments are made on the market price of capital. Since this price diminishes in period 5 and stays below steady state for the next 3 periods, the demand for credit will be low, implying a low cost of financing.²⁴

We next study the reaction of the economy to a more accommodative standard Taylor rule. Our approach is justified by the fact that during the recent bubble, central banks maintained interest rates at a lower level compared to what the Taylor rule would have predicted. The purpose of this exercise is to see how keeping interest rates too low can encourage risk accumulation and increase cycle volatility. We use the same Rule 1, but change the coefficient for β_π to 1.5 (compared to 2.06 at optimum). We present in Figure 3.3 the comparison between the *optimal* Rule 1 (solid line) and the *accommodative* Rule 1 (dashed line).

The impulse response functions show that a monetary authority which is less concerned with stabilizing inflation performs worse on all variables of interest. During the bubble, even if the increase in investments is only marginal, the expansion in output gap is more pronounced, mostly due to consumption effects. Less stabilization is also observed during the bust phase. Moreover, inflation volatility is higher in the accommodative scenario. The last panel of Figure 3.3, shows the difference between the level of credits obtained

²⁴ The model does not include a credit rationing mechanism, so the amount of credit is determined from the equilibrium on the credit market. Moreover, introducing speculative behavior during the bust phase prevents us from fully reproducing the dynamics of the external finance premium, which actually increased during the recent crisis.

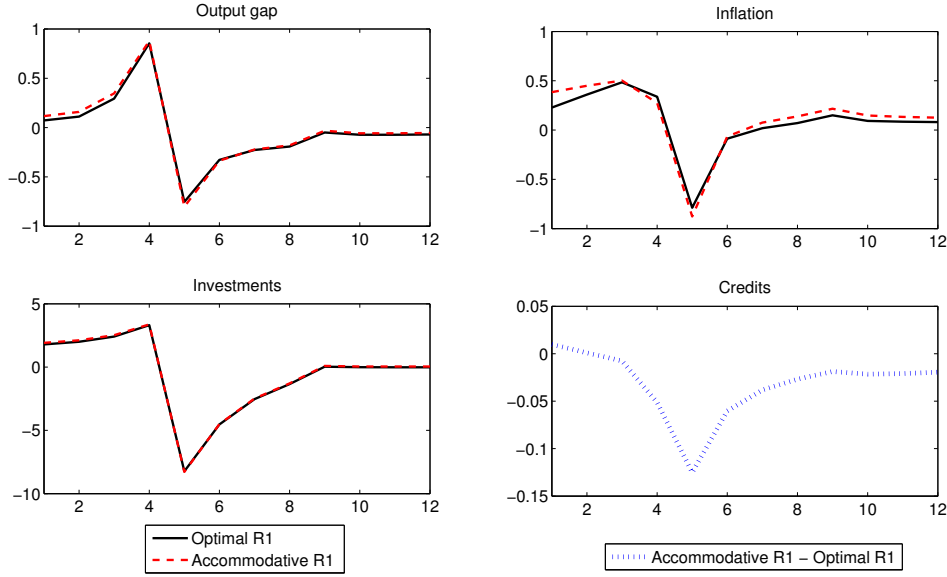


Figure 3.3: Optimal versus Accommodative Rule 1
% deviation from the steady-state

under the accommodative and the optimal rule. During the bubble phase, this difference is positive proving a higher credit expansion when the central bank does not react as much to inflation. Similarly, during the bust phase, credits tend to decrease more under the accommodative rule.

In view of these results, we can safely conclude that a more accommodative monetary policy stance can only worsen the amplitude of cycles and thus encourage the build-up of risk. The following subsection aims at revealing the effects of introducing a financial indicator in the Taylor rule.

3.2.2 Augmented Taylor Rules

We now consider the case of a central bank still endowed with the traditional objectives of output and inflation stability, but which integrates in its monetary policy rule a reaction to credits-to-GDP. The aim is to see how the central bank could intervene to improve the reaction of the economy in case of a financial bubble, by only acting on its main instrument, the interest rate. Two types of comparisons are performed, depending on whether the central bank uses the optimal coefficients or more accommodative ones. The augmented Taylor rule takes the following form:

$$r_t^n = \beta_0 r_{t-1}^n + (1 - \beta_0)(\beta_\pi \pi_t + \beta_y y_t + \beta_{by} by_t) \quad (\text{Rule 2})$$

with by_t the log-deviation of the credit-to-GDP ratio from its steady state. For the first comparison, we place ourselves in the optimal scenario and we compare Rule 1 and

Rule 2 under the optimal parameters for β_0 , β_π and β_y . For β_{by} , we consider first a small reaction, 0.1, which seems reasonable, given that the central bank does not have a financial stability objective and only monitors the evolution of credits in the economy. For robustness concerns, we also analyze the dynamics of our key variables to a more important reaction to β_{by} , 0.5.

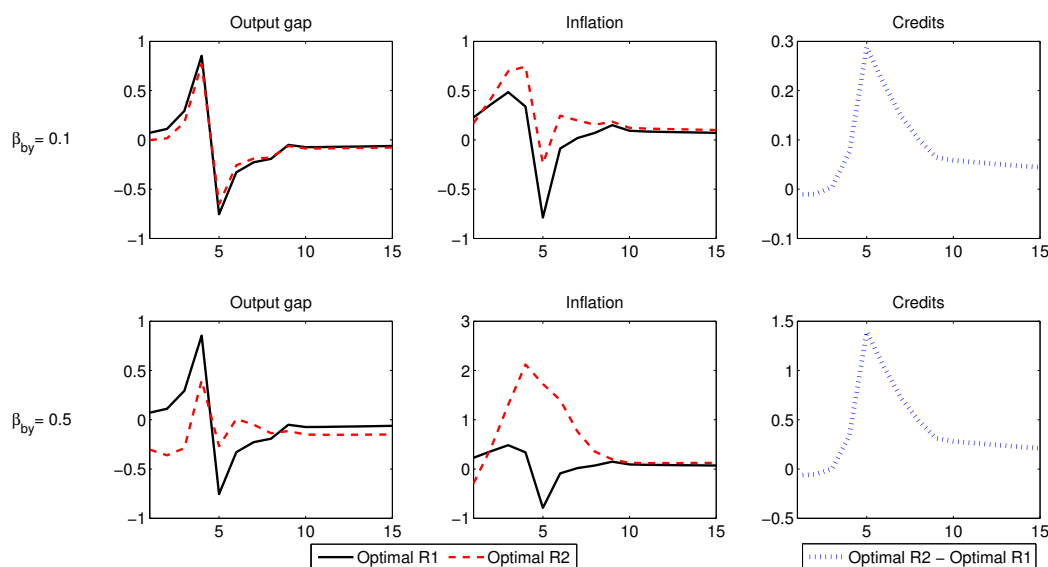


Figure 3.4: Rule 1 versus Rule 2 (optimal case)
% deviation from the steady-state

In Figure 3.4, the solid line is used to represent the dynamics under the optimal Rule 1, whereas the dashed line stands for the augmented Taylor rule. In the optimal case, a small response to credits-to-GDP has a beneficial effect on output and credit stabilization throughout the boom-bust process. However, the same cannot be asserted for inflation. If in the first periods of the boom, inflation is lower under the augmented Taylor rule, as the bubble continues and grows in value, inflation becomes higher. The bust phase does not improve things with regard to inflation. For a central bank that is more concerned with financial imbalances ($\beta_{by} = 0.5$), relative to one that has no such concerns, the improvements obtained in limiting the output gap and the credit cycles are clear. However, inflation is undoubtedly more volatile. An obvious difference in the IRFs of inflation appears between the upper and lower panel of Figure 3.4. This can be explained by the interaction between demand and supply. Through the same mechanisms as above, a rise in the central bank's interest rate has as effect a greater reduction in aggregate supply than the one in demand, relative to the levels obtained under Rule 1. This triggers the higher inflation rate.

When the central bank decides to lean against the wind, these results conclude to the existence of a trade-off between inflation, on the one hand, and credit and output stabi-

lization, on the other. In this respect, our result is similar to the one of De Grauwe and Gros (2009), who also find this type of trade-off. Therefore, even when the central bank uses optimal coefficients when leaning against the wind, the flexibility of the monetary authority remains limited by the occurrence of this trade-off.

Consider now the case where the central bank is accommodative. Similarly to the first scenario, we compare the dynamics under Rule 1 and Rule 2. Recall that for β_0 and β_y we use optimal values, whereas β_π is fixed to 1.5. We take β_{by} equal to 0.1, thus a small reaction to credit-to-GDP. The results of the comparison are reported in Figure 3.5.

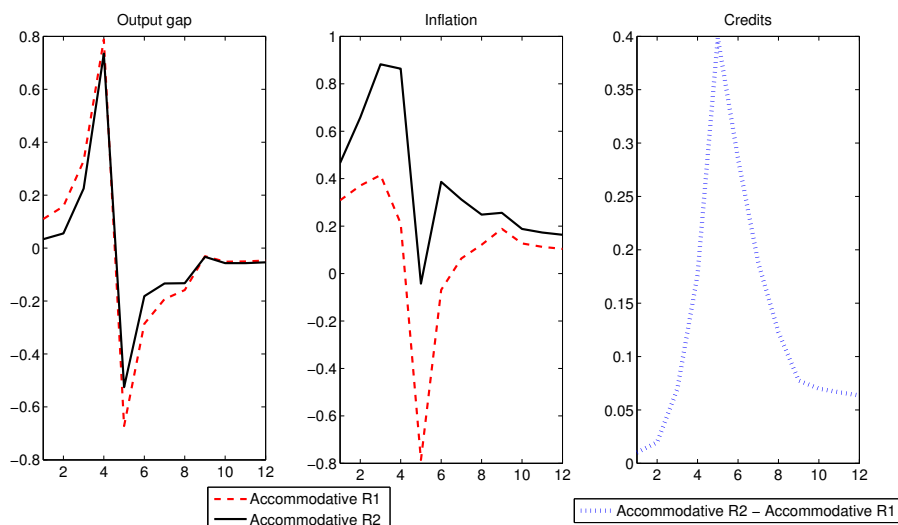


Figure 3.5: Rule 1 versus Rule 2 (accommodative case)
% deviation from the steady-state

The dashed line corresponds to the first rule, whereas the solid line represents the dynamics under Rule 2. We report in Figure 3.5 only the three variables of interest for the monetary authority. When the central bank takes into account credits-to-GDP in setting the interest rate, a higher nominal rate will prevail in the economy. However, this rate will not achieve its objectives. The output gap is the only variable that is better stabilized, not only in the boom phase, but during the bust as well. Nevertheless, the stability of output does not come from good fundamentals. By rising its interest rate, the central bank fails to discourage speculative investors. Actually, higher interest rates attract only risky agents (Stiglitz and Weiss, 1981). Therefore, productive investments are reduced (but still increasing) compared with the case where the central bank reacts only to inflation and output deviations. Less investments translate in a lower supply. Moreover, consumption is also reduced compared to its level under Rule 1, due to the real interest rate. Lower consumption and investments affect aggregate demand. As a consequence, a relative reduction in output is obtained, but with the cost of a more

volatile inflation, as the demand decreases less than the supply does, compared with Rule 1 levels. Rule 2 brings about a higher inflation relative to Rule 1.

The last panel gives the difference between the levels of credits under the second and the first rule. As the difference is always positive, the stability of credits is better preserved under Rule 1 during the bubble, and under Rule 2 throughout the bust. Knowing that the increase in the credit-to-GDP ratio is due to a larger increase in credits as compared to the one in GDP, we can conclude that more risky credits are distributed to the economy in this scenario. Therefore, had the accommodative central bank chosen to lean against the wind before the crisis, we would have been confronted, once the bubble burst, to a potentially worse economic outcome, with more credits defaulting. All in all, Rule 2, in its accommodative form, performs worse than Rule 1, leading us to the conclusion that leaning against the wind is not always a good idea. This depends on the aggressiveness of the monetary policy as we have seen in the optimal case.

In view of the analyses performed thus far, we believe that using a financial risk indicator when setting the interest rate, does not necessarily mean a better outcome for the economy as a whole. Hence, an accommodative central bank would thus not have improved the economic situation, if it had reacted to the credit-to-GDP ratio before the crisis. Instead, it would have obtained lower economic growth (the GDP is always better stabilized) and this without achieving price or financial stability. Without a doubt, the interest rate that integrates a response to credit-to-GDP is not the most adequate instrument for limiting risk-taking (admitting that credit expansion is accompanied by risk-taking). Therefore, a central bank that still takes interest in a macroprudential objective needs to explore other options at hand to see how it can improve economic dynamics. Another possibility is to integrate the credit-to-GDP ratio in the central bank's loss function, thus financial stability becomes an openly declared objective.

3.2.3 Optimization of the Central Bank's Behavior

In this subsection, we analyze a central bank that has an explicit financial stability objective and optimize its behavior under the standard (Rule 1) and the augmented Taylor rule (Rule 2). The additional objective is adopted by including the variance of the credit-to-GDP ratio into the loss function of the bank. In order to conduct our analysis, we compare results to a benchmark case where the monetary authority has only the traditional objectives of output and inflation stabilization (L_{CB0}). For robustness purposes, two specifications of the loss function are first considered – L_{CB1} which has a 0.3 weight on the financial stability objective and L_{CB2} which puts a higher weight on this objective, 0.35. Given that the purpose of our exercise is to analyze different scenarios and draw policy implications, we do not derive the loss function from the household

utility function. Therefore, in this section, we do not compare the losses issued from these functions, but the variances of each objective.

Although chosen arbitrary, the coefficients in the loss function reasonably assume that the central bank has as main objective inflation stabilization (thus the highest weight), and that output gap stabilization, although important, only comes as a secondary concern (in line with the ECB's objectives). Furthermore, we place a small weight on the financial stability objective as our analysis is an ex-post one and, before the crisis, central banks did not have such explicit concerns.²⁵ Optimal coefficients obtained under these scenarios are given in Table 3.4.

Table 3.4: Optimal response coefficients

	$L_{CB0} = 1.5var(\pi) + var(y)$	$L_{CB1} = 1.5var(\pi) + var(y) + 0.3var(by)$	$L_{CB2} = 1.5var(\pi) + var(y) + 0.35var(by)$
<i>Rule1</i>	$\beta_0 = 0.39, \beta_\pi = 2.06, \beta_y = 1.20$	$\beta_0 = 0.39, \beta_\pi = 3.98, \beta_y = 2.23$	$\beta_0 = 0.39, \beta_\pi = 5.25, \beta_y = 2.92$
<i>Rule2</i>	$\beta_0 = 0.39, \beta_\pi = 2.06, \beta_y = 1.20, \beta_{by} = 0.04$	$\beta_0 = 0.33, \beta_\pi = 3.98, \beta_y = 2.23, \beta_{by} = 0.24$	$\beta_0 = 0.30, \beta_\pi = 5.25, \beta_y = 2.92, \beta_{by} = 0.78$

Note: The table presents the coefficients obtained from the optimization of the three loss functions (for each of the two interest rate rules).

Under both Rule 1 and Rule 2, a central bank that intends to stabilize credit cycles, besides its traditional objectives, has to be more aggressive to both inflation and output gap. When considering the augmented Taylor rule, we can also see a more aggressive reaction to credits-to-GDP compared to the benchmark case. As during the recent crisis the central bank was blamed for keeping rates too low for too long, this aggressiveness can be seen as a way of fighting against the risk-taking channel in the future, should the central bank take charge of the macroprudential objective. By using higher coefficients for its response function, the monetary authority reduces risk incentives, thus diminishes the danger of risk accumulation. The following figure reinforces these arguments.

Figure 3.6 presents the evolution of reference variables when the central bank minimizes L_{CB0} compared to the results obtained when optimizing the second and third loss function, L_{CB1} and L_{CB2} , respectively. For all three functions, the standard Taylor rule was used. The higher the importance given to the financial stability objective, the higher the coefficients used by the monetary authority in the interest rate rule and the better the inflation and output stability will be. In addition, the credit cycle is attenuated both in the boom and bust side, proving the benefits of a more aggressive monetary policy.

Simulations show that the higher the coefficient associated with the macroprudential objective, the better the credit cycle reacts. Importantly, this figure reveals no arbitrage between the price and financial stability objectives. By using a loss function like L_{CB1} or L_{CB2} , the central bank performs better in stabilizing both inflation and credit cycles.

²⁵ Moreover, from a technical point of view, we are limited in the choice of β_{by} because values higher than 0.35 no longer lead to consistent coefficients for the standard Taylor rule.

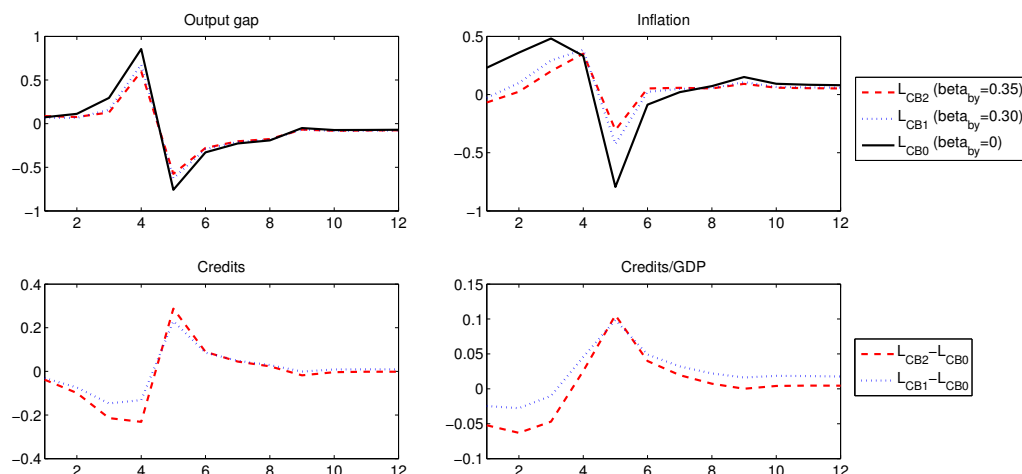


Figure 3.6: Dynamics under L_{CB0} , L_{CB1} and L_{CB2}
% deviation from the steady-state

Compared to the situation in which the macroprudential objective is addressed only with the interest rate rule, the use of the loss function for this purpose seems a better solution for the central bank.

In what follows, we engage in a comparison of variances in order to determine under which scenario the central bank performs best. In Table 3.5, we present the changes in variance for the case when a standard Taylor rule is used.

Table 3.5: Changes in variance under the standard Taylor rule

L_{CB0}	L_{CB1}	L_{CB2}
Reference case	$\sigma_{\pi_1}^2 = 39.47\%$	$\sigma_{\pi_2}^2 = 25.44\%$
	$\sigma_{y_1}^2 = 67.70\%$	$\sigma_{y_2}^2 = 50.44\%$
Normalized to 100%	$\sigma_{b_1}^2 = 96.65\%$	$\sigma_{b_2}^2 = 95.77\%$
	$\sigma_{by_1}^2 = 98.57\%$	$\sigma_{by_2}^2 = 98.45\%$

Note: Variances in the table are computed with respect to the reference case.

The specification of the loss function L_{CB2} clearly yields the best results in terms of cycle reduction as compared to both other specifications. This means that, as long as the social loss function is defined on these nominal, real and/or financial variables, the variance would be minimal under L_{CB2} , which will implicitly translate in a lower loss. However, the improvement in the stabilization of financial variables remains limited under L_{CB1} and L_{CB2} compared to the reference case. This improvement is more pronounced during the bubble phase and the first period of bust as it can also be seen in Figure 3.6. The central bank having a financial stability objective, but acting on the standard Taylor rule, has, however, a limited scope of action in terms of aggressiveness to output

and inflation. The limitation comes from the fact that the monetary authority cannot indefinitely increase the coefficients in the reaction function when the financial stability objective becomes more important. Actually, a coefficient of 0.35 given to the financial stability objective in the loss function represents a threshold in our model, beyond which the optimization no longer leads to results consistent with the requirements prescribed by the monetary policy rule.

We turn now to the case where the augmented Taylor rule is used when minimizing the loss function of the central bank. For clarity reasons, the reference with respect to which variances are computed remains the case of a traditional central bank (standard Taylor rule and traditional objectives). Results for this case are presented in Table 3.6.

Table 3.6: Changes in variance under the augmented Taylor rule (1)

L_{CB0}	L_{CB1}	L_{CB2}
$\sigma_{\pi}^2 = 100\%$	$\sigma_{\pi_1}^2 = 98.24\%$	$\sigma_{\pi_2}^2 = 93.04\%$
$\sigma_y^2 = 90.98\%$	$\sigma_{y_1}^2 = 39.78\%$	$\sigma_{y_2}^2 = 27.36\%$
$\sigma_b^2 = 98.50\%$	$\sigma_{b_1}^2 = 90.89\%$	$\sigma_{b_2}^2 = 90\%$
$\sigma_{by}^2 = 99.16\%$	$\sigma_{by_1}^2 = 95.85\%$	$\sigma_{by_2}^2 = 95.85\%$

Note: Variances in the table are computed with respect to the reference case.

Compared to the results of the previous table, introducing credit/GDP into the monetary policy rule, allows the central bank to reduce the cycles of financial variables, but at the same time, increases the variability in inflation. This situation illustrates well the idea of a trade-off between these two objectives. The output gap is far better stabilized when the augmented Taylor rule is used by the central bank. A higher interest rate, as a reaction to both output and credits-to-GDP, limits the expansion of credits in the economy, therefore investments and output are reduced. Moreover, the effect on output is also triggered by the adjustment in consumption which depends mainly on the dynamics of the real interest rate in the economy. As investment decisions are taken based on speculative prices, credits are less reactive than the output gap to the higher interest rate, which reflects both the lower performance on stabilizing credits-to-GDP compared to credits and the poorer stabilization of credits-to-GDP under L_{CB1} compared to L_{CB0} .

The analysis of the variances in Table 3.6 shows that including credits-to-GDP in the monetary policy rule allows for a better stabilization of real economic activity. Moreover, there is a gain in terms of financial variables' stabilization, but it remains very limited if the central bank uses (only) the interest rate as an instrument for financial stabilization. However, all this comes at the expense of inflation stabilization, which remains nevertheless the main objective of a central bank. The higher the response of the interest rate to

financial variables, the greater the loss in terms of price stability. Therefore, the effects of the monetary policy can be potentially harmful to social welfare.

Indeed, under the augmented Taylor rule, as the central bank becomes more concerned with the financial stability objective by giving it a more significant weight (more than 0.35 in our model), the interest rate becomes implicitly more reactive to the credit-to-GDP ratio.²⁶ To illustrate this situation, Table 3.7 presents the optimization results obtained by using different coefficients (greater than 0.35) for the financial stability objective.

Table 3.7: Changes in variance under the augmented Taylor rule (2)

$L_{CB3} = 1.5var(\pi) + var(y) + 0.5var(by)$	$L_{CB4} = 1.5var(\pi) + var(y) + var(by)$
$\beta_0 = 0.31, \beta_\pi = 3.98, \beta_y = 2.24, \beta_{by} = 0.35$	$\beta_0 = 0.27, \beta_\pi = 5.23, \beta_y = 2.94, \beta_{by} = 0.78$
$\sigma_{\pi_1}^2 = 169\%$	$\sigma_{\pi_2}^2 = 414.28\%$
$\sigma_{y_1}^2 = 33.28\%$	$\sigma_{y_2}^2 = 21.30\%$
$\sigma_{b_1}^2 = 88.66\%$	$\sigma_{b_2}^2 = 83\%$
$\sigma_{by_1}^2 = 94.80\%$	$\sigma_{by_2}^2 = 92.61\%$

Note: Variances in the table are computed with respect to the reference case. The coefficients for the financial stability objective are higher than in Table 3.6, meaning that this objective plays a more important role in the preferences of the central bank.

The analysis of the variance for the different variables in Table 3.7 shows that when the central bank puts more weight on financial stability, inflation volatility becomes much higher. This is justified by the fact that the increase in the nominal rate affects output, creating a deficit of supply over the demand for goods and services, with the effect of rising prices (see also the discussion in the previous subsection).

Bearing in mind the results of this analysis, we conclude that, in order to avoid the trade-off between inflation and financial stability, the central bank should maintain price stability by using the nominal interest rate and find other instruments for properly addressing the financial stability objective.

3.3 Conclusions

The recent crisis revealed flaws in both monetary and financial regulation, which led to excessive risk-taking. In this chapter, given the fact that we engage in an ex-post analysis, we consider that the only eligible authority that could have reacted to financial risk before the crisis was the central bank. With this in mind, we restrict the definition of the financial stability objective to maintaining a stable credit cycle. Adding a financial stability objective without giving the central bank a new instrument leaves little choice in terms of actions. We take into consideration two possibilities. First, the monetary

²⁶ This is in line with the results obtained by Agenor et al. (2013): “The greater the degree of interest rate smoothing, and the stronger the policy-maker’s concern with macroeconomic stability, the larger is the sensitivity of the regulatory rule to credit growth gaps.”

authority uses the interest rate rule to mitigate credit development and thus, risk-taking. The second and last option for the central bank is to integrate the credit-to-GDP indicator directly into its loss function.

Before the crisis, monetary policy was considered as being accommodating (see also Chapter 1). Under this hypothesis, a first result of our analysis shows that the reaction of the central bank to the chosen financial indicator, would have only reduced economic growth, without being able to limit the expansion of speculative credit. Moreover, leaning against the wind, even when the central bank behaves in an optimal way, does not necessarily lead to better performances. The flexibility of the central bank is limited in this case by the trade-off between stabilizing inflation and credit cycles, questioning the possibility of using an augmented Taylor rule for the purpose of maintaining financial stability. This conclusion is reinforced by the analysis of the case when the central bank explicitly declares a financial stability objective. The optimal behavior is obtained by using higher coefficients on both inflation and output in the standard Taylor rule. However, this behavior leads only to a small improvement in credit cycles. Higher coefficients should also be used when the central bank applies an augmented Taylor rule. The problem in this case is nonetheless, the occurrence of the trade-off. Although the “aggressiveness” of the monetary policy stance has the virtue of limiting the effects of the risk-taking channel, its benefits remain limited, first because coefficients cannot be raised indefinitely, and second, because the financial stability objective has to have a rather small weight in the loss function in order to avoid trade-offs.

To conclude, the study conducted in this chapter shows that leaning against the wind is not the best way to address financial instability in a framework where only the interest rate rule is used. We believe that an additional objective for the monetary authority, like the one of financial stability, should not be responded to with the same instrument, the nominal interest rate. This joins Tinbergen’s rule result which states that in order for economic policy to be effective, the number of instruments used must be equal to the number of objectives pursued. Our results could also explain the reluctance of some central banks to embrace a new objective: the appearance of a trade-off could penalize their main objective of price stability.

Further analysis is needed to see if the trade-off still appears when a new dedicated instrument is added. Therefore, we do not exclude the fact that, even when a macroprudential regulator has the main task of maintaining financial stability, monetary policy can still play a role in attaining this objective as well. This should be the case, especially because of its impact on risk as implied by the risk-taking channel, but also because an unstable financial environment could harm the inflation objective of the central bank.

Of course, this could demand coordination between the two authorities given that their objectives would be connected.

Moreover, massive institutional restructuring would be needed to include the financial stability objective among the duties of central banks. Since the outbreak of the financial crisis, several institutions have been created all over the world to address systemic risk. In the euro area, the European Systemic Risk Board is intended to deal with risk surveillance and issue recommendation for national authorities. Changes are also underway at several central banks, like the ECB or the Bank of England. The aim of these changes is to ultimately give central banks more power with respect to safeguarding financial stability.

The conclusions of this analysis open the way to future research. More precisely, as the interest rate is not an adequate instrument for the central bank to deal with financial stability, other instruments should be proposed and their effectiveness should be studied. Using again the propositions of the Basel III agreement (BIS, 2011), we believe that capital requirements or more precisely, the counter-cyclical buffer, can be used as a macroprudential instrument. This would help introduce a credit rationing mechanism in the model, as well as limit risk incentives. Another instrument that gained attention lately is the loan to value ratio (LTV), as the subprime bubble mainly came from house prices. In this respect, the model can be extended to include a housing sector and therefore, the LTV would help limit credit demand from households wanting to buy houses. We also acknowledge the fact that having an exogenous bubble may influence results and at the same time limit the scope of the analysis. Giving up rational expectations about price formation and introducing an endogenous mechanism to govern the bubble process would surely make the analysis more realistic. The interaction between monetary policy and macroprudential regulation is also a topic that needs more attention. These interactions are usually studied by means of DSGE models and we believe that the framework developed in this chapter is particularly suitable for this exercise as it includes several financial frictions and the possibility for risk to accumulate through the bubble process.

The scope of the next chapter is to deal with some of the above concerns by using a simplified theoretical framework. We therefore take interest in the emergence of trade-offs when an endogenous bubble is considered, both in the absence and in the presence of macroprudential regulation.

3.4 Appendix

A. Optimal contracts on the credit market

The aim of this appendix is to explain how the partial equilibrium is obtained on the credit market. To this end, we present and solve the optimizing programs of entrepreneurs, banks as creditors of entrepreneurs and households as creditors of banks.

Expected profits for the participants to the credit market

As mentioned in the main text, the return of the entrepreneurs is affected by an idiosyncratic risk, represented by a random variable $\omega \in [0, \infty]$ that follows a log-normal distribution with mean $\left(-\frac{\sigma^2}{2}\right)$ and variance σ^2 . This corresponds to a unit expected value for the random variable ω : $E(\omega) = 1$. Moreover, the cumulative distribution function is $F(x) = Pr(\omega < x) = \int_0^x f(\omega)d\omega$, where $F(0) = 0$ and $f(\omega)$ represents the density function associated to ω .

We define two threshold values for ω , issued from the optimal debt contract between the entrepreneur and the bank: (i) $\bar{\omega}^f$ which defines the default threshold for the entrepreneur, and (ii) $\bar{\omega}^b < \bar{\omega}^f$ which depicts the default threshold for the bank, given the risk of its credit portfolio.

As in Bernanke et al. (1999), we consider the following notations for all $\bar{\omega} \in \{\bar{\omega}^f, \bar{\omega}^b\}$:

$$\Gamma(\bar{\omega}) = \int_0^{\bar{\omega}} \omega f(\omega)d\omega + [1 - F(\bar{\omega})]\bar{\omega}, \quad (3.45)$$

with $\Gamma'(\bar{\omega}) = 1 - F(\bar{\omega}) > 0$ and $\Gamma''(\bar{\omega}) = -f(\bar{\omega}) < 0$.

$$G(\bar{\omega}) = \int_0^{\bar{\omega}} \omega f(\omega)d\omega, \quad (3.46)$$

with $G'(\bar{\omega}) = \bar{\omega}f(\bar{\omega}) > 0$.

Expected profit for the entrepreneur

The entrepreneur defaults on his credit if $\omega^f < \bar{\omega}^f$. $[1 - F(\bar{\omega}^f)]$ represents therefore the probability for the entrepreneur to be successful on his project. $\Gamma(\bar{\omega}^f)$ correspond to the gross part of the entrepreneur's earnings that is used to reimburse the banker: $\bar{\omega}^f$ if the realized return of the entrepreneur is sufficient to repay the debt to the bank or ω if the entrepreneur defaults (all his revenues are recovered by the bank during the costly monitoring procedure).

The entrepreneur's objective is to maximize his expected profit for each period (defined as earnings after the repayment of the banker). Using the fact that $R_{t+1}^B B_t = \bar{\omega}_{t+1}^f R_{t+1}^K Q_t K_{t+1}$, the expected profit becomes:

$$\Pi_{f,t+1}^e = E_t \left\{ \int_{\bar{\omega}_{t+1}^f}^{\infty} [\omega_{t+1} R_{t+1}^K Q_t K_{t+1} - R_{t+1}^B B_{t+1}] f(\omega_{t+1}) d\omega_{t+1} \right\} \quad (3.47)$$

$$= E_t \left\{ R_{t+1}^K Q_t K_{t+1} \int_{\bar{\omega}_{t+1}^f}^{\infty} [\omega_{t+1} - \bar{\omega}_{t+1}^f] f(\omega_{t+1}) d\omega_{t+1} \right\}, \quad (3.48)$$

where $\int_{\bar{\omega}_{t+1}^f}^{\infty} [\omega_{t+1} - \bar{\omega}_{t+1}^f] f(\omega_{t+1}) d\omega_{t+1}$ can be replaced by $\int_{\bar{\omega}_{t+1}^f}^{\infty} \omega_{t+1} f(\omega_{t+1}) d\omega_{t+1} - \int_{\bar{\omega}_{t+1}^f}^{\infty} \bar{\omega}_{t+1}^f f(\omega_{t+1}) d\omega_{t+1}$.

Or, the second term of this expression is $[1 - F(\bar{\omega}_{t+1}^f)] \bar{\omega}_{t+1}^f$, while the first one can be decomposed in $\int_0^{\infty} \omega_{t+1} f(\omega_{t+1}) d\omega_{t+1} - \int_0^{\bar{\omega}_{t+1}^f} \omega_{t+1} f(\omega_{t+1}) d\omega_{t+1}$, with $\int_0^{\infty} \omega_{t+1} f(\omega_{t+1}) d\omega_{t+1} = E(\omega_{t+1}) = 1$.

Taking into account these elements, the expression of the expected profit of the entrepreneur for the period $t + 1$ becomes:

$$\Pi_{t+1}^e = E_t \{ [1 - \Gamma(\bar{\omega}_{t+1}^f)] Q_t K_{t+1} R_{t+1}^K \}. \quad (3.49)$$

Expected profit for the banker

The expected profits of the banker are essential in justifying the bank's participation to the financial contract. Profits are computed as the difference between the expected return on the lending activity and the repayment (principal and interest) of the creditor, *i.e.* the household. Given that $\bar{\omega}_{t+1}^b < \bar{\omega}_{t+1}^f$, we can express the expected profit of the financial intermediary as follows:

$$\begin{aligned} \Pi_{b1,t+1}^e = E_t \left\{ \int_{\bar{\omega}_{t+1}^b}^{\bar{\omega}_{t+1}^f} [(1 - \mu^b) \omega_{t+1} R_{t+1}^K Q_t K_{t+1} - R_{t+1}^A A_{t+1}] f(\omega_{t+1}) d\omega_{t+1} + \right. \\ \left. [1 - F(\bar{\omega}_{t+1}^f)] [R_{t+1}^B B_{t+1} - R_{t+1}^A A_{t+1}] \right\}. \end{aligned} \quad (3.50)$$

The second term corresponds to the bank's expected earning when its debtor (the entrepreneur) does not go bankrupt and has sufficient resources to repay its entire debt. The

first term depicts the situation when the entrepreneur defaults, but the resources recovered by the bank after the costly monitoring procedure are at least sufficient to repay the household and to avoid the default of the bank. At this stage, we can simplify expression (3.50), by using the aforementioned notations. First of all, we replace $R_t^B B_t$ and $R_{t+1}^A A_t$ by their respective values: $R_t^B B_t = \bar{\omega}_{t+1}^f R_{t+1}^K Q_t K_{t+1}$ and $R_{t+1}^A A_t = (1 - \mu^b) \bar{\omega}_{t+1}^b R_{t+1}^K Q_t K_{t+1}$. The expected profit of the banker, $\Pi_{b1,t+1}^e$ corresponds to a part of the entrepreneur's expected gross return on capital, $R_{t+1}^K Q_t K_{t+1}$. This part depends on ω_{t+1} and is given by:²⁷

$$\int_{\bar{\omega}^b}^{\bar{\omega}^f} [(1 - \mu^b)(\omega - \bar{\omega}^b)] f(\omega) d\omega + [1 - F(\bar{\omega}^f)][\bar{\omega}^f - (1 - \mu^b)\bar{\omega}^b]. \quad (3.51)$$

After expanding this relation, we can rewrite it by grouping the terms as follows:

$$\begin{aligned} \int_0^{\bar{\omega}^f} (1 - \mu^b) \omega f(\omega) d\omega - \int_0^{\bar{\omega}^b} (1 - \mu^b) \omega f(\omega) d\omega - \int_{\bar{\omega}^b}^{\bar{\omega}^f} (1 - \mu^b) \bar{\omega}^b f(\omega) d\omega + [1 - F(\bar{\omega}^f)] \bar{\omega}^f \\ - [1 - F(\bar{\omega}^f)] (1 - \mu^b) \bar{\omega}^b. \end{aligned} \quad (3.52)$$

Adding the first and the fourth terms of this expression, we recognize $\Gamma(\bar{\omega}^f) - \mu^b G(\bar{\omega}^f)$. The second and the fifth terms can be regrouped in $\int_{\bar{\omega}^b}^{\infty} (1 - \mu^b) \bar{\omega}^b f(\omega) d\omega = [1 - F(\bar{\omega}^b)] (1 - \mu^b) \bar{\omega}^b$. After these manipulation, relation (3.51) corresponds to: $\Gamma(\bar{\omega}^f) - \mu^b G(\bar{\omega}^f) - (1 - \mu^b) \left[[1 - F(\bar{\omega}^b)] \bar{\omega}^b - \int_0^{\bar{\omega}^b} \omega f(\omega) d\omega \right]$. Further, this relation can be rewritten as: $\Gamma(\bar{\omega}^f) - \mu^b G(\bar{\omega}^f) - (1 - \mu^b) \Gamma(\bar{\omega}^b)$. Using this result, we can express the expected profit of the bank as:

$$\Pi_{b1,t+1}^e = E_t \left\{ [\Gamma(\bar{\omega}_{t+1}^f) - (1 - \mu^b) \Gamma(\bar{\omega}_{t+1}^b) - \mu^b G(\bar{\omega}_{t+1}^f)] R_{t+1}^K Q_t K_{t+1} \right\}. \quad (3.53)$$

Expected profit for the household

The participation of the household as creditor of the bank essentially depends on his expected earnings from this operation. The bank knows this and will take this into account when determining the terms of the financial contract negotiated with the entrepreneur. The profit of the household expects is:

²⁷ To simplify notations, we ignore hereafter the time index of ω .

$$\Pi_{a1,t+1}^e = E_t \left\{ \int_0^{\bar{\omega}_{t+1}^b} (1 - \mu^a)(1 - \mu^b) \omega_{t+1} R_{t+1}^K Q_t K_{t+1} f(\omega_{t+1}) d\omega_{t+1} + (1 - F(\bar{\omega}_{t+1}^b)) R_{t+1}^A A_{t+1} \right\}. \quad (3.54)$$

If the second term of this expression corresponds to the return on the household investment when the bank is able to entirely repay its debt (so, when there is no bank default), the first term defines the part of the debt recovered by the household from the bank after the costly monitoring procedure. Replacing $R_{t+1}^A A_{t+1}$, the expected profit of the household becomes:

$$E_t \left\{ \int_0^{\bar{\omega}_{t+1}^b} (1 - \mu^a)(1 - \mu^b) \omega_{t+1} R_{t+1}^K Q_t K_{t+1} f(\omega_{t+1}) d\omega_{t+1} + [1 - F(\bar{\omega}_{t+1}^b)] (1 - \mu^b) \bar{\omega}_{t+1}^b R_{t+1}^K Q_t K_{t+1} \right\}.$$

We finally write $[1 - F(\bar{\omega}_{t+1}^b)]$ as a function of $\Gamma(\bar{\omega}_{t+1}^b)$ and $G(\bar{\omega}_{t+1}^b)$ and we obtain the following expression for the expected profit of the representative household:

$$\Pi_{a1,t+1}^e = E_t \{ (1 - \mu^b) [\Gamma(\bar{\omega}_{t+1}^b) - \mu^A G(\bar{\omega}_{t+1}^b)] R_{t+1}^K Q_t K_{t+1} \}. \quad (3.55)$$

External finance premium for entrepreneurs

The terms of the contract between the bank and the entrepreneur and implicitly the external finance premium for the entrepreneur, S_t^f , are obtained from the resolution of an optimization program that seeks to maximize the entrepreneur's expected profit (equation 3.49), subject to the participation condition for the bank, and implicitly for the household. The constraints of the two agents take into account the presence of an opportunity cost of investment, given by the risk free rate. More precisely, the expected return of the bank and of the household should be at least equal to the return obtained if the funds were invested at the risk free rate. The maximizing program is:

$$\begin{aligned} & \text{Maximize}_{k_t, \bar{\omega}_{t+1}^f, \bar{\omega}_{t+1}^b} [1 - \Gamma(\bar{\omega}_{t+1}^f)] S_t^f k_{t+1} \\ & [\Gamma(\bar{\omega}_{t+1}^f) - (1 - \mu^b) \Gamma(\bar{\omega}_{t+1}^b) - \mu^b G(\bar{\omega}_{t+1}^f)] S_t^f k_{t+1} - n b f_t = 0 \\ & (1 - \mu^b) [\Gamma(\bar{\omega}_{t+1}^b) - \mu^A G(\bar{\omega}_{t+1}^b)] S_t^f k_{t+1} - (k_{t+1} - 1) = 0. \end{aligned}$$

where $k_{t+1} = \frac{Q_t K_t}{N_t^f + N_t^b}$, $S_t^f = E_t \left[\frac{R_{t+1}^K}{R_{t+1}^b} \right]$, $nbft = \frac{N_t^b}{N_t^b + N_t^f}$, and we take into account the fact that $Q_t K_{t+1} = N_t^f + N_t^b + A_t$. The solution to this program gives the firm's demand for capital and the value of the thresholds $\bar{\omega}_{t+1}^f$ and $\bar{\omega}_{t+1}^b$. The non-default loan rate associated to the contract between the entrepreneur and the bank (R_{t+1}^B) is then easily obtained from the relation (3.3) in the main text, whereas the gross return for households (R_{t+1}^A) is given by relation (3.5) in the main text.

Let us denote by λ_1 and λ_2 the Lagrange multipliers associated to the two participation constraints present in the maximization program. The first order conditions necessary to solve this optimization program, associated to $\bar{\omega}_{t+1}^f$, $\bar{\omega}_{t+1}^b$, k_{t+1} , λ_1 and λ_2 , are:

$$\bar{\omega}_{t+1}^f : \lambda_1 = \frac{\Gamma'(\bar{\omega}_{t+1}^f)}{\Gamma'(\bar{\omega}_{t+1}^f) - \mu^b G'(\bar{\omega}_{t+1}^f)} \quad (3.56)$$

$$\bar{\omega}_{t+1}^b : \lambda_2 = \frac{\lambda_1 \Gamma'(\bar{\omega}_{t+1}^b)}{\Gamma'(\bar{\omega}_{t+1}^b) - \mu^a G'(\bar{\omega}_{t+1}^b)} \quad (3.57)$$

$$k_{t+1} : S_t^f = \frac{\lambda_2}{1 - \Gamma(\bar{\omega}_{t+1}^f) + [\Gamma(\bar{\omega}_{t+1}^f) - (1 - \mu^b)\Gamma(\bar{\omega}_{t+1}^b) - \mu^b G(\bar{\omega}_{t+1}^f)]\lambda_1 + (1 - \mu^b)[\Gamma(\bar{\omega}_{t+1}^b) - \mu^a G(\bar{\omega}_{t+1}^b)]\lambda_2} \quad (3.58)$$

$$\lambda_1 : [\Gamma(\bar{\omega}_{t+1}^f) - (1 - \mu^b)\Gamma(\bar{\omega}_{t+1}^b) - \mu^b G(\bar{\omega}_{t+1}^f)]S_t^f k_{t+1} = nbft \quad (3.59)$$

$$\lambda_2 : k_{t+1} = -\frac{1}{\{(1 - \mu^b)[\Gamma(\bar{\omega}_{t+1}^b) - \mu^a G(\bar{\omega}_{t+1}^b)]\}S_t^f - 1} \quad (3.60)$$

We then substitute (3.58) in (3.60) to obtain the following form of k_{t+1} :

$$k_{t+1} = 1 + \frac{(1 - \mu^b)[\Gamma(\bar{\omega}_{t+1}^b) - \mu^a G(\bar{\omega}_{t+1}^b)]\lambda_2}{1 - \Gamma(\bar{\omega}_{t+1}^f) + [\Gamma(\bar{\omega}_{t+1}^f) - (1 - \mu^b)\Gamma(\bar{\omega}_{t+1}^b) - \mu^b G(\bar{\omega}_{t+1}^f)]\lambda_1} \quad (3.61)$$

Given the expressions of λ_1 and λ_2 in equations (3.56) and (3.57), we notice that k_{t+1} depends only on the threshold values $\bar{\omega}_{t+1}^f$ and $\bar{\omega}_{t+1}^b$. Moreover, using the notation:

$$\varphi(\bar{\omega}_{t+1}^f, \bar{\omega}_{t+1}^b) = \frac{(1 - \mu^b)[\Gamma(\bar{\omega}_{t+1}^b) - \mu^a G(\bar{\omega}_{t+1}^b)]\lambda_2}{1 - \Gamma(\bar{\omega}_{t+1}^f) + [\Gamma(\bar{\omega}_{t+1}^f) - (1 - \mu^b)\Gamma(\bar{\omega}_{t+1}^b) - \mu^b G(\bar{\omega}_{t+1}^f)]\lambda_1}, \quad (3.62)$$

k_{t+1} simply becomes:

$$k_{t+1} = 1 + \varphi(\bar{\omega}_{t+1}^f, \bar{\omega}_{t+1}^b). \quad (3.63)$$

Relation (3.58) can also be transformed to include the function $\varphi(\bar{\omega}_{t+1}^f, \bar{\omega}_{t+1}^b)$:

$$S_t^f = \frac{1}{1 + [\varphi(\bar{\omega}_{t+1}^f, \bar{\omega}_{t+1}^b)]^{-1}}. \quad (3.64)$$

Since k_{t+1} is an increasing function of $\varphi(\cdot)$ in equation (3.63), we can inverse the relation and thus consider that: $\varphi(\cdot) = \varphi_k(k_{t+1})$, where $\frac{\partial \varphi_k(k_{t+1})}{\partial k_{t+1}} > 0$. Then introduced in (3.64), this relation brings us to an expression which describes the link between k_{t+1} and the external finance premium for the firm:

$$S_t^f = \frac{1}{1 + [\varphi_k(k_{t+1})]^{-1}} g(\bar{\omega}_{t+1}^b), \quad (3.65)$$

where $g(\bar{\omega}_{t+1}^b) = \frac{1}{(1-\mu^b)[\Gamma(\bar{\omega}_{t+1}^b) - \mu^a G(\bar{\omega}_{t+1}^b)]}$. Since $\frac{\partial \varphi_k(k_{t+1})}{\partial k_{t+1}} > 0$, $\varphi_k(k_{t+1}) > 0$ and $g(\bar{\omega}_{t+1}^b) > 0$, we have a positive relation between S_t^f and k_{t+1} :

$$\frac{\partial S_t^f}{\partial k_{t+1}} = \frac{[\varphi_k(k_{t+1})]^{-2}}{[1 + [\varphi_k(k_{t+1})]^{-1}]^2} g(\bar{\omega}_{t+1}^b) \frac{\partial \varphi_k(k_{t+1})}{\partial k_{t+1}} > 0. \quad (3.66)$$

The intuition for the sign of $\varphi_k(k_{t+1})$ and $g(\bar{\omega}_{t+1}^b)$ is provided hereafter. However, since full details about the mathematical proofs were given in [Levieuge \(2003\)](#), [Sunirand \(2002\)](#) or [Faia and Monacelli \(2007\)](#), we will not insist on this point. In order to discuss the sign of $\varphi_k(k_{t+1})$, recall that, using (3.63), $\varphi_k(k_{t+1})$ corresponds to $\varphi(\bar{\omega}_{t+1}^f, \bar{\omega}_{t+1}^b)$ defined in (3.62). In this expression, μ^a and μ^b represent the monitoring costs for households and banks, respectively. These costs are proportional to the value of the evaluated assets and they respect the condition $0 < \mu^a, \mu^b < 1$ (otherwise the auditing would be more expensive than what the agents can recover after verification, and the monitoring would be counterproductive). Looking at equation (3.62), the expression $[\Gamma(\bar{\omega}_{t+1}^b) - \mu^a G(\bar{\omega}_{t+1}^b)]$ represents the part of the bank's gross return going to its creditor (the household). $1 - \Gamma(\bar{\omega}_{t+1}^f)$ is the part of the profit that the entrepreneur can obtain after the repayment of the debt towards the bank, while $\Gamma(\bar{\omega}_{t+1}^f) - (1 - \mu^b)\Gamma(\bar{\omega}_{t+1}^b) - \mu^b G(\bar{\omega}_{t+1}^f)$ gives the part of the revenues from the credit operation going to the bank. Or, to justify the participation of the agents to the financial contract, all these elements must be positive. λ_1 and λ_2 are also positive values. Moreover, $\Gamma'(\bar{\omega}_{t+1}^f) - \mu^b G'(\bar{\omega}_{t+1}^f)$ and $\Gamma'(\bar{\omega}_{t+1}^b) - \mu^a G'(\bar{\omega}_{t+1}^b)$ are also positive (see [Bernanke et al., 1999](#), [Levieuge, 2003](#) or [Sunirand, 2002](#), for more details). In light of these results, it follows that $g(\bar{\omega}_{t+1}^b)$ is positive.

Therefore, the entrepreneur's external finance premium is an increasing function of k_{t+1} as depicted in relation (3.10) in the main text.

External finance premium for banks

The terms of the financial contract between the bank and a representative household, and more particularly, the expression of the external finance premium for banks, are simply obtained by maximizing the expected bank's profit, subject to the household participation constraint. We note here that in the relationship between banks and households, the households analyze the banks' situation by looking at the evolution of the banking market, without having access to other information concerning the credit portfolio of each bank. So, as a lender, a representative household knows that the return of his borrower (the bank) is subject to an idiosyncratic risk that is not observable, denoted ε_{t+1} , where ε_{t+1} is independent from ω_{t+1} . $\varepsilon_{t+1} \in [0, \infty)$ is a random variable and follows a log-normal distribution. Its expected value is 1 ($E(\varepsilon) = 1$) and it has a cumulative distribution function $F(x) = \int_0^x f(\varepsilon)d\varepsilon$, with $F(0) = 0$. A threshold value $\bar{\varepsilon}_{t+1}$ is determined by the debt relationship between the bank and the household. This threshold satisfies the following condition (see also the main text):

$$\bar{\varepsilon}_{t+1} R_{t+1}^B B_t = R_{t+1}^A A_t. \quad (3.67)$$

Using the notations: $\Gamma(\bar{\varepsilon}_{t+1}) = \int_0^{\bar{\varepsilon}_{t+1}} \varepsilon_{t+1} f(\varepsilon) d\varepsilon + [1 - F(\bar{\varepsilon}_{t+1})]\bar{\varepsilon}_{t+1}$ and $G(\bar{\varepsilon}_{t+1}) = \int_0^{\bar{\varepsilon}_{t+1}} \varepsilon_{t+1} f(\varepsilon) d\varepsilon$, in a similar logic to the first part of this appendix, the optimization program becomes:

$$\begin{aligned} & \text{Maximize}_{B_t, \bar{\varepsilon}_{t+1}} E_t[1 - \Gamma(\bar{\varepsilon}_{t+1})] R_{t+1}^B B_t \\ & E_t[\Gamma(\bar{\varepsilon}_{t+1}) - \mu^A G(\bar{\varepsilon}_{t+1})] R_{t+1}^b B_t = R_{t+1} (Q_t K_{t+1} - N_t^f - N_t^b). \end{aligned}$$

We then denote by $k_{t+1}^b = \frac{B_t}{N_t^b}$ the ratio of loans over bank capital and by $S_t^b = \frac{R_{t+1}^B}{R_{t+1}^A}$ the bank's external finance premium. The previous optimization program takes the form:

$$\begin{aligned} & \text{Maximize}_{B_t, \bar{\varepsilon}_{t+1}} E_t[1 - \Gamma(\bar{\varepsilon}_{t+1})] S_t^B k_{t+1}^b \\ & E_t[\Gamma(\bar{\varepsilon}_{t+1}) - \mu^A G(\bar{\varepsilon}_{t+1})] S_t^B k_{t+1}^b = k_{t+1}^b - 1. \end{aligned}$$

The first order conditions that must be satisfied in order to optimize this program, with respect to $\bar{\varepsilon}_{t+1}$, k_{t+1}^b and λ_{t+1} (the Lagrange multiplier associated to the constraint), are:

$$\bar{\varepsilon}_{t+1} : \lambda_{t+1} = \frac{\Gamma'(\bar{\varepsilon}_{t+1})}{\Gamma'(\bar{\varepsilon}_{t+1}) - \mu^A G'(\bar{\varepsilon}_{t+1})} \quad (3.68)$$

$$k_{t+1}^b : S_t^b = \frac{\lambda}{1 - \Gamma(\bar{\varepsilon}_{t+1}) + [\Gamma(\bar{\varepsilon}_{t+1}) - \mu^A G(\bar{\varepsilon}_{t+1})]\lambda} \quad (3.69)$$

$$\lambda : k_{t+1}^b = 1 + \lambda \frac{\Gamma(\bar{\varepsilon}_{t+1}) - \mu^a G(\bar{\varepsilon}_{t+1})}{1 - \Gamma(\bar{\varepsilon}_{t+1})} \quad (3.70)$$

The computation of the derivatives of these three FOC shows that $\lambda_{t+1} = \lambda(\bar{\varepsilon}_{t+1})k_{t+1}^b = \varphi_{k^b}(\bar{\varepsilon}_{t+1})$ and $S_t^b = \varphi_{S^b}(\bar{\varepsilon}_{t+1})$ are all increasing functions of $\bar{\varepsilon}_{t+1}$ and that $\varphi_{k^b}(\cdot)$ and $\varphi_{S^b}(\cdot)$ are invertible functions.²⁸ We thus obtain $\bar{\varepsilon}_{t+1} = \varphi_{k^b}^{-1}(k_{t+1}^b)$ which positively depends on k_{t+1}^b . Introducing $\bar{\varepsilon}_{t+1}$ in the expression of the bank external finance premium, we find the following composed function:

$$S_t^b = \varphi_{S^b}(\bar{\varepsilon}_{t+1}) = \varphi_{S^b}(\varphi_{k^b}^{-1}(k_{t+1}^b)), \quad (3.71)$$

with $\frac{\partial S_t^b}{\partial k_{t+1}^b} = \frac{\partial \varphi_{S^b}(\bar{\varepsilon}_{t+1})}{\partial \bar{\varepsilon}_{t+1}} \frac{\partial \bar{\varepsilon}_{t+1}}{\partial k_{t+1}^b} > 0$.

This expression corresponds to equation (3.15) in the main text: $S_t^b = \Psi^b[k_{t+1}^b]$, where $\frac{\partial \Psi^b(\cdot)}{\partial k_{t+1}^b} > 0$, for $\Psi^b(\cdot) = \varphi_{S^b} \circ \varphi_{k^b}^{-1}(\cdot)$.

We have thus proven the inverse relation between the cost of external finance for banks and their financial health. For banks with a lower ratio of bank capital over loans, the external finance premium will be higher than for other more capitalized banks.

B. Retailers' maximization program and the Phillips Curve²⁹

Retailers are introduced in the model in order to allow for price rigidity. There is a continuum of retailers belonging to the interval $[0, 1]$ who conduct their activity in a monopolistic market. At each time t , a representative retailer j , buys final goods from the production sector at a price $\frac{1}{\mu_t}P_t$, differentiates them at no cost and sells them afterwards on the retail market at price P_t . μ_t represents the markup for the retailer. We denote by $\rho_t = \frac{1}{\mu_t}$ the real marginal cost of the retailer.

The supply of goods in the economy corresponds to the total production Y_t , therefore we can express the CES composite index of wholesale goods and the aggregate price index of these goods as follows:

$$Y_t = \left[\int_0^1 Y_t(j)^{\frac{\varepsilon-1}{\varepsilon}} dj \right]^{\frac{\varepsilon}{\varepsilon-1}} \quad \text{and} \quad P_t = \left[\int_0^1 P_t(j)^{1-\varepsilon} dj \right]^{\frac{1}{1-\varepsilon}}, \quad (3.72)$$

where ε represents the elasticity of substitution between the differentiated goods. As in Calvo (1983), a retailer has a probability θ to change the price in a given period. Therefore, at each period, a part $(1 - \theta)$ of the retailers does not adjust the price. Taking this reasoning into account, we can express the aggregate price dynamics as being a

²⁸ See Leveuge (2003) for more details on these characteristics.

²⁹ The proof provided here is similar to the one found in Badarau (2009).

weighted average of prices set by firms that reoptimize and prices from the previous period kept constant by non-reoptimizing firms:

$$P_t = \left[\theta P_{t-1}^{1-\varepsilon} + (1-\theta) \tilde{P}_t^{1-\varepsilon} \right]^{\frac{1}{1-\varepsilon}} \quad (3.73)$$

To determine prices for the next period ($\tilde{P}_t$), the fraction $(1-\theta)$ of retailers that is allowed to reset prices, maximizes the discounted future value of dividends. As dividends come from profits and each retailer faces an iso-elastic demand for his goods, the maximization problem can be written as:

$$\begin{aligned} & \text{Maximize } E_t \sum_{k=0}^{\infty} (\theta)^k \lambda_{t,t+k} \left[\tilde{P}_t(j) - \frac{1}{\mu_{t+k}} P_{t+k} \right] \\ & s.t. \quad Y_{t+k}(j) = \left(\frac{\tilde{P}_t(j)}{P_{t+k}} \right)^{-\varepsilon} C_{t+k}, \end{aligned}$$

where $\lambda_{t,t+k}$ is the real discounted dividend distribution rate and $\tilde{P}_t(j)$ is the adjusted price level of a representative retailer j . The constraint of the retail firm is nothing less than the demand for retail goods. To solve the maximization program, we first substitute $Y_{t+k}(j)$ in the objective function with the value given by the constraint. In equilibrium, the first order condition with respect to the price level $\tilde{P}_t(j)$ must be respected. Therefore:

$$E_t \sum_{k=0}^{\infty} (\theta)^k \lambda_{t,t+k} \left[Y_{t+k}(j) + \frac{\tilde{P}_t(j) - \rho_{t+k} P_{t+k}}{P_{t+k}} (-\varepsilon) \left(\frac{\tilde{P}_t(j)}{P_{t+k}} \right)^{-\varepsilon-1} C_{t+k} \right] = 0. \quad (3.74)$$

Expressing the constraint in an equivalent way, $Y_{t+k}(j) \left(\frac{\tilde{P}_t(j)}{P_{t+k}} \right)^{-1} = \left(\frac{\tilde{P}_t(j)}{P_{t+k}} \right)^{-\varepsilon-1} C_{t+k}$, we can simplify the FOC as follows:

$$E_t \sum_{k=0}^{\infty} (\theta)^k \lambda_{t,t+k} \left[Y_{t+k}(j) \left(1 - \varepsilon + \varepsilon \frac{\rho_{t+k}}{\tilde{P}_t(j)} \right) \right] = 0.$$

Multiplying this expression by $\frac{\tilde{P}_t(j)}{1-\varepsilon}$, we obtain:

$$E_t \sum_{k=0}^{\infty} (\theta)^k \lambda_{t,t+k} \left[Y_{t+k}(j) \left(\tilde{P}_t(j) - \frac{\varepsilon}{\varepsilon-1} \rho_{t+k} P_{t+k} \right) \right] = 0. \quad (3.75)$$

Equation (3.75) simply expresses the fact that retailers add a markup rate equal to $\frac{\varepsilon}{\varepsilon-1}$ to the future real marginal costs, ρ_{t+k} . We can further express equation (3.75) as a function of the evolution of prices. To this end, we replace $\lambda_{t,t+k}$ by the expression in equation (3.76). The term $\lambda_{t,t+k}$ represents the real discount rate of future dividends for the period $t+k$. The value of $\lambda_{t,t+k}$ is determined from the first order conditions of the representative household. As households are the owners of retailers and given that all

profits from the retail activity go to the owners, the non-discounted nominal dividend distribution rate is equal to one in each period of time. From equations (3.22) and (3.23), the real discounted value of this rate is given by $\frac{1}{R_{t+1}} = \beta \left(\frac{C_{t+1}}{C_t} \right)^{-\frac{1}{\sigma_c}} \frac{P_t}{P_{t+1}}$. We can remark that the real discount rate is influenced by both the household subjective discount factor β and the price evolution. Given that we are in an infinite periods framework, the real discounted value of the dividend distribution rate over several periods becomes:

$$\lambda_{t,t+k} = \beta^k \left(\frac{C_{t+k}}{C_t} \right)^{-\frac{1}{\sigma_c}} \frac{P_t}{P_{t+k}}. \quad (3.76)$$

Substituting this value in equation (3.75), we obtain:

$$\mathbb{E}_t \sum_{k=0}^{\infty} (\theta\beta)^k \left[\left(\frac{C_{t+k}}{C_t} \right)^{-\frac{1}{\sigma_c}} \frac{P_t}{P_{t+k}} Y_{t+k}(j) \left(\tilde{P}_t(j) - \frac{\varepsilon}{\varepsilon - 1} \rho_{t+k} P_{t+k} \right) \right] = 0. \quad (3.77)$$

By dividing the previous relation by P_{t-1} , we can express equation (3.77) as a function of inflation:

$$(C_t)^{\frac{1}{\sigma_c}} \mathbb{E}_t \sum_{k=0}^{\infty} (\theta\beta)^k \left[(C_{t+k})^{-\frac{1}{\sigma_c}} \frac{P_{t-1}}{P_{t+k}} Y_{t+k}(j) \left(\frac{\tilde{P}_t(j)}{P_{t-1}} - \frac{\varepsilon}{\varepsilon - 1} \rho_{t+k} \frac{P_{t+k}}{P_{t-1}} \right) \right] = 0. \quad (3.78)$$

In the last part of expression (3.78), we recognize the real marginal cost of period $t + k$, ρ_{t+k} , and the inflation rate between periods $t - 1$ and $t + k$, $\pi_{t-1,t+k} = \frac{P_{t+k}}{P_{t-1}}$. Next, we log-linearize equation (3.78) to express everything with respect to the steady state. In equilibrium, we suppose a zero inflation rate ($P_{t-1} = P_t$). Appendix D hereafter gives more details about the log-linearization technique. We obtain:

$$\hat{\hat{p}}_t = \hat{\hat{p}}_{t-1} + \sum_{k=0}^{\infty} (\theta\beta)^k \mathbb{E}_t(\pi_{t+k}) + (1 - \beta\theta) \sum_{k=0}^{\infty} (\theta\beta)^k \mathbb{E}_t(\rho_{t+k}). \quad (3.79)$$

Writing the same relation for period $t + 1$ and taking the difference between the two periods leads us to:

$$\hat{\hat{p}}_t - \hat{\hat{p}}_{t-1} = \beta\theta(\hat{\hat{p}}_{t+1} - \hat{\hat{p}}_t) + \pi_t + (1 - \beta\theta)\hat{\hat{p}}_t. \quad (3.80)$$

Finally, we introduce this result in the definition of the price index (equation (3.73)). The log-linear form of equation (3.73) is:

$$\hat{p}_t = \theta\hat{p}_{t-1} + (1 - \theta)\hat{\hat{p}}_t. \quad (3.81)$$

We can also express this equation as $\hat{\pi}_t = \hat{p}_t - \hat{p}_{t-1} = (1 - \theta)(\hat{\hat{p}}_t - \hat{\hat{p}}_{t-1})$. According to this relation, inflation results from the fact that firms which reoptimize their prices

choose a price that differs from the average price in the economy in the previous period. We substitute equation (3.80) in this last expression to get the New Keynesian Phillips Curve that we use in the main text:

$$\hat{\pi}_t = \beta E_t(\pi_{t+k}) + \kappa \hat{\rho}_t, \quad (3.82)$$

where $\kappa = \frac{(1-\theta)(1-\theta\beta)}{\theta}$.

C. Details on the speculative return on capital

We give in this appendix details about how the speculative return on investments is obtained in equation (3.39) (see also Bernanke and Gertler (1999)). The fundamental value of the firm's physical capital is given by the discounted sum of future dividends. Taking into account the fact that capital depreciates in time, we obtain the following formula for the fundamental price of capital:

$$\begin{aligned} Q_t &= E_t \sum_{i=0}^{\infty} \left[(1-\delta)^i \frac{D_{t+1+i}}{\prod_{j=0}^i R_{t+1+j}^k} \right] \\ &= E_t \left\{ \frac{[D_{t+1} + (1-\delta)Q_t]}{R_{t+1}^k} \right\}, \end{aligned} \quad (3.83)$$

where D represents the value of the dividends paid out by the firm. As assumed in the main text, the price of capital on the market, Z_t may temporarily deviate from its fundamental value, Q_t , giving rise in this way to an asset price bubble. If a bubble emerges at time t , it is supposed to increase with probability p , whereas the complement probability $(1-p)$ implies a bubble burst. We model this bubble as Bernanke and Gertler (1999), that is:³⁰

$$Z_t - Q_t = \frac{a}{p}(Z_{t-1} - Q_t)R_{t+1}^k, \quad (3.84)$$

where the assumptions made in subsection 4.1.3, about the parameters remain valid here. The expected value of the bubble can be computed as:

$$E_t \left(\frac{Z_{t+1} - Q_{t+1}}{R_{t+1}^k} \right) = a(Z_t - Q_t). \quad (3.85)$$

The speculative price can also be expressed as a function of discounted future dividend flows:

³⁰ In the main text, equation (3.38) is directly given in its log-linear form.

$$Z_t = E_t \left[\frac{D_{t+1} + (1 - \delta)Z_{t+1}}{R_{t+1}^Z} \right], \quad (3.86)$$

where R^Z stands for speculative return on capital. From equation (3.83), we can express $E_t(D_{t+1})$ as $R_{t+1}^K Q_t - (1 - \delta)Q_{t+1}$. This expression is inserted in equation (3.86):

$$R_{t+1}^Z Z_t = E_t \left[R_{t+1}^K Q_t + (1 - \delta)(Z_{t+1} - Q_{t+1}) \right], \quad (3.87)$$

that we can further rewrite as:

$$\frac{R_{t+1}^Z}{R_{t+1}^K} Z_t = E_t \left[Q_t + (1 - \delta) \frac{(Z_{t+1} - Q_{t+1})}{R_{t+1}^K} \right]. \quad (3.88)$$

Using the expression for the anticipated part of the bubble, we obtain:

$$\frac{R_{t+1}^Z}{R_{t+1}^K} Z_t = Q_t + a(1 - \delta)(Z_t - Q_t), \quad (3.89)$$

which can be further transformed as:

$$\frac{R_{t+1}^Z}{R_{t+1}^K} = \frac{Q_t}{Z_t} + a(1 - \delta) \left(1 - \frac{Q_t}{Z_t} \right). \quad (3.90)$$

Regrouping terms, we obtain the expression for the speculative return on capital (equation (3.39)):

$$R_{t+1}^Z = R_{t+1}^K \left[b + (1 - b) \frac{Q_t}{Z_t} \right], \quad (3.91)$$

where $b = a(1 - \delta)$.

D. Details on the log-linearization procedure

To log-linearize the DSGE model, we apply the following procedure. Let $f(X_t)$ be a function of X_t , where X_t may be any variable from the model. The first order log-linear approximation of this function around the steady state value X is:

$$E_t[f(X_t)] \approx E_t \left[\sum_i \frac{\partial f(X_t)}{\partial X_{it}} \Big|_{X_t=X} X_{it} x_t \right] = 0, \quad (3.92)$$

where $x_t = \log(X_t) - \log(X)$. Consequently, x_t should be interpreted in terms of percentage deviation from the steady state.³¹ We illustrate hereafter how to compute the

³¹ The same result can be obtained by first taking the log of the equation and then applying a first order Taylor series expansion around the steady state.

log-linear approximation of an equation. Take for example the case of the production function of entrepreneurs (equation (3.28)):

$$Y_t = O_t K_t^\alpha [H_t^\Omega (H^f)^{1-\Omega}]^{1-\alpha}.$$

Applying the formula above leads us to:

$$\begin{aligned} Y y_t &= K^\alpha [H^\Omega (H^f)^{1-\Omega}]^{1-\alpha} O o_t + \alpha O [H^\Omega (H^f)^{1-\Omega}]^{1-\alpha} K^{\alpha-1} K k_t \\ &\quad + (1-\alpha) \Omega O K^\alpha [H^{\Omega(1-\alpha)-1} ((H^f)^{1-\Omega})^{1-\alpha} H h_t. \end{aligned}$$

As H^f is not time varying, the derivative of the function with respect to this variable is 0. Moreover, as in Bernanke et al. (1999), we normalize the hours worked by entrepreneurs to one, therefore $H^f = 1$. Replacing the steady state value of the production function, *i.e.* $Y = O K^\alpha [H^\Omega]^{(1-\alpha)}$ and regrouping terms, we obtain the following expression:

$$Y y_t = Y o_t + \alpha Y k_t + (1-\alpha) \Omega Y h_t. \quad (3.93)$$

To obtain the exact form as the one given in the main text, we simply extract h_t from the above formula:

$$h_t = \frac{1}{(1-\alpha)\Omega} (y_t - \alpha k_t - o_t).$$

We apply the same procedure to all the equations of our model (see section 4.1.5).

E. Baseline calibration of the DSGE model

Description	Parameter	Value
Intertemporal elasticity of substitution	σ_c	0.75
Elasticity of labor disutility	σ_h	0.32
Subjective discount factor	β	0.99
Part of retailers with unchanged prices on the period	$1 - \theta$	0.60
Capital contribution to GDP	α	0.35
Part of entrepreneurial labor in total labor	$1 - \Omega$	0.01
Part of households labor in total labor	Ω	0.99
Depreciation rate for capital	δ	0.04
Elasticity of the price of capital to investment	χ	0.8
Part of inside capital transfers to survival banks	t^b	0.001
Banks external finance premium elasticity	ψ^b	0.005
Firms external finance premium elasticity	ψ^f	0.025
Steady State: Exogenous fixed values		
Real marginal cost	ρ	1/1.1
Banks inside capital/ loans ratio	N^b/B	0.2
Firms net wealth/ capital ratio	N^f/K	0.4
Public expenditures/GDP ratio	G/Y	0.16
Firms probability of default	$F(\bar{\omega}^f)$	0.03
Banks probability of default	$F(\bar{\omega}^b)$	0.007
Average external finance premium for firms (in annual basis)	$R^K - R^f$	0.02
Steady State: Calculated values		
Auditing cost for banks	μ^b	0.077
Auditing cost for households	μ^a	0.545
Variance for the ω distribution	σ	0.2531
ω threshold value for banks	$\bar{\omega}^b$	0.52
ω threshold value for firms	$\bar{\omega}^f$	0.6016
Banks probability to leave the market	$1 - \gamma^b$	0.01
Firms probability to leave the market	$1 - \gamma^f$	0.017
Investment/ GDP ratio	I/Y	0.2444
Banks consumption expenses/GDP	C^b/Y	0.006
Firms consumption expenses/GDP	C^f/Y	0.035
Total consumption expenses/GDP	$(C + C^b + C^f)/Y$	0.6

Chapter 4

Monetary Policy and Financial Stability: A Trade-off Analysis¹

The previous chapter underlined the fact that *trade-offs* between objectives can occur when financial stability is taken into account next to the traditional objectives of price and output stability. More precisely, a central bank pursuing several objectives at the same time and using the interest rate to lean against the wind might in the end perform worse on some of its targets. We have also argued in the previous chapters that since monetary policy has an impact on risk, the central bank should find a way to internalize the negative externalities arising from its actions. Leaning against the wind has been seen as one of the solutions to this problem, but the potential incompatibility between objectives proves that the response of the monetary authority to increasing risk in the financial sphere is not trivial. The question of trade-offs is very important in policy design and we consider therefore that further analysis is needed in order to have a better understanding of the situations in which conflicts between objectives might appear. This represents the aim of the present chapter.

As argued before, a trade-off can emerge because of the violation of the Tinbergen principle. Relying on a single instrument for two objectives may lead to undesirable policy achievements. Mishkin (2011) argues that it may be dangerous to use monetary policy to promote financial stability because such a framework can require tightening monetary policy when it is not needed at the macroeconomic level. De Nicolo et al. (2010) state that, in a context of low inflation and high risk-taking, tightening monetary policy generates a trade-off between financial stability and the inflation stabilization objective. In the same line of arguments, Issing (2003) asserts that the trade-off between inflation stability and financial stability is more likely to appear in the short run.

¹ This chapter is the outcome of a collaboration with A. Fouejieu.

King (2012) identifies three cases in which a trade-off can emerge between monetary and financial stability. The first one is the (too optimistic) misperception on the part of households, businesses and financial institutions about future incomes, leading to unsustainable spending and increase in the level of debt. Assuming that these misperceptions can be identified by the central bank, taking actions to correct them may generate a trade-off between stabilizing the financial system and hitting the inflation target. The second, referred to as the “cycle of confidence”, suggests that prolonged periods of stability (both macroeconomic and financial stability) can encourage exuberant behaviors, on the credit market for example, and generate subsequent instability. In the third case, trade-offs can appear due to the risk-taking channel, as described earlier. King (2012) further points out that, as compared with the traditional Taylor curve² which reflects inflation and output volatility, adding financial shocks moves the frontier upper and to the right (what he calls the Minsky-Taylor frontier). In other words, adding financial stability to the traditional macroeconomic stabilization objectives increases the volatility of both inflation and output.

In the above mentioned literature, the authors reach their conclusions with respect to the trade-off only by analyzing economic conditions and without explicitly resorting to a model. To provide evidence in support of this idea, we study, by means of a theoretical New-Keynesian model, the circumstances under which trade-offs may appear. To this end, we first relax the hypothesis made in chapter 3 regarding the bubble process. More precisely, we endogenize the boom-bust process, by allowing it to respond to monetary policy changes. As in the previous chapter, it is assumed that the deviation of an asset price from its fundamental value (the bubble process) captures risk accumulation in the financial sector. However, in this new framework, monetary policy affects both the bubble’s duration and amplitude. Furthermore, the financial bubble has an impact on the aggregate demand of the economy. The first analysis we engage in is performed by using a simplified framework where a reduced form DSGE model is supplemented with an equation for the bubble. Considering that the central bank adopts a leaning against the wind strategy, we examine the volatility of three variables – inflation, output gap and the bubble – when different types of shocks – asset price shocks, supply shocks or a mix of the two – are introduced in the model. This allows us to understand which situations give rise to trade-offs among objectives. Our results suggest that, when the central bank directly responds to financial imbalances, a trade-off indeed emerges between its primary objective of macroeconomic stability and the financial stability objective. Moreover, the results of the DSGE model are confirmed by this analysis which leads us to believe that a macroprudential regulator is needed to reduce this problem. Therefore, a second analysis

² The Taylor curve depicts the standard central bank’s objectives, namely inflation and output stabilization, and suggests that a trade-off can emerge between these objectives in the context of supply shocks.

of trade-offs is performed in an extended framework. We introduce in the model a banking sector building on the work of Bernanke and Blinder (1988) (see also Cecchetti and Li, 2008 or Nakornthab and Rungcharoenkitkul, 2010) and macroprudential regulation (Angeloni and Faia, 2009, Nakornthab and Rungcharoenkitkul, 2010) intended to limit the volatility of economic cycles.

In the next section, we present the model and the results of the first analysis. A literature review on the connections between macroprudential regulation and monetary policy is afterwards proposed before engaging in the second analysis mentioned previously.

4.1 Trade-offs in a simplified framework

The discussion in this section relies on a reduced form New-Keynesian model describing the economy through the equations for aggregate demand, aggregate supply and the central bank's reaction function. This conventional three-equation model is supplemented with a fourth relation describing risk accumulation in the financial market, *i.e.* an asset price bubble. The bubble's equation is presented in the first part of this section, before introducing the whole macroeconomic model.

4.1.1 The Bubble

Inspired by the rational asset price bubble of Blanchard and Watson (1982), we consider the following linear form of a bubble process:

$$b_t = \begin{cases} \frac{1+\bar{i}}{\bar{q}}(b_{t-1} - \tilde{q}_t) + \varepsilon_t^b & \text{if the bubble persists, } (q_t) \\ \varepsilon_t^b & \text{otherwise, } (1 - q_t) \end{cases} \quad (4.1)$$

where b_t denotes the asset price deviation from its fundamental value at time t . The bubble is assumed to persist with probability q_t and to burst with probability $(1 - q_t)$. We define $\bar{q}$ as the threshold value of the probability q_t above which the bubble bursts. Further, $\tilde{q}_t$ is the difference between q_t and $\bar{q}$. Finally, $\bar{i}$ is the equilibrium interest rate and ε_t^b is an exogenous shock with zero mean. According to the above equation, the bubble depends on its past value, as well as on its probability to persist. The bubble is self-fulfilling and grows without any connection to fundamentals, with $\frac{1+\bar{i}}{\bar{q}}$ superior to 1. Holding an asset experiencing a price bubble can be therefore motivated by the expectation that the price will continue to grow in subsequent periods.

At this stage of the discussion, the bubble process is strictly exogenous since it is not affected by any economic or policy change and is similar to the bubble considered in the previous chapter. However, since the 2008/2009 global financial crisis, the monetary

policy stance has been viewed as one of the main drivers of financial market activities, and potentially (at least in part) responsible of stakeholders' risk-taking behavior.³ Therefore, we rely on the realistic assumption that the asset price bubble is affected by monetary policy through the short term interest rate. Precisely, it is hypothesized that the central bank can influence the probability of the bubble to persist, q_t , as follows:

$$\tilde{q}_t = -\gamma \Delta i_{t-1} \quad (4.2)$$

where Δi_{t-1} is the variation of the short term interest rate from one period to another. Equation (4.2) suggests that monetary policy can lower the lasting probability of the bubble by raising the short term interest rate. Doing so will, by construction, increase the bursting probability, thus diminish the duration of the bubble. Such an action from the monetary authority may well be justified by the willingness to limit the disruptive consequences of a bubble collapse. As a means of prevention, the central bank may wish to prick the bubble before the risk accumulation becomes excessive. However, this policy affects not only the duration, but also the size of the bubble. Indeed, increasing the interest rate will translate in an upward reaction of the bubble.⁴

In the expression of $\tilde{q}_t$, it is assumed that changes in the interest rate matter more for the financial sector than the level of this rate. Consider for example a first situation in which the short term rate rises from 1 to 2%, and a second one where the rate goes from 1.5 to 2%. In both situations, the interest rate reaches the same level, however, in the first case, the rate increases by 1 percentage point, whereas the increase is of only 0.5 in the second case. We argue that financial markets will be more affected in the first scenario as compared with the second one.^{5,6}

Substituting equation (4.2) in the bubble's expression (4.1) yields:

$$b_t = \left[\frac{1 + \bar{i}}{\bar{q}} (b_{t-1} + \gamma \Delta i_{t-1}) \right] D + \varepsilon_t^b \quad (4.3)$$

where D is a dummy variable which takes the value of 1 as long as the bubble lasts and 0 when it bursts (*i.e.* when $q_t > \bar{q}$). The macro-model describing the economic framework, discussed in the next subsection, will be augmented with this expression of the asset price bubble.

³ See chapter 1.

⁴ Gali (2014) also argues that an increase in the policy rate in reaction to a growing bubble will entail a positive effect on the bubble's growth.

⁵ The main conclusions from our model do not change if we consider the levels rather than the changes of the short term rate in equation (4.2). See the robustness section for more details.

⁶ Gruen et al. (2005) use a similar approach to make the bubble process endogenous to policy setting. They build a macroeconomic model that includes a role for an asset price bubble and compare the optimal monetary policy response for two types of policymakers: a skeptic one which implements a (standard) inflation targeting-type policy, and an activist one which responds to asset price bubbles. In their sensitivity analysis, they assume that the bursting probability of the bubble is affected (with a lag) by the difference between the short term rate and its optimal path, chosen by the skeptic policymaker.

4.1.2 The Macroeconomic Framework

A three-equation New-Keynesian model is used to describe the macroeconomic framework considered for the purpose of the investigation. The log-linear inter-temporal relations take the following form:

$$\pi_t = \alpha \mathbb{E}_t(\pi_{t+1}) + (1 - \alpha)\pi_{t-1} + \lambda y_t + \varepsilon_t^\pi \quad (4.4)$$

$$y_t = \delta \mathbb{E}_t(y_{t+1}) + (1 - \delta)y_{t-1} + \sigma \left(i_t - \mathbb{E}_t(\pi_{t+1}) \right) + \varphi b_t + \varepsilon_t^y \quad (4.5)$$

$$i_t = \beta_i i_{t-1} + \beta_\pi \pi_t + \beta_y y_t + \beta_b b_t \quad (4.6)$$

where π_t , y_t and i_t represent respectively the inflation rate, the output gap, and the short term nominal interest rate under the central bank's control. The ε_s are exogenous shocks normally distributed, and $\mathbb{E}_t$ denotes the rational expectation operator. α , λ , δ , σ , φ , β_i , β_π , β_y , and β_b are the model's parameters.

The model consists of a hybrid New Keynesian Phillips curve (equation (4.4)) where current inflation is affected by both past and expected inflation, and by the current level of output gap. The hybrid IS curve (equation (4.5)) describes the current output gap as a function of its lagged and expected values, and of the real interest rate. This equation differs from the conventional hybrid IS curve in the presence of the bubble term. More precisely, it is assumed that the output gap is also positively affected by the asset price bubble. As argued in Filardo (2004), the fundamental component of asset prices does not really matter for output or its components. Conversely, the asset price bubble (the non-fundamental component) can affect aggregate demand by distorting economic decisions: changes in consumption through a wealth effect, changes in investment via the cost of capital, changes in government spending through the tax channel.⁷

Finally, equation (4.6) represents the central bank's reaction function. The monetary policy instrument is set in response to deviations of inflation from its target, the output gap, as well as deviations of asset prices from their fundamental value (the bubble). Moreover, a smoothing component is included in order to limit interest rate volatility. The central bank's reaction function portrays an augmented Taylor rule with a financial variable, suggesting a leaning against the wind policy. Such a policy has been advocated in recent discussions on the monetary policy stance among both academics and practitioners. The objective is to reinforce financial stability by reacting to increasing and unsustainable asset prices which can culminate in a financial crisis with significant real economic effects.

⁷ Even though the presence of the bubble in the aggregate demand equation has no microfoundations, the above arguments are more in favor of including the bubble in the IS curve rather than in the Phillips curve. Note however that, given the model specification, and more precisely, the fact that the aggregate demand enters the Phillips curve, asset price bubbles also affect aggregate supply, although indirectly.

However, as we argue in the introduction of this chapter, the central bank's efficiency in achieving its primary objectives can be affected in such a framework.

4.1.3 Model solution and calibration

To solve the model described by the four equations presented in the above subsections, we rely on the Blanchard-Kahn method (Blanchard and Kahn, 1980). This is a commonly used approach in the literature. However, the specification of the bubble equation gives to our model a structure that is less standard. In this respect, the model is solved for two states of nature: first, when the bubble is persistent (D is equal to 1 in equation (4.3)) and second, when the bubble only equals a random shock (D is equal to 0).⁸ Next, for each period of time, we switch between the two states of nature depending on the value of D , which in turn depends on whether the lasting probability of the bubble is above or below the threshold $\bar{q}$.

In the calibration of the model, the parameters for the standard New-Keynesian equations are taken from the estimated model of Smets (2000) and correspond to annual data for the euro area. Two other (non-standard) parameters are introduced in our model, namely γ and φ . As there exists no estimation for such parameters, we set their values relying on some ad-hoc assumptions,⁹ and we check the robustness of our main conclusions to changes in the values of these parameters. Table 4.1 in the appendix presents the baseline values of the parameters used to perform the simulations.

4.1.4 Results

The framework depicted in the reduced-form model characterized by equations (4.3), (4.4), (4.5) and (4.6) is used to investigate the existence of a trade-off between macroeconomic (inflation and/or output) stability and financial stability, when the central bank reacts to a financial variable. We rely on a simple procedure which can be summarized as follows: the economy is hit by exogenous shocks (supply and/or bubble shocks) which are assumed to randomly occur each period of time.¹⁰ Central banks respond to these shocks by setting the short term interest rate more or less aggressively. Given the aggressiveness of this response, we generate series of variances, calculated on 1000 periods, for each argument of the central bank's reaction function (inflation, output gap and bubble). We then compare the evolution of these variances to assess the monetary policy efficiency in

⁸ When the dummy is equal to 0, the Blanchard-Kahn conditions are verified, therefore the model is stable. When D is equal to 1, the model is unstable due to the way in which the bubble's equation is specified. However, on the long run the economy converges in probability to the steady state.

⁹ It is assumed that the effect of the interest rate on the bubble is of the same magnitude as the effect of the real interest rate on the output gap. It is also assumed that the asset price bubble affects the aggregate demand to a lesser extent than the real interest rate.

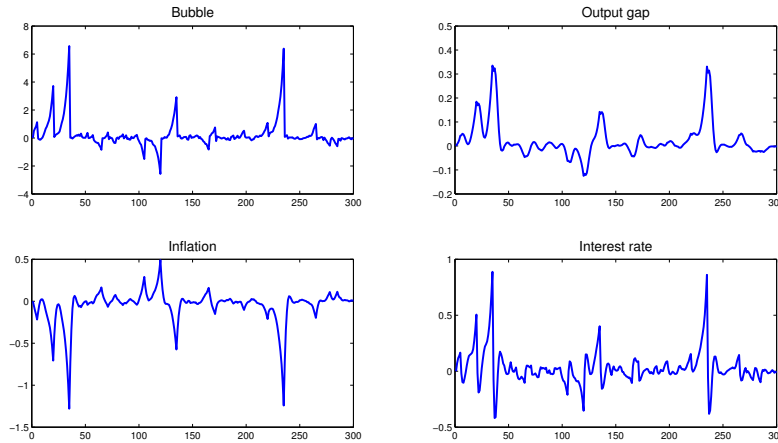
¹⁰ The shocks and the probability q_t are set according to a random process, following a normal and a uniform distribution, respectively.

achieving its objectives.

Confronted with the same shocks, central banks may react differently, both in terms of measures undertaken and in terms of intensity (or aggressiveness) of the policy. For example, faced with an asset price bubble shock, a central bank may decide to react indirectly through a stronger response to output gap (since the bubble affects aggregate demand), thus increasing β_y . Another central bank may rather react directly by strengthening its response to the bubble, increasing β_b . Moreover, in both cases, the responses may be more or less aggressive (a sharp or a more progressive increase in β). For each type of shock and each value of the β s, we generate the corresponding variances of π_t , y_t and b_t . We then represent these variances (in pairs) on graphs, in the spirit of a Taylor-type curve, in order to investigate potential trade-offs between objectives.

The analysis conducted here should not be view as an attempt to derive the optimal monetary policy stance. The purpose is much more modest and simply aims at investigating, through comparative statics, the challenges central banks can face when reacting to financial variables. More precisely, we focus on trade-offs between policy objectives. In addition, the differences in parameters in the central bank's reaction function can be viewed as responses from different central banks to the same shocks, and not necessarily as changes in a single central banks response over time.

Figure 4.1: Model's response to bubble shocks
deviation from the steady state



Note: The response of the variables (output gap, inflation and interest rate) to consecutive bubble shocks.

Before addressing the issue of trade-offs, we investigate the response of the model to bubble shocks, by looking at how the output gap, inflation and the interest rate react to deviations of the asset price from its fundamentals (Figure 4.1). In response to positive bubble shocks, the output gap increases as expected. Given the policy rule, the short term interest rate rises in reaction to higher output gap, but also in response to the

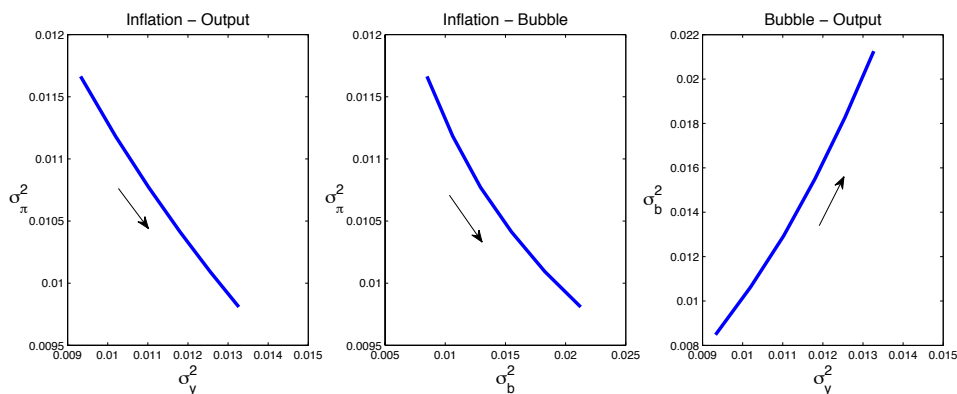
bubble. The higher level of the policy rate reduces inflation in the economy with respect to its steady state value.

We turn now to the investigation of potential trade-offs between central banks' objectives when responding to real or financial shocks. The economy is assumed to face (small) shocks in each period. The main results are discussed considering successively the central banks responses to each type of shock: supply shocks, bubble shocks and a combination of the two.

Supply shocks

Faced with positive supply shocks, central banks may respond by tightening monetary policy (increase in β_π). In Figure 4.2, a stronger response to inflation shocks results in better inflation stabilization, but at the cost of higher output and bubble volatility. The standard trade-off between inflation and output stabilization in a context of supply shocks emerges, but there also seems to be a trade-off between inflation and the asset price bubble. This implies that the stronger the central bank's reaction to inflation shocks, the higher the asset price bubble volatility. This finding is in line with the argumentation in De Grauwe and Gros (2009). In addition, there seems to be no trade-off between the output gap and the asset price bubble in case of cost push shocks.

Figure 4.2: Supply shocks (Response to inflation)



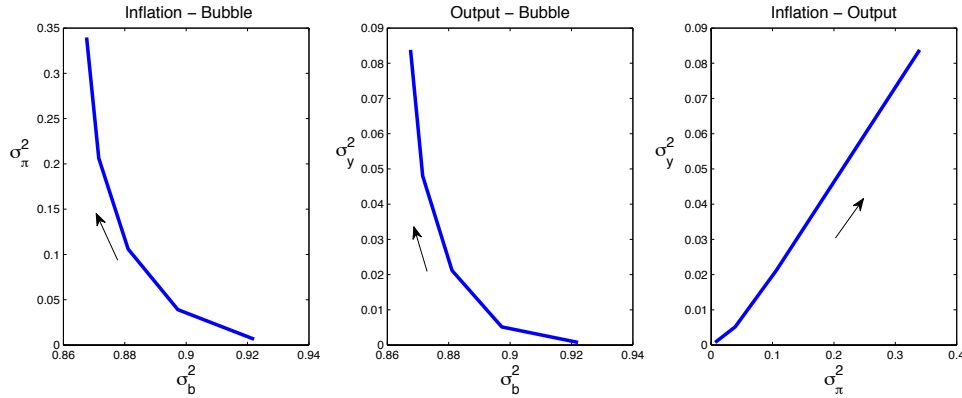
Note: Variances of inflation, output gap and the bubble following supply shocks. The response to inflation varies between 1.5 and 2.5 and all other parameters remain the same. The arrows indicate an increase in β_π .

Asset price bubble shocks

Since the asset price bubble enters the central bank's reaction function, the short term interest rate rises in response to positive bubble shocks. This type of reaction, intended to strengthen financial market stability, corresponds to the leaning against the wind strategy. Being more aggressive to the bubble (increase in β_b) reduces indeed the bubble volatility, as shown in Figure 4.3. However, this better financial market stabilization is

achieved at the cost of higher macroeconomic instability, since both inflation and output volatilities increase. These results suggest that a direct central bank's response to financial imbalances may be harmful for the monetary authorities' primary objectives. While such a strategy may be effective in containing a financial bubbles, it leads to a deterioration of the macroeconomic stance, generating a trade-off between this main monetary policy objective and the concern for financial stability.

Figure 4.3: Bubble shocks (Response to the bubble)



Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in β_b .

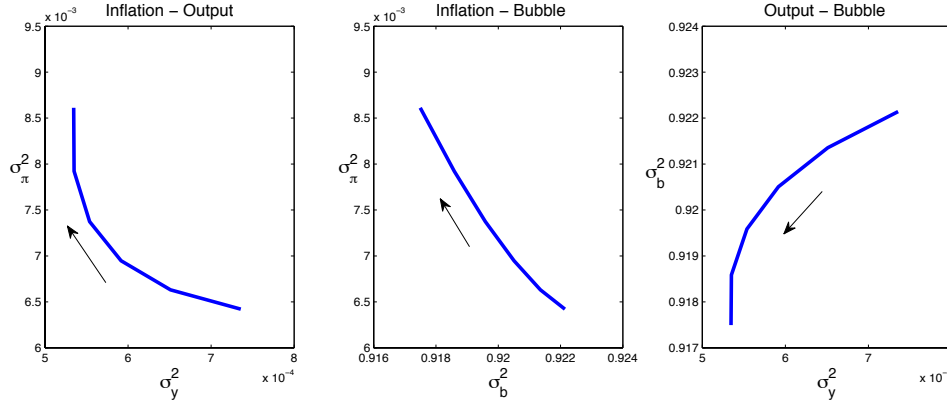
Alternatively, the central bank may choose to react indirectly to bubble shocks through a stronger response to output gap (increase in β_y), since it is assumed that the bubble positively affects aggregate demand. This approach seems to provide a better outcome than the former as it reduces not only the bubble, but also the output gap volatility. However, inflation volatility increases (recall that both output and inflation volatilities increase with the former central bank's response), making this strategy questionable. As a result of the central bank's actions, a trade-off between inflation and financial stability emerges, but the bubble and the output gap seem to stabilize (Figure 4.4).¹¹ To some extent, this result suggests that a standard Taylor rule provides a better outcome than a pure leaning against the wind strategy, even when facing financial shocks. Although not satisfactory, the standard rule seems to be less costly.

Supply and asset price bubble shocks

We assume now that the economy is faced with supply and bubble shocks at the same time. The results in this scenario are in line with the above discussion. A stronger response to output gap results in better bubble and output gap stabilization, while inflation

¹¹ Figure 4.4 also shows that there is a trade-off between inflation and the output gap. Such a trade-off is not to be expected in the context of demand shocks in standard models. Note however that our model is different from the standard New-Keynesian one, in the sense that it includes a bubble process which is assumed to affect aggregate demand. When removing this assumption, we reach the common conclusion of no trade-off between inflation and output.

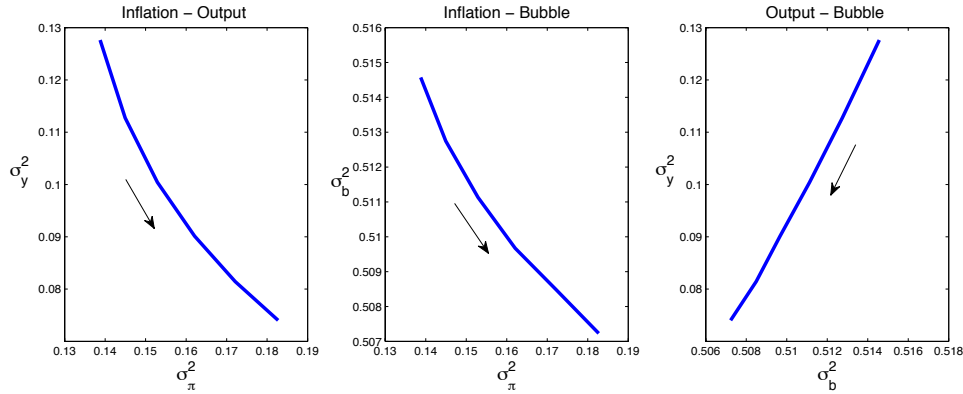
Figure 4.4: Bubble shocks (Response to output gap)



Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to output gap varies between 0.5 and 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

variability increases as shown in Figure 4.5. There is a trade-off between inflation and bubble stability, but also one between price stability and output gap stability.

Figure 4.5: Supply and bubble shocks (Response to output gap)

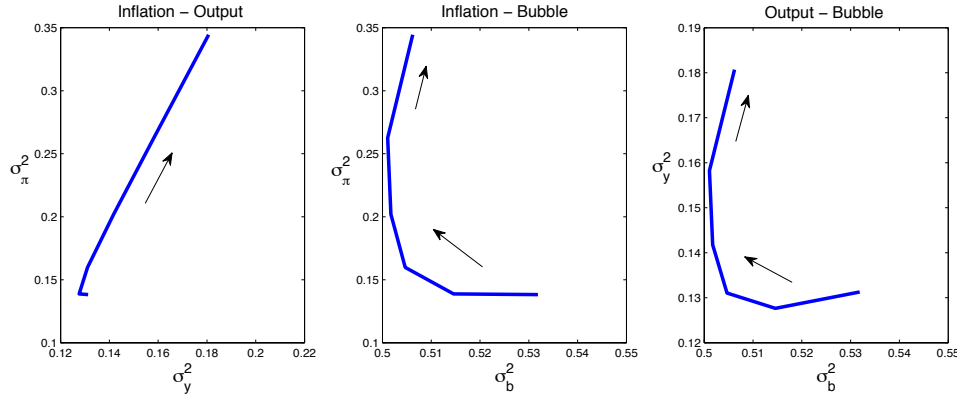


Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

If monetary authorities are more adverse to the bubble (increase in β_b), the bubble's variability decreases, whereas inflation and output volatilities increase. The results in Figure 4.6 also show that, in a later stage, when the central bank's reaction becomes more aggressive, all policy objectives are negatively affected (increase in output, inflation and bubble volatilities). In other words, when the central bank's response to the bubble exceeds a certain threshold, the effect on the economy becomes counterproductive, leading not only to a deterioration of the macroeconomic stability, but also to an increase in the bubble's volatility. This finding is in line with Galí (2014) who argues that increasing the interest rate in response to a growing bubble generates higher fluctuations in the latter, as the interest rate positively affects the bubble's growth. In a different frame-

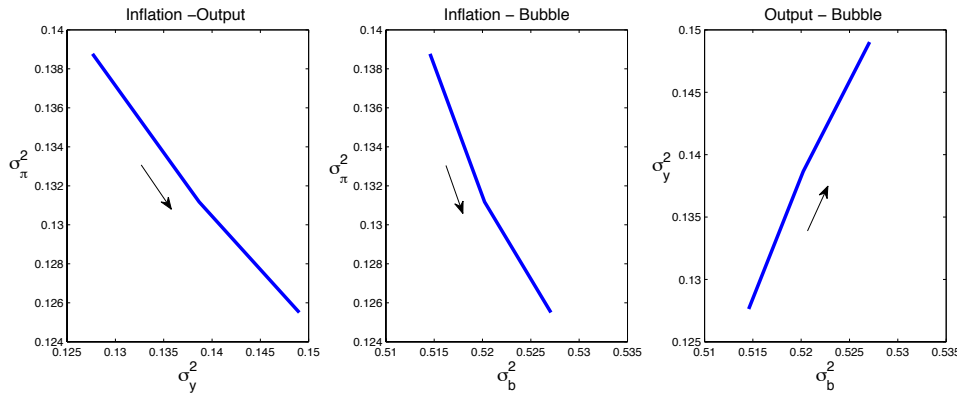
work with another definition for financial instability, Svensson (2013) also concludes to a counterproductive effect of tightening monetary policy to stabilize the financial system.¹²

Figure 4.6: Supply and bubble shocks (Response to the bubble)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in β_b .

Figure 4.7: Supply and bubble shocks (Response to inflation)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to inflation varies from 1.5 to 2.5 and all other parameters remain the same. The arrows indicate an increase in β_π .

In response to supply and bubble shocks, an increase in the reaction to inflation lowers its volatility, while there is an increase in output gap and bubble volatilities (Figure 4.7). A trade-off between inflation and bubble stability emerges, in addition to the standard inflation – output gap trade-off.

Globally, these results seem all against the leaning against the wind strategy. Regardless of the type of shock, a trade-off between inflation stability and financial stability is always present. At best, responding to the bubble by increasing β_b achieves financial stability, but endangers the main objectives of the central bank, as in this scenario both inflation and output volatilities increase. The best outcome, although not ideal, is

¹² Considering household indebtedness as an indicator of financial stability, Svensson (2013) shows that a tighter monetary policy to control the level of debt leads to an increase in the debt to GDP ratio. Tightening monetary policy more than necessary for inflation stabilization, will raise the real household debt and dampen the nominal GDP, increasing the debt to GDP ratio.

obtained by increasing the response of the policy rate to the output gap. This allows monetary authorities to attain both financial and output gap stability, but the price stability objective is left aside in this case. Several authors now (De Grauwe and Gros, 2009, Woodford, 2012) seem in favor of this strategy, where the central bank neglects its main objective in the short run, in order to avoid or to diminish the harmful effects of a financial bubble. It is however difficult to take sides on this discussion, because if bubble bursts are indeed avoided due to monetary policy action, we are not able to quantify the losses that the economy would have incurred if the bubble was left to develop.

4.1.5 Robustness Analysis

To check the robustness of our results, various analyses are conducted. First, the bubble is assumed to be affected by the levels of the short term interest rate rather than its changes. Second, we assess the extent to which our results are sensitive to changes in the values of the parameters φ and γ . Third, we examine different random selections for supply and financial shocks. And finally, an alternative random selection of the probability q_t is considered.

Bubble affected by levels rather than changes in interest rate

In the previous analysis, it is assumed that changes in the short term interest rate matter more for the financial sector than levels. However, it can be argued that the levels of the policy rate also matter since they can have important effects on the private sector's risk-taking behavior. We assess the extent to which our main results remain relevant if the bubble is affected by the level of the short term interest rate rather than its variation (in equation (4.3), Δi_{t-1} is replaced by i_{t-1}). With such a framework, our findings are the same as in the baseline model when supply shocks are considered. We also reach the same conclusions regarding bubble shocks. When the central bank responds to the bubble, a trade-off emerges between macroeconomic and financial stability. An indirect reaction through a response to the output gap produces a better outcome, as in the baseline analysis. When the economy is hit by the two shocks simultaneously, responding to the output gap and inflation produces the same effects found previously. The response to the bubble generates a trade-off between inflation and the bubble stabilization, but also between output gap and bubble stability. Overall, considering the levels of the policy rate does not change our conclusions highlighting the existence of trade-offs (Appendix B, Figure 1).

Robustness to different values of the parameters φ and γ

For robustness to parameters' values, we focus only on the trade-off between inflation and bubble stabilization. Indeed, our main conclusions so far suggest that this trade-off always emerges, regardless of the nature of the shock and of the central bank's reaction.

In a context of asset price bubble shocks and with the central bank responding either directly to the bubble or indirectly, through a response to the output gap, we investigate the existence of this trade-off for different values of φ (between 0.01 and 0.025). The results presented in Appendix B, Figure 2 confirm that whatever the value of φ considered, there is always a trade-off between inflation and financial stability.

The same investigation is conducted for different values of γ (with γ taking values between 0.02 and 0.07). The economy is hit by asset price bubble shocks and the central bank responds to the bubble or to the output gap. The findings are in line with our previous conclusions that the trade-off always appears between inflation and bubble stability (Appendix B, Figure 3).

Robustness to an alternative selection of shocks

As discussed earlier, the shocks are drawn on a random basis from a normal distribution. We perform a robustness check by considering another random selection of shocks and we conduct the same analysis as above. Regarding the responses to supply shocks, the findings are the same as in the baseline model. We also reach the same conclusions when the central bank reacts to bubble shocks. There is a trade-off between macroeconomic (inflation and output) stability and financial stability (although small and limited policy rate adjustments seem to succeed in reducing bubble and output volatilities). When the central bank is faced with the combination of the two shocks, the results are also in line with the baseline model. While a response to the bubble decreases the bubble's volatility, it raises both inflation and output variability. A response to output gap lowers output and bubble instability, but generates a greater variability of inflation. Finally, a response to inflation leads to the inflation-output trade-off, but also to an inflation-bubble trade-off (Appendix B, Figure 4).

Robustness to an alternative selection of q_t

The values of q_t are selected randomly following a uniform distribution. To reinforce our results, we also draw an alternative series of q_t following the same process and we conduct the same analysis. The findings regarding supply shocks are the same as in the baseline model. For bubble shocks, at first, tightening monetary policy by increasing the response to the bubble lowers the bubble's volatility, but at the cost of higher output gap and

inflation volatility. However, in a later stage, when the response is more aggressive, all three volatilities increase, leading to a deterioration of macroeconomic, as well as financial stability. Central banks which respond strongly to output gap in the context of bubble shocks seem to perform better, although not satisfactorily. As in the baseline model, the bubble and output volatilities decline, while inflation volatility rises. Considering the combination of the two shocks, a monetary authorities' response to the bubble reduces the bubble and the output gap volatilities at first, but worsens macroeconomic and financial stability later on, when this response is stronger. The responses to the output gap and inflation reveal the same outcome as in the baseline model.¹³

Overall, the alternative analyses conducted in this section highlight the robustness of our main result. A leaning against the wind strategy in which the central bank responds directly to financial instability is subject to trade-offs between the primary inflation stabilization objective and financial stability.

While the leaning against the wind strategy may be required, especially since the global financial crisis unfolded, this first analysis argues that such a policy can lead to trade-offs between objectives. Monetary authorities can face a challenge in achieving their objectives if the policy rate explicitly responds to financial instability. A second instrument is needed to tackle this issue. While central banks should continue to focus on the traditional macroeconomic goals and have only a secondary role in maintaining financial stability, a macroprudential framework should be developed to address financial imbalances. We therefore extend in what follows our initial framework so that it includes a banking sector and a macroprudential regulator. However, before presenting this extension, we propose a state of the literature on the interactions between monetary policy and macroprudential policy. This is a recent research topic which relies primarily on DSGE models and looking at these studies can help us to learn more about the effects of macroprudential policies on the achievement of objectives.

4.2 Interactions between monetary policy and macroprudential regulation

Bank capital regulation is seen as the main solution to the problem of increasing risk in the financial sector. Consequently, more and more research papers include this type of measures into dynamic stochastic general equilibrium models where financial frictions play an important role. Moreover, recent research also takes interest in the study of financial shocks, hitherto neglected in this literature. Before presenting the main papers treating this subject, we analyze the concept of *macroprudential regulation*.

¹³ We do not present these results due to space constraints, but they can be provided upon request.

Financial stability and macroprudential regulation

While in the case of monetary policy, we can clearly identify an objective – price stability – that we can quantify by the inflation rate, for macroprudential policy these aspects are challenging. Typically, macroprudential policy is supposed, along with microprudential regulation, to ensure financial stability. The microprudential approach, which was the only type of prudential regulation in place before the recent financial crisis, focuses on financial institutions taken individually and is intended to prevent the failure of each of these institutions. Conversely, macroprudential regulation is intended to maintain the stability of the entire financial system and should take into account the correlations between different financial institutions. From this point of view, macroprudential policy is closely linked to the concept of systemic risk.¹⁴ As defined by Hanson et al. (2011), the macroprudential part of financial regulation can be seen as “an effort to control the social costs associated with excessive balance-sheet shrinkage on the part of multiple financial institutions hit with a common shock”. Reducing balance sheets can result in either a limitation of credit, with negative consequences on the real economy, or asset fire sales, with a major negative impact on financial markets. Given that in such situations, the individual banks’ decisions affect the level of risk of the entire financial sector, macroprudential regulation should be designed such as to stop or mitigate this type of effects. In addition to the above features, Borio and White (2004) argue that macroprudential regulation should also help to reduce the procyclicality of the financial system. Thereby, financial institutions should be encouraged by macroprudential rules to accumulate more capital during booms, so that they can use it in times of economic downturn, which is precisely the scope of the countercyclical capital buffer newly introduced in the Basel III regulation. In addition, the scope of macroprudential regulation should not be limited only to banks, but it should include the financial market as a whole. This would avoid not only disloyal competition, but also the accumulation of risk coming from the shadow banking system.

The end objective of macroprudential policy is to maintain financial stability. However, this latter concept is also complex and difficult to define. As we have noted in chapter 3, in most cases, it is the notion of financial instability that is analyzed. According to the existing definitions of this concept, the difficulties originate in the financial sector and generate a disruption in financial services which subsequently has serious consequences for the real economy. Betbeze et al. (2011) identify financial instability as a polymorphic process. Indeed, looking back at the recent crisis, we can identify several sources of instability: a liquidity dry-up in the financial system, increased volatility for rates or asset prices, an important leverage level and insufficient bank capital to cover losses in case

¹⁴ Systemic risk is also related to the correlations between financial firms.

of a negative shock. To properly address these problems, it is first necessary to identify all possible sources of instability. Moreover, as these dimensions cannot be covered by a single measure, an appropriate instrument for each of them must be designed. This is also the approach adopted in the Basel III Agreement where several measures are proposed to deal with financial instability.

From a theoretical perspective, the modeling of macroprudential objectives is not obvious either, precisely because risk can come from various sources. This is why, in most macroeconomic models, financial stability is not explicitly defined, and authors only look at the overall dynamics of real and financial variables following shocks to the banking sector or to the financial market. Nevertheless, we can identify in the existing literature some proxies used to quantify financial stability and the macroprudential objective. Agenor et al. (2013) define financial stability as the real house prices volatility, but they do not include these prices in the reaction functions of either the monetary or the macroprudential authority. The ratio of credit to GDP is also considered as an alternative measure of financial stability in their model. Angelini et al. (2011) define the macroprudential objective in terms of credit growth and output. Using excessive credit growth as an indicator of financial instability is justified by empirical studies showing that such deviations tend to lead to financial crises (Borio and Drehmann, 2009, Reinhart and Rogoff, 2009). The choice of output as an indicator stems simply from the definition of financial instability since the disruption in the financial sector can have serious consequences for the real economy.

The definitions of financial stability, macroprudential regulation and systemic risk are still subject to discussion, but what became clear with the crisis is the need to introduce a macroprudential component to the existing framework to ensure financial stability in the future.

What macroprudential regulator?

Who should take responsibility for the macroprudential objective? If at first glance the choice of the institution seems unimportant, further reflection reveals several problems that might occur due to this choice. To some economists, it is obvious that this new responsibility must be integrated in the mandates of central banks, while to others a completely independent authority seems more appropriate. We provide some details hereafter.

One argument in favor of central banks is that, to some extent, monetary authorities already play an important role in maintaining financial stability: they act as lender of last resort, meaning that they provide liquidity to the financial system in order to reduce the impact of financial crises on the real sector. Since this type of intervention creates moral

hazard, the choice of which institutions to save from default must be restricted to solvent ones, which only deal with temporary liquidity problems. The easiest way to acquire this information is to give central banks a supervisory role (Mishkin, 2007). However, the responsibility for the macroprudential objective goes beyond the role of lender of last resort and involves preventing financial crises.

The second argument in favor of central banks is given by Betbeze et al. (2011) who speak about an “overlap” between monetary policy and macroprudential regulation. Knowing that monetary policy decisions affect financial stability (as suggested by the risk-taking channel), there is a need for strong cooperation between the two authorities responsible for price and financial stability. Given that cooperation can raise problems (poor communication, delays in data transmission and problems of trust), it is desirable that a single authority be responsible for the two objectives. The coordination failure is also the argument used by Angelini et al. (2011). They explain that if there were two separate entities, each responsible for its own objective, this would lead to suboptimal results. Due to the existence of the risk-taking channel, Angeloni et al. (2013) reach the same conclusion – monetary policy should take into account financial stability implications. However, in their model they do not assign the financial stability objective explicitly to the central bank.

In the same line of thought, Borio and White (2004) opt for a tightening of monetary policy in the face of increasing financial imbalances, even if inflationary pressures do not justify such an intervention. Communication on this type of strategy could even change the behavior of economic agents and reduce their incentives to take risks. Moreover, if the central bank reacts only when risk materializes, by decreasing the interest rate, this could create moral hazard and thus contribute to the buildup of imbalances. Since the financial imbalances affect output and inflation, the authors argue that the central bank does not even have to explicitly declare a financial stability objective. Nevertheless, for these authors the effort of monetary policy must be accompanied by macroprudential regulation which makes use of other instruments than the interest rate.

Another argument in favor of central banks as macroprudential regulator states that central banks should respond to financial instability because imbalances in the financial sector will ultimately have an impact on inflation (Borio and White, 2004, van den End, 2010), with a high deflation risk during crisis periods. This argument is also employed by the ECB when explaining why it takes into account financial variables in its monetary strategy. De Grauwe and Gros (2009) also see the central bank as the best candidate to deal with macroprudential regulation, even if this comes at the expense of price stability, the traditional monetary policy objective. As we have already seen, they support the idea that, in the event of a financial bubble, central banks must respond to increasing risk

and temporarily put aside the inflation target. Hence, they are in favor of a classification of objectives within central banks. Assuming that the monetary authority is responsible for both objectives – financial stability and price stability – van den End (2010) also advocates this idea: in particular cases, trade-offs between objectives may require some flexibility in the strategy of the central bank. This implies that all instruments at the central bank’s disposal may be used, at particular moments, for a single objective. We recognize here however a policy mix problem as, according the Mundell’s rule (Mundell, 1962), each instrument should be used for one objective. More precisely, according to this rule, instruments should be allocated based on their efficiency in achieving objectives.

Papademos (2009) also defends the idea according to which the central bank is the best choice for dealing with financial instability. However, this new objective for the central bank should be accompanied by the use of a new instrument as well. According to Blanchard et al. (2010), central banks are also the obvious candidate for the role of macroprudential regulator as they are best placed to monitor macroeconomic and financial developments. They have privileged information about the financial system and in several countries they are already involved in financial supervision. To defend the addition of the macroprudential objective to the mandate of central banks, they also evoke the coordination problems that can occur between two separate organizations, and the implications of monetary policy decisions on leverage and risk.

However, the arguments against the management of the macroprudential objective by central banks are not to be neglected. Agenor et al. (2013) draw the attention to the potential trade-offs that may arise between the objectives of price stability and financial stability. In such a situation, the central bank’s credibility, an essential component in the conduct of monetary policy, is endangered. Interest in this new objective may determine economic agents to believe that the central bank may now adopt a more flexible strategy when faced with inflationary pressures, which would weaken its credibility on the inflation target. The loss of credibility, which implies a clear decrease in the effectiveness of the monetary policy, is the argument most often used to suggest that central banks should not be responsible for banking and financial supervision (Angeloni et al., 2013, Betbeze et al., 2011, Goodhart and Schoenmaker, 1995). Further, having two independent authorities could strengthen accountability and commitment, both necessary for achieving objectives (Angelini et al., 2011). To defend the case of central banks, Blanchard et al. (2010) suggest that one way to address these criticisms is to enhance transparency.

Another solution proposed in the literature is to have a financial stability objective which is shared by two different institutions – the central bank and the prudential regulator – but this option is also problematic because it creates uncertainty as to the

liability for failure (Angelini et al., 2011). However, we will see later that this solution is the preferred one in macroeconomic models.

The special case of inflation targeters is also discussed in the literature. In the case of pure inflation targeting, macroprudential responsibility must lie with another authority, since this strategy implies no role for financial stability in the objective function of the central bank. In contrast, the flexible inflation targeting framework gives way to the integration of such an objective. Woodford (2012) supports this approach as long as the main objective of central banks remains price stability, while financial stability represents only a secondary concern. According to this author, the central bank should choose the alternative that gives the best outcome in the short term, in terms of financial stability, price stability and output, but there should be no compromise on the long term inflation target. In order to implement such a strategy, the central banks that practice inflation targeting must rethink the nature of the target and the horizon over which the target must be attained. However, Woodford (2012) argues that despite the attention paid to financial conditions, the central bank should not be the sole authority in charge of the financial stability objective.

All in all, from the above arguments we can see that whether or not the central bank would be at the same time responsible for price stability and for financial stability, there seems to be a clear consensus on the fact that new instruments should be introduced to deal with financial stability.

Indicators and instruments of macroprudential regulation

Interest in early warning indicators appeared long before the recent financial crisis. The most important discussions concerned asset prices as an indicator of financial bubbles. However, this indicator was widely criticized because of the difficulty to identify a drift in prices relative to their fundamental value. However, the 2007 crisis has reopened the discussions on the ability of such variables to predict crises. As the recent crisis had its origins in the real estate sector, we find in many macroeconomic models house prices in the reaction functions of the monetary authorities and/or the macroprudential regulator (for example, Angelini et al., 2011). To circumvent the problems posed by this type of indicator, Agenor et al. (2013) suggest to focus on the effect that asset price changes have on the evolution of credit relative to GDP. This would prevent central banks from deciding whether or not asset prices have moved away from their fundamental value. Thus, several authors choose this indicator to study macroprudential policy matters (Agenor et al., 2013, Angelini et al., 2011, Borio and Lowe, 2002, Borio and White, 2004 or Christensen et al., 2011). This measure can also be found in the Basel III regulation. More precisely, in a study of the BIS, Drehmann et al. (2010) prove that, from a wide range of indicators,

the ratio of credit to GDP is the best indicator for predicting crises. Moreover, empirical studies on banking crises in developing countries have shown that large increases in this ratio often precede the onset of financial crises (Agenor and Montiel, 2008, Demirguc-Kunt and Detragiache, 2005). Moreover, Alessi and Detken (2011) stress the importance of looking at credit growth at a global level, not solely at national level.

Angelini et al. (2011) consider that using only output as a proxy for the economic cycle is not desirable for the macroprudential regulator. The explanation is that this type of regulation should be responsible only for disturbances arising in the financial sector, and not for all other imbalances that emerge in the real sector. Moreover, looking only at the evolution of credit would not give the true level of risk. Precisely, if this increase in credit is proportional to the increase in GDP, this should not indicate a financial stability threat.

Aside from asset prices and the growth rate of credit to GDP, other indicators have been proposed in the literature. Given the multiple sources of risk, each indicator deserves attention. Angeloni and Faia (2013) suggest, for example, bank leverage as an indicator of financial instability, while Betbeze et al. (2011) and Borio and White (2004) propose indicators such as the interest rate spreads and credit spreads. Furthermore, according to Kannan et al. (2012), excessive investment and deteriorating external balances may contain information related to the state of the financial system. The share of housing investment in GDP is also proposed as a crisis indicator by Borio and Lowe (2002) and Kannan et al. (2012). Finally, Gray et al. (2011) introduce in their model the distance-to-default of the banking system in order to capture the risk of financial instability.

All the indicators mentioned above are integrated either in the reaction function of the central bank, in that of the macroprudential regulator or in both simultaneously. More details are provided further on.

In terms of instruments, the options for the macroprudential authority are also numerous. The countercyclical capital requirements and loan to value ratio are central to the debate on macroprudential instruments. The countercyclical component of prudential regulation implies accumulating more capital during periods of economic expansion and using it in downturns to help banks cope with the losses caused by crises. Therefore, this type of regulation would increase the resilience of the banking sector. The loan to value ratio is intended to limit the risk in case of default by the borrower. Already in place before the crisis, this criterion was very lax and the choice for its value was not regulated at a global level.

Other instruments within the reach of the macroprudential regulator are dynamic provisioning, additional liquidity requirements, incremental reserves on loans (Betbeze et al., 2011) or on deposits (De Grauwe and Gros, 2009), hybrid debt (N'Diaye, 2009) or debt

to income ratios (Gelain et al., 2013). These measures are also intended to decrease the procyclicality of the banking system and to foster financial stability. However, macroprudential regulation may also use discretion in choosing the institutions to which the standards apply.

The measures proposed in this literature, usually concern banks. The shadow banking system is less modeled, but some evidence on regulation applying to this sector can be found in Goodhart et al. (2013).

Modeling strategy and main results

The interaction between monetary policy and macroprudential regulation is most often studied in the context of dynamic stochastic general equilibrium (DSGE) models. The analyses include a banking sector and take into account imperfections in the credit market. Monetary policy is modeled through simple Taylor rules or through rules enhanced with various financial indicators, while prudential policy takes usually the form of a rule on bank capital and/or loan to value ratios.

It has long been recognized in the macroeconomic literature that financial intermediation has an important impact on economic cycles through the financial accelerator mechanism (for example, Bernanke and Gertler, 1989). However, the impact of financial shocks on economic fluctuations has only been recently considered in this literature. These types of shocks are important in our analysis, as macroprudential regulation is especially designed to limit the adverse effects of such shocks.

We provide hereafter a summary of some of the papers treating the interactions between monetary and macroprudential policy and the solutions typically proposed to fight financial instability. The topic has aroused a lot of interest in recent years and the number of papers treating this subject is increasing more and more. Therefore, we do not pretend to provide here an exhaustive literature review,¹⁵ but we present the main articles that help us draw afterwards (page 193) some interesting conclusions.

Agenor et al. (2013) use a model with bank capital and a financial accelerator mechanism in order to determine the optimal policy mix between monetary policy and macroprudential regulation. The model also includes a housing sector where collateral plays an important role in obtaining credit. The shock considered in the model applies to the demand for houses. The optimum is defined by the scenario where macroeconomic stability and financial stability are best preserved. The objective of macroeconomic stability is defined in terms of nominal output volatility (output and prices have equal weights in

¹⁵ For example, we do not present the papers that treat macroprudential regulation in a multi-country framework. That literature is as well very interesting as it allows one to study coordination between countries and the impact of the same type of regulation on heterogeneous countries (see for example, Quint and Rabanal, 2013, Poutineau and Vermandel, 2014). However, as our work is performed in a single country framework, we restrict ourselves to papers that adopt the same perspective.

the loss function), whereas financial stability is defined in terms of real property prices volatility. As an alternative measure for financial stability, they use the credit to GDP ratio and a loan spread. The monetary authority sets the interest rate by using an augmented Taylor rule in which credit growth is included. Macroprudential regulation follows Basel III and uses a rule-based countercyclical capital requirement depending on the same indicator considered by the central bank – the credit growth rate. The benchmark case to which they compare their results consists of a simple Taylor rule and no macroprudential regulation. The authors propose two alternative scenarios. First, they try to see how the two rules work independently of each other (one rule introduced at a time). In this configuration, following a positive housing shock, the two stability indicators (macroeconomic and macroprudential) are improved compared to the benchmark case. The results indicate the absence of arbitrage between the two objectives which implies substitutability between monetary policy and macroprudential regulation. The second configuration involves a combination of the two rules. The results suggest that in this case the marginal contribution of the countercyclical capital rule decreases rapidly once the augmented interest rate is used. Therefore, macroprudential regulation does not present significant benefits when, at the same time monetary policy is used to deal with financial instability. However, Agenor et al. (2013) find that the two policies are complementary when monetary policy is also concerned with the volatility of the interest rate. More precisely, if the central bank believes that significant changes in interest rates can have a destabilizing effect on financial markets, it will choose to react less to the financial stability indicator. Therefore, in this case, the implementation of macroprudential regulation is justified.

Christensen et al. (2011) propose a DSGE model with a banking sector to study the interactions between macroprudential policy and monetary policy. Because banks do not internalize their risk, their lending decisions impose a negative externality on the entire banking sector. This type of externality justifies the introduction of macroprudential regulation that translates in their model into a constraint on bank leverage in the spirit of Basel III. The indicator used by the macroprudential regulator is the credit to GDP ratio. The monetary policy rule is standard. Their results indicate that macroprudential policy needs to be aggressive only in the event of a financial shock (on bank capital). Productivity shocks must be fought with a more inflation-aggressive monetary policy. It is interesting to note that when a technology shock is considered, trade-offs occur between the financial stability and the inflation objectives if macroprudential regulation is also used. However, the financial shock involves no trade-off. The welfare analysis reveals that coordination between monetary policy and prudential regulation helps reduce trade-offs between objectives.

Angelini et al. (2011) start from the DSGE model of Gerali et al. (2010)¹⁶ and analyze the response of the economy in case of supply shocks and financial shocks. The loss function of the macroprudential authority includes the volatility of the credit to GDP ratio and of output, and the instrument used is the countercyclical bank capital buffer or, alternatively, the LTV ratio. The measure used to construct the countercyclical capital buffer is the growth rate of the output. Monetary policy uses a standard Taylor rule to minimize the volatility of inflation and output. The interaction between monetary policy and macroprudential regulation depends here, as in the model of Christensen et al. (2011), on the nature of shocks. In the event of supply shocks, macroprudential regulation provides marginal improvements compared to the case where only monetary policy is used to stabilize the economy. However, if macroprudential regulation is maintained, the best scenario involves cooperation between the two authorities. More precisely, cooperation translates in minimizing a common objective function and each authority uses its own instrument to achieve the common goals. However, macroprudential policy plays a key role if shocks to the supply of credit are introduced, such as a reduction in bank capital or a change in the preferences of households concerning the acquisition of houses. In this scenario, cooperation is also preferred over non-cooperation (the latter implies that each authority minimizes its own loss function, taking the rule of the other authority as given). Given that no conflict arises between the objective of financial stability and inflation stabilization, macroprudential policy is seen as complementary to monetary policy.

The interaction between macroprudential policy and monetary policy is also studied in the DSGE model of Beau et al. (2013). Their focus is on the impact of the policy mix – monetary and macroprudential regulation – on inflation. The central bank uses either a standard Taylor rule, or an augmented one where the financial indicator is the credit growth rate. The instrument of the macroprudential regulator is the loan to value ratio. If a financial shock is considered, the optimal strategy in terms of inflation stabilization implies an independent monetary policy which is only interested in price stability and a response to credit growth from the macroprudential regulator. An interesting result indicates that when the economy is hit by a productivity shock, trade-offs occur between financial stability and price stability objectives. In addition, using only the augmented interest rate rule has destabilizing effects on both inflation and output.

In the DSGE model of Angeloni and Faia (2009), banks are exposed to bank runs on deposits and to a risk of default on loans. In this configuration, the authors study

¹⁶ The model of Gerali et al. (2010) represents a first attempt to introduce factors influencing the supply of credit (the degree of competition in the banking sector, banks' strategies for setting interest rates and the financial health of banks) in a DSGE model. Consequently, this type of model allows for the introduction of a large number of shocks affecting the supply of credit and therefore gets closer to the type of events that triggered the 2007 crisis. However, their model does not include a role for macroprudential policy or for financial stability.

the best combination between a monetary policy that responds to risk and a prudential regulator. The interest rate rule includes – besides output, inflation and a smoothing term – a response to asset prices (Tobin's Q) and to bank leverage (the ratio of deposits to loans). In order to choose the optimal policy mix, they consider three criteria: the welfare of households, the volatility of output and the volatility of inflation. The three types of shocks considered – a monetary expansion, a positive productivity shock and a bubble in asset prices – are expected to increase bank leverage and risk in the economy. When Basel II type regulation is used, economic cycles are amplified and social welfare is diminished. The optimal solution combines an aggressive monetary policy in its response to inflation that also reacts to either asset prices or bank leverage and a macroprudential policy with moderate countercyclical capital. It is also interesting to note that they find no trade-off between objectives.

Paries et al. (2011) study countercyclical regulatory capital in a DSGE model with frictions in the credit market. The banking sector is similar to the one in Gerali et al. (2010). Monetary policy uses an interest rate rule that responds to inflation and output, to variations in these quantities, and to the relative change in house prices and credit. The rule on the countercyclical capital is built on the same financial metrics that the monetary policy rule. The loss function takes into account the volatility of inflation, of output and of the interest rate and is common to both authorities. In their analysis they find that in the absence of countercyclical regulatory capital, *i.e.* in a Basel II type regime, in case of a negative shock to bank capital, the volatility of both inflation and GDP increase. However, under a Basel III regime, macroprudential policy proves to be an important support for macroeconomic stability. Therefore, there is a complementarity between monetary policy and macroprudential policy.

In the DSGE model developed by Dib (2010), we find a banking sector where financial frictions appear in the supply of credit, but also in the demand for loans, more precisely on the interbank market and on the bank capital market. Prudential regulation is modeled to match the Basel II Agreement, therefore it does not include a macroprudential part. The policy rule is standard, but the central bank also practices unconventional monetary policy by injecting liquidity into the banking system. Interestingly, the results indicate a decrease in the amplitude of business cycles when capital requirements are imposed, indifferent of the type of shock considered: supply, demand or financial shocks. Thus, even if the different types of frictions introduced in the model are intended to amplify cycles, microprudential regulation alone manages to mitigate the effects of real and financial shocks and helps to stabilize the economy.

The financial accelerator DSGE model proposed by Gilchrist and Zakrajsek (2011) examines the impact of a financial shock when the monetary policy rule is augmented

with a credit spread. Their results indicate that in case of financial turmoil, such a rule helps to reduce the negative impact of financial shocks on economic activity. However, the volatility of inflation is amplified. Although the increase is modest, this result implies a trade-off between the objective of price stability and the one of financial stability. Curdia and Woodford (2010) also consider in their DSGE model an interest rate rule adjusted for changes in the interest rate spread. The results obtained with such a rule are better overall compared to the results obtained with a standard Taylor rule. However, the adjustment factor changes with the type of shock, making the implementation of such a rule difficult.

Bauducco et al. (2011) also consider the case of a central bank that is concerned with financial stability and that uses an augmented interest rate rule. Their financial stability indicator is the probability of default of firms since these defaults are a major component of credit risk and thus endanger financial stability. The Taylor rule that they propose actually depends on confidential information held by the central bank about the health of the financial system. Therefore, the augmented Taylor rule should be used only if the central bank observes a high level of risk in the banking system. Consequently, when financial stability is not threatened, the standard Taylor rule should be used. The central bank responds to the deteriorating health of the financial system by reducing its policy rate. The optimality criterion is the variance of consumption (Lucas (1987) welfare criteria). In this context, in case of a financial shock, the central bank must make a choice between the two objectives – macroeconomic or financial stability. More precisely, the optimality criterion implies less interest in the present for the stability of output and inflation in favor of a greater attention towards financial stability. This allows a faster return to steady state in the future. However, their results should be interpreted with caution since the welfare improvement remains negligible.

Kannan et al. (2012) analyze different policy scenarios using a DSGE model with a financial sector and a credit accelerator mechanism. Asset prices, or more precisely, house prices play a key role in their model. Indeed, the net wealth of households is given by their stock of houses which is marked-to-market. Net wealth determines the financing conditions for households. Thus, an increase in house prices leads to an improvement in borrowers' net wealth, which enables them to get a lower lending rate. The borrowing rate is also influenced by the macroprudential instrument which acts as if the central bank imposes higher capital requirements whenever credit growth exceeds its steady state level. Actually, the model they propose does not include bank capital and the fact that this instrument directly influences the interest rate for borrowers represents a shortcut of the true mechanism.¹⁷ Four economic scenarios are studied. First, the classic scenario

¹⁷ The mechanisms we refer to should work in the following way: when credit growth exceeds its steady state level, the central bank imposes higher capital requirements on commercial banks, as a macroprudential measure. Financial

where the central bank uses a standard Taylor rule with the usual coefficients – 1.5 for the inflation gap and 0.5 for the output gap – and a smoothing term with a coefficient of 0.7. Then an augmented Taylor rule is considered, where the growth rate of credit is the financial variable used in the interest rate rule. The ad-hoc coefficient for this new indicator is 0.5. The third scenario involves the use of the macroprudential instrument next to the augmented Taylor rule. Finally, in the fourth scenario the monetary and macroprudential rules are optimized. The objectives of the monetary authority are expressed only in terms of inflation and output gap, without considering financial conditions.

The conclusions drawn from the analysis differ depending on the type of shock. If a financial shock – taking the form of a loosening in lending standards – hits the economy, using the augmented Taylor rule together with macroprudential regulation turns out to have stabilizing effects for the economy. The optimization of the two instruments gives of course the best outcome. Despite the fact that the values they obtain for the optimal parameters are not realistic, monetary policy being very aggressive to inflation and output, some conclusions can be drawn from their optimization analysis. Accordingly, we retain that macroprudential policy has an important role in stabilizing the economy, whereas the optimal monetary policy rule implies no role for the financial indicator (a zero coefficient for the growth rate of credit). Therefore, macroprudential policy proves useful in case of financial shocks and more efficient than a simple increase in the interest rate when credit standards are loosened. In addition, the use of a macroprudential instrument reduces the aggressiveness of monetary policy in case of a financial shock. A positive productivity shock leads to very different results. This time, the best scenario is obtained by using the standard Taylor rule, without any intervention from the macroprudential regulator. In this scenario, it appears that responding to the growth rate of credit would limit investments (loan demand) which would afterwards imply downward pressure on inflation. Thus, inflation and output cycles are more volatile. Overall, the results underline the importance of correctly identifying the type of shock that affects the economy. This also involves a certain degree of discretion in the conduct of economic policies. Note that the trade-off between objectives does not appear in these analyses, neither when monetary policy acts alone, nor when it is accompanied by macroprudential policy. Moreover, financial stability is not explicitly modeled and the authors judge the situation of the banking sector by looking at financial variables in general.

Woodford (2012) proposes a reduced form model with imperfections in the credit market where the monetary authority follows a flexible inflation targeting strategy. Two regimes can be distinguished – normal and crisis times. The occurrence of crises is endogenous which allows one to see the impact of monetary policy on the probability

intermediaries will therefore increase their lending rates. In this model however, the macroprudential instrument influences directly the lending rates.

of a crisis. Moreover, this probability depends on the leverage of banks. The optimal monetary policy is evaluated through a loss function including not only inflation and the output gap, but also risk in the form of a short term credit spread (the differential between the short term interest rate at which the non financial sector can borrow funds and the short term interest rate on government liabilities). The results show a clear trade-off between price stability and financial stability. However, according to Woodford (2012), as long as the primary long-term objective remains price stability, in the short run the central bank may choose the strategy that gives the best results in terms of financial stability. For example, when the marginal probability of experiencing a crisis is high, the monetary authority should practice a restrictive policy, even if this means lower prices and below steady state activity for the next periods. In general, the results are in favor of the involvement of the monetary authority in maintaining financial stability, but given the trade-off that appears between the different objectives, the author underlines the need to use simultaneously a new instrument specifically designed for the financial stability objective. To improve the monetary policy framework, Woodford (2012) proposes, based on his results, the adoption of a longer horizon for the price stability objective, as this would allow a deviation from the target in the short and medium term. Another policy proposal would be to target the price level directly, as this would limit the risk of deflation when the central bank focuses on financial stability.

N'Diaye (2009) combines a model of standard monetary analysis with a contingent claims model (Merton, 1998) to show that prudential regulation can help monetary policy in stabilizing the output, while maintaining financial stability. The analysis is carried out in a multi-country framework where the interest rate responds to inflation, output and the exchange rate. The indicator used in the construction of countercyclical rules is the output. Therefore, the bank capital requirements evolve with the economic cycle. The model incorporates, next to the countercyclical capital, a constraint on the loan to value ratio. The underlying mechanism in the model is the financial accelerator. In the scenario where countercyclical regulation is not enforced, the financial accelerator amplifies business cycles. The introduction of macroprudential policy allows monetary authorities to achieve the same levels of inflation and output, but with fewer adjustments in the interest rate. Countercyclical rules also help reduce fluctuations in asset prices, so they are important for providing financial stability.

van den End (2010) aims to measure the trade-offs that occur between monetary stability and financial stability with an empirical model inspired by Kaminsky and Reinhart (1999). The central bank uses not only the interest rate, but also a macroprudential instrument. Although the central bank takes interest in financial stability, the main objective remains inflation stability. Therefore, financial variables are used as signals for the risk of

inflation. Trade-offs are quantified using the loss function of the monetary authority and the variable that indicates the trade-offs is the ratio of credit to GDP. The author finds that some flexibility must exist between the two objectives when trade-offs are present. More exactly, results show that in order to stabilize the economy (price stability and financial stability) in the long term, price stability needs to be given less importance in the short term, especially in situations when the financial stability is threatened. In this respect, this result joins the one obtained by Woodford (2012). Three proposals are made with regard to the way in which to achieve the best outcome: the central bank can (i) change its preferences with respect to financial stability and price stability, (ii) extend the horizon for the price stability objective and (iii) use a more flexible inflation target.

As N'Diaye (2009), Gray et al. (2011) incorporate contingent claims analysis (CCA) in a standard monetary policy analysis model. Their goal is to study, for an open economy, the economic implications of using an augmented Taylor rule. The financial indicator – the distance to default of the banking system – is calculated base on market data and bank balance sheets, using the CCA model. The idea of this indicator is to compare the expected value of the bank's assets with payments promised by the bank. The probability that the assets' value is lower than the expected promised payments gives the probability of default of the bank, while the normal cumulative distribution function of the threshold in this probability gives the distance to default. This risk indicator is integrated not only in the interest rate rule, but also in the equation of the output gap and in the condition for interest rate parity. The augmented Taylor rule manages to reduce the volatility of inflation and output in several calibrations of the model. However, financial stability is not an objective for the monetary authority and there is no macroprudential authority in the model.

Finally, Nakornthab and Rungcharoenkitkul (2010) take as a starting point a reduced form three equation model in which they incorporate a banking sector in the way suggested by Bernanke and Blinder (1988). Capital requirements establish how much capital banks should hold as a percentage of their assets. Besides the fixed part, a countercyclical buffer is added. The decisions for the macroprudential rule are based on the evolution of output with respect to its steady state. The central bank uses a standard Taylor rule with smoothing to minimize a loss function which integrates the volatility of inflation, of the output gap and of the interest rate. The macroprudential loss function is not specified in the model, as the authors simply look at the evolution of output, inflation, the interest rate and loans to see how the macroprudential instrument affects the economy. They compare impulse response functions in three configurations: no capital constraint, fixed capital constraint and countercyclical capital constraint. Under the countercyclical capital scenario, results for both demand and supply shocks reveal that macroprudential

regulation has a stabilizing role for output only, as inflation seems to be more volatile in this case. Their model underlines the existence of trade-offs between output and price stability, not only when macroprudential regulation is enforced, but also in the two other scenarios (no constraint and fixed capital constraint). However, trade-offs between monetary policy objectives and financial stability are not studied.

All in all, from the above literature, we can provide three main remarks. First, the type of shock that hits the economy plays an important role in the analysis of macroprudential policy. Most of the papers considered here find that the macroprudential regulator should intervene when financial shocks appear (Angelini et al., 2011, Agénor et al., 2013, Beau et al., 2013, Christensen et al., 2011, Kannan et al., 2012). Other type of shocks, like productivity shocks, for example, need to be handled with the interest rate rule only, either standard (Kannan et al., 2012), or augmented (Beau et al., 2013). However, in this case (technology shocks) if macroprudential regulation is maintained next to the monetary policy intervention, the best scenario is obtained when the two authorities cooperate (Angelini et al., 2011, Christensen et al., 2011). Our second remark concerns the trade-offs between objectives. Results at this level are rather mixed and no clear conclusion can be made. Some of the authors find no trade-off between macroeconomic stability and financial stability (Agénor et al., 2013, Angelini et al., 2011, Angeloni and Faia, 2009, Kannan et al., 2012). Others, find trade-offs only in particular scenarios: either when financial shocks occur (Woodford, 2012) or only when productivity shocks are considered (Beau et al., 2013, Christensen et al., 2011). Finally, and most importantly, in the studies considered, macroprudential policy seems to have a stabilizing role for both the financial sector and the real economy.

In light of these results, we propose ourselves to provide some new evidence on the existence of trade-offs and on the role played by macroprudential policies when different types of shocks are considered. To this end, we use the framework proposed by Nakornthab and Rungcharoenkitkul (2010), as it is close in spirit to our first model and it does not involve the use of a complex DSGE models where results might be difficult to trace. We present the extended version of the model together with the results in the next section.

4.3 Macprudential policy and trade-offs

The aim of this second analysis is to see if trade-offs between objectives still persist when, besides the monetary authority, a macroprudential regulator is included in the model, with the role of preserving financial stability. Adding a macroprudential rule

requires introducing a banking sector in the model. To this end, we follow Bernanke and Blinder (1988) and Nakornthab and Rungcharoenkitkul (2010) and supplement the model with equations for the main components of a bank's balance sheet (credit, deposits and capital). This allows us to impose afterwards a macroprudential rule, conceived as a constraint on bank leverage. The countercyclical buffer is, in our case, based on the deviations of the output gap from its steady state, but the results can easily be extended to consider either credit growth, or credit to GDP deviations. Furthermore, as we have seen from the literature review, the type of shock might influence the outcome in terms of trade-offs. Therefore, we study, as before, the results following both supply and financial shocks. The latter are modeled through the equation of the asset price bubble, with the difference that in this analysis, the bubble is influenced not only by monetary policy, but also by the evolution of credit in the economy. More precisely, credit is assumed to fuel the bubble. We describe hereafter the theoretical framework used to investigate the emergence of trade-offs.¹⁸

4.3.1 The theoretical framework

The first step in constructing our model is to define the aggregate demand equation as follows:

$$y_t = \delta \mathbb{E}_t(y_{t+1}) + (1 - \delta)y_{t-1} - \sigma \left(i_t - \mathbb{E}_t(\pi_{t+1}) \right) - v \left(i_t^c - \mathbb{E}_t(\pi_{t+1}) \right) + \varphi b_t + \varepsilon_t^y \quad \sigma, v > 0. \quad (4.7)$$

This hybrid IS curve differs from the one considered in the first section in the introduction of the real lending rate, $\left(i_t^c - \mathbb{E}_t(\pi_{t+1}) \right)$. This is justified by the existing connections between the real and the financial sector, as demand is supposed to be negatively influenced by the rate at which economic agents can obtain credit: the higher the interest rate, the lower their demand for credit, and thus their consumption and investment, with a negative impact on the output gap. We recognize here the bank lending channel, described in chapter 1. To model the banking sector, we consider the following four equations:

$$c_t^d = c_y y_t - c_i \left(i_t^c - \mathbb{E}_t(\pi_{t+1}) \right), \quad c_y, c_i > 0 \quad (4.8)$$

$$c_t^s = \left(1 - \frac{N}{C} \right) d_t + \frac{N}{C} n_t \quad (4.9)$$

$$d_t = d_y y_t - d_i \left(i_t - \mathbb{E}_t(\pi_{t+1}) \right), \quad d_y, d_i > 0 \quad (4.10)$$

$$n_t = n_y y_t, \quad n_y > 0. \quad (4.11)$$

¹⁸ All the notations used in the first analysis remain valid in this section.

In these equations, lowercase letters with time subscripts represent log-deviations of variables from their steady state, whereas uppercase letters without time subscripts are the respective steady state values. Equation (4.8) summarizes the evolution of real credit demand, c_t^d . It is assumed that credit demand increases with the economic activity, but decreases with the real lending rate. The equation for credit supply, c_t^s (equation (4.9)) results from the log-linear transformation of the bank balance sheet identity, *i.e.* $C_t = D_t + N_t$, where C_t , D_t and N_t stand for credit, deposits and bank capital, in aggregate form. Equation (4.10) describes the evolution of real deposits, d_t , by assuming that they depend positively on the output gap and negatively on the real interest rate. Since deposits are not remunerated, the real interest rate represents an opportunity cost, hence the negative relation between the two variables. Finally, real bank capital, n_t , is assumed to increase only with the output gap (equation (4.11)). At equilibrium, credit demand is equal to credit supply. Substituting deposits and bank capital into the resulting equilibrium relation yields the following expression of the real lending rate:

$$i_t^c - \mathbb{E}_t(\pi_{t+1}) = \left[\frac{c_y}{c_i} - \left(1 - \frac{N}{C}\right) \frac{d_y}{c_i} - \frac{N}{C} \frac{n_y}{c_i} \right] y_t + \left(1 - \frac{N}{C}\right) \frac{d_i}{c_i} (i_t - \mathbb{E}_t(\pi_{t+1})). \quad (4.12)$$

Substituting this expression of the real lending rate into the aggregate demand equation yields:

$$\omega^u y_t = \delta \mathbb{E}_t(y_{t+1}) + (1 - \delta) y_{t-1} - (\sigma + \kappa) \left(i_t - \mathbb{E}_t(\pi_{t+1}) \right) + \varphi b_t + \varepsilon_t^y \quad (4.13)$$

where $\omega^u = 1 - \frac{v}{c_i} \left[\left(1 - \frac{N}{C}\right) d_y + \frac{N}{C} n_y - c_y \right]$ and $\kappa = \frac{v}{c_i} \left(1 - \frac{N}{C}\right) d_i > 0$. Equation (4.13) gives the expression of the aggregate demand when the regulator does not constrain the banking sector by imposing capital requirements. The superscript “u” indicates that this is the *unconstrained* case.

To investigate the implications of prudential regulation on the macroeconomic and financial system, let us assume that banks are constrained by the following capital requirement:

$$N_t \geq \left[e + \frac{1}{\mu_1} \left(\frac{Y_t}{Y} \right)^{\mu_2} \right] C_t \quad (4.14)$$

where Y_t and Y stand for the output and its steady state respectively, e and μ_1 are positive constants, and $\mu_2 \geq 0$. With this simple definition of the capital rule, we intend to mimic the Basel III regulation introduced in the aftermath of the recent global financial crisis. The constant parameter e , can be thought of as the sum of the (fixed) minimum capital ratio and the capital conservation buffer. The term in brackets captures the countercyclical part of the bank capital requirements. This regulation intends to

increase capital requirements in good times (periods of expansion) and to decrease these requirements during downswings. The underlying idea is that risk accumulates during booms, therefore capital will be needed when a burst occurs to absorb the losses, as risk materializes. Moreover, this regulation is not only seen as an ex-post action, but also as an ex-ante intervention, because the countercyclical buffer is also aimed at limiting credit during expansions: banks are obliged to hold more capital, therefore they will extend less credit to the economy.

We follow Nakornthab and Rungcharoenkitkul (2010) and rely on deviations of GDP from its steady state as the variable representing the cyclical position of the economy. Output deviations from the steady state are therefore expected to capture potential risk accumulation. Angeloni and Faia (2009) also rely on a similar framework to mimic the Basel III regulatory regime. In our analysis, the case where $\mu_2 = 0$ will be referred to as the fixed capital requirement regime, whereas the case where $\mu_2 > 0$ will stand for the countercyclical capital requirement regime. The log-linear transformation of equation (4.14) leads to a new expression for the credit supply:

$$c_t^s = n_t - \frac{\mu_2}{\mu_1 e + 1} y_t. \quad (4.15)$$

Equalizing equation (4.15) with the demand for credit (equation (4.8)) and following the same simplifications and substitutions as above, leads us to the following expression for the aggregate demand:

$$\omega^c y_t = \delta \mathbb{E}_t(y_{t+1}) + (1 - \delta) y_{t-1} - \sigma \left(i_t - \mathbb{E}_t(\pi_{t+1}) \right) + \varphi b_t + \varepsilon_t^y, \quad (4.16)$$

where $\omega^c = 1 - \frac{v}{c_i} \left(n_y - c_y - \frac{\mu_2}{\mu_1 e + 1} \right)$. Equation (4.16) provides the expression of the aggregate demand when the banking sector is constrained by prudential regulation. The superscript “c” denotes the *constrained* case which encompasses the fixed capital requirement case ($\mu_2 = 0$) and the countercyclical capital requirement case ($\mu_2 > 0$).

As stated at the beginning of this section, the bubble evolution also changes with respect to the first analysis. As the recent financial crises emphasized, asset price bubbles are often preceded or accompanied by credit booms. Particularly, the housing price bubble that culminated in a crisis in the late 2000s was associated with an increase in bank loans and especially in mortgages. The literature has also largely documented this positive correlation between asset price bubbles and credit booms. Several empirical studies show that asset price inflation is usually preceded by an increase in domestic credit, making the latter a good forward indicator for the detection of asset price booms. The related literature for industrialized economies includes Detken and Smets (2004), Gerdesmeier et al. (2010), Helbling and Terrones (2003), Machado and Sousa (2006),

among others. To take into account this relationship between financial bubbles and domestic credit, we assume that the bubble process can be affected by bank loans. More precisely, credits are supposed to have a positive impact on the bubble:

$$b_t = \left[\frac{1 + \bar{i}}{\bar{q}} (b_{t-1} + \gamma \Delta i_{t-1} + \phi c_{t-1}^s) \right] D + \varepsilon_t^b, \quad (4.17)$$

where as before, D is a dummy variable which takes the value of 1 as long as the bubble persists and 0 when it bursts. To complete our framework, we add to the model described above, the equation for the New Keynesian Phillips Curve (equation (4.4)) and the equation governing the interest rate rule (equation (4.6)). These two equations do not change with respect to the first analysis, therefore we do not exclude the case where the central bank uses the augmented Taylor rule.

To solve the model, we apply the same approach as in the first section, *i.e.* the Blanchard-Kahn methodology is used to solve the model for the case where $D = 1$ and when $D = 0$. At each period of time, we switch between the two states depending on the value of D , which ultimately depends on whether the endogenous variable q_t is above or below the threshold $\bar{q}$.

Regarding the calibration of the model, for the parameters of the standard New-Keynesian equations we use the same values as in the first analysis. The parameters related to the banking sector equations are taken from Nakornthab and Rungcharoenkitkul (2010). All values correspond to annual data for the euro area. Finally, in choosing the value of ϕ , we assume that the effect of credit on the bubble is higher than the effect of the interest rate.¹⁹

4.3.2 Results

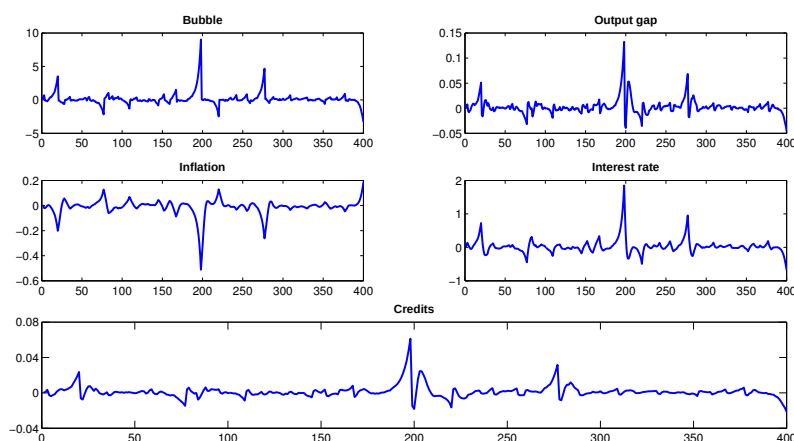
The reduced-form model described in the previous section is used to investigate various strategies that might be employed by the monetary authority and by the prudential regulator, to deal with different types of shocks. Moreover, we evaluate the relative performance of those strategies in achieving both macroeconomic (inflation and output gap) and financial stability. To this end, as previously done, we consider that in each period the economy is hit by random exogenous shocks (supply and/or bubble shocks). In response to these shocks, two main strategies are considered. First, a response through the sole monetary policy instrument, considering that the banking sector is unconstrained (no prudential instrument). Second, we consider the case where the prudential instrument is implemented and is potentially complemented by the central bank response to a financial variable. The prudential authority imposes either fixed, or countercyclical regulation.

¹⁹ Refer to Appendix A for the values of the parameters.

The central bank acts by setting the short term interest rate more or less aggressively to counteract shocks. Given the aggressiveness of these responses, we generate series of variances calculated on 1000 periods, for each of the three series we want to study (inflation, output gap and bubble). For each strategy considered, we compare the evolution of these variances in order to assess which one provides the best outcome in terms of macroeconomic and financial stabilization.

We start our analysis by looking at the response of the main variables to consecutive bubble shocks. For Figure 4.8, we employ the scenario when both monetary policy and macroprudential regulation are used to counteract financial shocks. The bubbles that form endogenously, have a positive impact on the output gap, which in turn, determines the supply of credit to the economy. As the central bank responds to positive financial shocks by increasing the nominal interest rate, inflation is better controlled. Output and credit are positively correlated. However, knowing that macroprudential regulation is enforced in this case, we assume that credit cycles are less volatile in this scenario than in the case where either no bank regulation is enforced, or fixed capital requirements are imposed on banks. To verify this fact, we turn to the analysis of trade-offs and compare the results between the unconstrained and the two constrained scenarios.

Figure 4.8: Model's response to bubble shocks
deviation from the steady state



Note: The response of the main variables to consecutive bubble shocks.

The main results are discussed considering first, the case where there is no prudential instrument (banks are unconstrained), and second, the case where the prudential authority imposes capital requirements on banks — fixed or countercyclical. For each strategy considered, we assess the response to asset price bubble shocks, as well as the response to the combination of asset price bubble and supply shocks. Note that, when supply shocks occur and the central bank increases its aggressiveness to inflation, the model reproduces,

in all configurations considered, the standard trade-off between inflation and the output gap. Therefore, we do not present these results and focus mainly on the response to financial shocks.

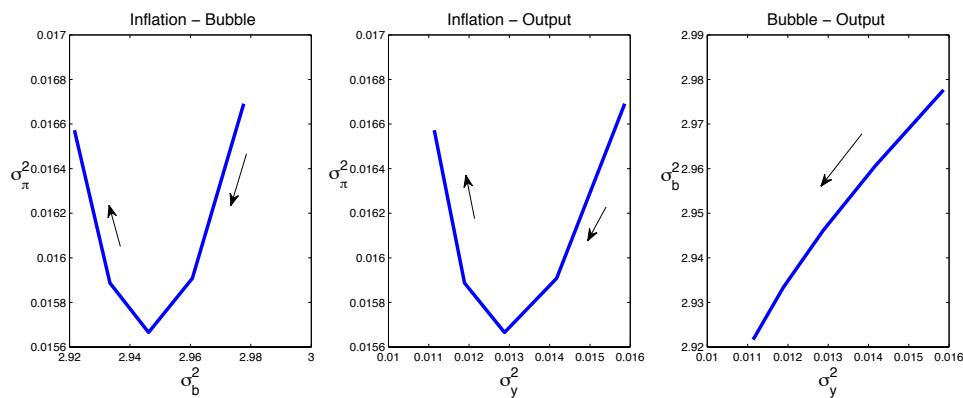
The unconstrained case

In the unconstrained case there is no prudential instrument and the only response to shocks occurs through the short term interest rate. The central bank can either respond by being more aggressive to the output gap, since the bubble has a direct impact on output, or it can react directly to financial shocks by leaning against the wind.

Unconstrained without leaning

In this case, it is assumed that the central bank does not react directly to financial imbalances ($\beta_b = 0$), but rather tightens the policy stance in response to the increase in output gap (which is a consequence of positive asset price bubble shocks). Figure 4.9 shows how the variances of π , y and b evolve with more aggressive central bank responses to the output gap (increase in β_y) in case of asset price bubble shocks. In a first stage, the results suggest that all the variances decrease, implying that this strategy produces the desired effect stabilizing the bubble and the macroeconomic environment. However, in a later stage, when the central bank's response becomes more aggressive, the volatility of the bubble continues to decrease, whereas inflation volatility starts rising. In other words, a stronger response to financial shocks generates a trade-off between inflation stability and financial stability.

Figure 4.9: Bubble shocks (Response to output gap)

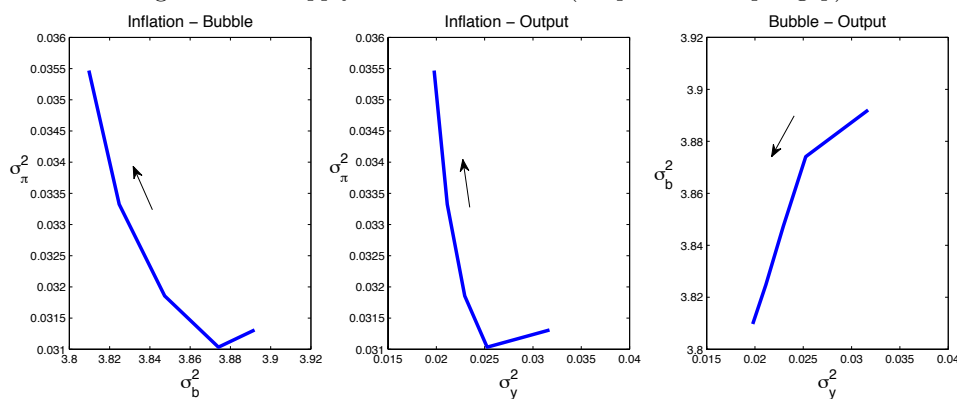


Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

Figure 4.10 provides the results for the case where both supply and financial shocks hit the economy. These results are broadly in line with the findings discussed above. Being more aggressive to the output gap stabilizes at first both the financial sector and

the macroeconomic environment. But when such a response becomes more aggressive, a trade-off emerges between financial stability and inflation stability. Note that in this case, the trade-off appears for lower values of β_y , as compared to the case where only bubble shocks occur.

Figure 4.10: Supply and bubble shocks (Response to output gap)



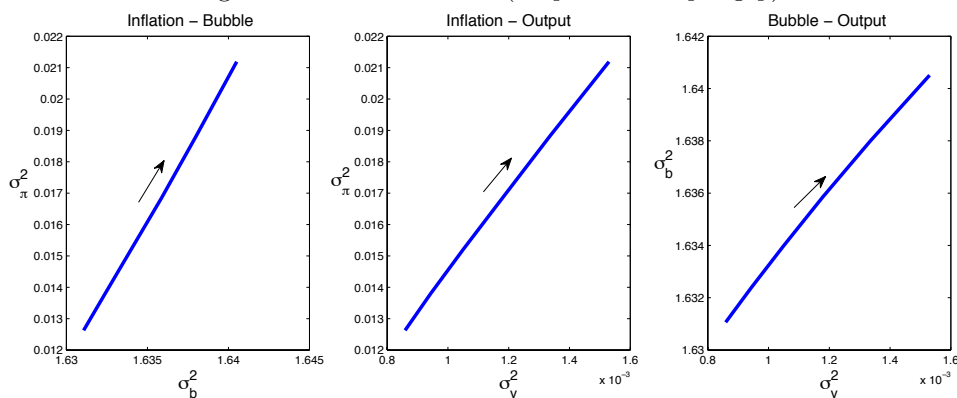
Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

Unconstrained with leaning

We assume here that the central bank follows a leaning against the wind strategy, *i.e.* the short term interest rate responds to asset price deviations from the fundamental value ($\beta_b \neq 0$). We consider two alternative strategies: an indirect response through the output gap (increase in β_y) or a direct response to the bubble (increase in β_b).

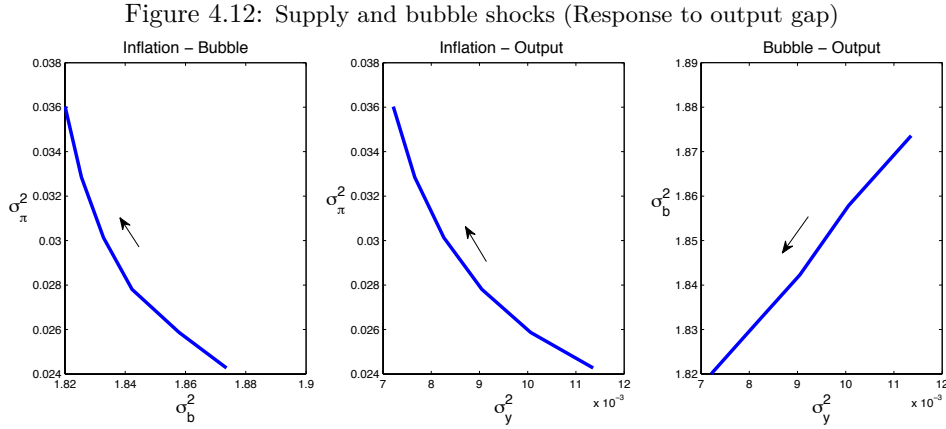
In case of bubble shocks, a response to the output gap generates an increase in volatility for all variables (Figure 4.11). This suggests that such a strategy is counterproductive in the sense that the central bank's actions stabilize neither the financial sector, nor the macroeconomic environment.

Figure 4.11: Bubble shocks (Response to output gap)



Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

Considering the combination of supply and bubble shocks, a response to the output gap stabilizes the bubble and the output gap (decrease in the bubble and output gap volatilities), but generates higher instability in terms of inflation. This strategy is therefore subject to a trade-off between objectives (Figure 4.12).



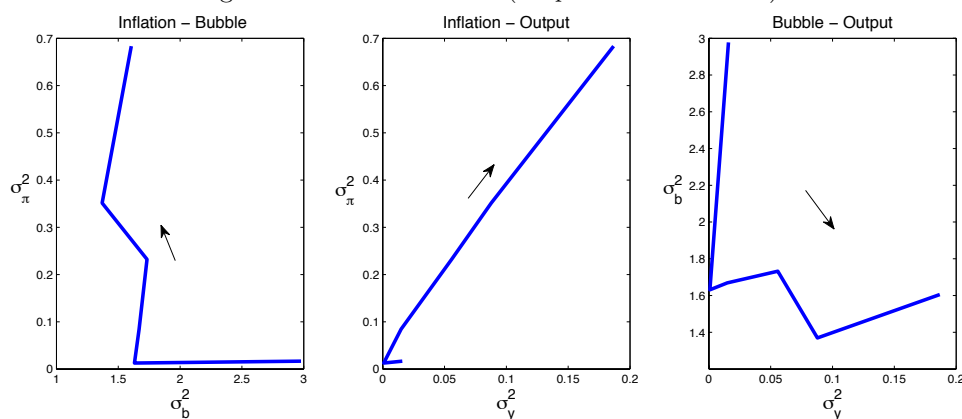
Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

An interesting remark is that, compared to the “unconstrained without leaning” case, the volatility of the bubble and of the output gap are significantly lower (given the same magnitude of the central bank’s response). The level of inflation volatility remains broadly unchanged. Based on this observation, we can argue that the strategy where the central bank relies, to a small extent, on a leaning against the wind approach, and at the same time, reacts more aggressively to the output gap, produces a better (although, not satisfactory) outcome.

Let us consider now the direct response to the bubble: increase in β_b in response to asset price bubbles or asset price bubble and supply shocks. Figures 4.13 and 4.14 show how the variances are affected by such a policy. Broadly speaking, the two figures look alike. The bubble volatility does not seem to describe a clear trend (as compared with the other strategies studied so far), suggesting higher instability for the financial sector. In addition, the levels of all variances are significantly higher as compared with those that result from an indirect response of the central bank through the output gap. This suggests that a strategy involving an increase in the policy rate in response to the bubble is not efficient as it deteriorates the stability of the financial sector and destabilizes the macroeconomic environment.

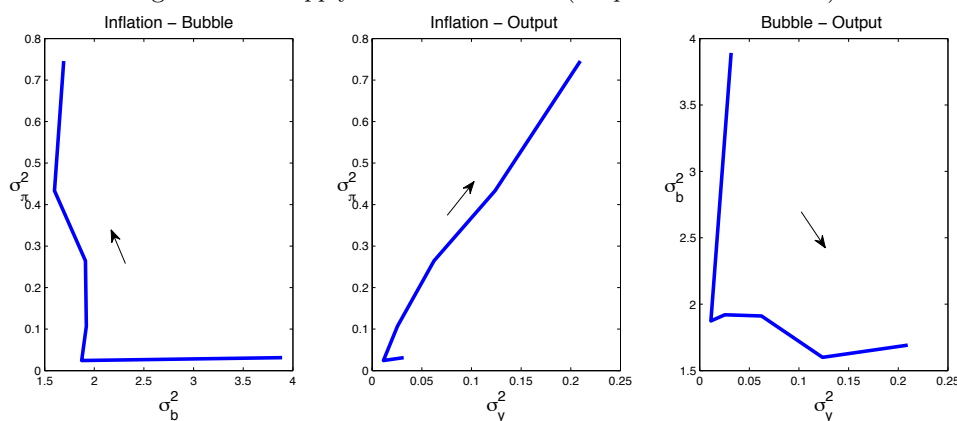
To summarize the findings at this stage of the analysis, we can state that it seems important for monetary policy to take into account financial imbalances when setting the policy rate. Although trade-offs still persist, leaning against the wind seems to reduce the volatility of interest variables. However, the central bank should react by strengthening the short term interest rate responses to the output gap, rather than increase its response

Figure 4.13: Bubble shocks (Response to the bubble)



Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in β_b .

Figure 4.14: Supply and bubble shocks (Response to the bubble)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in β_b .

to the bubble. Indeed, the model's simulations show that a stronger response to the bubble generates higher financial and macroeconomic instability.

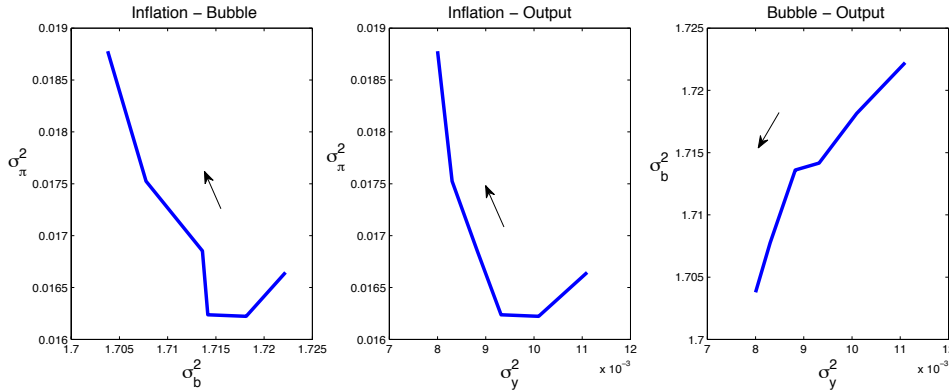
The constrained case

We consider now the case where a prudential instrument is used to stabilize the financial sector. In particular, a capital requirement is imposed on banks in order to reduce their loan supply and ultimately deflate the bubble. We further assume that this prudential instrument can be implemented in parallel with a leaning against the wind strategy of the central bank. Especially, as discussed earlier, two possible formulations of the prudential instrument are investigated: fixed and countercyclical capital requirement.

Fixed capital requirements

Let us first assume that since a prudential instrument is used to safeguard financial stability, the central bank does not respond directly to financial imbalances ($\beta_b = 0$), but rather strengthens the reaction to the output gap in response to shocks (increase in β_y). The results in Figure 4.15 suggest that, with fixed capital requirements in place, the central bank's response to the output gap improves the stability of the financial sector, as the volatility of the bubble is reduced. Moreover, this strategy also reduces the volatility of the output gap. As regards inflation, its volatility is at first reduced, but stronger interest rate responses to the output gap lead to an increase in volatility for this variable, generating a trade-off between inflation stability and financial stability.

Figure 4.15: Bubble shocks (Response to output gap)

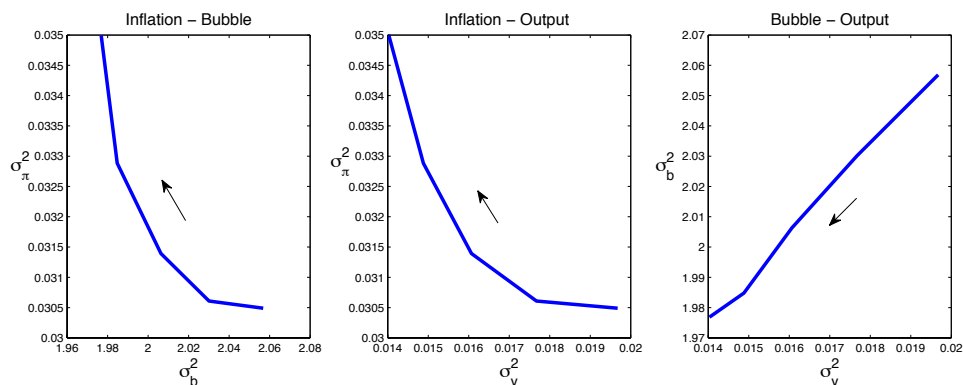


Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

Figure 4.16 provides the results obtained in the same context as above, but when bubble and supply shocks occur simultaneously. The simulations suggest that the central bank's response reduces both the bubble and the output gap volatilities, but generates higher inflation instability. Therefore, a trade-off also emerges in this case between the standard inflation stability objective and financial stability.

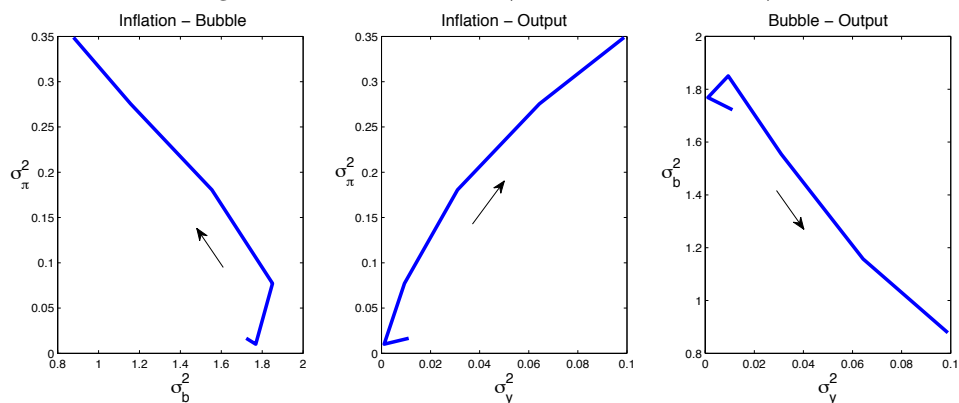
An alternative policy framework is the case where, despite the implementation of the prudential instrument, the central bank is (directly) concerned with financial imbalances when setting its policy rate ($\beta_b \neq 0$). Figures 4.17 and 4.18 show how a more aggressive response to asset price deviations affects the variables' volatilities in case of bubble shocks, and bubble and supply shocks, respectively. In line with previous findings, we find that a direct response to bubbles is not desirable, if compared to the response to the output gap. The financial sector seems to be more unstable, as the bubble volatility is higher. More importantly, the macroeconomic environment is much more volatile, as the variances significantly increase as compared with the previous case (see Figures 4.15/4.16 as compared to Figures 4.17/4.18).

Figure 4.16: Supply and bubble shocks (Response to output gap)



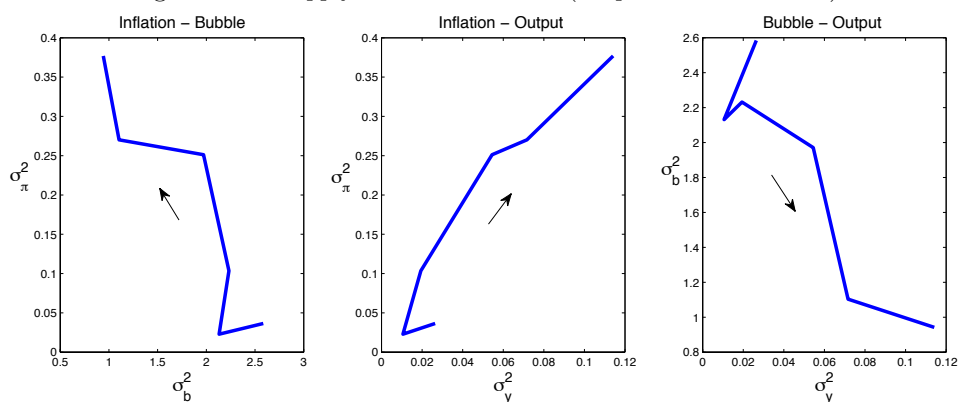
Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

Figure 4.17: Bubble shocks (Response to the bubble)



Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in β_b .

Figure 4.18: Supply and bubble shocks (Response to the bubble)

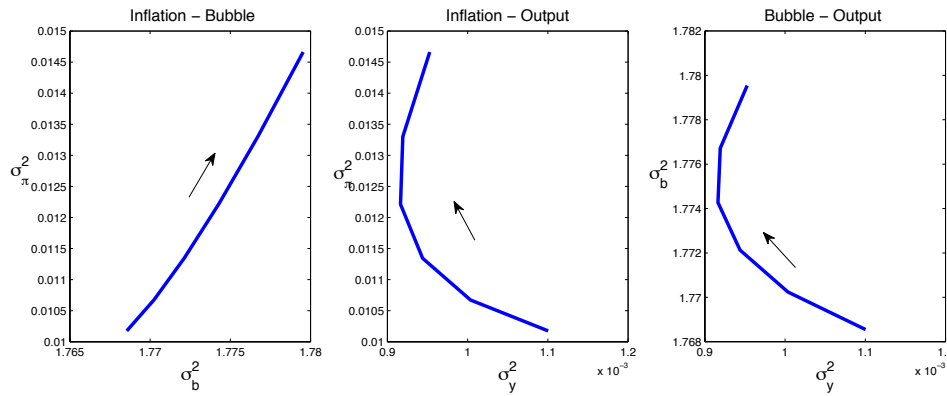


Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in β_b .

Let us assume now, that under the same circumstances (fixed capital requirements and a lean against the wind strategy) the increase in the aggressiveness of this central bank's response to shocks manifests through the output gap (increase in β_y). Figures 4.19

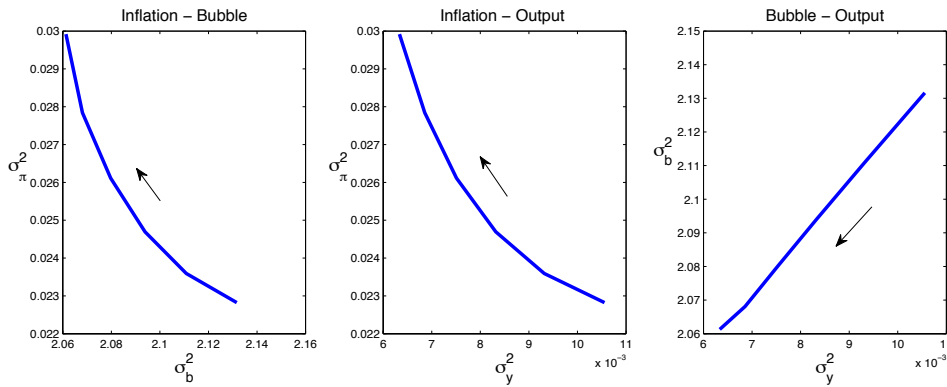
and 4.20 present the consequences of this strategy on the financial and macroeconomic stability. Figure 4.19 shows that in case of asset price bubble shocks, this strategy generates an increase in both inflation and bubble volatilities, while the output gap volatility decreases. When bubble and supply shocks occur simultaneously, Figure 4.20 shows that a trade-off emerges between inflation stabilization and financial stability. The bubble volatility decreases (as well as the output volatility) while inflation becomes more unstable. Note that this strategy provides a better outcome than the strategy studied in Figures 4.17 and 4.18, since the level of the variances are significantly lower, especially for the macroeconomic variables.

Figure 4.19: Bubble shocks (Response to output gap)



Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

Figure 4.20: Supply and bubble shocks (Response to output gap)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

The conclusions regarding the analysis of fixed capital requirements are in line with our discussion so far. First, the direct and more aggressive response to the bubble does not seem to provide a desirable outcome. When it might be necessary to strengthen the monetary policy response to financial shocks, central banks should rather increase the extent to which the policy interest rate reacts to the output gap. Second, the results

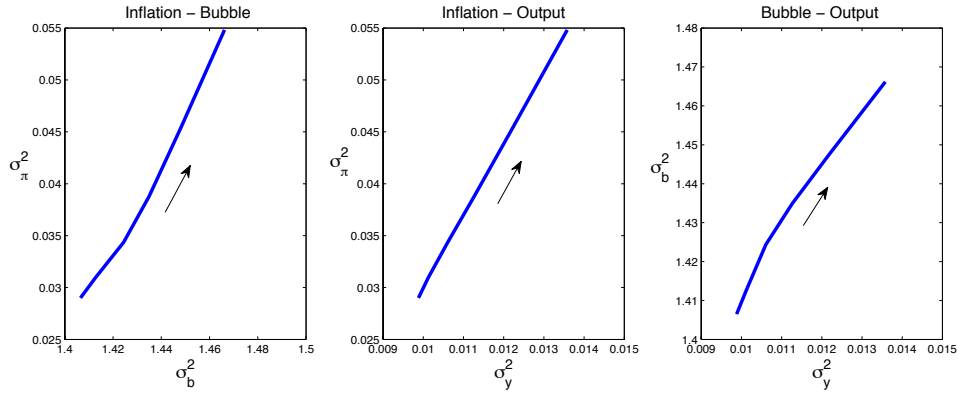
suggest that even if a prudential instrument exists and is devoted to financial stability, the central bank should also be concerned with financial imbalances when setting the policy rate. Indeed, irrespective of the nature of shocks considered in this analysis, the findings show that the combination of the leaning against the wind strategy and the implementation of the prudential instrument provides a better outcome, as compared with a framework in which only prudential policy is used to maintain financial stability. In fact, the former policy approach provides a much better macroeconomic stabilization outcome as compared to the latter, while the difference in terms of financial sector stabilization does not appear to be very important (see Figures 4.15/4.16 as compared to Figures 4.19/4.20).

Countercyclical capital requirement

It is now assumed that the bank capital requirements adjust with the economic cycle. As in the previous scenario, we first investigate the framework in which the authorities rely on the macroprudential instrument to control financial imbalances and where the central bank does not lean against the wind ($\beta_b = 0$). The monetary authority rather responds to shocks by strengthening the interest rate's reaction to output deviations (increase in β_y). In case of bubble shocks, such a strategy generates an increase in all the variables' volatilities (Figure 4.21). Although these findings may suggest a counterproductive effect of the central bank's reaction, note that the levels of the bubble volatility are much lower as compared to all the other strategies that have been investigated so far, highlighting the effectiveness of the countercyclical capital requirement as a macroprudential instrument. Considering the combination of supply and bubble shocks, Figure 4.22 shows that more aggressive responses to the output gap generate at first a decrease in the volatility of the bubble, while inflation instability increases (suggesting a trade-off). When the central bank's response becomes more aggressive, all the variances increase.

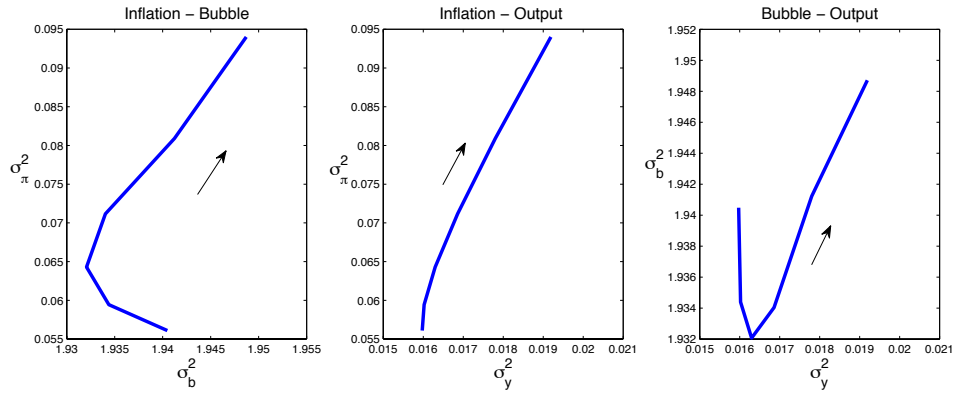
We assume now that in addition to implementing the macroprudential policy, the central bank responds to financial imbalances by tightening its monetary policy ($\beta_b \neq 0$). Figures 4.23 and 4.24 show that the resulting outcome is not desirable (in line with previous conclusions regarding this particular framework). This strategy generates the highest levels of volatility for the macroeconomic indicators (inflation and output gap) that the simulations have shown so far. Regarding the bubble volatility, when considering asset price shocks, the levels are close to the ones found in the previous strategy in which the interest rate responses occur through the output gap (Figure 4.23). These levels are much higher when asset price bubble and supply shocks occur at the same time (Figure 4.24). As before, we conclude that the strategy in which the central bank responds more

Figure 4.21: Bubble shocks (Response to output gap)



Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

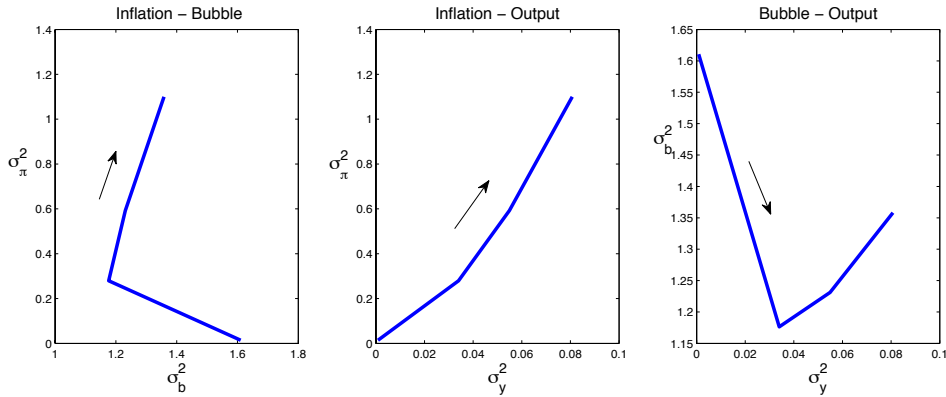
Figure 4.22: Supply and bubble shocks (Response to output gap)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

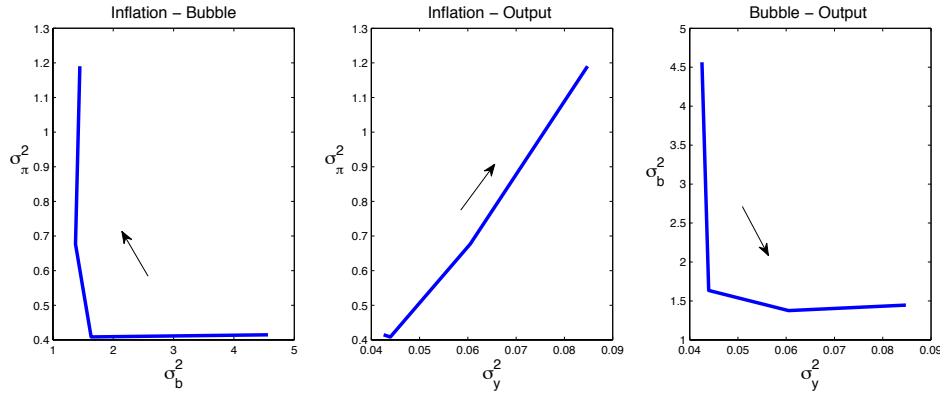
aggressively to the bubble is too costly and cannot be considered as a policy response to shocks.

Figure 4.23: Bubble shocks (Response to the bubble)



Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in β_b .

Figure 4.24: Supply and bubble shocks (Response to the bubble)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in β_b .

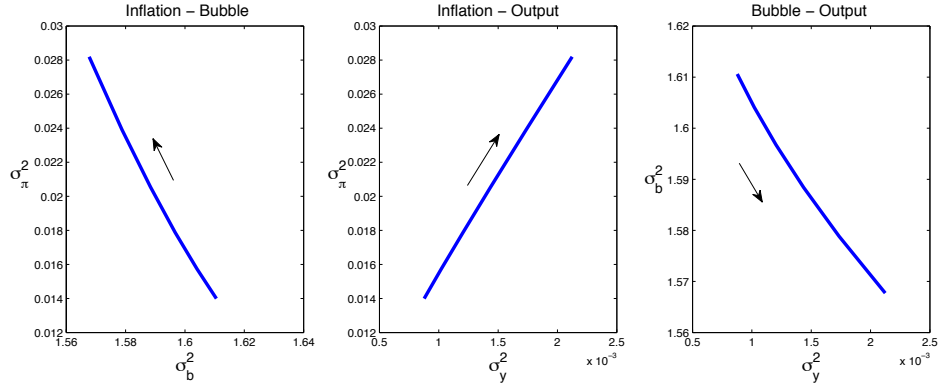
Finally, let us now consider a framework in which the central bank implements a leaning against the wind strategy ($\beta_b \neq 0$, but set to a small value) to complement the macroprudential policy, and shocks are dealt with more aggressive responses to the output gap (increase in β_y). Figure 4.25 shows the effects of this strategy on both macroeconomic and financial stability in case of asset price bubble shocks. The results suggest that the bubble volatility decreases, while output and inflation instability increase. Therefore, a trade-off emerges between macroeconomic and financial stability. Note however that this strategy provides a better outcome in terms of macroeconomic stabilization, as compared with the strategy in which prudential policy is implemented without the leaning against the wind strategy. When the central bank's response is the most aggressive (when β_y reaches its highest value) inflation and output gap volatilities are lower by about 50% and 85%, respectively. Regarding the bubble volatility, the levels appear to be higher with this latter strategy by about 7%. If we consider that the gains in terms macroeconomic stabilization exceed the losses in terms of financial stability, this strategy may be preferred to the framework that excludes leaning against the wind.²⁰

Figure 4.26 shows the effects of the same strategy considered above when bubble and supply shocks occur at the same time. The simulation results show that the bubble volatility decreases, but at the cost of higher inflation instability. The output gap volatility also decreases at first, but increases subsequently when the central bank's response becomes more aggressive. Therefore, the trade-off between macroeconomic and financial stability remains relevant in this case. Compared to the framework in which the prudential instrument is used without a response from the central bank to financial imbalances, this strategy provides a better outcome in terms of macroeconomic stabilization. Inflation and output gap volatilities are much lower, while the difference in terms of bubble

²⁰ This type of comparison is purely quantitative and may bear some limitations in the sense that a 1% increase in the bubble volatility is certainly not worth a 1% increase in inflation or output gap volatility, in terms of welfare.

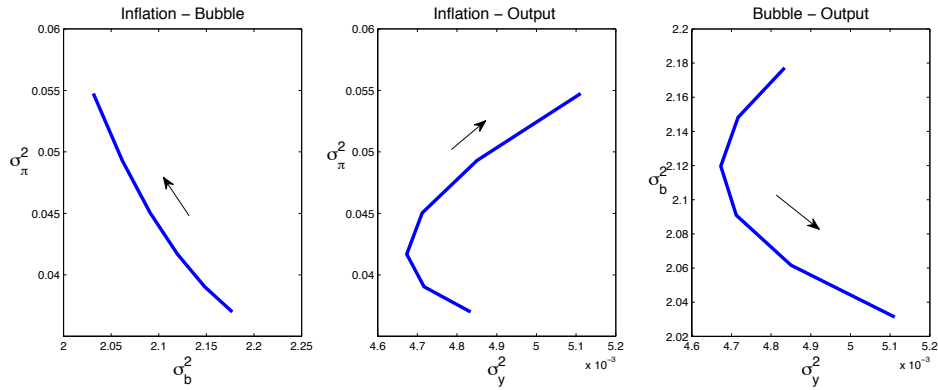
volatility is less significant (differences are approximately of the same magnitude as in the previous case). This finding also supports the relevance for central banks to lean against the wind, even when a prudential instrument is implemented.

Figure 4.25: Bubble shocks (Response to output gap)



Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

Figure 4.26: Supply and bubble shocks (Response to output gap)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

All in all, our analysis of the effectiveness of alternative strategies when a countercyclical capital requirement is enforced reveals broadly the same conclusions as in the previous investigations. A direct and strong response of the central bank to the bubble is not the best strategy. If a tighter monetary policy seems to be required in response to shocks, the short term interest rate should react more aggressively to output deviations (since the bubble affects the output gap), rather than to financial imbalances. Although constraining the credit supply through a countercyclical capital requirement seems to be effective in improving the financial sector stability, our analysis also points out the relevance for central banks to lean against the wind. A framework that combines these two pillars provides a much better macroeconomic stabilization outcome (even if the perfor-

manances in terms of financial stability are slightly impaired as compared to the strategy that does not include the leaning against the wind policy).

4.3.3 Comparing cases

The previous section discusses the main results considering successively the unconstrained case, the fixed capital requirement case and the countercyclical capital requirement case. The findings from these different scenarios are discussed separately, without a comparison between their respective performances in achieving both macroeconomic and financial stability. We therefore proceed with a comparative analysis in order to assess whether one of these alternative strategies may perform better than the others, given the type of shocks.

Unconstrained versus fixed capital requirements

For the unconstrained case, we find that the best strategy is the one that implies a leaning against the wind approach (with a low coefficient on the financial variable), while the central bank responds more aggressively to the output gap. Complementing this strategy with a fixed capital requirement yields a framework which significantly improves the macroeconomic stabilization performances. Precisely, when β_y reaches its highest value, in case of asset price bubble shocks, inflation and output gap volatilities are both approximately 30% and 37% lower, respectively, while the bubble volatility is about 8% higher. Assuming that the gain in terms of macroeconomic stabilization offsets the losses in terms of financial stability, the framework that includes the fixed capital requirement seems to perform better in case of bubble shocks.

When supply and bubble shocks occur simultaneously, the conclusions are more mixed. The introduction of the prudential instrument lowers inflation and output gap volatilities by about 16% and 12% respectively, and the bubble volatility is approximately 13% higher (as compared to the baseline framework in which the central bank leans against the wind and responds more aggressively to the output gap). Choosing between the two frameworks is in this case less obvious and discretion might be needed to deal with such situations. In this respect, an interesting extension of the model would consist in a welfare analysis based on the loss functions defined for each of the regulators (monetary and macroprudential). This would of course require that the optimal behavior be derived for the two authorities. Such an exercise would also allow us to consider coordination problems between the two authorities, an issue of much interest nowadays.

This first comparative analysis suggests that in case of financial shocks, the framework which relies on a fixed capital requirement in addition to the leaning against the wind strategy provides a better macroeconomic and financial stabilization outcome (compared

to the framework in which only leaning against the wind is used). When asset price bubble and supply shocks occur at the same time, the comparison is rather inconclusive.

Fixed versus countercyclical capital requirement

The simulations regarding the implementation of the countercyclical capital requirement show that this formulation of the prudential instrument is more effective than the fixed capital requirement in stabilizing the financial sector. This finding is in line with the recommendations of the Basel Committee. We further show that, when complemented with a moderate leaning against the wind strategy in which the central bank responds more aggressively to the output gap, the countercyclical framework generates a better outcome. Compared with the fixed capital requirement framework (which also includes the leaning against the wind strategy) in case of bubble shocks, the bubble volatility is about 12% lower. However, inflation and output gap volatilities increase significantly (roughly double). This makes the two frameworks more competing and highlights the trade-off between macroeconomic and financial stability.

When considering the case where asset price bubble shocks occur together with supply shocks, conclusions are again mixed. The bubble and the output gap volatilities are 1.5% and 20% lower, respectively, while the volatility of inflation is 83% higher (compared to the framework that includes fixed capital requirements and a leaning strategy).

Overall, the above results suggest that, the countercyclical capital requirement which adjusts to the economic cycle performs better than the fixed capital requirement. Our simulations show that the lowest levels of financial instability are found when the countercyclical capital requirement is implemented. However, the simulations also evidence that this framework does not provide the best macroeconomic stability conditions, suggesting that the implementation of macroprudential policy generates higher macroeconomic instability. When considering the case where there are both asset price bubble and supply shocks, our analysis seems to be rather inconclusive. The preferred strategy may depend on the financial and macroeconomic conditions prevailing in the economy. The use of discretion may, in this case as well, be required.

4.4 Conclusions and Policy Implications

This chapter explores the extent to which trade-offs can emerge between macroeconomic and financial stability. The first analysis we conduct relies on a central bank which responds directly to financial imbalances. The macroeconomic framework is described through a New-Keynesian model consisting of aggregate demand and aggregate supply equations, and the central bank's reaction function (an augmented Taylor-type rule in

which the policy rate responds to a financial bubble). This basic model is supplemented with a fourth equation capturing risk accumulation in the financial sector, the asset price bubble equation. We endogenously modeled the bubble assuming that it can be affected by monetary policy.

Various forms of central bank's responses and the strength of these responses are assessed when the economy is confronted with different shocks. The main conclusion of the analysis is that, central banks practicing the leaning against the wind strategy will face trade-offs between traditional macroeconomic objectives (inflation and output stabilization) and financial stability. More precisely, when the central bank responds to financial imbalances, in the best-case scenario, such a policy can succeed in dampening financial risks, but at the cost of higher price instability. Our results also seem to highlight the worse-case scenario in which the policy is counterproductive with respect to all the monetary policy objectives (increase in macroeconomic and financial instability). Therefore, this first analysis underlines the need for the introduction of another instrument, especially designed to deal with financial stability concerns.

In the existing literature, there also seems to be a consensus on this matter, as more and more papers introduce macroprudential regulation in models with financial frictions. The findings generally point to the key role of macroprudential rules in stabilizing not only the financial sector, but also the overall economy.

In our second analysis, we add a banking sector and a macroprudential rule to the simplified four equation framework considered in the first section. For the monetary authority we consider two alternative strategies – one where the standard Taylor rule is used and the other where a leaning against the wind strategy is preferred. For the prudential regulator, we consider three cases: no regulation, fixed capital requirements and countercyclical capital requirements. The instrument of the prudential regulator takes the form of a constraint on bank capital meant to reduce credit supply and to contain the bubble. The simulations allow us to derive some interesting conclusions with regard to the effectiveness of these different strategies. First, our findings suggest that if the central bank reacts directly and aggressively to asset price bubbles, the outcome is undesirable. Indeed, an increase in the response to bubbles generates the highest levels of macroeconomic volatility observed in each of the cases considered. Moreover, such a strategy does not seem to improve the stability of the financial sector either. We find that a better strategy for the central bank is to increase the responses to the output gap (since the bubble affects the output). This “indirect” response provides a better outcome in terms of both macroeconomic and financial stability.

Second, the simulations suggest that although the prudential instrument effectively improves the financial sector's stability (reduces the bubble's volatility, as compared

to the framework without prudential policy), the central bank should also contribute to maintaining financial stability by implementing a leaning against the wind strategy. This two pillar framework delivers much better results in terms of economic stability. Note however that, as stressed above, an increase in the strength of the leaning strategy in response to financial shocks is not desirable. When necessary, the intensification of the policy rate's reaction to shocks should rather be based on the output gap. These conclusions seem to be particularly relevant since they hold whatever the nature of the prudential instrument (none, fixed or countercyclical capital requirements) and whatever the nature of the shocks considered (asset price bubble shocks or bubble and supply shocks).

The framework we developed in this chapter can be used to perform further analyses. In the last section, we took the macroprudential policy as given and did not study the changes in the intensity of the countercyclical capital requirement. The simplest way to study trade-offs when the degree of aggressiveness of the macroprudential regulator increases would be to consider different values for the parameter ω_c . Additionally, more in-depth analysis can be realized if instead of using the output gap as an indicator of cyclical fluctuations, one uses the credit to GDP ratio. Further, we considered throughout the chapter that financial stability is given by the volatility of the asset price bubble. As we introduce a banking sector in the second analysis, one could also look at the volatility of credits or credits to GDP in order to assess financial stability. Even more, a financial stability index could be envisaged, combining both the bubble's volatility and the credit to GDP indicator. This would be in line with the idea that financial instability has various sources. Defining loss functions for each of the authorities and optimizing their behavior would also represent an interesting avenue for future research. This would also allow studying the cases of cooperation versus non-cooperation between authorities.

4.5 Appendix

A. Baseline calibration of the model

Table 4.1: Model calibration

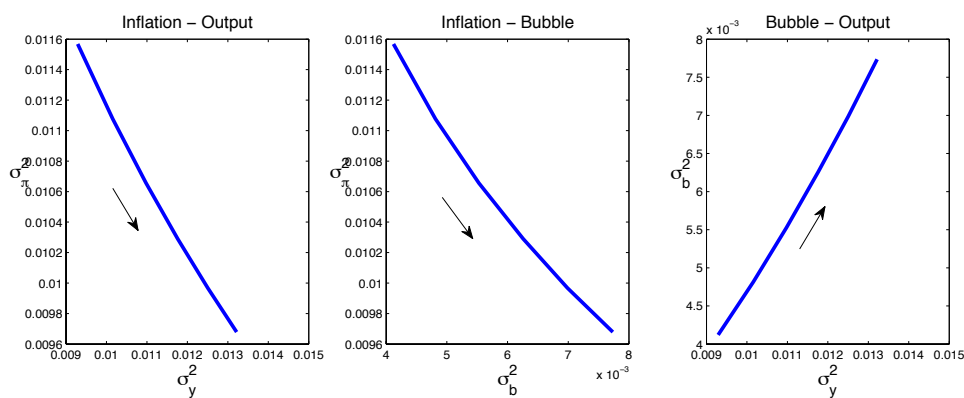
Parameters	α	λ	δ	σ	φ	γ	$\bar{q}$	$\bar{i}$	β_i	β_π	β_y	β_b
Value	0.52	0.18	0.56	0.06	0.02	0.06	0.8	0.04	0.98	1.5	0.5	0.15
Parameters	$\frac{N}{C}$	c_y	d_y	n_y	e	$\frac{v}{c_i}$	d_i	μ_1	μ_2	ϕ		
Value	0.105	1.5	1.5	1.5	0.105	0.29	0.08	1000	110	0.1		

Note: The values for the first four parameters are set according to Smets (2000). The values for φ and γ are chosen arbitrarily, but robustness tests to these values are provided hereafter. The interest rate smoothness parameter is chosen so as to match the euro area data. The parameters specific to the banking sector are taken from Nakornthab and Rungcharoenkitkul (2010).

B. Robustness Checks

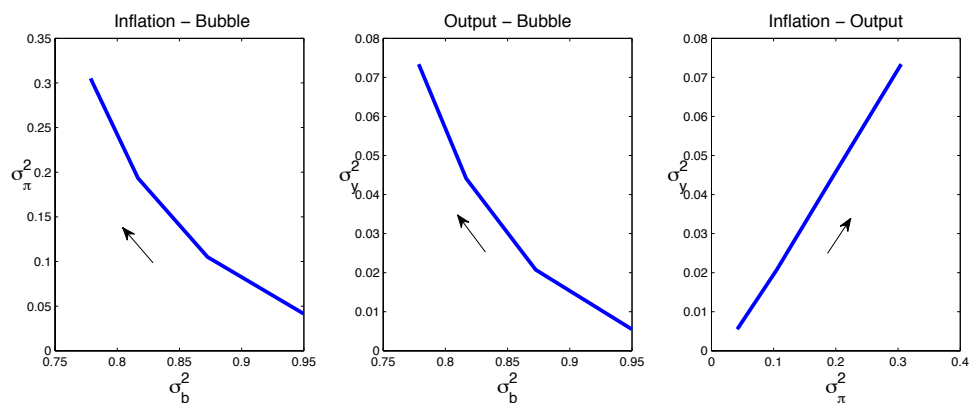
Bubble affected by levels rather than changes in interest rate

Figure (1a) Supply shocks (Response to inflation)



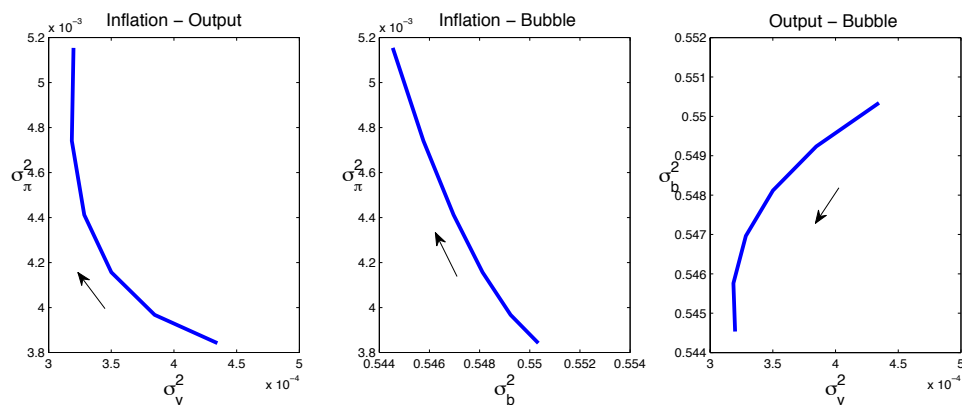
Note: Variances of inflation, output gap and the bubble following supply shocks. The response to inflation varies from 1.5 to 2.5 and all other parameters remain the same. The arrows indicate an increase in β_π .

Figure (1b) Bubble shocks (Response to the bubble)



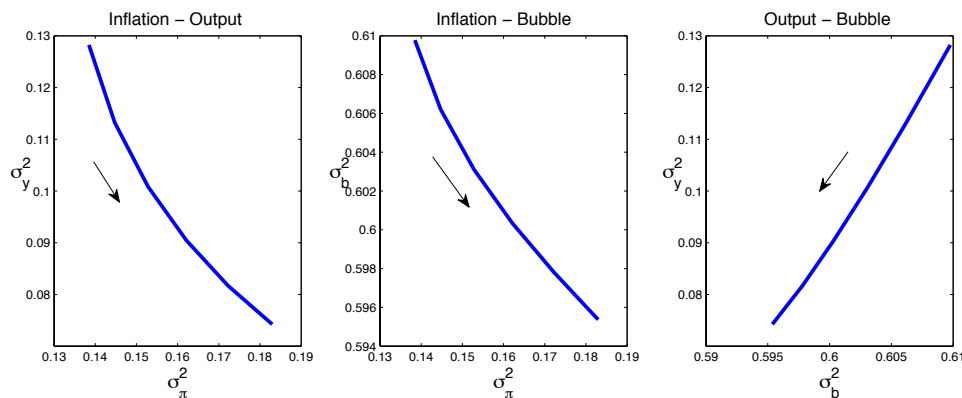
Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in β_b .

Figure (1c) Bubble shocks (Response to output gap)



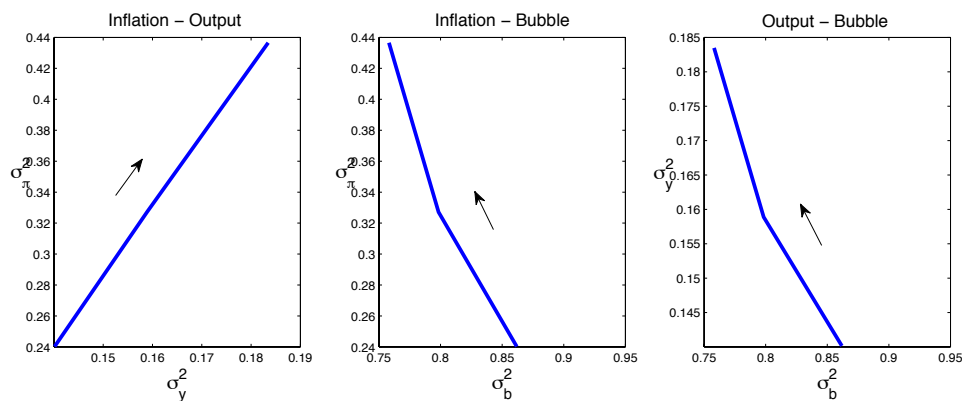
Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

Figure (1d) Supply and bubble shocks (Response to output gap)



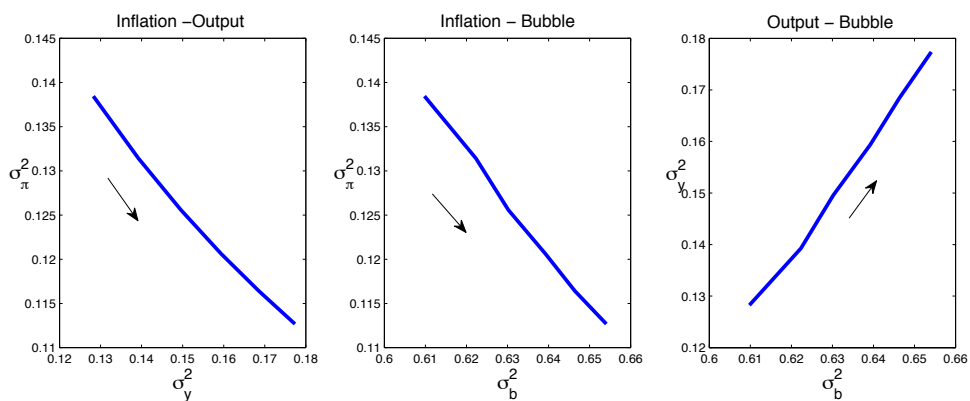
Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

Figure (1e) Supply and bubble shocks (Response to the bubble)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in β_b .

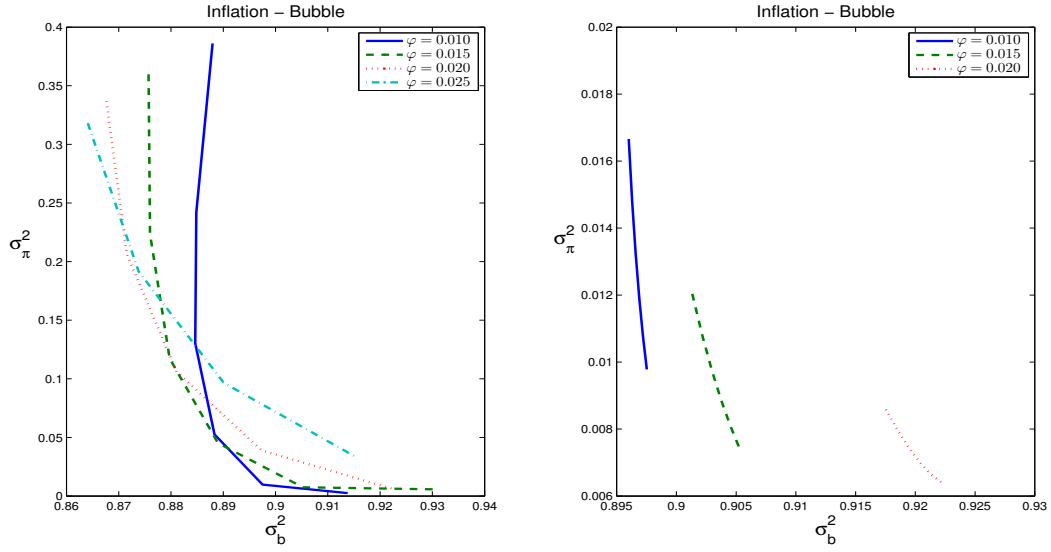
Figure (1f) Supply and bubble shocks (Response to inflation)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to inflation varies from 1.5 to 2.5 and all other parameters remain the same. The arrows indicate an increase in β_π .

Robustness to φ

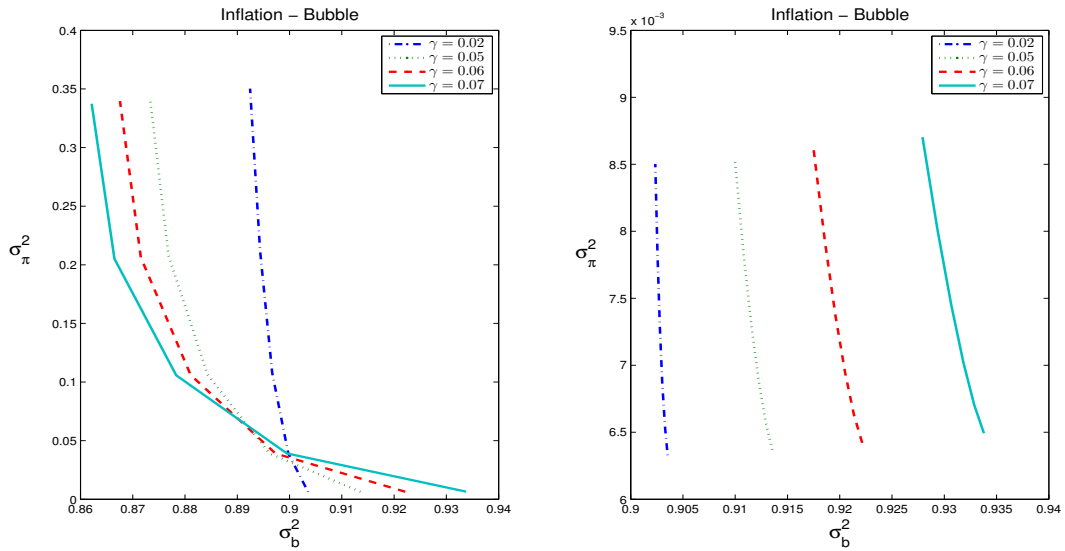
Figure (2) Bubble shocks (Response to the bubble [left] and to the output gap [right])



Note: Left panel – Response to the bubble: Variances of inflation and the bubble following bubble shocks. The response to the bubble varies from 0.15 to 0.75 and all other parameters remain the same. Right panel – Response to the output gap: Variances of inflation and the bubble following bubble shocks. The response to the output gap varies from 0.5 to 1.5 and all other parameters remain the same. We do not present in this panel the result for $\varphi = 0.025$, as the volatilities are much reduced and these smaller values make the figure difficult to read. Note however that the trade-off is still present.

Robustness to γ

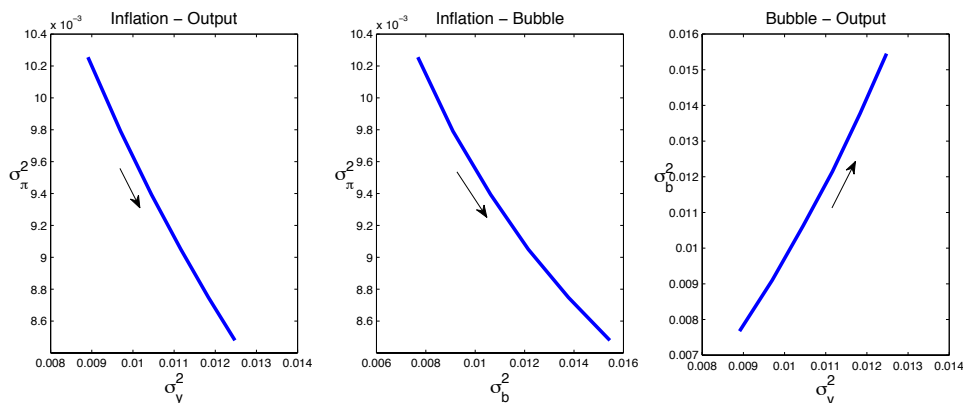
Figure (3) Bubble shocks (Response to the bubble [left] and to the output gap [right])



Note: Left panel – Response to the bubble: Variances of inflation and the bubble following bubble shocks. The response to the bubble varies from 0.15 to 0.75 and all other parameters remain the same. Right panel – Response to the output gap: Variances of inflation and the bubble following bubble shocks. The response to the output gap varies from 0.5 to 1.5 and all other parameters remain the same.

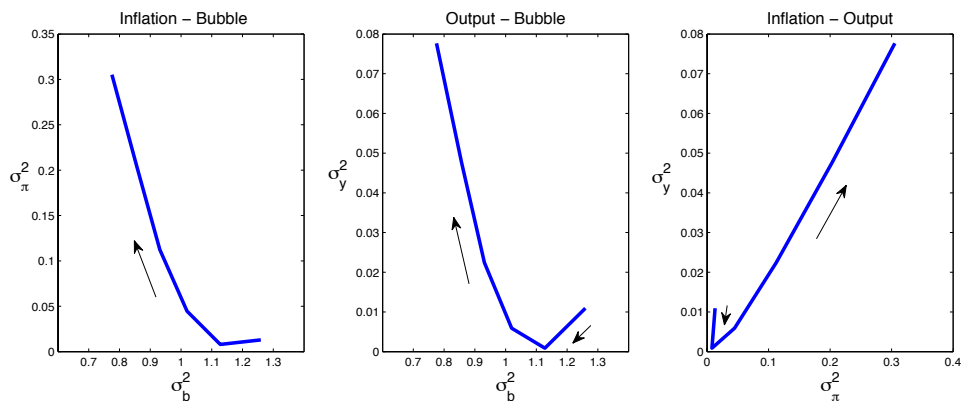
Robustness to an alternative selection of shocks

Figure (4a) Supply shocks (Response to inflation)



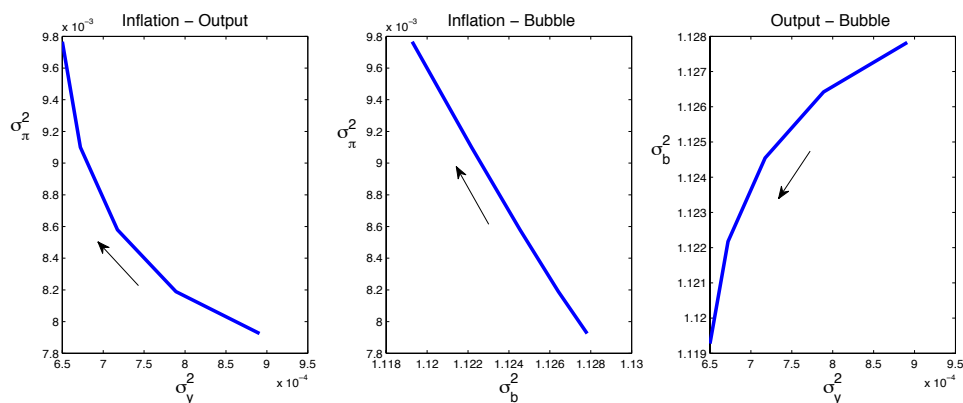
Note: Variances of inflation, output gap and the bubble following supply shocks. The response to inflation varies from 1.5 to 2.5 and all other parameters remain the same. The arrows indicate an increase in β_π .

Figure (4b) Bubble shocks (Response to the bubble)



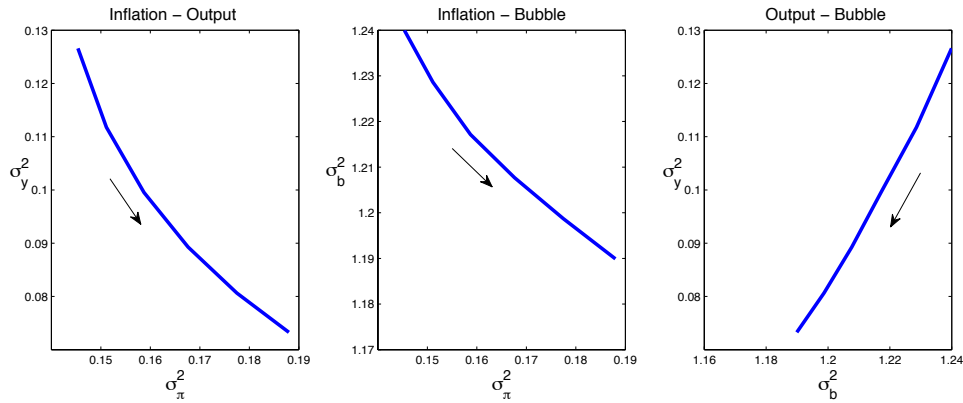
Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in β_b .

Figure (4c) Bubble shocks (Response to output gap)



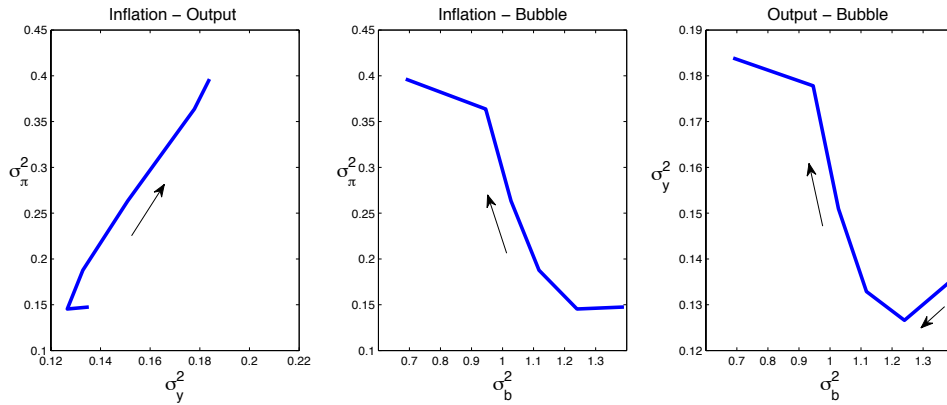
Note: Variances of inflation, output gap and the bubble following bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

Figure (4d) Supply and bubble shocks (Response to output gap)



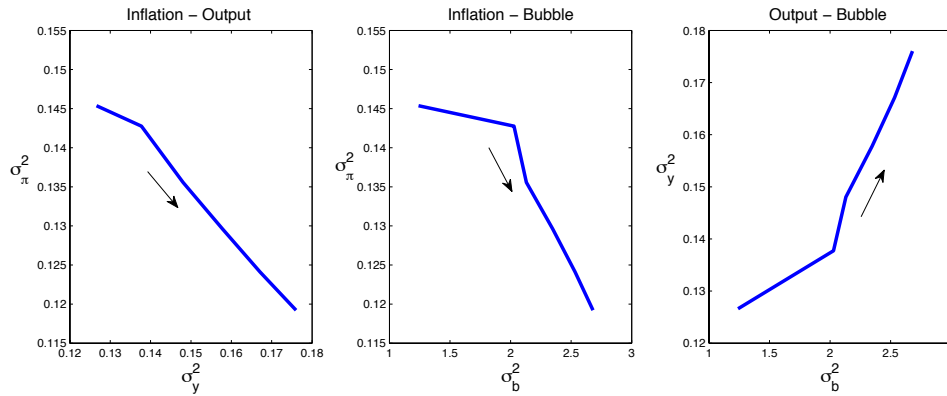
Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to output gap varies from 0.5 to 1.5 and all other parameters remain the same. The arrows indicate an increase in β_y .

Figure (4e) Supply and bubble shocks (Response to the bubble)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to the bubble varies from 0 to 0.75 and all other parameters remain the same. The arrows indicate an increase in β_b .

Figure (4f) Supply and bubble shocks (Response to inflation)



Note: Variances of inflation, output gap and the bubble following supply and bubble shocks. The response to inflation varies from 1.5 to 2.5 and all other parameters remain the same. The arrows indicate an increase in β_π .

General Conclusion

The recent financial crisis came as a surprise to many economists, as in the middle of the years 2000 almost everybody thought that stability objectives were met due to good policy design.²¹ However, the flaws identified after the outbreak of the crisis with respect to the macroeconomic policy framework were numerous. Monetary policy, prudential regulation and fiscal policy were one by one analyzed and judged by economists to determine what went wrong and why the crisis was so severe. Several of these flaws and some potential solutions for the future macroeconomic framework are analyzed in this dissertation.

The thesis begins with an examination of the risk-taking channel of monetary policy, a central theme of this work. This new transmission mechanism tries to explain one of the causes of the crisis. More precisely, it explains how risk accumulation is possible in an environment characterized by low and stable interest rates. The analysis in this chapter (Chapter 1) relies on pre-crisis data for the euro area and it uses long term causality measures to show that indeed, the monetary policy stance had an important role to play in the increase in financial risk. While usually in the literature, the papers dealing with the risk-taking channel look only at short run effects, our approach also allows us to see the impact of the interest rate on risk at longer horizons. This is an important feature of our analysis, as one of the main specificities of this channel is precisely the duration of easy monetary policy conditions: the interest rate leads to risk accumulation mostly after several periods.

Our results show that the above reasoning is valid, as in several of the configurations considered there is no causality in the short run, whereas at longer horizons our measures become significant. Another interesting results of this chapter is the proof that risk had no influence on the conduct of monetary policy. This confirms that, before the crisis, the European Central Bank did not account for financial risk. We give two possible explanations to this finding: either the central bank did not integrate risk in its policy as no explicit regulation imposed this, or because risk was not correctly evaluated. Finally, we also conclude from our analysis that the risk-taking channel works through the same mechanisms as two other existing channels: the balance sheet channel and the bank

²¹ Indeed, only a few economists emphasized the accumulation of risk and the threat that this posed to the economy. See, for example, Rajan (2006) or Borio (2004).

lending channel. We argue therefore that the risk-taking channel is just an extension of these two mechanisms, taking the analysis of interest rate effects one step further to look at agents' behavior with respect to risk.

One of the conditions specified in the definition of the risk-taking channel is that monetary policy should be accommodating. Whereas for the United States this is easier to prove, for the euro area this result is less obvious. It remains nonetheless true that interest rates were at a low level during several years in the euro area, even if this cannot be explicitly interpreted as an *accommodative* policy stance.

The analysis conducted in Chapter 1 was based on a VAR with three variables. This allowed us to trace the mechanisms through which risk accumulates when interest rates are low. However, an analysis with more than one auxiliary variable could also prove valuable in the computation of causality measures. This would help strengthen our conclusions concerning the existence of this new monetary policy transmission mechanism in the euro area. Moreover, applying our analysis on US data might further confirm the existence of this channel, implying that one should not neglect the effects of monetary actions on risk if future financial distress is to be avoided.

Admitting the existence of the risk-taking channel raises some relevant questions with respect to policy making. *First of all*, we underline in our study the fact that no risk measure employed before the crisis was capable of capturing the real risk accumulation. This can be interpreted as a major default in microprudential regulation and proves the necessity for (i) introducing macroprudential policies and (ii) measuring systemic risk in a consistent way. We deal with systemic risk measures in Chapter 2, whereas the macroprudential regulation is briefly considered in Chapter 4.

Systemic risk measures have only been proposed recently in the financial literature and they were conceived exclusively for financial institutions. We transpose three of these measures to the case of sovereign states, in order to measure systemic risk in the euro area. In an in-sample analysis, our results show that these measures can capture both a size and an yield effect when transposed to countries. We therefore identify countries that were confronted with difficulties during the sovereign debt crisis (yield effect), but also the biggest Eurozone countries (size effect), as the ones being the most systemically risky.

To the best of our knowledge, this represents the first attempt of applying such measures to countries. Therefore, our research should be in the future completed by an out-of-sample study in order to evaluate their forecasting power. Once this is done and if the results prove to be satisfactory and reliable, they can be included in the fiscal policy framework. We maintain this argument, as the debt crisis proved, on the one hand, that deteriorated public finances can harm financial stability, and on the other hand,

that existing regulation on countries' public debt and deficits was not enough to avoid a sovereign crisis. Accordingly, the fiscal framework also needs revising and such measures can prove useful in this process.

Nevertheless, one limitation of our study should be taken into consideration when computing systemic risk measures for countries. More exactly, our results are conditional on the existence of Arch effects in the yields series. The debt crisis in the Eurozone insured that this condition is satisfied for our data set. However, in calm periods, yields are known to have a more steady evolution. The problem could be dealt with by using a VAR approach instead of the DCC model. This would allow the study of yields dynamics, needed afterwards in the computation of systemic risk measures at country level.

Second, from the results obtained in Chapter 1, we conclude that the effects of the central bank's behavior on the risk level can also be thought of as a negative externality on the economy. Therefore, monetary authorities should find the optimal way of internalizing these effects. One possible solution that we consider in this dissertation is the use of the "leaning against the wind" strategy. We study the consequences of employing such an approach in different configurations. This represents the aim of Chapter 3, but the topic is also approached in Chapter 4.

Using a DSGE model, we examine the behavior of the central bank in two specific cases. First, we consider that monetary authorities do not integrate financial stability in their objective function and we compare the results obtained under a standard Taylor rule with an augmented rule which takes into account the financial cycle. The aim of this study is to see if, before the crisis, the central bank could have improved, or at least reduced, the negative effects of the bursting bubble. The theoretical framework is particularly adequate for our analysis, as it integrates not only two financial accelerator mechanisms which create more volatility in the economy, but also an asset price bubble which allows risk to accumulate. Our results show that a central bank which would have decided to lean against the wind would have only reduced output and credit cycles, whereas inflation would have been more volatile. This is true whatever the strategy followed by the monetary authority: optimal or accommodative.

The second analysis deals with the case where the central bank explicitly integrates financial stability among its objectives. Results indicate that, when using only one instrument, the interest rate rule, the central bank cannot simultaneously achieve three objectives. We conclude that no blame can be thus put on central banks, because with the only tool available, whatever the strategy considered, the crisis could not have been avoided. From our results, we also infer that when the monetary authority is endowed with a single instrument, leaning against the wind is not the best strategy to use. We

believe that price stability should remain the main focus of monetary authorities and that the interest rate should be dedicated mainly to this objective.

However, the analysis performed here does not weaken the relevance of the leaning against the wind strategy. With hindsight from the crisis, we understood the importance of involving the central bank in maintaining financial stability. As we are heading now towards a new policy framework, this strategy might prove to be a useful solution. At present, the policy framework is going through major changes as macroprudential regulation is introduced to explicitly deal with financial instability risks. Microprudential regulation has also been revisited such that banks are requested to provide more and better-quality assets for their Tier 1 capital. Moreover, an additional conservation buffer is imposed on all banks. Further research on this topic is needed before deriving a clear conclusion on the relevance of the leaning against the wind strategy. A study which can be included in this strand of literature is provided in the last part of Chapter 4.

The results obtained based on the DSGE model also bring out another problem that needs careful analysis, as this could change the way in which future policies would be designed. This relates to trade-offs between objectives as they seem to emerge in case of financial shocks (the only type of shock considered in our analysis). The last chapter (Chapter 4) aims at studying this matter in more depth.

One main drawback of the framework used in Chapter 3 is that the asset price bubble is exogenous, meaning that no policy influences the bubble. This hypothesis can be relaxed by considering an endogenous bubble which responds to monetary policy actions. Moreover, the DSGE framework can be easily extended to include a housing sector, as the subprime crisis was triggered by major problems in the mortgage market. This extension is also particularly useful once macroprudential regulation is considered, because besides countercyclical capital buffers, loan-to-value ratios will be used to reduce risk-taking and excessive credit creation. Additionally, the risk-taking behavior of economic agents during periods of euphoria is said to be irrational. Actually, DSGE models which assume rational expectations on all markets have been recently criticized because of herd behavior and imperfect information (De Grauwe, 2008). Therefore, the rational expectation assumption should be loosened. The solution would consist, in our case, in considering that at least a part of the agents are “irrational” and that they form adaptative expectations with respect to the future evolution of prices. This would also help to obtain an endogenous bubble as the one presented in Adam and Marcet (2011).

Going further, as mentioned above, the last chapter of the thesis studies the emergence of trade-offs between policy objectives. Knowing in which configuration these trade-offs appear can have important implications for policymakers. For example, depending on the type of shocks, coordination between monetary and macroprudential authorities might be

needed, or a leaning against the wind strategy might prove useful in only a certain type of configuration. We study these issues by means of a reduced form New-Keynesian model, in which we first integrate an endogenous bubble responding to the interest rate, and then consider a more complete framework, where a banking sector and macroprudential regulation are added.

From the first scenario, we confirm the results obtained with the DSGE model (where the asset price bubble was exogenous). More precisely, as long as the Tinbergen principle is not met, the central bank has no role to play in maintaining financial stability unless it trades off price stability. It is however evident that central banks will always be responsible in the first place for price stability, be that in the short or medium run. Therefore, no monetary authority should be interested in trading-off its primary objective to maintain financial stability. However, it is argued in the literature that, in the short run, this might represent an advantageous solution (Woodford, 2012). Given that this type of response would compromise the credibility of the central bank, we consider that more research needs to caution this strategy before adopting it.

However, as things begin to take shape with respect to the future regulatory framework, the scenario in which only one instrument is used loses a little bit of its attraction. In the euro area, the fall of 2014 will represent a historic event as the ECB takes officially the role of an area wide macroprudential regulator. While national authorities will be in charge with applying their own measures based on their own evaluations of risk, the central bank will have a supervisory role and more importantly, will have the final say in the application of the macroprudential rules of Basel III. Therefore, a framework including this type of regulation is more realistic for studying trade-offs between objectives.

In the model where the interest rate and a countercyclical capital buffer are used to attain macroeconomic and financial stability, the role of the central bank appears to be different with respect to the first analysis. In this second model, our results show in most of the configurations, that the leaning against the wind strategy is desirable as it reduces both the volatility of the bubble and of macroeconomic variables, when macroprudential regulation complements monetary policy. However, this response of the central bank to financial variables needs not be too aggressive, confirming somehow Mundell's principle (Mundell, 1962): each objective should be addressed with the instrument that proves to be the most effective in achieving that specific objective. Therefore, monetary policy should be mostly concentrated on price stability, but we need to remember that its actions have an influence on financial risk. In conclusion, an augmented Taylor rule with a low degree of leaning is recommended. In addition, macroprudential policy is essential in mitigating financial instability.

Our reduced form model shows however that trade-offs between objectives still persist when financial shocks occur. Therefore, a more complex modeling framework would be needed to study scenarios where coordination or non-coordination between authorities is explicitly considered. We also argue in this dissertation that financial instability has various sources, therefore different instruments should be considered in the analysis. They can be used simultaneously or can be made state-contingent depending on which strategy performs better. The DSGE model developed in Chapter 3 can be employed in order to study these policy questions, especially if the above mentioned extensions (housing sector, endogenous bubble and bank capital constraints) are integrated.

Conclusion Générale

La récente crise financière a été une surprise pour de nombreux économistes, puisque dans le milieu des années 2000, presque tous pensaient que les objectifs de stabilité étaient atteints grâce à une bonne mise en œuvre des politiques macroéconomiques.²² Cependant, les faiblesses identifiées après le déclenchement de la crise concernant le cadre de la politique macroéconomique sont nombreuses. La politique monétaire, la réglementation prudentielle et la politique budgétaire ont chacune été analysées et discutées par les économistes pour comprendre ce qu'il s'est passé et pourquoi la crise était si profonde. Plusieurs de ces faiblesses ainsi qu'une partie des solutions possibles pour améliorer le futur cadre macroéconomique sont analysées dans cette thèse.

La thèse commence par un chapitre qui examine le canal de la prise de risque, un thème central de ce travail. Ce nouveau mécanisme de transmission tente d'expliquer l'une des causes de la crise. Plus précisément, il explique comment l'accumulation des risques est possible dans un environnement caractérisé par des taux d'intérêt faibles et stables. L'analyse présentée dans ce chapitre (Chapitre 1) s'appuie sur des données antérieures à la crise et relatives à la zone euro. Elle utilise des mesures de causalité de long terme pour montrer qu'en effet, la politique monétaire joue un rôle important dans l'accroissement du risque financier. Bien que généralement dans la littérature, les articles traitant du canal de la prise de risque ne regardent que des effets de court terme, notre approche nous permet également de voir l'impact du taux d'intérêt sur le risque à plus long terme. Il s'agit d'un aspect important de notre analyse, étant donné que l'une des principales spécificités de ce canal est précisément la durée pendant laquelle la politique monétaire accommodante est maintenue. Le plus souvent, le taux d'intérêt conduit à une accumulation des risques seulement après plusieurs périodes.

Nos résultats montrent que le raisonnement ci-dessus est valable, puisque dans plusieurs des configurations considérées le lien de causalité n'est pas présent à court terme, alors qu'à plus long terme nos mesures deviennent significatives. Un autre résultat intéressant de ce chapitre concerne l'absence de causalité du risque sur la conduite de la politique monétaire. Cela confirme que, avant la crise, la Banque Centrale Européenne

²² En effet, seuls quelques économistes ont souligné l'accumulation des risques et la menace que cela représentait pour l'économie. Voir, par exemple, Borio (2004) ou Rajan (2006).

n'a pas tenu compte des risques financiers. Nous donnons deux explications possibles à ce constat. Soit la banque centrale n'a pas intégré le risque dans sa politique puisqu'aucune réglementation explicite n'imposait cela, soit le risque n'a pas été évalué correctement. De notre analyse, nous concluons également que le canal de la prise de risque agit par les mêmes mécanismes que deux autres canaux existants : le canal du bilan et le canal du crédit bancaire. Nous déduisons donc que le canal de la prise de risque représente une extension de ces deux mécanismes. En effet, par ce canal, l'analyse des effets des taux d'intérêt est amenée un pas plus loin car elle s'intéresse au comportement des agents en matière de prise de risques.

L'une des conditions nécessaires au bon fonctionnement du canal de la prise de risque est que la politique monétaire soit *accommodante* pendant plusieurs périodes. Alors que pour les États-Unis cela est plus facile à démontrer, pour la zone euro ce résultat est moins évident. Il n'en demeure pas moins que, dans la zone euro, les taux d'intérêt étaient à un niveau bas pendant plusieurs années avant la crise, même si cela ne peut pas être explicitement interprété comme une politique accommodante.

L'analyse menée dans le Chapitre 1 est basée sur un VAR à trois variables, dont une seule variable auxiliaire. Cela nous a permis de retracer les mécanismes par lesquels le risque s'accumule lorsque les taux d'intérêt sont bas. Cependant, une analyse avec plus d'une variable auxiliaire pourrait également s'avérer utile dans le calcul des mesures de causalité. Cela contribuera à renforcer nos conclusions concernant l'existence de ce nouveau mécanisme de transmission de la politique monétaire dans la zone euro. En outre, l'application de notre analyse sur des données américaines pourrait en outre confirmer l'existence de ce canal en général. Cela soulignerait une fois de plus l'importance de prendre en compte les effets des mesures de politique monétaire sur le risque si nous souhaitons à l'avenir éviter les difficultés financières.

Admettre l'existence du canal de la prise de risque soulève de sérieuses questions en ce qui concerne l'élaboration des politiques macroéconomiques.

Tout d'abord, nous soulignons dans notre étude le fait qu'aucune mesure de risque employée avant la crise n'était capable de saisir l'accumulation du risque réel. Cela peut être interprété comme un défaut majeur de la réglementation microprudentielle et prouve la nécessité (i) d'introduire des politiques macroprudentielles et (ii) de mesurer le risque systémique d'une manière cohérente. Nous abordons la mesure du risque systémique dans le Chapitre 2, alors que la réglementation macroprudentielle est examinée brièvement dans le Chapitre 4.

La mesure du risque systémique est un sujet qui a été récemment abordé dans la littérature financière, mais les mesures proposées jusque là ont été conçues exclusivement pour les institutions financières. Nous transposons trois de ces mesures aux pays, afin

de mesurer le risque systémique dans la zone euro. Dans une analyse “in-sample”, nos résultats montrent que ces mesures peuvent saisir à la fois un effet taille et un effet rendement lorsqu’elles sont transposées aux pays. Nous identifions donc les pays qui ont été confrontés à des difficultés lors de la crise de la dette souveraine (effet rendement), mais aussi les plus grands pays de la zone euro (effet taille), comme étant les pays les plus risqués d’un point de vue systémique.

Au mieux de notre connaissance, il s’agit de la première tentative de l’application de ces mesures aux pays. Par conséquent, notre recherche devrait être complétée à l’avenir par une étude out-of-sample afin d’évaluer leur pouvoir de prévision. Une fois cela fait et si les résultats s’avèrent satisfaisants et fiables, ces mesures peuvent être prises en compte dans la conduite de la politique budgétaire. Nous maintenons cet argument, puisque la crise de la dette a démontré, d’une part, que des finances publiques détériorées peuvent nuire à la stabilité financière, et d’autre part, que les réglementations du Pacte de Stabilité et de Croissance sur la dette et les déficits publics des pays n’ont pas été suffisantes pour éviter une crise souveraine. En conséquence, le cadre budgétaire a également besoin d’être réformé et de telles mesures peuvent s’avérer utiles dans ce processus.

Néanmoins, une limite de notre étude devrait être prise en considération lors du calcul des mesures de risque systémique pour les pays. Plus précisément, nos résultats sont conditionnels à l’existence des effets Arch dans la série des rendements. La crise de la dette dans la zone euro assure que cette condition est satisfaite pour notre échantillon. Cependant, dans les périodes calmes, les rendements obligataires ont une évolution plus stable. Ce problème pourrait être traité en utilisant une approche VAR au lieu du modèle DCC. Cela permettrait d’étudier la dynamique des rendements, nécessaire ensuite au calcul des mesures de risque systémique au niveau des pays.

Par ailleurs, à partir des résultats obtenus dans le Chapitre 1, nous jugeons que les effets du comportement de la banque centrale sur le risque peuvent également être considérés comme une externalité négative sur l’économie. Par conséquent, les autorités monétaires doivent trouver la meilleure façon d’internaliser ces effets. Une solution possible que nous analysons dans cette thèse est l’utilisation de la stratégie de “leaning against the wind”. Différentes configurations dans lesquelles cette approche est intégrée sont étudiées. Cela représente l’objectif du Chapitre 3, mais le sujet est également abordé dans le Chapitre 4.

A l’aide d’un modèle DSGE, nous examinons le comportement de la banque centrale dans deux cas de figure. Premièrement, nous considérons que les autorités monétaires n’intègrent pas la stabilité financière dans leur fonction objective, et nous comparons les résultats obtenus en utilisant une règle de Taylor standard avec une règle augmentée qui prend en compte le cycle financier. Le but de cette étude est de savoir si avant

la crise, la banque centrale aurait pu améliorer, ou du moins réduire les effets négatifs de l'éclatement de la bulle. Le cadre théorique est particulièrement adéquat pour notre analyse, car il intègre non seulement deux mécanismes d'accélérateur financier qui créent une plus grande volatilité dans l'économie, mais aussi une bulle des prix d'actifs qui permet l'accumulation graduelle du risque. Nos résultats montrent qu'une banque centrale qui aurait décidé de faire du *leaning* serait arrivée à réduire les cycles de production et de crédit, alors que l'inflation aurait été plus volatile. Cela est vrai quelle que soit la stratégie suivie par l'autorité monétaire : optimale ou accommodante.

En second lieu, nous traitons le cas où la banque centrale intègre explicitement la stabilité financière parmi ses objectifs. Les résultats indiquent que, lorsque vous utilisez un seul instrument, le taux d'intérêt, la banque centrale ne peut pas atteindre simultanément trois objectifs. Nous concluons que les banques centrales ne doivent pas être désignées responsables pour la crise, car avec ce seul outil à leur disposition, quelle que soit la stratégie envisagée, la crise n'aurait pas pu être évitée. De nos résultats, nous concluons également que lorsque l'autorité monétaire est dotée d'un instrument unique, la stratégie de *leaning against the wind* n'est pas la meilleure approche à utiliser. Nous défendons l'idée selon laquelle la stabilité des prix doit rester l'objectif principal des autorités monétaires et que le taux d'intérêt devrait être principalement consacré à cet objectif.

Cependant, l'analyse effectuée ici ne réduit en rien la pertinence de la stratégie du *leaning*. Avec les enseignements tirés de la crise, nous avons compris l'importance d'impliquer les banques centrales dans le maintien de la stabilité financière. Comme nous nous dirigeons maintenant vers un nouveau cadre de politique macroéconomique, cette stratégie pourrait s'avérer une solution utile. À présent, le cadre réglementaire passe par des changements majeurs. La réglementation macroprudentielle est introduite avec l'objectif de réduire les risques d'instabilité financière. La réglementation microprudentielle a également été revisitée pour obliger les banques à détenir plus d'actifs et d'une meilleure qualité dans leur fonds propres de base "Tier 1". En outre, un volant de conservation supplémentaire est imposé à toutes les banques. De plus amples recherches sur ce sujet sont alors nécessaires avant de tirer une conclusion claire sur la pertinence de la stratégie du *leaning against the wind*. Une étude qui peut être incluse dans ce courant de littérature est prévue dans la dernière partie du Chapitre 4. Les résultats obtenus sur la base du modèle DSGE renseignent également sur un autre problème qui a besoin d'une analyse plus approfondie, car cela pourrait changer la façon dont les politiques futures seraient conçues. Ce problème concerne les arbitrages entre les objectifs puisque dans notre modèle ces arbitrages semblent se dégager en cas de chocs financiers (le seul type de choc

considéré dans notre analyse). Le dernier chapitre (Chapitre 4) vise alors à étudier cette question d’une manière plus profonde.

Un inconvénient principal du cadre utilisé dans le Chapitre 3 est que la bulle sur les prix d’actifs est exogène, ce qui signifie qu’aucune politique n’influence le développement de la bulle. Cette hypothèse peut être assouplie en considérant une bulle endogène qui répond aux mesures de politique monétaire. En outre, étant donné que la crise des subprimes s’est déclenchée suite aux problèmes liés au marché hypothécaire, notre modèle DSGE peut être facilement étendu afin d’inclure un secteur du logement. Cette extension est particulièrement utile une fois que la réglementation macroprudentielle sera prise en compte. Plus précisément, les ratios prêt-valeur (*loan to value*) qui visent le marché du logement, seront également utilisés en parallèle au volant de fonds propres contracycliques, afin de réduire la prise de risque et la création excessive de crédit. En outre, la prise de risque des agents économiques pendant les périodes d’euphorie est considérée comme irrationnelle. En réalité, en raison de ce type de comportement, les modèles DSGE qui présument des anticipations rationnelles sur tous les marchés ont été récemment critiqués (De Grauwe, 2008). Par conséquent, l’hypothèse d’anticipation rationnelle devrait être relâchée. La solution consisterait, dans notre cas, à considérer qu’au moins une partie des agents sont “irrationnels” et qu’ils forment des anticipations adaptatives à l’égard de l’évolution future des prix. Cela permettrait également d’obtenir une bulle endogène comme celle proposée par Adam and Marcet (2011).

Pour aller plus loin dans l’analyse et comme il est mentionné ci-dessus, le dernier chapitre de la thèse étudie l’apparition de trade-off entre les objectifs de stabilité. Savoir dans quelle configuration ces arbitrages apparaissent peut avoir d’importantes implications pour les décideurs politiques. Par exemple, en fonction du type de chocs, la coordination entre les autorités monétaire et macroprudentielle pourrait être nécessaire. Ou encore, la stratégie de *leaning against the wind* pourrait s’avérer utile seulement dans un certain type de scénario. Nous étudions ces questions en utilisant un modèle Néo-Keynésien, sous une forme réduite dans lequel nous intégrons d’abord une bulle endogène répondant au taux d’intérêt, puis nous considérons un cadre plus complet, où un secteur bancaire et une règle macroprudentielle sont ajoutés.

Dans le modèle avec une bulle endogène répondant au taux d’intérêt, les résultats confirment les conclusions obtenues avec le modèle DSGE (où la bulle des prix d’actifs était exogène). Plus précisément, tant que le principe de Tinbergen n’est pas satisfait, la banque centrale n’a pas de rôle à jouer dans le maintien de la stabilité financière si elle ne souhaite pas négliger la stabilité des prix. Il est toutefois évident que les banques centrales seront toujours responsables en premier lieu de la stabilité des prix, que cela soit sur le court ou moyen terme. Par conséquent, aucune autorité monétaire

ne devrait être intéressée par un compromis sur son objectif principal afin de maintenir la stabilité financière. Néanmoins, nous trouvons dans la littérature que, à court terme, cela pourrait être une solution avantageuse (Woodford, 2012). Comme la crédibilité de la banque centrale risque d'être compromise, nous considérons qu'une telle stratégie mérite plus de recherche avant son application.

Cependant, comme le futur cadre réglementaire se précise de plus en plus, le scénario dans lequel un seul instrument est utilisé perd un peu de son intérêt. Dans la zone euro, l'automne 2014 marque un événement historique étant donné que la BCE prend officiellement le rôle de régulateur macroprudentiel. Alors que les autorités nationales seront chargées d'appliquer leurs propres mesures fondées sur leurs propres évaluations des risques, la banque centrale aura un rôle de surveillance et, surtout, aura le dernier mot dans l'application des règles macroprudentielles stipulées dans les Accords de Bâle III. Par conséquent, un modèle intégrant ce type de réglementation est plus réaliste pour l'étude des arbitrages entre les objectifs.

Dans le modèle où la banque centrale utilise le taux d'intérêt et un volant de fonds propres contracyclique pour atteindre ses objectifs de stabilité macroéconomique et financière, le rôle de la banque centrale s'avère différent par rapport à notre première analyse. Dans ce deuxième modèle, nos résultats montrent dans la plupart des configurations, que la stratégie du *leaning against the wind* est souhaitable car elle réduit à la fois la volatilité de la bulle et des variables macroéconomiques, lorsque la réglementation macroprudentielle est utilisée en complément de la politique monétaire. Cependant, cette réponse de la banque centrale aux variables financières n'a pas besoin d'être trop agressive, confirmant en quelque sorte le principe de Mundell²³ : chaque objectif doit être traité avec l'instrument qui se révèle être le plus efficace dans la réalisation de cet objectif spécifique. Par conséquent, la politique monétaire devrait être surtout concentrée sur la stabilité des prix, mais il faut garder à l'esprit que ses actions ont une influence sur le risque financier. De fait, une règle de Taylor augmentée est recommandée, mais avec un degré de *leaning* faible. En outre, la politique macroprudentielle est essentielle à la réduction de l'instabilité financière.

Notre modèle sous forme réduite montre cependant que les arbitrages entre les objectifs persistent lorsque des chocs financiers se produisent. Par conséquent, un cadre de modélisation plus complexe serait nécessaire pour étudier des scénarios où la question de la coordination entre les autorités sera explicitement traitée. Nous défendons également dans cette thèse la position que l'instabilité financière a diverses sources, et donc différents instruments doivent être pris en compte dans l'analyse. Ils peuvent être utilisés simultanément ou séparément en fonction de chaque scénario. Le modèle DSGE

²³ Mundell (1962)

développé dans le Chapitre 3 peut être utilisé afin d'étudier ces questions de stratégie, en particulier si les extensions mentionnées ci-dessus sont intégrées (secteur du logement, bulle endogène et exigence de fonds propres des banques).

Bibliography

- [1] Acharya, V. and M. Richardson (2009). *Restoring financial stability: how to repair a failed system*. Vol. 542. John Wiley & Sons.
- [2] Acharya, V. V., R. F. Engle, and M. Richardson (2012a). “Capital Shortfall: A New Approach to Ranking and Regulating Systemic Risks”. *American Economic Review* 102.3, pp. 59–64.
- [3] Acharya, V. V., L. H. Pedersen, T. Philippon, and M. P. Richardson (2012b). *Measuring Systemic Risk*. CEPR Discussion Paper 8824. C.E.P.R. Discussion Papers.
- [4] Adam, K. and A. Marcet (2011). “Internal rationality, imperfect market knowledge and asset prices”. *Journal of Economic Theory* 146.3, pp. 1224–1252.
- [5] Adrian, T. and M. K. Brunnermeier (2011). *CoVaR*. NBER Working Paper 17454. National Bureau of Economic Research, Inc.
- [6] Adrian, T. and H. S. Shin (2008). *Financial intermediary leverage and value at risk*. Staff Reports 338. Federal Reserve Bank of New York.
- [7] — (2009). “Money, Liquidity, and Monetary Policy”. *American Economic Review* 99.2, pp. 600–605.
- [8] — (2010). *Financial Intermediaries and Monetary Economics*. Handbook of Monetary Economics. Elsevier, pp. 601–650.
- [9] Adrian, T., E. Moench, and H. S. Shin (2010). “Macro Risk Premium and Intermediary Balance Sheet Quantities”. *IMF Economic Review* 58.1, pp. 179–207.
- [10] Agenor, P.-R. and P. J. Montiel (2008). *Development Macroeconomics: Third Edition*. Princeton University Press.
- [11] Agenor, R. P., K. Alper, and L. P. d. Silva (2013). “Capital Regulation, Monetary Policy, and Financial Stability”. *International Journal of Central Banking* 9.3, pp. 198–243.
- [12] Akaike, H. (1973). “Information theory and an extension of the maximum likelihood principle”. *Second International Symposium on Information Theory*, pp. 267–281.
- [13] — (1974). “A new look at the statistical model identification”. *IEEE Transactions on Automatic Control* 19.6, pp. 716–723.

- [14] Alessi, L. and C. Detken (2011). “Quasi real time early warning indicators for costly asset price boom/bust cycles: A role for global liquidity”. *European Journal of Political Economy* 27.3, pp. 520–533.
- [15] Allen, F. and E. Carletti (2009). “The global financial crisis: causes and consequences”. *Paper presented at the Conference on: Global Market Integration and Financial Crises, The Hong Kong University of Science and Technology (HKUST) Business School*.
- [16] Allen, F. and D. Gale (2000). *Asset Price Bubbles and Monetary Policy*. Center for Financial Institutions Working Paper 01-26. Wharton School Center for Financial Institutions, University of Pennsylvania.
- [17] — (2009). *Understanding Financial Crises*. OUP Catalogue. Oxford University Press.
- [18] Altunbas, Y., L. Gambacorta, and D. Marques-Ibanez (2009). *An Empirical Assessment of the Risk-Taking Channel*. Mimeo. BIS.
- [19] — (2010). “Bank risk and monetary policy”. *Journal of Financial Stability* 6.3, pp. 121–129.
- [20] Angelini, P., S. Neri, and F. Panetta (2011). *Monetary and macroprudential policies*. Temi di discussione (Economic working papers) 801. Bank of Italy, Economic Research and International Relations Area.
- [21] Angeloni, I. and E. Faia (2009). *A Tale of Two Policies: Prudential Regulation and Monetary Policy with Fragile Banks*. Kiel Working Paper 1569. Kiel Institute for the World Economy.
- [22] — (2013). “Capital regulation and monetary policy with fragile banks”. *Journal of Monetary Economics* 60.3, pp. 311–324.
- [23] Angeloni, I., E. Faia, and M. Lo Duca (2013). *Monetary policy and risk taking*. SAFE Working Paper Series 8. Center of Excellence SAFE - Sustainable Architecture for Finance in Europe, Goethe University Frankfurt.
- [24] Artzner, P., F. Delbaen, J.-M. Eber, and D. Heath (1999). “Coherent Measures of Risk”. *Mathematical Finance* 9.3, pp. 203–228.
- [25] Badarau, C. and G. Leveuge (2011). “Assessing the effects of financial heterogeneity in a monetary union a DSGE approach”. *Economic Modelling* 28.6, pp. 2451–2461.
- [26] Badarau, F.-C. (2009). “Politiques macroéconomiques et disparités régionales dans la zone Euro”. PhD thesis. Université d’Orléans.
- [27] Badarau, F.-C. and A. Popescu (2014). “Monetary Policy and Credit Cycles: A DSGE Analysis”. *Economic Modelling* 42 (2014), pp. 301–312.
- [28] Bandt, O. de, J.-C. Heam, C. Labonne, and S. Tavoraro (2013). *Measuring Systemic Risk in a Post-Crisis World*. Tech. rep. 6.
- [29] Banulescu, G.-D. and E.-I. Dumitrescu (2014). “Which are the SIFIs? A Component Expected Shortfall approach to systemic risk”. *Journal of Banking & Finance*.

-
- [30] Battistini, N., M. Pagano, and S. Simonelli (2013). *Systemic Risk and Home Bias in the Euro Area*. European Economy - Economic Paper 494. Directorate General Economic and Monetary Affairs (DG ECFIN), European Commission.
 - [31] Bauducco, S., A. Bulir, and M. Cihak (2011). “Monetary Policy Rules with Financial Instability”. *Czech Journal of Economics and Finance (Finance a uver)* 61.6, pp. 545–565.
 - [32] Beau, D., C. Cahn, L. Clerc, and B. Mojon (2013). *Macro-Prudential Policy and the Conduct of Monetary Policy*. Working Papers Central Bank of Chile. Central Bank of Chile.
 - [33] Bekaert, G., M. Hoerova, and M. Lo Duca (2013). “Risk, uncertainty and monetary policy”. *Journal of Monetary Economics* 60.7, pp. 771–788.
 - [34] Benoit, S., G. Colletaz, C. Hurlin, and C. Perignon (2013). *A Theoretical and Empirical Comparison of Systemic Risk Measures*. Working Paper halshs-00746272. HAL.
 - [35] Bernanke, B. and M. Gertler (1989). “Agency Costs, Net Worth, and Business Fluctuations”. *American Economic Review* 79.1, pp. 14–31.
 - [36] — (1999). “Monetary policy and asset price volatility”. *Economic Review Q IV*, pp. 17–51.
 - [37] Bernanke, B., M. Gertler, and S. Gilchrist (1996). “The Financial Accelerator and the Flight to Quality”. *The Review of Economics and Statistics* 78.1, pp. 1–15.
 - [38] Bernanke, B. S. and A. S. Blinder (1988). “Credit, Money, and Aggregate Demand”. *American Economic Review* 78.2, pp. 435–39.
 - [39] Bernanke, B. S. and M. Gertler (2001). “Should Central Banks Respond to Movements in Asset Prices?” *American Economic Review* 91.2, pp. 253–257.
 - [40] Bernanke, B. S., M. Gertler, and S. Gilchrist (1999). “The financial accelerator in a quantitative business cycle framework”. *Handbook of Macroeconomics*. Ed. by John B. Taylor and Michael Woodford. Vol. Volume 1, Part C. Elsevier, pp. 1341–1393.
 - [41] Betbeze, J.-P., C. Bordes, J. Couppey-Soubeyran, and D. Plihon (2011). “Banques centrales et stabilité financière”.
 - [42] BIS (2011). *Basel III: A global regulatory framework for more resilient banks and banking systems - revised version June 2011*.
 - [43] Bisias, D., M. Flood, A. W. Lo, and S. Valavanis (2012). “A Survey of Systemic Risk Analytics”. *Annual Review of Financial Economics* 4.1, pp. 255–296.
 - [44] Blanchard, O., G. Dell’Ariccia, and P. Mauro (2010). “Rethinking Macroeconomic Policy”. *Journal of Money, Credit and Banking* 42, pp. 199–215.
 - [45] Blanchard, O. J. and M. W. Watson (1982). *Bubbles, Rational Expectations and Financial Markets*. NBER Working Paper 0945. National Bureau of Economic Research, Inc.
 - [46] Blanchard, O. J. and C. M. Kahn (1980). “The Solution of Linear Difference Models under Rational Expectations”. *Econometrica* 48.5, p. 1305.

- [47] Blanchard, O. J. and D. Quah (1989). “The Dynamic Effects of Aggregate Demand and Supply Disturbances”. *American Economic Review* 79.4, pp. 655–73.
- [48] Bloom, N., M. Floetotto, N. Jaimovich, I. Saporta-Eksten, and S. J. Terry (2012). *Really Uncertain Business Cycles*. NBER Working Paper 18245. National Bureau of Economic Research, Inc.
- [49] Borio, C. (2005). “Monetary and Financial Stability: So Close and Yet So Far?” *National Institute Economic Review* 192.1, pp. 84–101.
- [50] Borio, C. and C. M. Drehmann (2009). *Towards an operational framework for financial stability: “fuzzy” measurement and its consequences*. BIS Working Paper 284. Bank for International Settlements.
- [51] Borio, C. and P. W. Lowe (2002). *Asset prices, financial and monetary stability: exploring the nexus*. BIS Working Papers 114. Basel: Bank for International Settlements.
- [52] Borio, C. and H. Zhu (2012). “Capital regulation, risk-taking and monetary policy: A missing link in the transmission mechanism?” *Journal of Financial Stability* 8.4, pp. 236–251.
- [53] Borio, C., C. Furfine, and P. Lowe (2001). *Procyclicality of the financial system and financial stability: issues and policy options*. BIS Working Paper No. 1. Bank for International Settlements.
- [54] Borio, C. E. V. and W. R. White (2004). *Whither Monetary and Financial Stability? The Implications of Evolving Policy Regimes*. BIS Working Paper 147. Rochester, NY: Social Science Research Network.
- [55] Borio, C. E. (2004). *Market distress and vanishing liquidity: anatomy and policy options*. Tech. rep. Bank for International Settlements.
- [56] Bracke, T. and M. Fidora (2008). *Global liquidity glut or global savings glut? A structural VAR approach*. Working Paper Series 0911. European Central Bank.
- [57] Breitung, J. and B. Candelon (2007). *Testing for multistep causality*.
- [58] Breitung, J. and B. Candelon (2006). “Testing for short- and long-run causality: A frequency-domain approach”. *Journal of Econometrics* 132.2, pp. 363–378.
- [59] Brownlees, C. T. and R. F. Engle (2012). *Volatility, Correlation and Tails for Systemic Risk Measurement*. Tech. rep. Rochester, NY: Social Science Research Network.
- [60] Bruneau, C. and E. Jondeau (1999). “Long-run Causality, with an Application to International Links Between Long-term Interest Rates”. *Oxford Bulletin of Economics and Statistics* 61.4, pp. 545–568.
- [61] Brunnermeier, M. K. (2009). “Deciphering the Liquidity and Credit Crunch 2007–2008”. *The Journal of Economic Perspectives* 23.1, pp. 77–100.
- [62] Buch, C. M., S. Eickmeier, and E. Prieto (2014). “In search for yield? Survey-based evidence on bank risk taking”. *Journal of Economic Dynamics and Control*. The Role of Financial Intermediaries in Monetary Policy Transmission 43, pp. 12–30.

-
- [63] Calvo, G. A. (1983). “Staggered prices in a utility-maximizing framework”. *Journal of Monetary Economics* 12.3, pp. 383–398.
 - [64] Campbell, J. and J. H. Cochrane (1999). “By Force of Habit: A Consumption-Based Explanation of Aggregate Stock Market Behavior”. *Journal of Political Economy* 107.2, pp. 205–251.
 - [65] Carlstrom, C. and T. S. Fuerst (1997). “Agency Costs, Net Worth, and Business Fluctuations: A Computable General Equilibrium Analysis”. *American Economic Review* 87.5, pp. 893–910.
 - [66] Cecchetti, S. G., H. Genberg, and J. Lipsky (2000). *Asset Prices and Central Bank Policy*. Tech. rep. Geneva: International Center for Monetary and Banking Studies.
 - [67] Cecchetti, S. G. and L. Li (2008). “Do Capital Adequacy Requirements Matter for Monetary Policy?” *Economic Inquiry* 46.4, pp. 643–659.
 - [68] Chan-Lau, J. A., M. Espinosa, K. Giesecke, and J. A. Sole (2009). *Assessing the Systemic Implications of Financial Linkages*. SSRN Scholarly Paper 2. Rochester, NY: Social Science Research Network.
 - [69] Christensen, I., C. Meh, and K. Moran (2011). *Bank Leverage Regulation and Macroeconomic Dynamics*. CIRANO Working Paper 2011s-76. CIRANO.
 - [70] Cline, W. R. (1984). *International debt: Systemic risk and policy response*. Institute for international economics Washington, DC.
 - [71] Curdia, V. and M. Woodford (2010). “Credit Spreads and Monetary Policy”. *Journal of Money, Credit and Banking* 42, pp. 3–35.
 - [72] Danielsson, J. et al. (2001). *An Academic Response to Basel II*. Working Paper.
 - [73] Davidson, R and J MacKinnon (2004). *Econometric Theory and Methods*. New York: Oxford University Press.
 - [74] De Grauwe, P. (2008). “DSGE-modelling when agents are imperfectly informed”. *ECB Working paper series No 897*, pp. 1–57.
 - [75] De Grauwe, P. and D. Gros (2009). *A New Two-Pillar Strategy for the ECB*. CESifo Working Paper Series 2818. CESifo Group Munich.
 - [76] De Nicola, G., G. Dell’Ariccia, L. Laeven, and F. Valencia (2010). *Monetary Policy and Bank Risk Taking*. SSRN Scholarly Paper ID 1654582. Rochester, NY: Social Science Research Network.
 - [77] Delis, M. D. and G. P. Kouretas (2011). “Interest rates and bank risk-taking”. *Journal of Banking & Finance*. Crete Conference 2010: The Future of Universal Banking 35.4, pp. 840–855.
 - [78] Dell’Ariccia, G. and R. Marquez (2006). “Lending Booms and Lending Standards”. *The Journal of Finance* 61.5, pp. 2511–2546.
 - [79] Demirguc-Kunt, A. and E. Detragiache (2005). *Cross-Country Empirical Studies of Systemic Bank Distress: A Survey*. IMF Working Paper 05/96. International Monetary Fund.

- [80] Detken, C. and F. R. Smets (2004). *Asset price booms and monetary policy*. Working Paper Series 0364. European Central Bank.
- [81] Diamond, D. W. and R. G. Rajan (2006). “Money in a Theory of Banking”. *American Economic Review* 96.1, pp. 30–53.
- [82] — (2009). “The Credit Crisis: Conjectures about Causes and Remedies”. *American Economic Review* 99.2, pp. 606–10.
- [83] Dib, A. (2010). *Capital Requirement and Financial Frictions in Banking: Macroeconomic Implications*. Working Paper 10-26. Bank of Canada.
- [84] Dickey, D. A. and W. A. Fuller (1981). “Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root”. *Econometrica* 49.4, pp. 1057–72.
- [85] Dixon, H. and H. Le Bihan (2012). “Generalised Taylor and Generalised Calvo Price and Wage Setting: Micro-evidence with Macro Implications”. *The Economic Journal* 122.560, pp. 532–554.
- [86] Drehmann, M. and N. Tarashev (2011). “Systemic importance: some simple indicators”. *BIS Quarterly Review*.
- [87] Drehmann, M., C. E. V. Borio, L. Gambacorta, G. Jimenez, and C. Trucharte (2010). *Countercyclical Capital Buffers: Exploring Options*. SSRN Scholarly Paper ID 1648946. Rochester, NY: Social Science Research Network.
- [88] Dubecq, S., B. Mojon, and X. Ragot (2009). *Fuzzy Capital Requirements, Risk-Shifting and the Risk Taking Channel of Monetary Policy*. Working paper 254. Banque de France.
- [89] Dufour, J.-M. and E. Renault (1998). “Short Run and Long Run Causality in Time Series: Theory”. *Econometrica* 66.5, p. 1099.
- [90] Dufour, J.-M. and A. Taamouti (2010). “Short and long run causality measures: Theory and inference”. *Journal of Econometrics* 154.1, pp. 42–58.
- [91] Dufour, J.-M. and D. Tessier (2006). *Short-Run and Long-Run Causality between Monetary Policy Variables and Stock Prices*. Working Paper 06-39. Bank of Canada.
- [92] ECB (2008). *Financial Stability and Oversight*. Monthly Bulletin, 10th Anniversary of the ECB. Frankfurt am Main: European Central Bank, pp. 117–132.
- [93] Eijffinger, S. C. W. (2010). *Defining and measuring systematic risk*. Open Access publications from Tilburg University. Tilburg University.
- [94] Engle, R. F. and K. Sheppard (2001). *Theoretical and Empirical properties of Dynamic Conditional Correlation Multivariate GARCH*. NBER Working Paper 8554. National Bureau of Economic Research, Inc.
- [95] Engle, R. F., E. Jondeau, and M. Rockinger (2014). “Systemic Risk in Europe”. *Review of Finance* forthcoming.
- [96] Fagan, G., J. Henry, and R. Mestre (2005). “An area-wide model for the euro area”. *Economic Modelling* 22.1, pp. 39–59.

-
- [97] Faia, E. and T. Monacelli (2007). “Optimal interest rate rules, asset prices, and credit frictions”. *Journal of Economic Dynamics and Control* 31.10, pp. 3228–3254.
 - [98] Farhi, E. and J. Tirole (2009). *Collective Moral Hazard, Maturity Mismatch and Systemic Bailouts*. NBER Working Paper 15138. National Bureau of Economic Research, Inc.
 - [99] Ferguson, R. (2002). “Should Financial Stability Be an Explicit Central Bank Objective?” *Speech presented at the IMF Conference*. Washington, D.C.
 - [100] Filardo, A. (2004). *Monetary policy and asset price bubbles: calibrating the monetary policy trade-offs*. BIS Working Paper 155. Bank for International Settlements.
 - [101] Fisher, I. (1933). “The Debt-Deflation Theory of Great Depressions”. *Econometrica* 1.4, p. 337.
 - [102] Fostel, A. and J. Geanakoplos (2008). “Leverage Cycles and the Anxious Economy”. *The American Economic Review* 98.4, pp. 1211–1244.
 - [103] Gali, J. (2014). “Monetary Policy and Rational Asset Price Bubbles”. *American Economic Review* 104.3, pp. 721–752.
 - [104] Gauthier, C., A. Lehar, and M. Souissi (2012). “Macroprudential capital requirements and systemic risk”. *Journal of Financial Intermediation* 21.4, pp. 594–618.
 - [105] Geanakoplos, J. (2009). *The Leverage Cycle*. Cowles Foundation Discussion Paper 1715R. Cowles Foundation for Research in Economics, Yale University.
 - [106] Gelain, P., K. J. Lansing, and C. Mendicino (2013). “House Prices, Credit Growth, and Excess Volatility: Implications for Monetary and Macroprudential Policy”. *International Journal of Central Banking* 9.2, pp. 219–276.
 - [107] Gerali, A., S. Neri, L. Sessa, and F. M. Signoretti (2010). “Credit and Banking in a DSGE Model of the Euro Area”. *Journal of Money, Credit and Banking* 42, pp. 107–141.
 - [108] Gerdesmeier, D., H.-E. Reimers, and B. Roffia (2010). “Asset Price Misalignments and the Role of Money and Credit”. *International Finance* 13.3, pp. 377–407.
 - [109] Geweke, J. (1982). “Measurement of Linear Dependence and Feedback between Multiple Time Series”. *Journal of the American Statistical Association* 77.378, pp. 304–313.
 - [110] Giavazzi, F. and A. Giovannini (2010). *Central Banks and the Financial System*. Working Paper 16228. National Bureau of Economic Research.
 - [111] Gilchrist, S. and E. Zakrajsek (2011). “Monetary Policy and Credit Supply Shocks”. *IMF Economic Review* 59.2, pp. 195–232.
 - [112] — (2012). “Credit Spreads and Business Cycle Fluctuations”. *The American Economic Review* 102.4, pp. 1692–1720.
 - [113] Goeij, P. de and W. Marquering (2006). “Macroeconomic announcements and asymmetric volatility in bond returns”. *Journal of Banking & Finance* 30.10, pp. 2659–2680.

- [114] Goodhart, C. and D. Schoenmaker (1995). "Should the Functions of Monetary Policy and Banking Supervision Be Separated?" *Oxford Economic Papers* 47.4, pp. 539–60.
- [115] Goodhart, C. A. E., A. K. Kashyap, D. P. Tsomocos, and A. P. Vardoulakis (2013). "An Integrated Framework for Analyzing Multiple Financial Regulations". *International Journal of Central Banking* 9.1, pp. 109–144.
- [116] Granger, C. W. J. (1969). "Investigating Causal Relations by Econometric Models and Cross-Spectral Methods". *Econometrica* 37.3, pp. 424–38.
- [117] Gray, D. F., C. J. Garcia, L. Luna, and J. E. Restrepo (2011). *Incorporating Financial Sector Risk Into Monetary Policy Models: Application to Chile*. Central Banking, Analysis, and Economic Policies Book Series. Central Bank of Chile, pp. 159–197.
- [118] Gruen, D., M. Plumb, and A. Stone (2005). "How Should Monetary Policy Respond to Asset-Price Bubbles?" *International Journal of Central Banking* 1.3.
- [119] Hall, G. J. and T. J. Sargent (2010). *Interest rate risk and other determinants of post WWII U.S. government debt/GDP dynamics*. Working Paper 01. Brandeis University, Department of Economics and International Business School.
- [120] Hamilton, J. (1994). *Time Series Analysis*. Princeton University Press.
- [121] Hannan, E. J. and B. G. Quinn (1979). "The determination of the order of an autoregression". *Journal of the Royal Statistical Society* B41, pp. 190–195.
- [122] Hanson, S. G., A. K. Kashyap, and J. C. Stein (2011). "A Macroprudential Approach to Financial Regulation". *Journal of Economic Perspectives* 25.1, pp. 3–28.
- [123] Hatanaka, M. (1996). *Time-Series-Based Econometrics: Unit Roots and Co-integrations*. OUP Catalogue. Oxford University Press.
- [124] Hayek, F. A. (1939). *Profits, interest and investment*. London: Routledge.
- [125] Helbling, T. and M. Terrones (2003). "When bubbles burst". *World Economic Outlook* 2, pp. 61–94.
- [126] Hellmann, T., K. C. Murdock, and J. E. Stiglitz (2000). "Liberalization, Moral Hazard in Banking, and Prudential Regulation: Are Capital Requirements Enough?" *American Economic Review* 90.1, pp. 147–165.
- [127] Hodrick, R. J. and E. C. Prescott (1997). "Postwar U.S. Business Cycles: An Empirical Investigation". *Journal of Money, Credit and Banking* 29.1, pp. 1–16.
- [128] Hofmann, B. and B. Bogdanova (2012). "Taylor rules and monetary policy: a global "Great Deviation"?" *BIS Quarterly Review*.
- [129] Ioannidou, V. P., S. Ongena, and J.-L. Peydro (2009). *Monetary Policy, Risk-Taking, and Pricing: Evidence from a Quasi-Natural Experiment*. Discussion Paper 2009-31 S. Tilburg University, Center for Economic Research.
- [130] Issing, O. (2003). "Monetary and financial stability: Is there a trade-off?" BIS, Basel.

-
- [131] Ivanov, V. and L. Kilian (2005). “A Practitioner’s Guide to Lag Order Selection For VAR Impulse Response Analysis”. *Studies in Nonlinear Dynamics & Econometrics* 9.1, pp. 1–36.
 - [132] Jimenez, G., S. Ongena, J. L. Peydro, and J. Saurina (2009). *Hazardous times for monetary policy: What do twenty-three million bank loans say about the effects of monetary policy on credit risk-taking?* Banco de Espana Working Paper 0833. Banco de Espana.
 - [133] Johansen, S. (1995). *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models*. OUP Catalogue. Oxford University Press.
 - [134] Kaminsky, G. and C. Reinhart (1999). *The twin crises: The causes of banking and balance of payments problems*. MPRA Paper 14081. University Library of Munich, Germany.
 - [135] Kane, E. J. (1989). *S&L Insurance Mess, The: How Did It Happen?* MIT Press.
 - [136] Kannan, P., P. Rabanal, and M. Scott Alasdair (2012). “Monetary and Macprudential Policy Rules in a Model with House Price Booms”. *The B.E. Journal of Macroeconomics* 12.1, pp. 1–44.
 - [137] Keeley, M. C. (1990). “Deposit Insurance, Risk, and Market Power in Banking”. *American Economic Review* 80.5, pp. 1183–1200.
 - [138] Keister, T. (2010). *Bailouts and financial fragility*. Staff Reports 473. Federal Reserve Bank of New York.
 - [139] Keys, B. J., T. Mukherjee, A. Seru, and V. Vig (2010). “Did Securitization Lead to Lax Screening? Evidence from Subprime Loans”. *The Quarterly Journal of Economics* 125.1, pp. 307–362.
 - [140] Kilian, L. (1998). “Small-sample Confidence Intervals for Impulse Response Functions”. *Review of Economics and Statistics* 80.2, pp. 218–230.
 - [141] — (2001). “Impulse Response Analysis in Vector Autoregressions with Unknown Lag Order”. *Journal of Forecasting* 20.3, pp. 161–79.
 - [142] Kindleberger, C. P. (2000). *Manias, Panics and Crashes: A History of Financial Crises, Fourth Edition*. New York, Wiley Investment Classics.
 - [143] King, M. (2012). “Twenty years of inflation targeting”. London School of Economics: Bank of England.
 - [144] Kirsanova, T., C. Leith, and S. Wren-Lewis (2009). “Monetary and Fiscal Policy Interaction: The Current Consensus Assignment in the Light of Recent Developments”. *Economic Journal* 119.541.
 - [145] Kwiatkowski, D., P. C. B. Phillips, P. Schmidt, and Y. Shin (1992). “Testing the null hypothesis of stationarity against the alternative of a unit root: How sure are we that economic time series have a unit root?” *Journal of Econometrics* 54.1-3, pp. 159–178.
 - [146] Lambertini, L., C. Mendicino, and M. Teresa Punzi (2013). “Leaning against boom–bust cycles in credit and housing prices”. *Journal of Economic Dynamics and Control*. Rethinking Economic Policies in a Landscape of Heterogeneous Agents 37.8, pp. 1500–1522.
 - [147] Leeper, E. (2010). *Monetary Science, Fiscal Alchemy*. NBER Working Papers 16510. National Bureau of Economic Research, Inc.

- [148] Levieuge, G. (2003). “Les banques centrales doivent-elles réagir aux mouvements des prix d’actifs ?” PhD thesis. Orléans.
- [149] Lewis, R. and G. C. Reinsel (1985). “Prediction of multivariate time series by autoregressive model fitting”. *Journal of Multivariate Analysis* 16.3, pp. 393–411.
- [150] Lucas, R. (1987). *Models of business cycles*. Oxford: Blackwell.
- [151] Luo, D., I. B.-F. Mariscal, and P. Howells (2011). *The effect of monetary policy on investors’s risk perception: Evidence from the UK and Germany*. Working Paper 1107. University of the West of England, Bristol.
- [152] Lutkepohl, H. (2005). *New Introduction to Multiple Time Series Analysis*. Berlin: Springer-Verlag.
- [153] Lutkepohl, H. and M. M. Burda (1997). “Modified Wald tests under nonregular conditions”. *Journal of Econometrics* 78.2, pp. 315–332.
- [154] Lutkepohl, H. and M. Muller (1994). *Testing for Multi-Step Causality in Time Series*. SFB 373 Discussion Paper 1994,3. Humboldt University of Berlin, Interdisciplinary Research Project 373: Quantification and Simulation of Economic Processes.
- [155] Machado, J. F. and J. Sousa (2006). *Identifying asset price booms and busts with quantile regressions*. Working Paper w200608. Banco de Portugal, Economics and Research Department.
- [156] Maddaloni, A. and J.-L. Peydro (2011). “Bank Risk-taking, Securitization, Supervision, and Low Interest Rates: Evidence from the Euro-area and the U.S. Lending Standards”. *Review of Financial Studies* 24.6, pp. 2121–2165.
- [157] Matsuyama, K. (2007). “Credit Traps and Credit Cycles”. *American Economic Review* 97.1, pp. 503–516.
- [158] Merton, R. C. (1998). “Applications of Option-Pricing Theory: Twenty-Five Years Later”. *American Economic Review* 88.3, pp. 323–49.
- [159] Mian, A. and A. Sufi (2008). *The Consequences of Mortgage Credit Expansion: Evidence from the 2007 Mortgage Default Crisis*. NBER Working Paper 13936. National Bureau of Economic Research, Inc.
- [160] Minsky, H. P. (1976). *John Maynard Keynes*. Macmillan.
- [161] Mishkin, F. (2011). “How Should Central Banks Respond to Asset-Price Bubbles? The ‘Lean’ versus ‘Clean’ Debate After the GFC”. *RBA Bulletin*, pp. 59–70.
- [162] Mishkin, F. S. (1996). *The Channels of Monetary Transmission: Lessons for Monetary Policy*. Working Paper 5464. National Bureau of Economic Research.
- [163] — (2007). *Monetary Policy Strategy*. MIT Press Books. The MIT Press.
- [164] Montes, G. C. and G. B. T. Peixoto (2014). “Risk-taking channel, bank lending channel and the paradox of credibility: Evidence from Brazil”. *Economic Modelling* 39, pp. 82–94.

-
- [165] Mundell, R. A. (1962). “The appropriate use of monetary and fiscal policy for internal and external stability”. *Staff Papers-International Monetary Fund*, pp. 70–79.
 - [166] Nakornthab, D. and P. Rungcharoenkitkul (2010). *Marrying Monetary Policy with Macroprudential Regulation: Exploration of Issues*. Bank of Thailand.
 - [167] N’Diaye, P. (2009). *Countercyclical Macro Prudential Policies in a Supporting Role to Monetary Policy*. IMF Working Paper 09/257. International Monetary Fund.
 - [168] Newey, W. K. and D. McFadden (1994). “Chapter 36 Large sample estimation and hypothesis testing”. *Handbook of Econometrics*. Ed. by Robert F. Engle and Daniel L. McFadden. Vol. Volume 4. Elsevier, pp. 2111–2245.
 - [169] OECD (2011). *National Accounts at a Glance 2011*. Paris: Organisation for Economic Co-operation and Development.
 - [170] Papademos, L. (2009). “Financial stability and macro-prudential supervision: objectives, instruments and the role of the ECB”. *Speech at the conference “The ECB and its Watchers XI” Frankfurt*.
 - [171] Paries, M. D., C. K. Sorensen, and D. Rodriguez-Palenzuela (2011). “Macroeconomic Propagation under Different Regulatory Regimes: Evidence from an Estimated DSGE Model for the Euro Area”. *International Journal of Central Banking* 7.4, pp. 49–113.
 - [172] Phillips, P. C. B. and P. Perron (1988). “Testing for a Unit Root in Time Series Regression”. *Biometrika* 75.2, pp. 335–346.
 - [173] Poutineau, J.-C. and G. Vermandel (2014). *Design and Coordination of Macroprudential Policy in the Eurozone with International Banks*. Tech. rep.
 - [174] Quint, D. and P. Rabanal (2013). *Monetary and Macroprudential Policy in an Estimated DSGE Model of the Euro Area*. IMF Working Paper 13/209. International Monetary Fund.
 - [175] Rajan, R. G. (2006). “Has Finance Made the World Riskier?” *European Financial Management* 12.4, pp. 499–533.
 - [176] — (2009). “The credit crisis and cycle-proof regulation”. *Review, Federal Reserve Bank of Saint Louis* Sep, pp. 397–402.
 - [177] Reinhart, C. and K. Rogoff (2009). *Banking Crises: An Equal Opportunity Menace*. CEPR Discussion Paper 7131. C.E.P.R. Discussion Papers.
 - [178] Repullo, R. and J. Suarez (2008). *The Procyclical Effects of Basel II*. CEPR Discussion Papers 6862. C.E.P.R. Discussion Papers.
 - [179] Rodriguez-Moreno, M. and J. I. Pena (2013). “Systemic risk measures: The simpler the better?” *Journal of Banking & Finance* 37.6, pp. 1817–1831.
 - [180] Rudebusch, G. D. (2005). “Monetary policy and asset price bubbles”. *FRBSF Economic Letter*.
 - [181] Scaillet, O. (2004). “Nonparametric Estimation and Sensitivity Analysis of Expected Shortfall”. *Mathematical Finance* 14.1, pp. 115–129.

- [182] Scaillet, O. (2005). “Nonparametric Estimation of Conditional Expected Shortfall”. *Insurance and Risk Management Journal* 74, pp. 639–660.
- [183] Schularick, M. and A. M. Taylor (2012). “Credit Booms Gone Bust: Monetary Policy, Leverage Cycles, and Financial Crises, 1870-2008”. *American Economic Review* 102.2, pp. 1029–1061.
- [184] Schwarz, G. (1978). “Estimating the Dimension of a Model”. *The Annals of Statistics* 6.2, pp. 461–464.
- [185] Shin, H. S. (2009). “Discussion of “The Leverage Cycle” by John Geanakoplos”. *Discussion prepared for the 2009 NBER Macro Annual*.
- [186] Silverman, B. (1986). *Density Estimation for Statistics and Data Analysis*. London: Chapman & Hall.
- [187] Simonoff, J. S. (1996). *Smoothing Methods in Statistics*. Springer Science & Business Media.
- [188] Sims, C. A. (1980). “Macroeconomics and Reality”. *Econometrica* 48.1, pp. 1–48.
- [189] Sims, C. A., J. H. Stock, and M. W. Watson (1990). “Inference in Linear Time Series Models with some Unit Roots”. *Econometrica* 58.1, p. 113.
- [190] Smets, F. (2000). *What horizon for price stability*. Working Paper Series 0024. European Central Bank.
- [191] Stiglitz, J. E. and A. Weiss (1981). “Credit Rationing in Markets with Imperfect Information”. *American Economic Review* 71.3, pp. 393–410.
- [192] Sunirand, P. (2002). *The Role of Bank Capital and The Transmission Mechanism of Monetary Policy*. FMG Discussion Paper dp433. Financial Markets Group.
- [193] Svensson, L. E. (2013). *“Leaning Against the Wind” Leads to Higher (Not Lower) Household Debt-to-GDP Ratio*.
- [194] “Symposium: The Monetary Transmission Mechanism” (1995). *Journal of Economic Perspectives* 9.4.
- [195] Tabellini, G. (2011). *The Eurozone Crisis: What Needs to be Done*.
- [196] Tarashev, N., C. Borio, and K. Tsatsaronis (2010). *Attributing systemic risk to individual institutions*. BIS Working Paper 308. Bank for International Settlements.
- [197] Taylor, J. B. (1993). “Discretion versus policy rules in practice”. *Carnegie-Rochester Conference Series on Public Policy* 39, pp. 195–214.
- [198] Tetlow, R. J. (2005). “Monetary Policy, Asset Prices, and Misspecification: the robust approach to bubbles with model uncertainty”. Bank of Canada.
- [199] Tinbergen, J. (1952). “On the theory of economic policy.” *Contributions to economic analysis; 1*.
- [200] Townsend, R. M. (1979). “Optimal contracts and competitive markets with costly state verification”. *Journal of Economic Theory* 21.2, pp. 265–293.

- [201] van den End, J. W. (2010). *Trading off monetary and financial stability: a balance of risk framework*. DNB Working Papers 249.
- [202] Wand, M. and M. Jones (1995). *Kernel Smoothing*. London: Chapman & Hall.
- [203] Wilson, L. and Y. W. Wu (2010). “Common (stock) sense about risk-shifting and bank bailouts”. *Financial Markets and Portfolio Management* 24.1, pp. 3–29.
- [204] Woodford, M. (2012). *Inflation Targeting and Financial Stability*. Working Paper 17967. National Bureau of Economic Research.
- [205] Wren-Lewis, S. (2010). “Macroeconomic policy in light of the credit crunch: the return of counter-cyclical fiscal policy?” *Oxford Review of Economic Policy* 26.1.

Alexandra – Mihaela POPESCU
Risque et enjeux des politiques macroéconomiques

Résumé :

La conduite des politiques économiques a été mise en question après le déclenchement de la crise financière en 2007. Cette thèse analyse les faiblesses identifiées dans la réglementation existante avant la crise et propose des pistes d'amélioration. Le premier chapitre s'intéresse à l'existence du canal de la prise de risque en zone euro. Par le biais des mesures de causalité de long terme, nous démontrons que la politique monétaire a une influence sur le niveau de risque financier. Un autre constat tiré de cette analyse concerne l'absence des mesures de risque systémique. Par conséquent, le deuxième chapitre étudie les mesures proposées après la crise pour les institutions financières et les applique aux États membres de la zone euro. À l'aide de ces mesures, les autorités pourront imposer des règles plus strictes aux pays les plus risqués d'un point de vue systémique. Le chapitre trois envisage une première solution visant à atténuer l'effet des décisions monétaires sur le risque. Nous étudions, à travers un modèle DSGE, l'impact de la stratégie de "leaning against the wind" sur les cycles économiques et financiers. Les résultats montrent qu'une telle approche n'est pas suffisante pour stabiliser l'économie et que des arbitrages entre objectifs apparaissent. Pour cette raison, le dernier chapitre porte plus en détail sur les arbitrages entre objectifs, et propose, comme une deuxième solution, l'intégration des mesures macroprudentielles dans l'analyse. En utilisant un modèle Néo-Keynésien sous forme réduite, nous trouvons que les fonds propres contracycliques aident à réduire la volatilité des cycles, mais que les trade-offs demeurent en cas de chocs financiers. Le rôle de la banque centrale dans le maintien de la stabilité financière s'avère aussi important, puisque l'utilisation du leaning against the wind semble améliorer la volatilité des cycles.

Mots clés : canal de la prise de risque, politique monétaire, dette souveraine, leaning against the wind, bulles des prix d'actifs, arbitrages.

Risk and Macroeconomic Policy Challenges

Abstract:

The conduct of economic policy has been called into question after the outbreak of the financial crisis in 2007. This thesis analyzes the flaws identified in the regulation enforced before the crisis and offers suggestions for improvement. The first chapter focuses on the existence of the risk-taking channel in the Eurozone. Through measures of long-term causality, we demonstrate that monetary policy influences the level of financial risk. Another conclusion drawn from this analysis is the absence of systemic risk measures. Therefore, the second chapter analyzes the measures proposed after the crisis for financial institutions and applies them to members of the Eurozone. Based on these measures, authorities may impose stricter rules on countries that prove to be systemically risky. Chapter three considers a first solution to mitigate the effect of monetary policy decisions on risk. We study, through a DSGE model, the impact of the "leaning against the wind" strategy on economic and financial cycles. The results show that this approach is not sufficient to stabilize the economy and that it gives rise to trade-offs between objectives. For this reason, the last chapter examines in more detail the trade-offs between objectives, and proposes as second solution, the integration of macroprudential measures in the analysis. Using a reduced form New-Keynesian model, we find that countercyclical capital helps to reduce the volatility of cycles, but trade-offs appear in case of financial shocks. The role of the central bank in maintaining financial stability seems also important, as the use of leaning against the wind improves cycles' volatility.

Keywords: risk taking channel, monetary policy, sovereign debt, leaning against the wind, asset price bubbles, trade-offs.



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