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Alexandra Campmas

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THÈSE PRÉSENTÉE

POUR OBTENIR LE GRADE DE

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L'UNIVERSITÉ DE BORDEAUX**

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SPÉCIALITÉ SCIENCES ÉCONOMIQUES

Par **Alexandra CAMPMAS**

**INSTITUTIONAL ENVIRONMENT AND BANK
BEHAVIOUR**

The case of European banks

Sous la direction de **Sophie BRANA**, Professeure des Universités

et de **Ion LAPTEACRU**, Maître de Conférences HDR

Soutenue le 26 Novembre 2020

Membres du jury:

M. Olivier Brossard

Professeur des Universités, Directeur de Science Po Toulouse, *président du jury*

Mme Catherine Refait-Alexandre

Professeure des Universités, Université de Franche-Comté, *rapporteuse*

M. Laurent Weill

Professeur des Universités, Université de Starsbourg, *rapporteur*

M. Grégory Levieuge

Professeur des Universités, Université d'Orléans, Économiste à la Banque de France, *suffragant*

Mme Sophie Brana

Professeure des Universités, Université de Bordeaux, *co-directrice de thèse*

M. Ion Lapteacru

Maître de Conférences HDR, Université de Bordeaux, *co-directeur de thèse*

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Résumé en français

Depuis la création de l'institution émettrice et gardienne de l'euro, le système bancaire n'a cessé d'évoluer dans un environnement institutionnel complexe. Ce dernier est défini par Davis and North (1970) comme un ensemble de normes et de règles qui, en imposant des contraintes, encadrent les actions individuelles ou collectives. Lorsque l'on étudie le comportement des banques, deux politiques façonnent principalement leur environnement institutionnel: la politique monétaire et la politique prudentielle. Alors que la première régit l'offre de monnaie des banques, la seconde exige que les banques se conforment aux règles prudentielles afin de limiter le risque systémique.

Au cours de ces deux dernières décennies, l'environnement institutionnel a été marqué et façonné par de nombreuses réformes politiques et des crises majeures de nature très différente. Jusqu'à l'aube de la crise financière, les pays européens ont connu une convergence des taux d'intérêt à court et à long terme dès l'année 1998, accélérant de surcroît l'intégration financière. Le développement des marchés financiers était encouragé afin de favoriser une allocation optimale des capitaux et donc la croissance économique (Gelb, 1989; Bencivenga and Smith, 1991; Atje and Jovanovic, 1993; Levine, 1997*a*). Il convient néanmoins de mentionner que certains travaux, tels que Gelb (1989), ont mis en garde contre une libéralisation brutale et ses conséquences néfastes sur la stabilité financière.

La crise des subprimes a en effet démontré les limites de cette libéralisation. Les recherches se sont ensuite développées autour des origines de la crise financière et de la désignation des différents coupables. La question de savoir "qui est responsable" s'est même étendue aux décideurs politiques, qui ont fait preuve de laxisme en réagissant aux signes avant-coureurs. Selon ses propres termes, la commission d'enquête américaine sur la crise financière a conclu que cette crise était "évitable" et que "la crise était le résultat de l'action et de l'inaction de l'homme, et non de Mère Nature ou de dysfonctionnements de modèles informatiques" (The Financial Crisis Inquiry Commission, 2011, p.18).

Parmi les “coupables” désignés, plusieurs économistes ont accablé la conduite de la politique monétaire, jugée d’avoir maintenu les taux d’intérêt à un trop faible niveau. Taylor (2009) déclare que les taux d’intérêt sont restés “trop bas pendant trop longtemps”. La littérature, tant théorique qu’empirique, corrobore cette affirmation selon laquelle des taux d’intérêt “trop bas” et stables ont encouragé les banques à prendre des risques excessifs, mettant en péril la stabilité financière. Borio and Zhu (2012) nomment un tel mécanisme le canal de la prise de risque. En particulier, ce canal traduit le fait qu’une modification du taux directeur agit sur la perception et la tolérance au risque des banques et donc sur le niveau de risque d’un portefeuille ou sur le prix des actifs.

Après la crise, le déclin de la “doctrine de Greenspan”, selon laquelle les autorités monétaires avaient le contrôle exclusif du cycle économique, a soulevé de nombreuses questions quant au rôle de la politique monétaire vis-à-vis de la stabilité financière. Certains travaux argumentent en faveur d’une politique monétaire à “contre-courant”, c’est-à-dire une politique qui serait plus restrictive que nécessaire, permettant ainsi de lutter contre les déséquilibres financiers.

Cependant, face aux difficultés engendrées par la crise de la dette souveraine et à l’objectif primaire de la Banque Centrale Européenne (BCE) non respecté, l’institution n’a eu d’autre choix que de baisser durablement son taux d’intérêt directeur, atteignant alors le taux plancher. Comme une impression de déjà-vu, la gestion d’une telle politique a remis en question l’efficacité de l’outil principal des banques centrales. Au-delà de la question du canal de la prise de risque, certains travaux ont remis en question l’efficacité d’une variation du taux d’intérêt directeur à un niveau aussi bas (voir par exemple Apergis and Christou, 2015). La BCE, ainsi que ses homologues européens, se sont alors tournés vers des instruments dits “non-conventionnels”, ouvrant la voie à une injection massive de liquidités.

Par conséquent, l’avènement de ces instruments inédits soulève deux problématiques distinctes. La première concerne la question de l’élargissement de la définition originale

du canal de prise de risque bancaire. Alors que ce dernier n'implique à l'origine que l'effet d'une modification du taux d'intérêt directeur, les injections massives de liquidités à travers les outils non-conventionnels peuvent, à moyen et long terme, aplatir la courbe des taux et réduire les primes de risque, ce qui pourrait inciter les banques à prendre plus de risques et à ajuster leur ratio d'endettement. La seconde a suscité une vive inquiétude quant à ses effets sur la rentabilité des banques (Blot and Hubert, 2019). Le maintien des taux d'intérêt directeurs à un niveau bas affecte mécaniquement les activités traditionnelles des banques en comprimant les taux prêteurs, ce qui comprime à son tour les marges d'intérêt nettes si les banques sont réticentes voire dans l'incapacité de diminuer leurs taux d'intérêt sur les dépôts. Néanmoins, l'effet final de telles actions sur la rentabilité globale n'est pas clairement défini. La conduite de cette politique a des effets positifs sur le coût de refinancement des banques et est susceptible de réduire la probabilité de défaillance des ménages et des entreprises à mesure que les charges d'intérêt diminuent (Madaschi and Pablos Nuevo, 2017).

En parallèle, malgré la volonté politique précoce de créer un cadre réglementaire solide face au risque systémique, les défaillances des institutions financières en matière de gouvernance d'entreprise et de gestion des risques ont été identifiées comme des facteurs à l'origine de la crise. Bien que l'environnement bancaire fût principalement soumis à une politique microprudentielle, la somme des actions individuelles s'est révélée insuffisante pour préserver la stabilité financière. Plus important encore, les instruments prudentiels établis ont exacerbé la gravité de la crise via leur nature procyclique (voir par exemple Goodhart and Taylor, 2006).

Ainsi, afin de prévenir à la fois la nature procyclique de ces instruments et de limiter la gestion des risques bancaires, la politique macroprudentielle est devenue le centre d'intérêt des décideurs politiques. En dépit d'une absence de définition concrète, Ebrahimi Kahou and Lehar (2017) montrent, à travers une revue de la littérature, que la politique macroprudentielle répond à trois objectifs: la stabilité financière, le risque systémique et

la procyclicité du secteur financier. Dans cette thèse, nous nous concentrerons essentiellement sur les outils prudentiels visant à lutter contre la procyclicité (tels que le coussin de capital anticyclique ou le ratio d'endettement prêts sur valeur) car une fois implémentés, ils représentent une véritable contrainte pour les banques, capables d'affecter leur comportement, par exemple, en termes de prise de risque, de rentabilité ou de prêt.

Il est important de noter que dans la zone euro, et plus largement dans l'Union Européenne, les autorités bancaires ont conçu des outils complémentaires pour remédier aux déséquilibres financiers pouvant alors mettre en péril la stabilité financière. En revanche, alors que l'application de certains instruments soumettent les banques à des contraintes strictes (comme par exemple les outils basés sur les fonds propres), l'implémentation d'autres instruments (comme par exemple le ratio d'endettement prêt sur valeur) sont laissés à la discrétion des autorités nationales et, en l'absence d'action nationale ou (au moins) d'action non contraignante, aux institutions financières elles-mêmes. Dans un tel marché financier intégré, le domaine sur lequel s'applique la règle macroprudentielle est pertinent pour éviter les comportements bancaires évasifs (Cerutti et al., 2017; Cizel et al., 2016). En outre, la mise en œuvre de règles macroprudentielles peut également encourager les banques à adopter un comportement de “nivellement par le bas” pour se conformer aux règles.

Aujourd'hui, si l'on peut s'attendre à un nouvel assouplissement de la politique macroprudentielle, la politique monétaire européenne n'est pas encore prête à faire marche arrière. Au contraire, face à l'apparition récente de la crise du coronavirus, la BCE a déployé l'artillerie lourde. Pour aider l'économie à absorber le choc, l'action innovante de la banque centrale est le programme d'achat d'urgence en cas de pandémie, qui prévoit d'injecter 1 350 milliards d'euros pour réduire le coût des emprunts et stimuler les prêts. Parmi les mesures complémentaires mises en place - dont la plupart sont une extension des mesures de politique monétaire existantes -, certaines concernent la politique macroprudentielle. Le contrôle bancaire de la BCE a décidé d'utiliser la flexibilité de la politique

macroprudentielle. À cet égard, l'institution a décidé d'assouplir le montant des capitaux que les banques doivent détenir afin d'augmenter leur capacité de prêt. En outre, l'autorité bancaire européenne a introduit une certaine flexibilité dans la mise en œuvre de ses lignes directrices, qui vise à réduire le montant des prêts non performants détenus par les banques.

Compte tenu de l'importance de l'environnement institutionnel en constante évolution et qui suggère que des actions encore plus sophistiquées vont émerger dans un avenir proche, cette thèse s'attache à montrer **dans quelle mesure le comportement des banques européennes a été affecté par les changements de politique monétaire et macro-prudentielle au cours des deux dernières décennies.**

Afin de répondre à cette question de recherche, la thèse s'articule en trois chapitres. Dans le premier chapitre, nous étudions empiriquement l'existence d'un canal de la prise de risque en Europe. Nous nous appuyons sur un échantillon européen, qui comprend à la fois des banques sous la supervision de la BCE et des banques établies dans des pays en dehors de la zone euro. Sur la base de la définition originale du canal de prise de risque, nous analysons les effets d'une modification du taux d'intérêt directeur sur deux mesures de risque complémentaires: l'une est une mesure du risque basée sur la comptabilité, l'autre se fonde sur le risque de marché. Nous complétons cette première analyse en testant la possibilité d'un "canal de la prise de risque de la politique monétaire non conventionnelle". À cet égard, nous utilisons deux outils capable de mesurer les actions inédites des banques centrales, à savoir le taux d'intérêt de la facilité de dépôts¹ et le taux d'intérêt fantôme Krippner (2014), qui surmonte l'obstacle du taux plancher et est capable de prendre en compte le rôle des politiques non-conventionnelles. Nous recueillons également des informations annuelles sur le montant des actifs détenus par chaque banque centrale étudiée afin de saisir les mesures d'assouplissement quantitatif.

¹Selon Borio and Zabai (2016), le taux d'intérêt de la facilité de dépôts peut être considéré comme un indicateur de la politique monétaire non conventionnelle puisque de nombreuses banques centrales européennes ont fixé ce taux directeur en dessous de zéro

L'originalité de ce travail réside dans le modèle qui teste l'existence d'effets non linéaires de la politique monétaire sur le risque bancaire. Nos résultats montrent que l'assouplissement de la politique monétaire via des taux d'intérêt bas et l'augmentation de la liquidité des banques centrales a un effet néfaste sur le risque des banques, confirmant l'existence du canal de la prise de risque. En outre, nous montrons que cette relation est non linéaire, c'est-à-dire que les effets des taux d'intérêt de la politique monétaire (les montants du bilan des banques centrales) sur le risque bancaire sont plus forts en-deçà (au-delà) d'un certain seuil.

Le chapitre 2 examine le lien entre l'environnement de taux d'intérêt bas, le comportement prudentiel des banques et la rentabilité. La baisse durable des taux d'intérêt pourrait mettre en péril la rentabilité des banques par le biais des activités d'intermédiation bancaire; les banques gagnent la différence entre le taux d'intérêt généré par l'activité de crédit qui s'applique généralement aux longues échéances et les taux d'intérêt payés sur l'activité de dépôt qui s'appliquent aux courtes échéances. De plus, les achats massifs d'actifs devraient aplatir la courbe de rendement, ce qui comprimerait encore davantage la marge d'intérêt nette. La compression de la marge d'intérêt nette se produit à condition que le taux d'intérêt payé sur les dépôts reste stable. Étant donné le faible niveau des taux d'intérêt sur les prêts dû à la politique de taux d'intérêt, les banques sont réticentes - ou parfois légalement contraintes - à fixer des taux d'intérêt négatifs, ou à réduire davantage le taux d'intérêt sur les dépôts pour éviter de perdre des clients. Cependant, ces arguments doivent être tempérés. Premièrement, ces mesures exceptionnelles de politique monétaire ont un effet positif sur les coûts de refinancement des banques, puisque celles-ci se financent auprès de la banque centrale à un taux d'intérêt négatif. Deuxièmement, la baisse des charges d'intérêt pour les ménages et les entreprises réduit le risque de défaillance. Dans ce contexte et compte tenu de l'existence du canal de la prise de risque, nous examinons le comportement des banques européennes afin d'évaluer si le taux d'intérêt directeur nuit à leur rentabilité. Nous constatons que les risques de crédit et d'insolvabilité des banques

ont un impact négatif sur les bénéfices : plus le risque est élevé, plus le bénéfice est faible. Notre analyse suggère également que le principal instrument de la politique monétaire a un effet négatif sur les bénéfices des banques. Néanmoins, lorsque les taux d'intérêt directeurs sont particulièrement bas, alors que son effet sur la marge d'intérêt nette reste négatif, son effet sur la rentabilité globale devient positif. Ces résultats indiquent que les banques européennes réussissent à augmenter leur rentabilité malgré une compression de leurs revenus d'intérêts nets.

Le dernier chapitre explore le rôle des outils macroprudentiels dans un environnement institutionnel turbulent. Face au développement de menaces incontrôlables sur la stabilité financière résultant d'une politique monétaire expansionniste, certaines économies présentent, comme un sentiment de déjà vu, un secteur bancaire fortement exposé au marché du logement sur fond de hausse rapide des prix de l'immobilier et d'un endettement privé croissant. La crise sanitaire actuelle devrait encore aggraver la capacité des ménages et des entreprises à rembourser leurs prêts. Dans ce contexte, ce chapitre contribue à établir le lien entre l'utilisation flexible des instruments macroprudentiels et leurs effets encore inexplorés. En particulier, nous étudions l'efficacité de la flexibilité des outils macroprudentiels en cas de choc externe (telle que la pandémie) qui affecterait considérablement le secteur privé dans sa capacité à rembourser sa dette. Dans le même temps, cette flexibilité ne devrait pas mettre en péril la stabilité financière. Notre travail se concentre sur deux instruments flexibles, qui sont considérés comme relativement efficaces pour préserver la stabilité financière : l'exigence de fonds propres réglementaires et le ratio d'endettement prêt sur valeur. Nos modèles empiriques et théoriques corroborent tous deux le fait qu'un scénario de facilité de la politique macroprudentielle permet d'atténuer les effets négatifs d'un tel choc. Plus précisément, le modèle DSGE suggère que les décideurs politiques exploitent la flexibilité macroprudentielle en assouplissant le ratio d'endettement prêt sur valeur ; ce dernier se révélant plus efficace que celui du ratio d'adéquation des fonds propres.

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General introduction

“Whatever it takes”². It took only three words to save European countries from an unprecedented sovereign crisis. At the time of writing, these three words are not “locked down” but repeatedly echoed. This time, the European Central Bank (ECB) is not the only actor making the most of it. Almost all European governments do; these three words are becoming the European states’ COVID-19 pledge. Also, at the time of writing, all European countries are being hit by the pandemic. Of course, history has witnessed sanitary crises, such as the Spanish flu after the World War I. However, so far, macroeconomics is not ready to address health-related crises. While economists are used to reasoning in terms of shocks, the nature of the current shock is unclear³. By putting our economies in a medically-induced coma, we are not experiencing the traditional shift in supply and demand curves, but their disappearance. Unlike the financial turmoil that hit in 2008, the origin of the current crisis is of an atypical nature, raising the same important question on almost everyone’s lips: “will this crisis become financial?”

Against this background, scrutinising banks’ soundness vis-à-vis the environment in which they operate takes on its full meaning. The banking system has been evolving within an intricate institutional framework in constant development. Davis and North (1970) define the institutional environment as a set of norms and rules that frame individual or collective actions by imposing constraints. When exploring banks’ behaviour, two key

²On July 26, 2016, Mario Draghi claimed that the ECB would do “whatever it takes” to save the Euro zone.

³A survey carried out by the IGM Forum (2020) Forum reveals high uncertainty amongst top leading US and European economists regarding the type of the current shock.

policies mainly shape their institutional environment: monetary policy and prudential policy. While the former rules over banks' supply of money, the latter requires banks to comply with the prudential rulebook to limit systemic risk.

The last year of the 20th century marked by the creation of the euro and its issuer represents a historic milestone in shaping the European financial landscape. The introduction of a single currency is, according to the economic theory, one of the essential steps to ensure the European financial integration (Mundell, 1961). The common monetary policy is the main by-product of the euro creation, which has profoundly changed the institutional banking environment. Such a change implies that Eurozone countries renounced their own monetary policy and thus any tools for reacting to asymmetric shocks. Therefore, all banks established in these jurisdictions are "constrained" by the ECB's decisions.

But the transformation of the European banking institutional environment began even before the euro came into circulation. Policy makers' willingness to push financial integration forward contributes to the understanding of banks' behaviour over the past two decades.

In 1987, the financial integration process was first fostered by the Single European Act, which paved the way for the establishment of an internal market for goods, persons, services, and capital. At the same time, by its very nature, deep financial integration could contribute to jeopardising financial stability, as shocks spread rapidly to the banking system and, more broadly, to the economy as a whole. Therefore, the advent of prudential rules - albeit less sophisticated than today - did not wait for the creation of the European Systemic Risk Board in 2011 but was already one of the objectives set out in the Financial Services Action Plan adopted in 1999. This action plan geared towards achieving a "single market for wholesale financial services, open and secure retail markets and state-of-the-art prudential rules and supervision". In short, all these initiatives, coupled with national actions towards capital liberalisation and the acceleration of technological development, catalysed the pace of financial integration and triggered structural changes in the banking

sector.

In the early 2000s, a significant number of mergers and acquisitions consequently took place in several Member States, leading to the creation of financial conglomerates. In this context, driven by arbitrage behaviour, interbank market operations between countries intensified. Banks - mainly large ones - benefited from the liquidity pool throughout the Euro Area. As of 1998, the share of intra-euro interbank claims increased by more than one-third before levelling off and accounted for almost half of the worldwide interbank claims, as reported by the Bank of International Settlement (see Galati and Tsatsaronis, 2001). This development was favoured by a context of low and converging interest rates (see Figure 1).

The planned introduction of the euro triggered the “well-known” convergence⁴ of short- and long-term interest rates as of 1998. As such, interest-rates differentials between countries faded away. Figure 1 shows that after the advent of the European monetary union, spreads on government bonds closed the gap. More generally, a growing body of literature advocated that a far-reaching financial integration, together with a broad development of financial markets, fostered both capital allocation and economic growth (see among others, Bencivenga and Smith, 1991; Atje and Jovanovic, 1993; Levine, 1997*a,b*). Even though some works warned against an abrupt liberalisation and its adverse consequences on financial stability (such as Gelb, 1989), the common belief around the virtues of a deep financial integration was accompanied and reinforced by the so-called “Greenspan doctrine”.

Indeed, the “Greenspan doctrine”, which asserts that price stability leads to financial stability, is a consequence of the work of Anna Schwartz, who claims that a central bank “able to maintain price stability would also incidentally minimize the need for lender-of-last-resort intervention,” (Schwartz, 1995, p.53). According to the author, financial

⁴Indeed, a strand of the literature suggests that by eliminating exchange rate uncertainty and cutting cross-frontier financial transaction costs, the common currency increases capital mobility. See for instance (Aglietta and Brand, 2013).

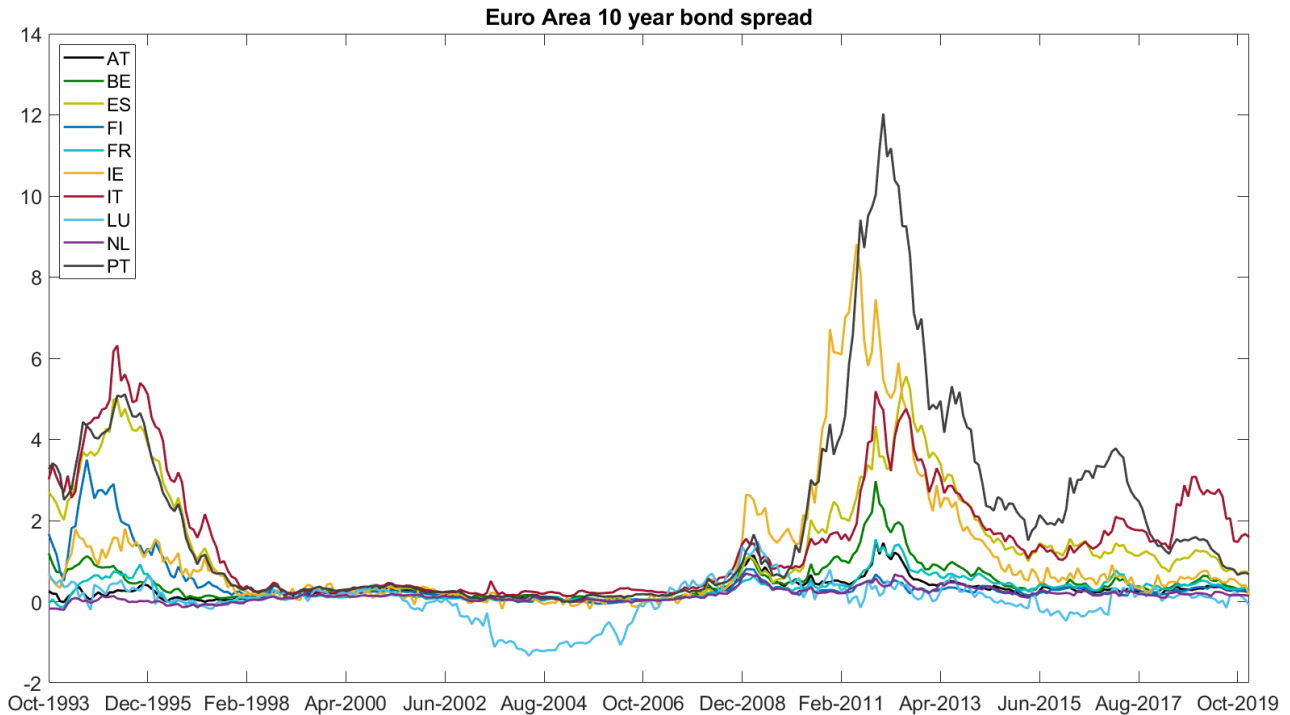


Figure 1: Core Euro Area 10 year bond vs. German 10 year bond spread

instability is caused and jeopardised by fluctuations in price expectations. Therefore, a monetary policy that upholds price stability would also promote financial stability. This doctrine led to the conviction that central banks were fully in “control” of economic cycles and that the issue of financial stability had been resolved. In this context, the implications for financial stability were marginal or of lesser importance, until the outbreak of the 2008 financial crisis. This crisis cast doubt on this belief.

The financial crisis, generated by the bursting of the mortgage bubble, shaped the current banking environment and caused great and long-lasting difficulties for banks. In particular, banks faced significant liquidity constraint. With the loss in value of real estate assets, many agents who could not repay their variable-rate loans went bankrupt. The mortgage credit system stipulates that in such cases, the bank owns the real estate backed by the loans. However, as the price of these properties fell, banks were unable to recover the money lent to the agents when they sold them. Such colossal losses led to

dramatic damages in the real economy. In this context, academic research proliferated in order to analyse the roots of the financial crisis and seek various culprits. The “who’s to blame?” question has even expanded to policy makers, who have been lax in responding to early warning signs. In its own words, the US Financial Crisis Inquiry Commission concluded that this crisis was “avoidable” and that “[it] was the result of human action and inaction, not of Mother Nature or computer models [that have] gone haywire” (The Financial Crisis Inquiry Commission, 2011, p.18).

Albeit a plethora of studies pointed to global structural imbalances (Obstfeld and Rogoff, 2001, 2007; Rogoff, 2007; Altuzarra et al., 2010), a lack of a sound regulatory framework (Acharya et al., 2011; Moshirian, 2011; Kane, 2012), and even derivatives in personal behaviour and culture (Akerlof and Shiller, 2010), failures in financial institutions’ corporate governance and risk management have been identified as key drivers of the crisis (see for instance The Financial Crisis Inquiry Commission, 2011). Although the banking environment was mainly subject to microprudential policy, the sum of individual actions was not enough to contain systemic risk (see for instance, de Bandt and Hartmann, 2000) and therefore safeguard financial stability. More importantly, existing limitations in the established prudential instruments exacerbated the severity of the crisis.

Warnings were issued in the literature beforehand. The experience of frequent financial crises led many to believe that the regulatory framework was too fragile to ensure stability (Minsky, 1972, 1982; Kindleberger, 2000), underlying the need for a sound macro-based financial regulatory framework (Davis, 1999; Crockett, 2001; Borio, 2003, among others). More specifically, the procyclical nature of prudential policy was criticised (see for instance Goodhart and Taylor, 2006). Under Basel II, default and market risks diminished during expansion phases and banks were consequently less attentive to risk. Once the cycle was reversed, the effects were devastating as risks exploded and capital collapsed. The Basel II prudential ratio has well-evidenced this procyclicality. At the same time, infringements of best management practices blossomed not only throughout the whole financial industry,

but also in the rating agencies that failed to provide a proper assessment of credit risk (Mattarocci, 2014).

To mitigate the procyclical nature of existing prudential policy instruments and limit bank risk management, macroprudential policy has become policy makers' focal point of interest. The objectives of macroprudential policy are complex because no common definition has been reached among policy makers. Through a literature review, Ebrahimi Kahou and Lehar (2017) highlight, however, that such a policy should address financial stability, systemic risk, and procyclicality in the financial industry. According to the authors, macroprudential instruments aim to achieve these objectives by following two dimensions, namely the cross-sectional dimension and the time dimension. The group of instruments belonging to the first dimension is used to estimate each bank's contribution to systemic risk. For example, these tools refer to VaR or Shapley's value. The second group of instruments focuses on reducing systemic risk by means of tailor-made prudential measures for each type of bank identified in the first step, while coping with procyclicality. The early work of Haldane and May (2011) echoes clearly this two-step approach. After developing a model in which a shock hits a single bank and has a knock-on effect on the entire banking system, the authors recommend the use of macroprudential instruments according to the bank's contribution to the systemic risk.

However, while this toolkit is useful for policymakers because it allows, in the first stage, to target risky financial institutions, the instruments dealing with the time dimension, i.e. procyclicality, are more central to this thesis. Once implemented, these instruments represent a real constraint for banks, capable of affecting their behaviour, for instance, in terms of risk-taking, profitability or lending. In fact, procyclicality issues are closely akin to the well-known financial accelerator mechanism, which emphasises the linkage between the financial and real spheres (Bernanke and Gertler, 1989; Holmstrom and Tirole, 1997; Bernanke et al., 1999, among others). In our work, the mechanism could be described as follows: a change in monetary policy could induce a change in

economic agents' or financial institutions' net worth (see for instance, Farhi and Tirole, 2012). Because of imperfect information, the terms under which an economic agent is able to borrow affect finance premium, which is inversely related to net worth. The procyclical behaviour of net worth over the business cycle negatively impacts the finance premium, which in turn exacerbates swings in, for instance, lending, spending or production. More importantly, any shock (positive or negative) could aggravate this loop. As such, countercyclical macroprudential instruments could play a crucial role in modifying banks' behaviour, thus implying changes in the real economy.

One of the main instruments to mitigate procyclicality is the countercyclical capital buffer. This tool is designed in such a way that, during an economic downturn, the capital built up over prosperous time is released to provide liquidity to the economy and counteract credit crunch. Tirole (2011) shows that such a tool is capable of mitigating credit booms. However, to comply with the requirement, in some circumstances, banks may find optimal to cut lending or increase the lending interest rate. Another important tool is dynamic provisioning. Since banks behave cyclically by underestimating risk in good times, which aggravates their losses in times of economic downturn, such a tool requires them to set aside provisions when their revenues are high. Finally, the loan-to-value (LTV) ratio is also one of the most widely used countercyclical macroprudential instruments. Even though several borrower-based ratios exist (such as the Debt-to-Income or the Loan-to-Income ratios), the use of the LTV ratio is found to be the most effective to curb excessive lending (Wong et al., 2011; International Monetary Fund, 2013; Krznar and Morsink, 2014).

It is worth stressing that, in the European Union, authorities have recently designed complementary tools to address imbalances resulting from the housing market, such as the LTV ratio. However, if capital-based instruments are binding on all banks established in the European Union because these instruments fall under a regulation (Capital Requirement Regulation packages), this is not the case for tools aiming at correcting

property prices as they are “only” subject to a Directive (Directive 2014/17/EU related to consumer mortgage credit agreements). Unlike Regulations, which are immediately applicable, Directives need to be transposed and may leave some room to Member States to adapt the rules. In other words, the use of these complementary tools is still partially left to the discretion of national authorities and thus, in the absence of national action or (at least) non-binding action, to financial institutions themselves. In such a financial integrated market, the area on which the macroprudential rule applies is relevant to avoid evasive banking behaviour. Although Cerutti et al. (2017) and Cizel et al. (2016) conclude that, overall, macroprudential instruments have stabilising effects for the economy and are therefore able to reduce risk-taking, they identify such behaviours in their work. The use of macroprudential policy in integrated financial systems, as in the Euro Area or even the European Union, is associated with an increase in cross-border borrowing, which according to the authors, reveals evasive behaviour by banks. In addition, the implementation of macroprudential rules may also encourage banks to “race to the bottom” to comply with the rules. Finally, Viñals and Nier (2014) show that assessing the effectiveness of embedded macroprudential tools faces the difficult task of evaluating a complex group structure with foreign subsidiaries or branches, which can make prudential policies less effective.

Furthermore, the conduct of monetary policy, deemed as too expansive, was at the crux of the debate. Taylor (2009) stated that interest rates have stayed “too low for too long”. A large body of the literature, involving both theoretical and empirical works, has shown that “too low” and stable interest rates have encouraged banks to take on excessive risks, thereby causing financial imbalances and putting financial stability under stress. Borio and Zhu (2012) first defined such a mechanism as the effect of a change in the policy interest rate on banks’ risk perception and tolerance and, in turn, on the level of risk of a portfolio (i.e. credit risk) or on the pricing of assets (i.e. market risk).

The low and stable inflation rates that prevailed for more than a decade in the ad-

vanced economies encouraged monetary authorities to believe that they, indeed, had full control of the business cycle. Nonetheless, this successful performance resulted in central banks conducting monetary policies that were at times overly expansionary. Historical experience shows that policy interest rates in the early 2000s and up to the crisis were below what a Taylor rule would have dictated (see Taylor, 2009). This trend has been confirmed in countries such as Greece, Ireland, Spain, and Portugal (Brzoza-Brzezina et al., 2015). The rejection of the “Greenspan doctrine” (see, for example, subsequent studies which reject this hypothesis Blot et al., 2015; Leveuge et al., 2019) raises many questions surrounding the role of monetary policy in terms of financial stability. For instance, Cúrdia and Woodford (2016) show that, in the presence of financial frictions on credit, monetary policy is no longer effective in its price stability role. Gambacorta and Signoretti (2013) complement the previous analysis by concluding that the central bank has a strong incentive to pay attention to financial variables when credit supply conditions are important for stimulating the real economy. This allows for a better trade-off between inflation and growth stability and increases the welfare of agents. Hence, they argue that, when necessary, it is in the central bank’s interest to pursue a “leaning against the wind” monetary policy. In other words, the aim is to pursue a policy that is more restrictive than necessary, enabling financial imbalances to be tackled.

However, after the outburst of the 2008 financial crisis, key interest rates swiftly reached the “zero lower bound” (ZLB), leaving little room for central banks to gear their policy on their main monetary tool⁵. Indeed, nominal interest rates, bounded by zero, led to a liquidity trap, where investors were no longer encouraged to invest and preferred to hoar money. Reaching this floor rate has called into question the effectiveness of a variation of the policy interest rate at such a low level. For instance, Apergis and Christou (2015) show that when the policy interest rate goes below a certain threshold, close to the ZLB, an increase of the liquidity hampers the traditional bank lending channel by its

⁵It is worth noting that in Europe, the Sveriges Riksbank in Sweden and the National Swiss Bank in Switzerland have even set negative policy interest rates.

inability to stimulate consumption and investment decisions.

Central banks had no choice, but to resort to unconventional monetary tools, paving the way for a massive injection of liquidity. In Europe, the need for central liquidity was exacerbated by the prevailing financing structure; the share of bank financing remains very high (around 70%) compared to market financing, whereas in the United States, market financing dominates (around 80%). As a result, the ECB committed itself to establish easier financing conditions for banks, such as a tender procedure with fixed interest rates, a wider range of eligible collateral put in place in exchange for liquidity and the provision of foreign exchange currency (mainly in US dollars), and an extension of the average maturity of these operations with the introduction of several programmes: the Main Refinancing Operations, the Long-Term Refinancing Operations and the Very Long-Term Refinancing Operations. At the same time, given the size of the bond market, the ECB launched, from July 2009 to June 2010, a purchase programme for covered bonds, triggering a bond purchase amounting to 60 billion euros.

Nevertheless, in May 2010, the tensions on the sovereign bond spread impelled the ECB to re-examine its asset purchase programme and trigger the Securities Markets Program in order to alleviate market pressures on the most vulnerable countries of the Euro Area (see Figure 1). At its inception, the programme exclusively targeted countries suffering from severe financial distress (i.e., Greece, Portugal and Ireland). Later, in August 2011, it was extended to Spain and Italy. As market conditions improved, the programme ended in early 2012. It should be noted that the mere mention of the Outright Monetary Transactions programme, designed to enable the ECB to purchase unlimited government bonds, helped combat market pressure and dampen high-risk premia, even if this programme has never been used so far.

In early 2015, as the inflation target was not achieved, the ECB implemented a Quantitative Easing (QE) programme to inject liquidity in the real economy. It involved a massive repurchase of public and private debt, 60 billion euros each month at least until

September 2016. In addition to keeping its main interest rate at 0% and turning the marginal deposit interest rate into negative (-0.40%) as inflation did not return to the ECB's target, the programme was extended until the end of 2018. The ECB decided to increase the amount of its bond-buying programme to 80 billion euros and the range of repurchase debt securities was broadened to corporate bonds with high quality. On the long run, however, such exceptional and deep actions raised significant concerns.

The effects of these unprecedented instruments pose the question of broadening the original definition of the bank risk-taking channel. While the latter merely implies the effect of a change in the policy interest rate, massive liquidity injections can, over the medium to long term, flatten the yield curve and reduce risk premia, which could encourage banks to take on more risk and adjust their leverage ratio. As a result, the literature on the channel of bank risk-taking has lately not only examined a change in the policy interest rate but has also paid attention to the influence of unconventional monetary policy (UMP) instruments on banks' risk behaviour (see, for instance, Lambert and Ueda, 2014; Kandrac and Schlusche, 2016; Delis et al., 2017).

At the same time, central banks' actions have been lately criticised because the low interest rate environment that has persisted for many years, coupled with massive asset purchase flattening the yield curve, has raised great concern of its impact on banks' profitability (Blot and Hubert, 2019). Keeping key interest rates at a low level mechanically affects the bank traditional business by squeezing lending rates, which in turn compresses net interest margins (NIM) if banks are reluctant to decrease their deposit interest rates. Nonetheless, the final effect of such actions on the overall profitability is not clear cut. The conduct of this policy has positive effects on banks' cost of refinancing and is likely to reduce households' and businesses' probability to default as interest charges decrease (Madaschi and Pablos Nuevo, 2017). Research has developed around this issue, but no consensus has been reached. By way of example, Borio et al. (2017), Claessens et al. (2013) and Dell'Araccia et al. (2017) find that abnormally low interest rates and an ab-

normally flat yield curve erode bank profitability. By contrast, Altavilla et al. (2017), Madaschi and Pablos Nuevo (2017) and Lopez et al. (2018) conclude that banks maintain their overall profitability.

While a further easing of macroprudential policy can be expected, European monetary policy is not yet ready to back off. By contrast, faced with the recent outbreak of the coronavirus crisis, the ECB has pulled out the heavy artillery. To help the economy absorb the shock, the central bank's innovative action is the pandemic emergency purchase programme, which plans to inject 1,350 billion euros to reduce borrowing costs and boost lending. Among the complementary measures put in place - most of which are an extension of existing monetary policy measures - some relate to macroprudential policy. The ECB's banking supervision has decided to use macroprudential policy's flexibility. In this respect, the institution decided to reduce the amount of capital that banks must hold in order to increase banks' lending capacity. In addition, the European Banking Authority (EBA) introduced flexibility in the implementation of its guidelines, which aim to reduce the amount of non-performing loans held by banks.

Given the importance of the ever-changing institutional environment and which suggests that even more sophisticated actions will emerge in the near future, this thesis focuses on **the extent to which the behaviour of European banks has been affected by changes in monetary and macroprudential policy over the last two decades.**

From this pivotal question and against the background sketched out in this introduction, three lines of research are covered. The first examines **both the nonlinear effects of conventional and UMP on the risk-taking behaviour of banks.**

Taking into account the relevance of the risk-taking channel of banks, the second line of investigation looks into **the nexus between a low interest rate environment, the prudential behaviour of banks and their profit.**

Finally, in light of the outbreak of the COVID-19 crisis and unintended risks that could

result from an expansionary monetary policy, the last line investigates **whether the use of a (more) flexible macroprudential policy could help counteract expected adverse effects on bank lending activity and, more generally, on the economy.**

If the institutional environment is capable of influencing the behaviour of banks, it is crucial to study the mechanisms by which policy operates, the empirical and theoretical effects, and the safeguards to prevent the banking system from failing in ways that would put the economy at risk.

To answer these questions, the thesis is organised into three parts. In the first Chapter, we empirically investigate the existence of a bank risk-taking channel in Europe over the period 2000-2015. We rely on a European sample, which does not only include banks under the ECB supervision, but also banks established in non-euro jurisdictions. Based on the original definition of the risk-taking channel, we analyse the effects of a change in the policy interest rate on two complementary risk measures: one is an accounting-based risk measure; the other is a market-based risk measure. Furthermore, we complement our analyses by testing the possibility of a “risk-taking channel of UMP” since the main tool of central banks has been lately constrained by the ZLB. In this respect, to overcome this shortfall, we employ different tools to proxy UMP. We use the deposit interest rate, which according to Borio and Zabai (2016) can be considered as an indicator of UMP since many European central banks have set this policy rate below zero; and the Krippner (2014) shadow interest rates, which overcomes the ZLB and accounts for the role of unconventional monetary instruments. We also collect yearly information on the amount of assets each surveyed central bank holds to capture QE measures. The originality of this work lies in the model that tests for the existence of nonlinear effects of monetary policy on bank risk. Our results show that lowering interest rates and increasing central banks’ liquidity have a harmful effect on bank risk, confirming the existence of the risk-taking channel. Moreover, we show that this relationship is nonlinear, i.e. the effects of monetary policy interest rates (the total assets on the balance sheet of central banks) on

banking risk are stronger below (above) a certain threshold.

In Chapter 2, we investigate the nexus between low interest rate environment and profitability, while accounting for banks' prudential behaviour. The lasting fall in interest rates could jeopardise banks' profitability through bank intermediation activities; banks earn the difference between the interest rate generated by credit activity that generally applies to long maturities and the interest rates paid on deposit activity that apply to short maturities. In addition, massive asset purchases are expected to flatten the yield curve, further squeezing the NIM. The compression of the NIM occurs, provided that the interest rate paid on deposit remains stable. Given the low level of interest rates on loans due to the interest rate policy, banks are reluctant or sometimes legally constrained to set negative interest rates or to further cut the interest rate on deposits to avoid losing customers. Nonetheless, these arguments should be tempered. First, such exceptional monetary policy actions positively affect banks' refinancing costs since banks finance themselves at the central bank at a negative interest rate. Second, lower interest charges on households and businesses reduce the risk of default. Against this background and bearing in mind the existence of the risk-taking channel, we look into the behaviour of European banks to assess whether the policy interest rate harms their profitability. We find that bank credit and insolvency risks have a negative impact on profits: the higher the risk, the lower the profit. Unsurprisingly, our analysis also suggests that monetary policy's main instrument adversely affects NIM. Nevertheless, we cannot conclude that the conduct of monetary policy has harmed bank overall profitability, but it seems that when policy interest rates are particularly low, the effect of the policy interest rate on the overall profitability turns to be positive. These results induce that European banks succeed in increasing their profitability despite a monetary policy close to the ZLB and the compression of their net interest income.

The final Chapter explores the role of macroprudential tools in a turbulent institutional environment. Faced with the development of unintended threats to financial stability

resulting from an expansionary monetary policy, as a sign of déjà-vu, some economies have a banking sector with large exposures to the housing market in a context of rapidly rising house prices coupled with increasing private indebtedness. However, the outbreak of the COVID-19 is expected to worsen the capacity of households and businesses to repay their loans. In this respect, the Chapter helps bridge the gap between the flexible use of macroprudential instruments and their yet unknown effects. In particular, we study the effectiveness of the flexibility of macroprudential tools in the event of an external shock, such as a pandemic, which is expected to dramatically affect the private sector to pay off its debt. However, at the same time, such flexibility should not jeopardise financial stability. Our work focuses on two flexible instruments, which have proved to be relatively efficient to safeguard financial stability: the regulatory capital requirement and the LTV ratio. Both our empirical and theoretical models corroborate that an ease scenario of macroprudential policy allows mitigating the adverse effects stemming from the COVID-19 shock. Besides, the Dynamic and Stochastic General Equilibrium (DSGE) model suggests that policy makers could make the most of macroprudential flexibility by relaxing the LTV ratio. This relaxation is found to be more effective than a similar relaxation of the capital adequacy ratio.

Chapter 1

The European bank risk-taking channel of (un)conventional monetary policies⁶

Studying the risk-taking channel is a relatively recent area of research that was neglected before the Global Financial Crisis (GFC) for two main reasons. On the one hand, financial innovation was considered as a stabilising factor for the financial cycle, under the hypothesis that it permitted better risk sharing. On the other hand, financial stability was not seen as a threat since most central banks had slowly shifted towards tight inflation-targeting, which they considered their best means of fostering economic growth (Svensson and Woodford, 2004; Altunbas et al., 2018).

Recent works argue that the prolonged pre-crisis period of low interest rates under favourable economic and financial conditions encouraged a sense of overconfidence in financial markets and created financial imbalances (Taylor, 2009). Indeed, persistently low interest rates affected banks' risk perception and valuation, which increased the credit supply (Dell'Ariccia and Marquez, 2006; Borio and Zhu, 2012). The concerns over this

⁶This chapter is co-authored by Sophie Brana and Ion Lapteacru and is published in *Economic Modelling*, Volume 81, September 2019, Pages 576-593.

excessive lending supply related not only to the quantity of granted loans but also, and primarily, to these loans becoming riskier. In the run-up of the GFC, banks levered up markedly. Alongside their business core, they engaged in highly hazardous side activities, such as investing in Credit Default Swap (CDS) contracts (Aldasoro and Ehlers, 2018), senior tranches of asset-backed securities (Gorton and Metrick, 2012), or risky exposures to housing, resulting in consequent losses. Against this background, the risk-taking channel is defined as the impact of a change in interest rates on risk tolerance and risk perception, triggering a change in credit supply. It began to draw attention only after the fallout had already occurred. Empirical studies have since rapidly developed and confirmed the existence of this channel⁷ (see for instance Ioannidou et al., 2009; Jiménez et al., 2009; Delis and Kouretas, 2011; Dell’Ariccia et al., 2017).

In the aftermath of the GFC, major central banks have adopted unconventional tools, including expansionary balance-sheet policies, keeping policy interest rates near or below zero and attempting to actively manage agents’ expectations. In the short run, the implementation of UMP may benefit banks, as the average maturity of a bank’s portfolio tends to exceed the average maturity of its liabilities, and when interest rates drop, banks’ funding costs fall more quickly than their interest income, and NIM rise (see Altavilla et al., 2017). Moreover, QE, or large-scale central bank asset purchases designed to support asset prices, may have positive valuation effects. However, in the medium run, UMP may affect bank risk through the flattening of the yield curve and the cut in the term premium. Hence, banks may rationally take on additional risk and leverage. Ultimately, the overall effects of UMP on bank risk are ambiguous.

As the most of studies focus on the pre-crisis period (see for instance Jiménez et al., 2009; Maddaloni and Peydró, 2011; Delis and Kouretas, 2011; Buch et al., 2014), the first contribution of this Chapter is to consider the post-crisis period to study the effect of monetary policy on bank risk-taking and, especially, the impact of UMP. Following the

⁷Except Buch et al. (2014); Lambert and Ueda (2014).

GFC, short- and long-term interest rates have been at historically low levels. Thus, concerns have been growing regarding the possible adverse effect of UMP on bank profitability and, hence, on the soundness of the banking sector (Borio et al., 2017).

As a second contribution, we investigate the possibility of nonlinearities in the relationship between UMP and bank risk-taking behaviour, an aspect that has been previously neglected in the empirical literature. Many studies support the existence of a regime-dependent effect as central banks' instruments entail shocks to the monetary policy transmission mechanism, which may, in turn, affect bank profitability, credit supply, inflation or output growth (Li and St-Amant, 2010; Fry-McKibbin and Zheng, 2016). Ignoring such nonlinearities may underestimate the effects of very low interest rates (Borio et al., 2017). To investigate the possibility of nonlinearity, we introduce a dynamic panel threshold model, relying on the methodology of Kremer et al. (2013), to control for endogeneity and risk persistence. Our approach includes a nonlinear response of bank risk-taking behaviour to easing of monetary policy stance. To the best of our knowledge, such an empirical specification has not yet been used. The panel threshold model developed by Hansen (1999) has the advantage of both testing whether a nonlinear relationship exists and identifying the date of rupture without predetermining it. We focus on 20 European countries over the period 2000-2015 to capture the unconventional character of monetary policy. Since UMP can take many forms, we add a third contribution to the literature when testing for two different aspects, negative interest rates and balance-sheet policy. The last contribution is that we use different complementary measures of bank risk: the asymmetric Z-score, applying the real distribution of the Return-on-Assets (ROA) variable, and the Distance-to-Default (DD) measure.

The empirical analysis endorses the existence of nonlinear effects of monetary policy on both bank risk measures. Even though the bank risk-taking channel is at play before the threshold estimated by the model – which confirms the above-mentioned studies focusing on this issue before the outburst of the GFC – we find that this relationship is even

stronger in the aftermath of the crisis. When interest rates are below a certain threshold, we find a positive relationship between both bank risk measures and monetary policy, inducing that bank risk-taking behaviour increases after a loosening of monetary policy via lower interest rates. In the end, accounting for central banks' balance sheet policy indicates that additional liquidity encourages banks to take riskier positions with a more critical effect above a specific level of monetary creation for the DD. As robustness checks, we conduct the same analysis with other bank risk measures, the Loan-to-Asset ratio and the traditional Z-score, and we perform our main regressions with a country-level shadow rate, which allows checking the stability of our results. Moreover, splitting the country sample into two regions, advanced and emerging Europe, shows that our main findings are mostly driven by advanced European countries.

In the subsequent section (Section 2), we provide an overview of the results in the related literature. Then, the following two sections outline the methodology used to estimate bank risk (Section 3) and UMP (Section 4) measures. In section 5, we describe the data, explain the empirical methods and comment upon the results. In Section 6, we present further analysis and robustness checks. Finally, the last section (Section 7) summarises our main findings and concludes.

1.1 Literature survey

The risk-taking channel is justified by several theoretical approaches and operates in several different ways.

The first relevant mechanism, described by Borio and Zhu (2012), reveals that low interest rates affect risk tolerance through valuations, income and cash flows. This is close in spirit to the financial accelerator developed by Bernanke et al. (1999). Indeed, low interest rates increase valuations and boost the net worth of agents, namely their assets and collateral value. Hence, a rise in collateral value, following a policy rate cut, decreases the probability of default of agents, which banks will respond to by granting

more loans. However, even if it may stimulate lending, as the risk-bearing capacities of banks (i.e., their net worth) also increase, the financial risk is not necessarily worsened.

Afanasyeva and Guntner (2018) argue that the effect of a monetary expansion on risk is more complex due to the market power of banks. Following an exogenous increase in the external financial premium, banks may have a keen interest in lending more to obtain a greater “share of the pie”. Consequently, agents become more leveraged and, in turn, more likely to default *ex-post*. However, De Nicoló et al. (2010) introduce the “skin-in-the-game” effect, which predicts that banks will be more cautious in case they engage in highly risky projects. This effect is even more relevant when banks’ net worth rises after a policy rate cut because banks with high franchise values have much to lose.

Rajan (2005) clarifies a second approach: the search-for-yield mechanism. The author explains that an expansionary monetary policy decreases the returns obtained from short-term investments composed of risk-free assets. However, if the returns associated with these assets remain low for a long time, these investments will not fulfil the commitments of long-term liabilities. To increase the probability of receiving a higher return, financial institutions are encouraged to invest in risky and high-yield financial assets.

Adrian and Shin (2010) examine a third mechanism relating to leverage and bank’s balance sheet. A boom in asset prices encourages financial institutions to expand their balance sheets to maintain their levels of leverage. However, this situation might lead banks to take on more risk. On the liability side, they take on more short-term debts, while on the asset side, they search for potential borrowers, which might have been perceived as riskier in the recent past.

The last mechanism reveals that monetary policy affects the risk-taking channel via its communication policies. A high degree of predictability of future decisions of policymakers can reduce the uncertainty in the market and can lead banks to take risky positions. For instance, a bad economic outcome can affect the agents’ perceptions, believing that the central bank will ease monetary policy and cushion the economic risk of slackness. Thus,

banks anticipate this insurance effect and take on additional risk (Borio and Zhu, 2012).

Many empirical studies confirm the existence of the bank risk-taking channel and provide an interesting background for our analysis. Jiménez et al. (2009) and Ioannidou et al. (2009) are the first studies to examine the risk-taking channel of monetary policy with micro-level data. By using a duration model, Jiménez et al. (2009) proxy for risk with a loan hazard rate. They control for the macroeconomic environment, country-level risk and for bank, borrower and loan characteristics, and they find that banks relax their lending standards and easily grant new loans to riskier borrowers when interest rates are low. Small banks appear to be more reactive to a monetary policy change. In the same vein, Ioannidou et al. (2009) compute the probability of default for each loan and conclude that a decrease in the federal funds rate⁸ prior to loan origination encourages Bolivian banks to take on more risk. In contrast, expansionary monetary policy over the life of a loan lowers the risk. Banks with more liquidity and less equity tend to take on greater risk when interest rates are low.

In line with the use of individual loan characteristics, many studies provide scattered evidences confirming the negative relationship between the interest rate and bank risk during the pre-crisis period in a particular country. For instance, Maddaloni and Peydró (2011), Delis et al. (2012), Dell’Ariccia et al. (2017), Paligorova and Santos (2017) unveil evidence from the U.S. More particularly, Maddaloni and Peydró (2011) analyse the effect of monetary policy on lending standards in the United-States (1991-2008), but also in the Euro zone (2002-2008). Paligorova and Santos (2017) investigate corporate loan pricing policies⁹ from 1990 to 2010. Unlike Ioannidou et al. (2009), the authors are able to control for borrowers’ characteristics, which might solve the omitted variable issue. In addition, the literature offers pieces of evidence from Austria (Gaggl and Valderrama, 2010), from Colombia (Lopez et al., 2011) and from Portugal (Bonfim and Soares, 2018).

⁸The federal funds rate is taken as a proxy for monetary policy because the Bolivian currency was pegged to the dollar during the period of study.

⁹Data are retrieved from the Senior Loan Officers Opinion Survey (SLOOS).

Another strand of this literature – to which the study of Maddaloni and Peydró (2011) belongs – makes use of the Bank Lending Survey (BLS) to identify the bank risk-taking channel and instead focuses on changes in bank lending conditions (see among others Cappiello et al., 2010; Kok and Hempell, 2010; Musso and Gambetti, 2012; Bassett et al., 2014; Ciccarelli et al., 2015). To the best of our knowledge, de Bondt et al. (2010); Maddaloni and Peydró (2011); Dajcman (2017); Schmidt (2018) are the only papers relying on the ECB’s BLS to achieve the identification of this specific channel. All these latter studies confirm the existence of an operational risk-taking in the Euro zone. Nonetheless, Kok and Hempell (2010) raise the questionable use of the ECB’s BLS, which might hardly disentangle risk-related factors. In other words, it is unclear whether the bank risk-taking channel is attributed to a risk factor affecting the demand side or the supply side of banks’ loan activity. To this purpose, Dajcman (2017) applies a structural model able to extract what the authors name the “pure risk aversion” of banks from the credit risk component. Finally, Schmidt (2018) examines two different samples (i.e., pre- and post-crisis) to disentangle the effects of conventional and unconventional monetary policies. They conclude that changes in lending standards react “disproportionately”¹⁰ to monetary policy. Loosening in lending standards is even more pronounced during the UMP period.

While a body of the literature investigates the existence of the bank risk-taking channel through loan-level data (Jiménez et al., 2009; Ioannidou et al., 2009; Maddaloni and Peydró, 2011; Dell’Ariccia et al., 2017), many studies employ measures of risk at the bank level. Altunbas et al. (2012) focus on quarterly data of 643 European and American listed banks over the period 1987-2008. Risk is measured by the Expected Default Frequency (EDF), a forward-looking and market-based indicator of risk. The GMM econometric model highlights a negative relationship between interest rates and risk. Furthermore,

¹⁰As the authors rely on a risk measure comparing lending standards and macroeconomic risk, they specify that it is “disproportionately” in the sense that lending standards are more affected by an expansionary monetary policy shock than the macroeconomic risk.

small, liquid, and well-capitalised banks seem to take on less risk. Reconsidering their previous paper, Altunbas et al. (2014) add institutional variables, such as competition, securitisation activity, and intensity of regulation indicators, to disentangle the effect of the bank risk-taking channel from the financial accelerator and the bank-lending channels. Their findings remain unchanged. Gambacorta (2009) provides similar outcomes, focusing on the same regions but a restricted period (2007-2008). Indeed, his study aims to explain the evolution of bank risk during the financial crisis with EDF as an explanatory variable. Finally, Michalak (2012) focuses on the relationship between bank risk-taking and banking market structure. His sample covers listed bank holding companies located in Western Europe from 1997 to 2008. The author provides empirical evidence that an extended period of expansionary monetary policy, corresponding to a short-term interest rate below the rate implied by a Taylor rule, has a negative impact on the EDF of European banks.

More recently, Gaggli and Valderrama (2019) explore a comprehensive panel of matched Austrian firms and banks over 2000-2008. They mainly assess the effect of the ECB's interest rate from 2003q3 to 2005q3, when the policy interest rate was persistently low, on the EDF. Although low capitalised banks mainly drive their results, they suggest that this "unique episode"¹¹ led banks to hold riskier loan portfolio.

Other studies use *ex-post* indicators as explanatory variables for bank risk, such as the risky asset ratio and the non-performing loan ratio, and they focus on the pre-crisis period. By using the GMM¹², although these analyses focus on various countries and/or regions, they all report a negative relationship between bank risk and interest rates (Brissimis and Delis, 2010; De Nicoló et al., 2010; Delis and Kouretas, 2011; Tabak et al., 2015).

Unsurprisingly, with the appearance of UMP after the crisis, most of the previous studies rather explore the mechanism of the risk-taking channel during the pre-crisis

¹¹The authors consider the period 2003Q3-2005Q3 as a "unique episode of persistently low policy rates" because first, the ECB's main refinancing rate was kept at a low level of 2% and second, there was a perception that this latter would remain low and stable over an a prolonged period (see Gaggli and Valderrama, 2019, p.4)

¹²Except De Nicoló et al. (2010), who use the GLS method and Brissimis and Delis (2010), who more precisely use a local GMM.

period, i.e., before 2008. Obvious variables, such as the policy interest rate, to measure monetary policy, are no longer good proxies because they are constrained by the ZLB. Only a few recent studies have analysed the impact of UMP on bank risk-taking behaviour. UMP flattens the yield curve and tends to encourage banks to take on higher risk and increase their leverage.

Lambert and Ueda (2014) and Kandrac and Schlusche (2016) focus on U.S. banks during the post-crisis period. Lambert and Ueda (2014) conduct a panel analysis of bank profitability, balance-sheet repair, and risk-taking. By using the GMM methodology, they find that UMP has an ambiguous effect on both profitability and bank risk. UMP seems to reduce the leverage and short-term debt ratios, but increases the ratio of risk-weighted assets to total assets. Kandrac and Schlusche (2016) analyse QE transmission and assess the effect of bank-level reserve accumulation on lending activity and risk-taking. Their results from the Instrumental Variable method show that reserves created by the Fed, resulting from QE programs, induced higher total loan growth. Consequently, banks' loan portfolios became riskier and led to hazardous lending activity.

Delis et al. (2017) also investigate the bank risk-taking channel in the United-States, but they consider both pre- and post-crisis periods (1987-2012) and build a loan-level data from corporates. Moreover, to account for the issue related to the ZLB, the authors resort to the shadow interest rate (Krippner, 2014). They highlight that *ex-ante* risk-taking behaviour is negatively associated with monetary policy innovations. Unlike previous studies, Nakashima et al. (2017) exploit a bank-firm loan-level data set from 1999 to 2015 in Japan. The key outcomes of their paper suggest that an expansionary monetary policy induces an increase in lending coupled with high credit risk. In their analyse, an expansionary policy comes in two forms. First, they consider a decrease in the policy interest rate, under dramatically low-interest-rate regimes. Second, they account for qualitative easing measures, that is the purchase of unconventional assets.

The previous studies are exclusively based on linear models and neglect the possi-

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ble existence of a nonlinear relationship between monetary policy and bank risk-taking. Nonetheless, some papers show that monetary policies have different effects between normal and financial stress periods (Brana and Prat, 2016; Saldías, 2017), between pre- and post-crisis periods (Mallick et al., 2017), and among different periods of the business cycle (Avdjiev and Zeng, 2014). Studies that consider the nonlinear effects of monetary policy analyse its impact on its transmission mechanism or its objectives, but few papers examine its impact on bank risk-taking behaviour.

Furthermore, “there is very limited analyses of nonlinearities in monetary transmission linked to the level of interest rates” (Borio and Hofmann, 2017, p.15). Indeed, a few authors assess the nonlinear relationship while considering periods of low interest rates. Altunbas et al. (2014) evidence a nonlinear relationship between the EDF and monetary policy when performing robustness checks. In particular, the relationship is reinforced when the policy interest rate is particularly low. Lambert and Ueda (2014) find that low interest rates are associated with lower risk-weighted asset ratio in the short term, but a prolonged period of low interest rates may increase risk.

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This section explains the methodology used to estimate our measures of bank risk, namely the asymmetric Z-score and the DD. We consider two conceptually different risk measures to consider both balance-sheet vulnerability and market perception of bank risk.

The Z-score is the most widely used accounting-based risk measure in the banking literature to identify the balance-sheet vulnerability, since it considers a bank’s capital being insufficient to cover its losses in case of a default event. Compared to other accounting-based risk measures, its main advantage is the concept of risk on which it is based, which is not the case of measures such as the ratio of non-performing loans, the ratio of risky

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assets, or loans loss provisions. These measures are merely asset quality indicators and are not related to any default event, i.e., a bank may be aware that the quality of its assets is deteriorating without being threatened by default. Moreover, loan loss provisions may be used not only to create reserve cushions for non-performing loans but also as an income-smoothing tool (Bikker and Metzmakers, 2005; Fonseca and González, 2008; Pérez et al., 2008). Such income smoothing behaviour has been found for both Western (Bouvatier et al., 2014) and Central and Eastern European (CEE) banks (Skala, 2017). However, the probability of default and the default event to which it is related are eliminated in the traditional formula, since it is based on some unrealistic simplifications and assumptions. To avoid such drawbacks, the real distribution of banks' ROA is considered.

The market perception of bank risk is measured by the DD, which is computed with standard Black and Scholes (1973) and Merton (1974) option models and is applied to estimate individual (Laeven, 2002; Vassalou and Yuhang, 2004; Andries et al., 2018) and systemic bank risks (Lehar, 2005). Other authors, such as Altunbas et al. (2018), apply the EDF to measure the market perception of bank risk, which represents the probability that a bank will default within a given time horizon and is computed only by Moody's KMV and is not publicly available. Aside from the problem of data unavailability, the EDF is measured as a probability of default, in contrast to the DD, which is a quantile in the estimation of the probability of default. As such, it is constrained to take values between 0 and 1, while the DD is not.

1.2.1 The asymmetric Z-score

The original concept of the Z-score issues from the probability of default definition, where the default event occurs when current losses exhaust capital or, equivalently, when the bank's profits, π , are lower than its negative capital, $-C$: $Pr[\pi \leq -C]$. Dividing by total assets, the probability of default is $Pr[\pi \leq -C] = Pr[ROA \leq -COA]$, where ROA is a random variable and COA is the Capital-on-Assets ratio (Hannan and Hanweck, 1988;

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Boyd and Runkle, 1993). To provide a simple formula, Hannan and Hanweck (1988) and Boyd and Runkle (1993) suggested considering a normal distribution for the ROA random variable. Centring and reducing ROA variable, one obtains that the probability of default is $N(-COA; \mu, \sigma) = N(-\frac{COA+\mu}{\sigma})$, where $N(., \mu, \sigma)$ is the cumulative distribution function of the normal law with expected value μ and standard deviation σ of ROA, and $N(.)$ is the cumulative distribution function of the normal law with $\mu = 0$ and $\sigma = 1$. Thus, the traditional formula of the Z-score, that is $Z_{trad} = \frac{COA+\mu}{\sigma}$, is obtained under the (unrealistic) normal distribution hypothesis. Hence, the negative traditional Z-score is the point at which the normal cumulative distribution function $N(.)$ is equal to the probability of default, as computed with the normal cumulative distribution function, $Z_{trad} = -N^{-1}(N(-COA; \mu, \sigma)) = \frac{COA+\mu}{\sigma}$.

Lapteacru (2016) shows that the normal distribution hypothesis is inappropriate for the concept of the probability of default and suggests applying a flexible distribution function that can comprise many other distributions, including the normal one. The stable distribution allows for better consideration of forms of the ROA distribution and thus provides consistent estimates of the Z-score. A random variable is considered stable if its characteristic function can be written as $\phi(t; \beta, \alpha, \mu, \sigma) = \exp[it\mu - |\sigma t|^\beta(1 - i\alpha \operatorname{sgn}(t)\phi)]$, where: $\phi = \begin{cases} \tan(\frac{\pi\beta}{2}), & \text{if } \beta \neq 1 \\ -\frac{2}{\pi} \log|t|, & \text{if } \beta = 1 \end{cases}$ and $\beta \in (0, 2]$ represents the stability index, $\alpha \in [-1; 1]$ the skewness parameter, $\mu \in \mathbb{R}$ the location parameter and $\sigma > 0$ the scale parameter. This very flexible distribution comprises the normal distribution (for $\beta = 2$), Cauchy distribution (for $\beta = 1$ and $\alpha = 0$) and Lévy distribution (for $\beta = 1/2$ and $\alpha = 1$) and, hence, can cover the most of real distributions of ROA.

We follow the approach of Lapteacru (2016) to build our asymmetric Z-score and replace the normal distribution by an estimated stable cumulative distribution function, $F_{StD}(., \beta, \alpha, \mu, \sigma)$, as follows:

$$Z_{score} = -N^{-1}(F_{StD}(-COA; \beta, \alpha, \mu, \sigma)), \quad (1.1)$$

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where β, α, μ and σ are its parameters to be estimated.

Thus, compared to the traditional Z-score, Z_{trad} , our asymmetric Z-score is computed with stable cumulative distribution function, $F_{StD}(\cdot)$, instead of the normal one, $N(\cdot)$. Because the stable distribution has no analytical functions, we determine its parameters by minimising the distance between the stable probability density function and that of the smooth kernel distribution. In the literature, the traditional Z-score is computed by applying a three- or five-year rolling window to determine the mean and standard deviation of ROA. However, according to the probability of default concept, this risk measure is linked to the distribution of the random variable ROA. The estimated mean and standard deviation are the parameters of this distribution, but, in our opinion, they cannot be estimated with only three or five observations. Such a small number cannot provide the correct form for the actual ROA distribution, this is why we use a seven-year rolling window to estimate the parameters of our stable distribution function. It is a compromise between having a large number of observations, to correctly draw the distribution function, and the size of our sample. Considering such a number of observations for the rolling window does not affect our sample size since once the stable distribution is estimated, it is applied for all the COA observations that are related to the rolling window. We do not estimate the stable distribution on the entire time sample because performing a rolling window computation allows us to consider the evolution of a bank's COA ratio with respect to the distribution of its returns. Thus, all distributions are estimated for each year and for each bank, excepting the first six years.

1.2.2 The Distance-to-Default

The DD is computed with the Merton (1974) option model and shows how far a bank is from a default event, i.e., the lower its values, the closer the bank is to insolvency. This measure has been applied to price deposit insurance (Ronn and Verma, 1986; Duan and Yu, 1994) and to estimate individual (Laeven, 2002; Vassalou and Yuhang, 2004;

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Chan-Lau et al., 2015; Andries et al., 2018) and systemic bank risk (Lehar, 2005).

To derive the DD, the value of bank assets is considered to follow a geometric Brownian motion, $\frac{dV_t}{V_t} = \mu_V dt + \sigma_V dW_t$, and bank liabilities consist of zero-coupon debt. A bank finances its assets using debt and equity, and the market value of its assets at time t is, therefore, $V_t = S_t + D_t^m$, where S_t is the market value of the bank's equity and D_t^m is the market value of its debt. In a default situation, i.e., when the market value of a bank's assets is less than the market value of its debt, the bank does not reimburse its creditors. A bank's equity is therefore considered to be a call option on the bank's assets, the strike price of which is the book value of the bank's debt, D . The latter is a zero-coupon bond with maturity T , which grows with its interest rate r . Its market value at time t , D_t^m , and that of its equity, S_t , are expressed using the Black and Scholes (1973) model:

$$S_t = V_t N(d_t) - D e^{-r(T-t)} N(d_t - \sigma_V \sqrt{T-t}), \quad (1.2)$$

$$D_t^m = V_t - S_t = V_t N(-d_t) + D e^{-r(T-t)} N(d_t - \sigma_V \sqrt{T-t}), \quad (1.3)$$

where $d_t \equiv \frac{\ln(\frac{V_t}{D}) + (r + \frac{1}{2}\sigma_V^2)(T-t)}{\sigma_V \sqrt{T-t}}$.

Applying Itô's lemma, the market value of the bank's assets at debt maturity T is $V_T = V_t \exp[(\mu_V - 0.5\sigma_V^2)(T-t) + \sigma_V \sqrt{T-t} Z_t]$, where μ_V and σ_V are the expected return and the return volatility of the market value of the bank's assets, respectively, and $Z_t \rightarrow N(0; 1)$. The default situation therefore occurs when $V_T < D$ and the DD is defined as:

$$DD_t \equiv \frac{\ln(\frac{V_t}{D}) + (\mu_V - \frac{1}{2}\sigma_V^2)(T-t)}{\sigma_V \sqrt{T-t}}. \quad (1.4)$$

To compute the DD, we apply the Duan and Yu (1994) and Duan (2000) estimation approach to estimate μ_V and σ_V , as explained in Appendix B.

1.2.3 Are default events unlikely to happen?

Figure 1.1 illustrates that both risk measures are different and their pattern also varies. For all regions, the asymmetric Z-score seems to better describe the occurrence of crisis events. In line with subsection 1.2.1, the graph clearly indicates that values associated with the asymmetric Z-score are more consistent and meaningful than those associated with the traditional one.

First, the values obtained by the traditional Z-score are inconsistent with the original concept of probability of default. Its lowest average level is for Non-Euro Area banks in 2008, which means, according to the above formulas, a probability of default of $N(-8) = 7.62 \times 10^{-24}$. Such a probability does not make sense in terms of the occurrence of a default event, especially during a crisis period. However, with an asymmetric Z-score, the previous probability of default becomes $N(-4.75) = 0.0001\%$. This is still low level, because of the definition of a default event that is too constraining, but has a comprehensible meaning.

Second, the evolution of the traditional Z-score does not reflect the main events as well as the asymmetric Z-score. For example, although both measures of bank risk indicate a low risk for banks in North Europe, the asymmetric Z-score reflects a steady increase of risk until 2008 while the traditional Z-score remains more or less constant until 2007. This latter experienced a sharp increase following the GFC, corresponding to a decline of bank risk and, thus, ignoring the sovereign debt crisis while this event is well-caught by the asymmetric Z-score. A similar difference is depicted for the Non-Euro Area. For South Europe, after a period of decline in the traditional Z-score (increased risk), it suddenly increases after 2007, which means that the financial crisis has a positive effect on the capitalisation of banks in South Europe with respect to the distribution of their returns. As for the asymmetric Z-score, it decreases continuously after 2007 till 2011 and increases thereafter, which corresponds to different capitalisation programs that benefited banks from Greece, Ireland, Italy and Spain. This decrease from 2007 to 2011 is explained by the harmful effects of the 2007-2008 GFC but also by those of the 2010-2011 sovereign

1.2 Bank risk: Default measurement and a last two decades prospecting

debt crisis in Europe which mainly affected the countries of this zone. For CEE, the asymmetric Z-score decreases from 2004 till 2013, which means that the risk of CEE banks increases throughout the period, whereas the traditional Z-score, as for other European zones, increases from 2008. In the end, the developments in asymmetric and traditional Z-scores are similar after 2008 only for European countries outside of the Euro Area. However, there is a high difference between their values. The most striking contrast is for banks from North Europe zone. The minimum value of the asymmetric Z-score is around 3, which corresponds to the probability of default of $N(-3) = 0.13\%$, whereas the minimum value of the traditional Z-score is about 30, which means a probability of default of $N(-30) = 4.91 \times 10^{-196}$, which makes little sense.

Third, the evolution of the asymmetric Z-score corresponds better to that of the DD.

Finally, there is a much larger difference between these the asymmetric Z-score and the traditional one across banks, as the Spearman rank correlation coefficient is 0.23 for the entire sample and ranges from very low values to very high correlations as follows: -0.0056 (for Austria), 0.0022 (for Croatia), 0.82 (for the Czech Republic), 0.61 (for Denmark), -0.45 (for Finland), -0.41 (for France), 0.67 (for Germany), 0.13 (for Greece), -0.66 (for Hungary), 0.45 (for Ireland), 0.39 (for Italy), 0.05 (for the Netherlands), 0.49 (for Norway), 0.56 (for Poland), 0.38 (for Romania), -0.19 (for Slovakia), -0.47 (for Spain), 0.07 (for Sweden), 0.51 (for Switzerland), -0.19 (for the United Kingdom). Thus, the important difference between two risk measures may lead to opposite conclusions for countries where Spearman rank correlation coefficient is negative or zero. As one may observe further, for panel data regressions, such a difference leads to very important discrepancies in the results.

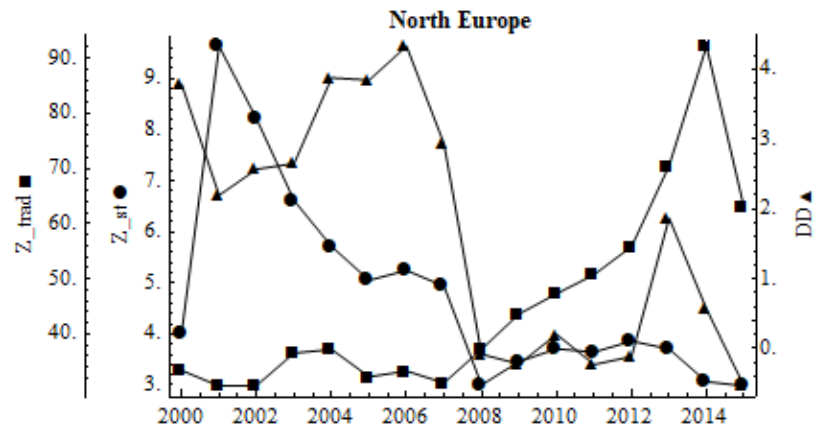
We notice that, with very few exceptions, the asymmetric Z-score and the DD follow the same evolution. Both of these measures experienced a sharp decline in all regions of Europe at the time of the GFC, with some delay for the asymmetric Z-score in CEE. It means that the banks of these countries underwent a very gradual worsening of the

1.2 Bank risk: Default measurement and a last two decades prospecting

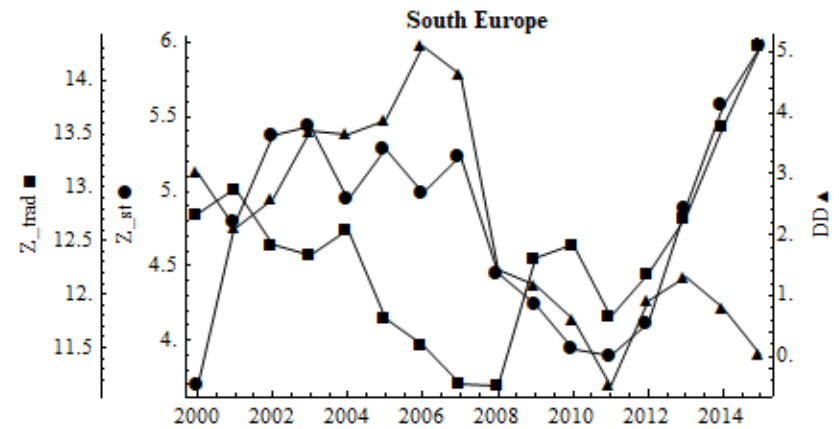
capitalisation profile with respect to the distribution of their returns. However, these banks show a stronger solidity, even during the financial crisis (values of the Z-score are higher).

The evolution of these two measures of risk is driven by different factors. Being a market-based risk measure, the DD reflects both the evolution of banks' market value and their ability to cover the market value of their total debt. As a result of the collapse of stock markets across Europe, the market value of European banks has fallen, threatening their ability to repay debt. As CEE banks were scarcely affected by the crisis, the minimum level of the DD does not reflect a threat to the stability of these banking systems. The largest decreases were recorded by banks in Austria, Finland, France, Germany and the Netherlands (North Europe zone) and, of course, in Greece, Ireland, Italy and Spain (South Europe zone). As expected, due to the highly indebted profile of these banks, followed by concerns about the sovereign debt crisis, the DD fell sharply until 2012¹³. Since the crisis period, most of European banks have been highly capitalised; thus, their Z-scores increased after that.

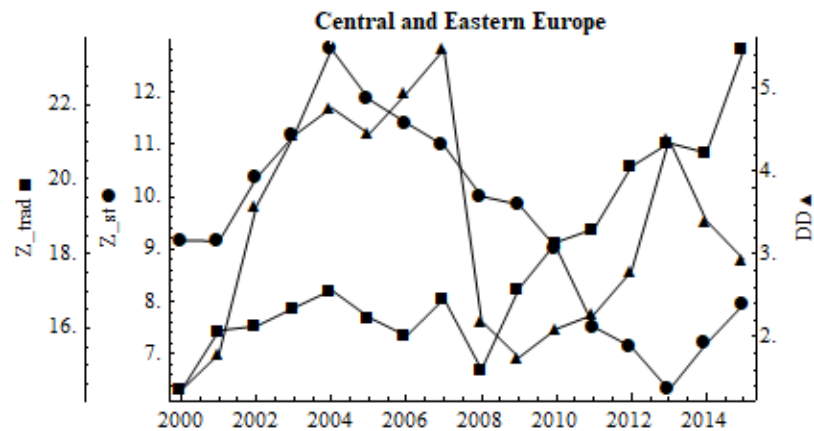
¹³Until Mario Draghi's speech on 26 July 2012, which pledged to do "whatever it takes" to save the Euro zone.



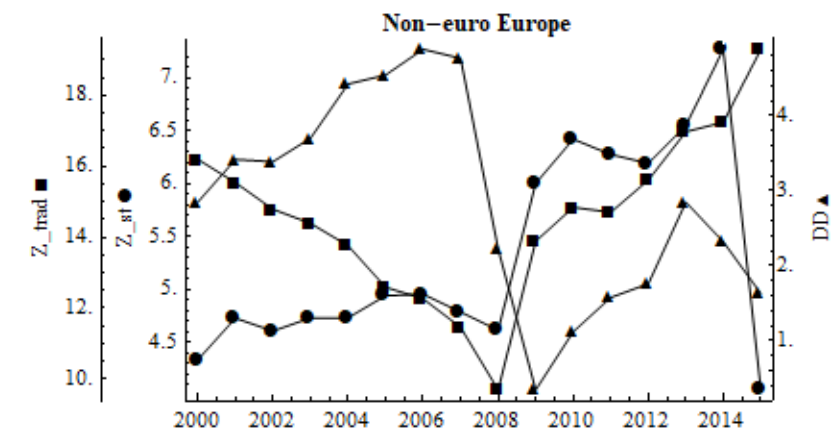
(a)



(b)



(c)



(d)

Figure 1.1: Evolution of bank risk in Europe described by the traditional Z-score (Z_{trad}), the asymmetric Z-score (Z_{st}) and the Distance to Default (DD). North Europe: Austria, Finland, France, Germany and the Netherlands. South Europe: Greece, Ireland, Italy and Spain. Central and Eastern Europe: Croatia, the Czech Republic, Hungary, Poland, Romania and Slovakia. Non-Euro Europe: Denmark, Sweden, Switzerland and the United-Kingdom.

1.3 (Un)conventional monetary policies: Instruments and evolution

After focusing on bank risk measures and their evolution over the last two decades, this section draws attention to monetary policy.

In a first step, this section introduces the different monetary policy instruments used in the analysis. Given the dominant role of UMP after the crisis, it is crucial to account for variables that are able to grasp the unconventional character of monetary policy. Against this background, and to also ensure the robustness of our results, the following section features four different variables, able to capture both the conventional and unconventional natures of monetary policy. One will note that the selected variables do not restrict the analysis to interest rate policy, but also consider QE policy.

In a second step, the section offers insights on the evolution of monetary policy over the last two decades across European countries encompassed in the empirical model.

1.3.1 Conventional and unconventional instruments

To capture the conventional and, primarily, the unconventional character of monetary policy, we rely on four different variables. We first consider an observable interest rate variable, the policy interest rate (i^r), the principal central banks' instrument. However, according to some authors, this variable only allows for the consideration of a conventional monetary policy stance (Brissimis and Delis, 2010; Delis and Kouretas, 2011; Buch et al., 2014), because of the ZLB. Furthermore, we rely on the interest rate on the deposit facility (i^d), which may be an indicator of UMP since many European central banks have set this policy rate below zero (Borio and Zabai, 2016). Moreover, to entirely overcome the ZLB constraint, we calculate a shadow short rate (i^{shadow}). For the countries belonging to the Euro zone, we rely on the shadow short rate estimated by Krippner (2014, 2016) using

the Euro Area Overnight Indexed Swap curve. For Non-Euro Area countries, we compute a country-level shadow rate.

We apply the Krippner (2014, 2016) approach to the estimation of the i^{shadow} variable, which is “the shortest maturity rate from the estimated shadow yield curve” (Krippner, 2014, p.1). According to the author, the model of Wu and Xia (2016), which is a three-factor shadow/lower-bound term structure model (SLM), displays excess sensitivity and can induce a misinterpretation of the policy implications. Krippner relies on a two-factor SLM and uses a continuous-time Gaussian affine term structure model to shape the shadow term structure. He reproduces the Black (1995) lower bound mechanism, $\underline{r}(t) = \max\{r_L, r(t)\}$ where $\underline{r}(t)$ is the lower bound short rate, namely the interest rates on the market, $r(t)$ denotes the i^{shadow} and r_L is the lower bound for the interest rate corresponding to a strike price of a call option. The latter is used to impose the ZLB on the shadow bond and is set at 0.00125 in our estimations. The right-hand-side, $\max\{r_L, r(t)\}$, imposes the lower bound. This constraint first entails that the interest rates on the market, $r(t)$, are constrained by a ZLB and, second, that the i^{shadow} cannot be superior to the highest value of $r(t)$. However, for few countries, higher estimates of the i^{shadow} reflect occasional abnormal economic events before the pre-lower bound period¹⁴ (e.g., for Romania, Croatia, Poland, Hungary, Slovak Republic, Greece and Norway).

In an environment where conventional monetary policy prevails, the i^{shadow} may follow the current policy rate because the latter may be close to the data used to estimate the i^{shadow} . Indeed, Krippner uses data from the yield curve with different maturities: 0.25, 0.5, 1, 2, 3, 5, 10, and 30 years. We follow this approach by including the maximum data available per maturity for each country in our sample. The i^{shadow} is very close to the policy interest rate for all countries. However, for some CEE countries (as Romania), the data used for the yield curve and, hence, for the estimation of the i^{shadow} reveal interbank interest rates that are higher at the beginning of the period sample than the policy interest

¹⁴See Appendix C.

rate (see Figure 1.2).

In a lower bound/unconventional environment, the i^{shadow} can take on negative values to reflect a global stance of monetary policy that can be more accommodative than the zero-interest rate itself. In other words, the i^{shadow} considers the effects of UMP on the interest rates of securities with longer maturities since it is estimated from the yield curve, and a negative value can be interpreted as the synthesis of a current zero-interest rate policy plus unconventional monetary actions. To estimate the i^{shadow} , Krippner relies on an arbitrage-free model of Nelson and Siegel (1987) with two state-variables that evolve as a correlated vector Ornstein-Uhlenbeck process, which are the Level, $L(t)$, and Slope, $S(t)$, variables. The i^{shadow} is the sum of these state-variables: $r(t) = L(t) + S(t)$. As expected, this unconstrained interest rate is negative during unconventional monetary periods.

Finally, following Lambert and Ueda (2014) and Brana and Prat (2016), we also use the central bank's assets in log (CBA) to capture QE measures. While the policy interest rate indicator might be bounded by a zero lower limit, CBA captures the unconventional monetary stance with an unusually high increase of the central bank's balance sheet (see Figure 1.2).

Monetary policy data are individual to countries, except for the interest rate variables, which are identical for Euro Area members after their accession. The CBA data are individually collected for all countries.

1.3.2 Monetary policy across Europe: A two decade description

Since the GFC, all policy interest rates and deposit facility rates have sharply declined (Figure 1.2). Some central banks have set a negative deposit facility rate (the ECB, Danmarks Nationalbank, Magyar Nemzeti Bank, Sveriges Riksbank, and National Swiss Bank). While several central banks have reached the zero interest rate limit, few have set a negative policy interest rate (the Sveriges Riksbank and National Swiss Bank).

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Figure 1.2 also confirms that before the imposition of UMP, the i^{shadow} closely follows the policy interest rate, except for CEE at the beginning of the period, as explained above. When monetary policy becomes unconventional, the i^{shadow} sharply declines for most regions, except for CEE, where its trend remains above zero. In all other regions, this unbounded interest rate becomes negative.

Monetary creation, already high before the crisis in developed countries, particularly in the Euro Area, accelerated after the GFC with the introduction of QE programs. As expected, monetary creation was much stronger in the Euro Area countries, which were hit twice, first by the GFC and then by the European debt crisis. Banks in Non-Euro Area countries, excluding the CEE countries, have also benefited from very accommodating monetary policies (Denmark, Sweden, Switzerland and the United-Kingdom).

1.4 (Un)conventional monetary policy and bank risk-taking: A nonlinear relationship?

The following section brings the reader into the core of the identified research question of this chapter, that is, does a nonlinear relationship exist between (un)conventional monetary policy and bank risk-taking?

To answer this question, in what follows, we first provide a comprehensive description of the data coverage. It is important to note that the number of banks included in the sample is limited by the use of the market-based risk measure. In order to make our results comparable, we restrict the data coverage to listed banks. Moreover, focusing on both Euro and Non-Euro Area countries in our sample allows to investigate the nonlinearity of the “bank risk-taking channel of (un)conventional monetary policy” at the European level allows for greater variability in some of the monetary policy instruments taken into account. Finally, the data spans the last two decades to account for the unconventional character of monetary policy.

1.4 (Un)conventional monetary policy and bank risk-taking: A nonlinear relationship?

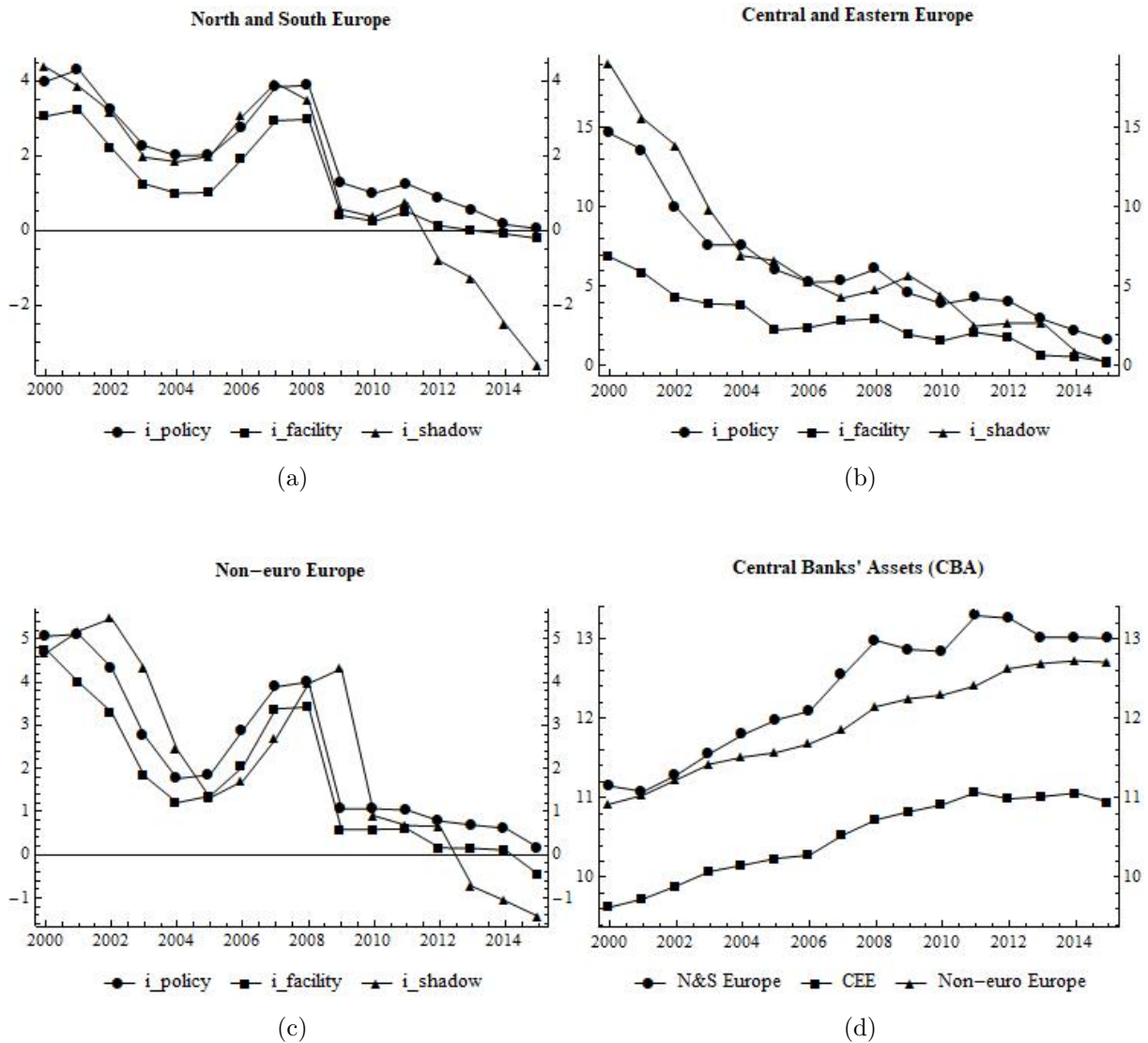


Figure 1.2: Evolution of monetary policy rates described by the interest policy (i_{policy}), the interest on the deposit facility ($i_{facility}$) and the shadow short rate (i_{shadow}). CBA is in logarithm. North and South Europe: Austria, Finland, France, Germany, the Netherlands, Greece, Ireland, Italy, and Spain. Central and Eastern Europe: Croatia, the Czech Republic, Hungary, Poland, Romania and Slovakia. Non-Euro Area: Denmark, Sweden, Switzerland and the United-Kingdom.

Second, while a linear relationship between risk-taking and monetary policy has been confirmed by empirical studies (see, *inter alia*, Altunbas et al., 2009; Gambacorta, 2009; Neuenkirch and Matthias, 2018; Wischnewsky and Neuenkirch, 2018), the methodology specified below helps perform dynamic regressions with threshold effects. Thus, we describe the econometric model used to assess the impact of monetary policy on European

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banks' risk. Given several arguments highlighted in the literature, the linkage between monetary policy and risk-taking is subject to endogeneity. In this perspective, we mimic the work of Kremer et al. (2013), which accounts for this issue and permits to test for nonlinearity. This methodology was first introduced by Hansen (1999) and applied on a static cross-sectional balanced panel. Kremer et al. (2013) adds a new feature to the model by allowing this latter to be dynamic. The model follows a two-step estimation.

Third, we present and comment on the results. This last section supports strong evidence with regard to the presence of a nonlinear relationship between monetary policy and risky bank behaviour. In fact, our model does not only corroborate the existence of the bank risk-taking channel before the advent of UMP but completes the literature by suggesting that the effect of monetary policy on bank risk-taking policy is even more active during the use of unconventional tools. The research findings bolster this conclusion for both measures of risk.

1.4.1 Data description

Our data cover 126 banks¹⁵ in 20 European countries and span from 2000 to 2015. To make our analysis comparable between our two bank risk measures, which are conceptually different, we reduce our sample to listed banks only. Indeed, as the market capitalisation of banks determines the market perception of their risk, the DD (i.e., the market-based risk measure) can only be estimated for listed banks, while the Z-score (i.e., the accounting-based risk measure) covers banks with very different risk profiles. Considering the largest listed banks from each European country under the condition that the data are available, we obtain a sample of approximately 200 listed banks. However, the necessity to have a balanced panel of the period sample constrains us to eliminate banks with missing data between 2000 and 2015. Table 1.1 and Figure 1.3 present further details about the structure of our database.

¹⁵Commercial banks, saving banks, cooperative banks, investment banks, specialised government credit institutions, bank holding and holding companies and multi-lateral government banks.

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Table 1.1 describes the number of listed banks for each country. Our database includes 10 Euro Area members and 10 Non-Euro Area countries, allowing us to study the effect of UMP in terms of risk across European banks. Due to the significant presence of Western banks in CEE countries, one may notice that the latter – except Poland – have, on average, less listed banks than North and South and Non-Euro Area countries. By contrast, in North and South countries, the banking sector accounts for a higher proportion of listed banks. However, it is important to state that the number of banks included in the sample is limited by the availability of the data over the considered period.

Table 1.1: Countries and number of banks included in the sample

	List of countries	# of banks	Monetary authority
1	Austria	5	ECB
2	Croatia	2	Hrvatska Narodna Banka
3	The Czech Republic	1	Česká Národní Banka
4	Denmark	16	Nationalbanken
5	Finland	2	ECB
6	France	14	ECB
7	Germany	6	ECB
8	Greece	5	ECB
9	Hungary	1	Magyar Nemzeti Bank
10	Ireland	3	ECB
11	Italy	12	ECB
12	The Netherlands	3	ECB
13	Norway	15	Norges Bank
14	Poland	9	Narodowy Bank Polski
15	Romania	2	Banca Națională a României
16	Slovak Republic	2	ECB
17	Spain	5	ECB
18	Sweden	4	Sveriges Riksbank
19	Switzerland	14	Swiss National Bank
20	The United-Kingdom	5	Bank of England
	Total	126	

Source: authors' realisation.

Figure 1.3 provides information about European banks' market shares in terms of total assets in each country of our sample and on average over the period 2000-2015. On average, our data cover 50% of the total banks' market shares in the sample period.

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However, CEE countries have few listed banks, and their particular banking structure explains why their bank market shares in our sample are rather low. Indeed, as explained above, there is a high proportion of foreign banks, mainly from Western Europe. Moreover, the German tiered banking market involves numerous banks. Even though our data include the largest German banks in terms of assets, this complex structure underlines the difficulty of obtaining a high market share for Germany. Finally, Finnish banks in our sample represent only approximately 11% of the total market share of the country. This small percentage is explained by the presence of Nordea Bank, a Swedish bank that accounts for an enormous market share. However, this is accounted for in our sample.

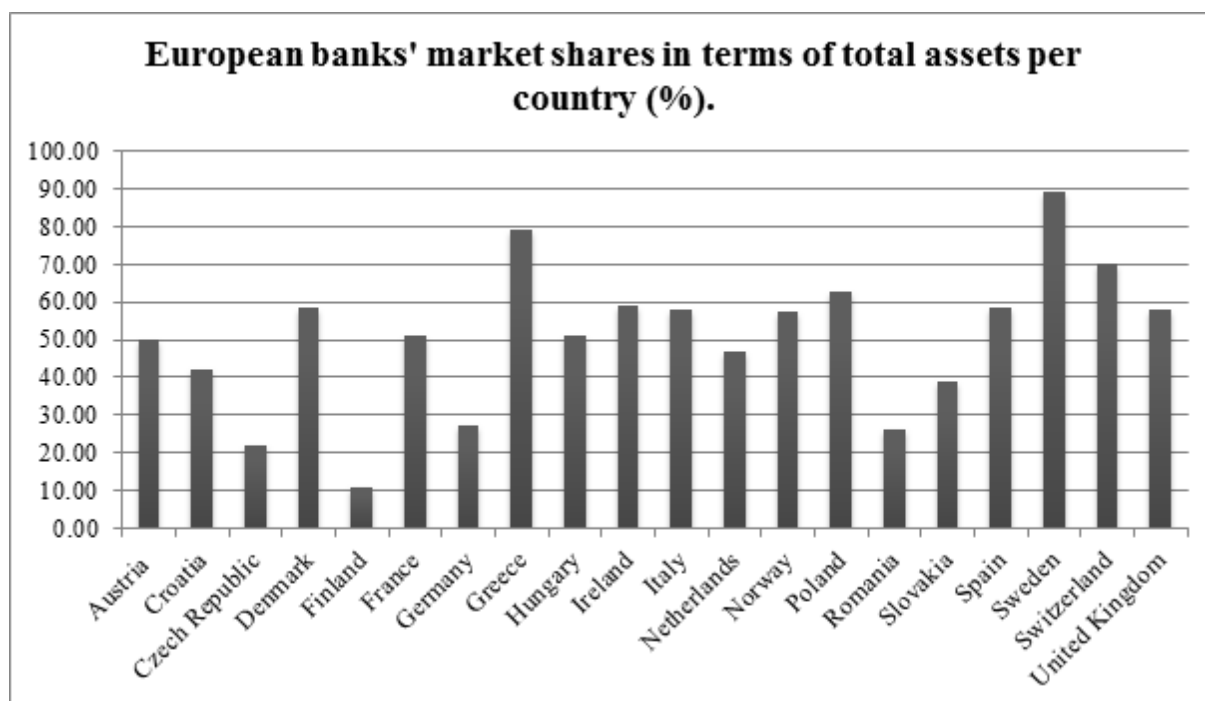


Figure 1.3: European banks' market shares in terms of total assets in each country of our sample and in average for the period 2000-2015. The figure is built from unconsolidated data. We rely on unconsolidated data as, throughout the analysis, we are interested in the banks' individual behaviour. In addition, the use of consolidated data when including several European countries may hide important information at the national level. *Source:* authors' computations based on data extracted from BankScope and Fitch Connect.

Table 1.2 provides some summary statistics. The data cover listed banks with different characteristics regarding equity, liquidity and size, and various banking markets in terms of concentration, real gross domestic product (GDP) growth and banking supervision and

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regulation. One may notice that very high interest rates correspond to the crisis periods of the 1990s in many CEE countries. The highest values for the interest rates correspond to Romania. Similarly, the maximum value for the i^{shadow} , which is greater than the policy interest rate, also corresponds to Romania. As explained in subsection 1.3.1, the country experienced a dramatic rise of the interest rates on its government bonds. Negative values reflect unconventional monetary events. Note that the very negative and very high values of the GDP rate correspond to the effects of the GFC in 2009 and the very high and recent Irish economic boom, respectively. We include a regulatory index¹⁶, as bank risk-taking may also be driven by the regulatory environment that prevails in each country (Laeven and Levine, 2009; Barrell et al., 2010). This may exert an influence on the level of risk a financial institution may take, i.e., strengthened banking regulation is expected to discourage risk-taking behaviour.

1.4.2 Dynamic panel model with threshold effects

As we suspect a nonlinear response of bank risk-taking behaviour to a relaxed monetary policy, we follow and apply the methodology of Kremer et al. (2013) to run the dynamic panel threshold estimations. First, based on a static cross-sectional balanced panel threshold model introduced by Hansen (1999), this methodology determines an optimal threshold and estimates a coefficient for each regime. The panel threshold regression model with individual specific effects is given by the following equation:

$$y_{i,t} = \mu_i + \beta_1' x_{i,t} \mathbb{I}(q_{i,t} \leq \gamma) + \beta_2' x_{i,t} \mathbb{I}(q_{i,t} \geq \gamma) + \epsilon_{i,t}, \quad (1.5)$$

where $\mathbb{I}(\cdot)$ is the indicator function, which takes the value of 1 if true, 0 otherwise. These same indicators are used as their own regime-dependent variable. $q_{i,t}$ is the threshold variable and γ is the optimal threshold value. The subscripts i and t stand for the cross-sectional and time dimensions, respectively. The dependent variable $y_{i,t}$ and the threshold

¹⁶The construction of this index is presented in Appendix A.

Table 1.2: Definition and descriptive statistics of risk measures and explanatory variables.

Variables	Description	Nr. of obs.	Mean (SD)	Min	Max	Source
<i>Risk measures (Risk)</i>						
DD	Distance to Default estimated with Duan's approach, Eq. (4) and Appendix B	2014	2.44 (2.62)	-5.07	17.18	Datastream and authors' computations
Asymmetric Z-score	Z-score in logarithm estimated with stable cumulative distribution function, Eq. (1)	2016	8.78 (18.98)	-1.90	378.61	BankScope and authors' computations
Traditional Z-score	Z-score in logarithm estimated with $Z_{trad} = \frac{COA+\mu}{\sigma}$	2016	28.22 (34.72)	-1.67	402.3386	BankScope and authors' computations
Loans/Assets	Loans to total assets ratio (%)	2016	58.87 (21.98)	0.21	93.25	BankScope and authors' computations
<i>Monetary policy variables (MP)</i>						
CBA	Central banks' total assets expressed in natural logarithm	2016	11.88 (1.13)	8.19	14.09	Datastream and central banks' annual reports
i^r	Policy interest rate	2016	2.78 (3.08)	-0.75	35	Datastream and central banks' annual reports
i^d	Interest rate on the deposit facility	2016	1.68 (1.76)	-1.1	11.5	Datastream and central banks' annual reports
i^{shadow}	Shadow short interest rate of Krippner (2014, 2016)	2016	2.44 (4.79)	-5.55	87.71	Datastream, authors' computations and Krippner estimations
<i>Bank control variables (X)</i>						
EQUITY	Equity to total assets ratio (%)	2016	7.86 (3.52)	-3.93	21.58	BankScope, banks' annual reports and authors' computations
LCR	Liquidity coverage ratio, estimated as total liquid assets on total liquid liabilities (%)	2016	23.86 (23.04)	0.62	212.33	BankScope, banks' annual reports and authors' computations
SIZE	Size of banks, expressed as natural logarithm of banks' total assets expressed in millions of USD	2016	9.85 (2.30)	3.79	15.15	BankScope, banks' annual reports and authors' computations
ACTIVITY	Loans to total assets ratio	2027	58.94 (21.94)	0.21	93.25	BankScope, banks' annual reports and authors' computations
<i>Country control variables (Y)</i>						
MC	Market concentration, computed with Herfindahl index	2016	0.07 (0.04)	0.02	0.37	Bankscope, Datastream and authors' computation
RGDPG	Real GDP growth rate (%)	2016	1.64 (2.63)	-9.13	26.28	Datastream
GDP/capita	Real GDP per capita expressed as natural logarithm	2016	10.55 (0.66)	8.41	11.42	Datastream
STOCK INDEX	Stock market index per country, normalised at 100 in 2005	2016	105.01 (54.28)	9.03	805.83	Datastream
MPI	Macroprudential Index (Appendix A)	2016	1.33 (1.33)	0	5	Global Macroprudential Policy Instruments Database (Cerutti et al., 2017)

Notes: This table reports summary statistics of all variables. The DD is the Distance-to-Default and describes the distance of banks' balance-sheet structure from a structure that corresponds to the default event: the higher the DD, the lower is the bank risk. The Z-score describes the capitalisation profile of banks with respect to the distribution of their returns: the higher the Z-score, the lower is the bank risk. All bank control variables are collected at each annual closing date.

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variable $q_{i,t}$ are scalar matrices. The regressor $x_{i,t}$ is the vector of explanatory variables, and $\epsilon_{i,t}$ is the error term.

The observations are divided into two regimes depending on whether the threshold variable $q_{i,t}$ is smaller or larger than the threshold value γ . The individual effects μ_i are assumed to be the same in both regimes. Thus, the two regimes are distinguished by different regression slopes β'_1 and β'_2 .

However, growing empirical literature on bank risk-taking supports arguments in favour of a dynamic model, since it mitigates the potential endogeneity issue the equation might face between risk and monetary policy. Two main problems are underscored:

- (i) Omitted variables: bank risk and interest rates might be endogenous to the local macroeconomic conditions (Ioannidou et al., 2009; Jiménez et al., 2009; Gaggl and Valderrama, 2010; Maddaloni and Peydró, 2011).
- (ii) Reverse causality: a future higher risk might entail current monetary expansion (Ioannidou et al., 2009; Delis et al., 2012).

Even though Delis and Kouretas (2011) and Altunbas et al. (2012) claim that this endogeneity problem is less significant in European countries, financial stability has become a major issue for central banks. Indeed, before 2008, there is no evidence that European monetary authorities had set policy rates by looking into bank risk because the main objective was to target price stability. Nevertheless, the failure of Lehmann Brothers triggered tensions in the credit market and raised European central banks' concerns about financial stability at the end of 2008. For this reason, our study considers potential endogeneity, as our sample considers the crisis period.

Finally, using a dynamic model is a principal advantage given the dynamic nature of bank risk (i.e., it includes the lagged dependent variable as an explanatory variable). The literature provides some reasons to explain risk persistence. Delis and Kouretas (2011) argue that the relationship between a risky borrower and the bank has a lasting effect on

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the level of risk despite the historic relationship, which improves efficiency. Moreover, they suggest that bank regulation leads to risk persistence, and coercive measures (e.g., capital requirements) may exacerbate the moral hazard issue by encouraging riskier investments over a long period of time. Finally, as bank risk is associated with the business cycle, banks may need time to smooth the effect of macroeconomic shocks.

To introduce the dynamic nature of bank risk in the estimation, we follow the methodology of Kremer et al. (2013). In a first step, we estimate a reduced form regression for the endogenous variable $z_{i,t}$ (i.e., our lagged dependent variable) as a function of instruments $x_{i,t}$, which includes a set of explanatory variables. The regression includes time and bank fixed effects and is estimated with panel-corrected standard errors, robust to heteroscedasticity, at the bank and annual level, and to autocorrelation. Then, the endogenous variable is replaced by its predicted values $\widehat{z}_{i,t}$ in the structural equation. In step two, we estimate Equation 1.6 via least squares for a fixed threshold, where $Risk_{i,k,t}$, which denotes our two bank risk measures, the Z-score and the DD, for bank i in the country k at time t , is replaced by $\widehat{z}_{i,t}$, as follows:

$$\begin{aligned}
 Risk_{i,k,t} = & \mu_i + \theta_1 Risk_{i,k,t-1} + \lambda_1 MP_{k,t} \mathbb{I}(q_{k,t} \leq \gamma) + \delta_1 \mathbb{I}(q_{k,t} \leq \gamma) \\
 & + \lambda_2 MP_{k,t} \mathbb{I}(q_{k,t} > \gamma) + \theta_2 EQUITY_{i,k,t-1} + \theta_3 LCR_{i,k,t-1} \\
 & + \theta_4 SIZE_{i,k,t} + \theta_5 MC_{k,t} + \theta_6 RGDPG_{k,t} + \theta_7 GDP/capita_{k,t} \\
 & + \theta_8 STOCKINDEX_{k,t} + \theta_9 MPI_{k,t} + \epsilon_{i,t}.
 \end{aligned} \tag{1.6}$$

MP captures a set of four monetary instruments for each country k at time t (i^r , i^d , i^{shadow} and CBA), considered as regime-switching indicators to test whether central bank instruments have a nonlinear effect on bank risk-taking behaviour. The model estimates two coefficients: λ_1 and λ_2 . The index 1 denotes the effect of the instrument of UMP below the optimal threshold level, while the index 2 denotes the effect of the instrument of UMP when it exceeds the optimal threshold level.

We control for a set of bank-specific factors for bank i in year t and country k . We

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include three individual bank characteristics: the equity-to-total-assets ratio (EQUITY), which controls for banks' capitalisation, the liquidity coverage ratio (LCR), which controls for banks' liquidity and the natural logarithm of the banks' total assets, which controls for banks' size (SIZE). These three measures are widely used in the literature (Akinci et al., 2013; Apergis and Christou, 2015; Boateng and Nguyen, 2015; Lapteacru, 2017), because of their appraisal of bank risk. Capitalisation (proxied by EQUITY) and liquidity (proxied by LCR) are treated as endogenous variables and, consequently, are lagged. Banks are expected to provide a higher level of capital for riskier assets. The level of risk undertaken by banks may affect the level of liquidity. The effect of bank size is more ambiguous, but according to Delis and Kouretas (2011), at any given time, banks are aware of their size when they make risk decisions. Hence, this variable is not treated as endogenous.

The level of capitalisation should reduce the risk of banks for the DD because the financial market may positively react to a better capitalisation profile. The value of the Z-score depends on the linkage between the distribution of return and the level of capitalisation. If the distribution of returns compensates for a cut in equity, thus, the value of the Z-score decreases. Moreover, the low liquidity level makes banks fragile, and the recent financial crisis, as was the case in the 1990s for the CEE economies, revealed once again that banking institutions with low liquidity levels are the first to fail. Bank risk also depends on their size. On the one hand, large banks can be perceived by the market as less risky because they should always be secured. On the other hand, the latter feature may encourage them to take on more risk and accumulate less capital (Brown and Dinç, 2011; Demirgüç-Kunt and Huizinga, 2013).

We include a set of country-specific factors that control for the characteristic of country k at time t . We introduce the real GDP growth rate (RGDPG) for each country in the sample to control for the business cycle (Jiménez et al., 2009; Brissimis and Delis, 2010; Delis and Kouretas, 2011; Lapteacru, 2017). We also include the GDP per capita expressed in natural logarithm to capture the development gap effects that may exist

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between advanced and developing countries. Since many studies (Berger et al., 2009; Michalak, 2012; Schaeck and Cihák, 2014; Tabak et al., 2015) have addressed the effect of market power on bank risk-taking and have shown that risky behaviour might depend on the competitive structure of the market, we also add the Herfindahl index as a proxy for market concentration (MC) within each country. Due to the tightening of prudential policy after the GFC, which may have modified bank risk-taking behaviour and its relationship with monetary policy, we include a regulatory variable (MPI). We decide to rely on the measure developed by Cerutti et al. (2017) because it includes a large range of instruments of macroprudential policies (see Appendix A). Finally, to control for financial instability, we also introduce a stock market index per country, normalised at 100 in 2005 (STOCK INDEX). All bank and country characteristics are treated as regime-independent variables.

1.4.3 Nonlinear relationship: Results meet expectations

Table 1.3 presents the results of Equation 1.6. First, our results strongly support the existence of a nonlinear relationship between bank risk-taking and monetary policy. The significance of the thresholds confirms the nonlinear structure of the model. The coefficients of all variables become significant or stronger above (for CBA) or under (for interest rates) the threshold when monetary policy becomes unconventional. Also, the persistence of bank risk is well captured by the model for the DD. The values of these coefficients entail that bank risk displays persistence with a moderate speed of adjustment.

When the interest rate variables are over the thresholds, or when the creation of a monetary base is below a certain threshold, which globally corresponds to the pre-crisis period (see Figure 1.4), we observe that, for both bank risk measures, expansive monetary policy is likely to encourage risk-taking behaviour. In line with many studies that conclude that before the emergence of UMP policy, interest rates were too low and encouraged risk accumulation, our results confirm this finding during this period through i^r .

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Thus, our work confirms that the bank risk-taking channel influences central banks' key interest rates during the period of conventional monetary policy, but as a new contribution, we reveal that this is also the case after the GFC. We show that the relationship between the policy interest rate, as well as the other "unconventional interest rates" of monetary policy, and both bank risk measures, is even stronger when these indicators fall below a certain threshold. Under a UMP regime, all monetary policy instruments, including the central bank deposit rate and the shadow interest rate, have an impact on bank behaviour, which was not the case for conventional monetary policy. Monetary policy variables that were not significant become so (λ_1 for i^d and i^{shadow} for the DD), while monetary policy variables that were significant (i^r) exhibit coefficients which have sharply increased.

According to the definition of the Z-score, low interest rates are not compensated by higher financial returns (or a better distribution of ROA), which in turn encourages banks to take on more risk. As the DD is a wide measure of risk that incorporates a high quantity of information, the lasting positive effect between the DD and monetary policy indicators may be motivated by market perception, which may have integrated unfavourable macroeconomic news flows throughout the studied period (e.g., the Dotcom crisis, the GFC, the sovereign debt crisis and bank frauds and fines).

All thresholds associated with policy and shadow interest rate variables for the DD and the Z-score correspond to the prevailing values during the GFC event (2008-2009). For the Z-score, the threshold values intervene later for the deposit interest rate, during the 2011-2012 period of the European debt crisis. For the DD, whose threshold is slightly higher, it is interesting to note that the threshold had also been reached for key interest rates during the period of great moderation, between 2003 and 2006. This result confirms that monetary policy has been too accommodating over this period. The threshold differences between the Z-score and the DD can be explained by the different natures of the two measures. The DD, which is a market indicator, had a faster and sharper decline during the outburst of the GFC for all the regions in our sample. For the Z-score, the threshold is

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later, which is due to the partly structural content of this indicator (level of capitalisation). This indicator was also more sensitive to the sovereign debt crisis (2011-2012).

To account for UMP, and more particularly QE programs, we also look at the impact of the central bank monetary creation (CBA). The results obtained with interest rates are confirmed likewise. The creation of a monetary base has a positive impact on bank risk. This effect becomes significant above a threshold for Z-score (although the estimated threshold is not significant). This threshold corresponds to the year 2003 for the DD (date from which monetary policy is considered to become too accommodating), and to 2009 for the Z-score, which corresponds to the implementation of QE policies in Europe.

Due to our measures of bank risk, which are conceptually different, the control variables may affect them differently. However, for both measures, the bank capitalisation ratio reduces the probability of default: the more capitalised the bank, the lower the risk of default. Similar to Altunbas et al. (2012), we find that well-capitalised banks are also considered less risky by the market. This result is expected because the market may integrate favourable information when a bank is well-capitalised since a higher level of capitalisation may serve as a stronger buffer and enhance the risk profile. In the same way, the more liquid banks are also perceived as less risky by the market (but the variable LCR is not a significant determinant of the Z-score).

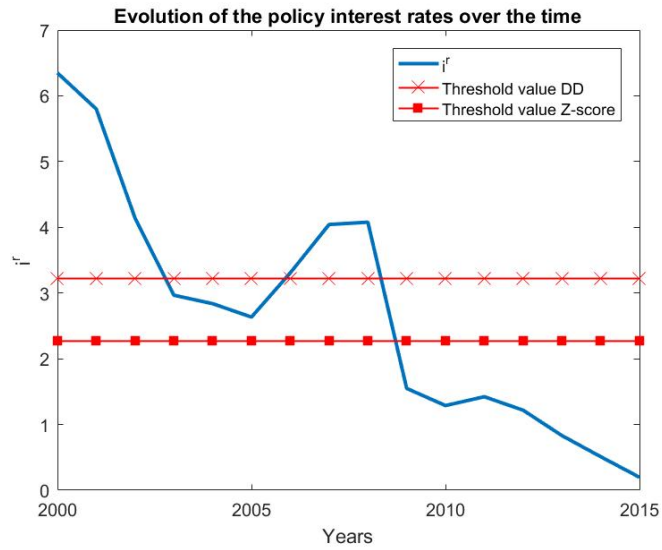
While the size of banks displays a negative sign on the Z-score equation, it is rather the concentration (MC) of the banking system that weighs negatively on the risk for the market. The larger the institutions, the more concentrated the banking system and the more likely banks are to take risks.

Shifting to country-control effects, we observe that, regardless of the risk measure, the tightening of prudential policy (MPI) restricts banks from accumulating risk. Similarly, an increase in real GDP growth reduces the probability of default, whether one considers an accounting-based or market-based risk measures. The good economic situation improves banks' financial conditions, which reduces their risk of default.

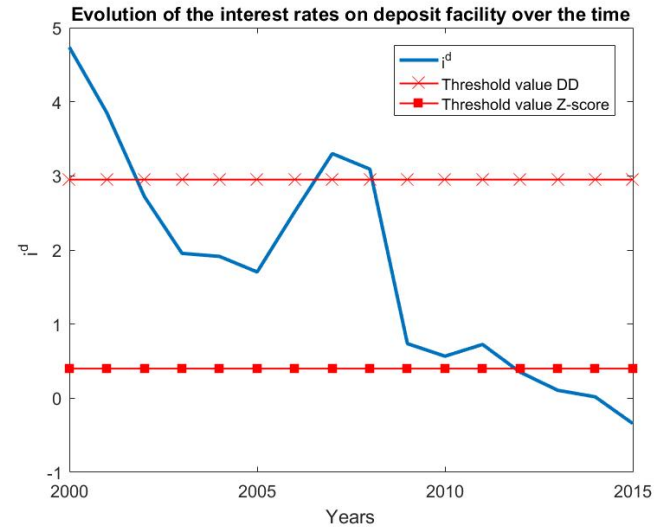
Table 1.3: Dynamic panel threshold estimations: nonlinearity between monetary policy indicators and bank risk-taking.

	Z-score				Distance to Default			
	i^r	i^d	i^{shadow}	CBA	i^r	i^d	i^{shadow}	CBA
Threshold estimate	2.27**	0.40***	3.15*	10.77	3.22***	2.95***	3.45***	11.76***
95% confidence interval	[0.03 ; 2.29]	[0.13 ; 0.43]	[2.45 ; 3.16]	[10.63 ; 10.78]	[3.21 ; 3.46]	[2.94 ; 2.98]	[3.40 ; 3.46]	[11.72 ; 11.77]
<i>Regime-dependent coefficients</i>								
λ_1	0.132*** (0.020)	0.485*** (0.075)	0.048*** (0.007)	-0.038 (0.111)	0.667*** (0.072)	0.548*** (0.068)	0.291*** (0.030)	-1.962*** (0.163)
λ_2	0.042*** (0.008)	0.019** (0.009)	0.020*** (0.005)	0.058* (0.049)	0.119*** (0.035)	-0.020 (0.044)	0.015 (0.020)	-1.875*** (0.154)
<i>Regime-independent coefficients: Impact of covariates</i>								
$Risk_{t-1}$	-0.112* (0.065)	-0.100 (0.067)	-0.099 (0.065)	-0.094 (0.065)	0.504*** (0.042)	0.505*** (0.046)	0.490*** (0.039)	0.374*** (0.041)
$EQUITY_{t-1}$	0.011* (0.007)	0.013* (0.007)	0.014** (0.007)	0.013* (0.007)	0.086*** (0.027)	0.119*** (0.028)	0.106*** (0.027)	0.150*** (0.027)
LCR_{t-1}	8.65e-4 (0.001)	5.8e-5 (0.001)	-6.15e-4 (0.001)	-5.12e-06 (0.001)	0.010*** (0.003)	0.012*** (0.003)	0.012*** (0.003)	0.014*** (0.003)
SIZE	-0.080* (0.047)	-0.143*** (0.046)	-0.087* (0.046)	-0.118** (0.048)	0.171 (0.167)	0.087 (0.161)	0.053 (0.164)	0.581*** (0.169)
MC	0.278 (0.807)	0.092 (0.809)	0.241 (0.804)	1.907** (0.838)	-24.742*** (2.943)	-22.341*** (2.906)	-24.626*** (2.941)	-9.604*** (2.972)
RGDPG	0.014*** (0.005)	0.018*** (0.005)	0.015*** (0.005)	0.009* (0.005)	0.130*** (0.020)	0.114*** (0.020)	0.137*** (0.020)	0.091*** (0.020)
GDP/capita	-0.130 (0.100)	-0.161 (0.100)	-0.053 (0.099)	0.056 (0.107)	-1.889*** (0.376)	-1.674*** (0.378)	-0.977*** (0.385)	0.992** (0.386)
STOCK INDEX	0.002*** (4.22e-4)	0.002*** (4.25e-4)	0.001*** (4.12e-4)	0.001** (4.11e-4)	-0.002** (0.001)	-0.004*** (0.001)	-0.005*** (0.001)	-0.004*** (0.001)
MPI	0.026 (0.029)	0.042 (0.028)	0.044* (0.028)	0.060** (0.029)	0.296*** (0.113)	0.376*** (0.112)	0.437** (0.110)	0.620*** (0.109)
δ_1	3.966*** (1.035)	4.895*** (1.039)	3.32*** (1.039)	3.078*** (1.070)	19.628*** (3.377)	18.305*** (3.384)	11.849*** (3.520)	7.616** (3.552)
Obs.	1764	1764	1764	1764	1764	1764	1764	1764

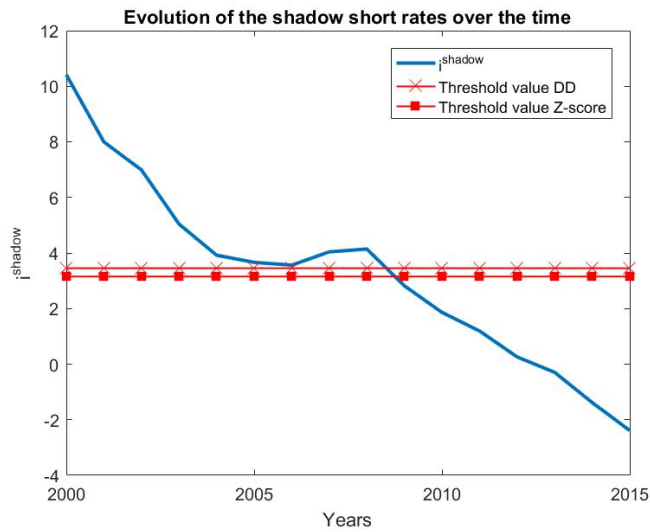
Notes: λ_1 and λ_2 are the coefficients estimated for each regime. The DD is the Distance to Default and describes the distance of banks' balance-sheet structure from a structure that corresponds to the default event: the higher the DD, the lower the bank risk. The Z-score is in logarithm and describes the capitalisation profile of banks with respect to the distribution of their returns: the higher the Z-score, the lower the bank risk. CBA denotes central banks' total assets expressed in natural logarithm. i^r , i^d and i^{shadow} represent the policy interest rate, the interest rate on the deposit facility and the shadow short interest rate, respectively. EQUITY is the ratio equity on total assets. LCR is the liquidity coverage ratio, computed as total liquid assets on total liquid liabilities. SIZE is the natural logarithm of banks' total assets in millions of dollars. All bank control variables are collected at each annual closing date. RGDPG denotes the real GDP growth rate for each country. GDP/capita is the real GDP per capita expressed as natural logarithm. MC is the Herfindahl index and describes the concentration of European banking markets. STOCK INDEX is the stock market index per country, normalised at 100 in 2005. MPI is a macroprudential index included as a differenced variable.



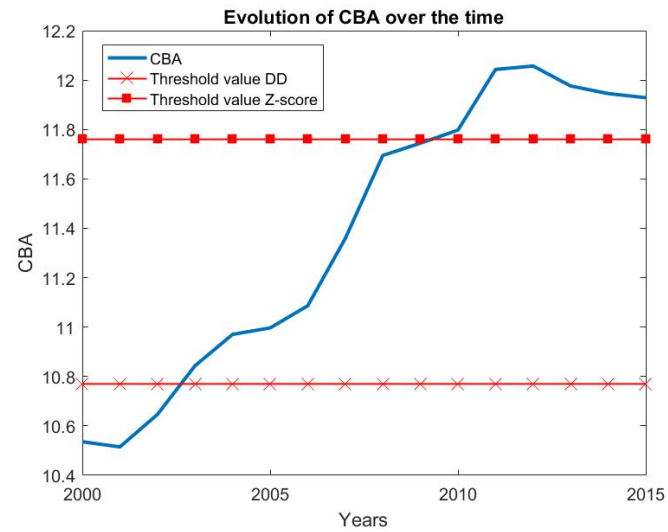
(a)



(b)



(c)



(d)

Figure 1.4: Evolution of monetary policy indicators over the time and threshold value for bank risk measures.

1.5 Robustness of findings

To refine our conclusions, we conduct further analyses and robustness checks. First, we verify whether our results differ when considering the traditional formula to compute the Z-score, that is, $Z_{trad} = \frac{COA+\mu}{\sigma}$, where μ and σ are the empirical mean and standard deviation of ROA, respectively, which are estimated on the same seven-year rolling window. Second, we perform our analyses with the Loans-to-Assets ratio, as an alternative risk measure. Third, to provide a more thorough analysis of the economic mechanism behind our findings, we split the country sample between advanced Europe and emerging Europe. Since the impact of the recent financial crisis was different in these two regions, one may expect that the effect of monetary policy will also have a different impact. Finally, although the monetary policy is the same within the Euro zone, its effect on the interbank and money markets may be very different among the member countries of the Euro zone. Therefore, we compute a shadow interest rate at the country level for each member country of the Euro zone, which is based on the interbank and sovereign debt interest rates. Hence, our main regressions are performed with a country-level shadow rate, which allows us to check the stability of our results.

1.5.1 Alternative bank risk measures

Although the traditional Z-score has important drawbacks, it has been and continues to be a prevailing risk indicator in the banking literature. It is therefore important to check whether this standard risk measure provides different results with respect to our asymmetric Z-score. The results with the traditional Z-score are presented in Table 1.4, which also indicates the extent to which they differ with respect to our main findings.

First, the tests confirm the existence of nonlinearities between monetary policy instruments and banks' risk-taking behaviour, as well as the sign and significance of the different explanatory variables. However, the thresholds for interest rates (shadow interest

Table 1.4: Dynamic panel threshold estimations, nonlinearity between monetary policy indicators and bank risk-taking: alternative risk measures

	Traditional Z-score				Loans/Assets			
	i^r	i^d	i^{shadow}	CBA	i^r	i^d	i^{shadow}	CBA
Threshold estimate	3.22*	2.21***	3.45	11.70*	3.22***	3.00***	4.78***	10.93***
95% confidence interval	[3.21 ; 3.46]	[2.15 ; 2.25]	[3.40 ; 3.46]	[11.65 ; 11.75]	[3.08 ; 3.46]	[2.96 ; 3.10]	[4.55 ; 4.80]	[10.85 ; 10.96]
<i>Regime-dependent coefficients</i>								
λ_1	0.037*** (0.013)	0.059*** (0.015)	0.020*** (0.006)	-0.032 (0.030)	-1.531*** (0.246)	-0.459** (0.199)	-0.056 (0.093)	-2.475*** (0.540)
λ_2	0.005 (0.006)	-0.009 (0.007)	0.009** (0.004)	-0.052* (0.028)	-0.446*** (0.119)	0.426*** (0.152)	-0.446*** (0.085)	-1.930*** (0.517)
<i>Regime-independent coefficients: Impact of covariates</i>								
$Risk_{t-1}$	0.030 (0.022)	0.023 (0.022)	0.035* (0.022)	0.015 (0.021)	0.255*** (0.084)	0.265*** (0.086)	0.344*** (0.085)	0.315*** (0.086)
$EQUITY_{t-1}$	0.057*** (0.005)	0.060*** (0.005)	0.057*** (0.005)	0.059*** (0.005)	0.204** (0.106)	0.172* (0.107)	0.226** (0.106)	0.195* (0.064)
LCR_{t-1}	5.86e-4 (7.97e-4)	7.31e-4 (7.87e-4)	3.73e-4 (8.01e-4)	8.76e-4 (7.79e-4)	-0.163*** (0.016)	-0.170*** (0.016)	-0.147*** (0.015)	-0.164*** (0.015)
SIZE	-0.286*** (0.038)	-0.290*** (0.036)	-0.268*** (0.037)	-0.256*** (0.038)	-6.178*** (0.704)	-5.110*** (0.694)	-5.288*** (0.689)	-4.186*** (0.746)
MC	-3.088*** (1.431)	-2.710*** (0.599)	-3.170*** (0.608)	-2.822*** (0.632)	-0.788 (10.951)	-6.890 (10.938)	-7.613 (10.964)	-7.490 (11.269)
RGDPG	0.008** (0.004)	0.008** (0.004)	0.009** (0.004)	0.003 (0.004)	-0.413*** (0.076)	-0.433*** (0.077)	-0.464*** (0.076)	-0.426*** (0.077)
GDP/capita	0.313*** (0.082)	0.382*** (0.081)	0.341*** (0.081)	0.436*** (0.083)	15.147*** (1.888)	14.472*** (1.942)	12.113*** (1.896)	12.813*** (1.837)
STOCK INDEX	0.002*** (2.94e-4)	0.002*** (2.93e-4)	0.002*** (3.00e-4)	0.001*** (2.96e-4)	0.013*** (0.005)	0.018*** (0.005)	0.009* (0.005)	0.010** (0.005)
MPI	0.077*** (0.012)	0.072*** (0.011)	0.086*** (0.012)	0.109*** (0.012)	-1.325*** (0.220)	-1.067*** (0.220)	-1.148*** (0.226)	-0.461** (0.236)
δ_1	2.135*** (0.726)	1.431** (0.735)	1.660** (0.739)	1.137 (0.733)	-49.255*** (13.783)	-55.154*** (14.040)	-32.638** (14.049)	-26.252* (13.986)
Obs.	1764	1764	1764	1764	1764	1764	1764	1764

Notes: λ_1 and λ_2 are the coefficients estimated for each regime. The Loans/Assets is the loans-to-assets ratio: the higher the ratio, the higher the bank risk. The traditional Z-score is in logarithm and describes the capitalisation profile of banks with respect to the distribution of their returns: the higher the Z-score, the lower the bank risk. CBA denotes central banks' total assets expressed in natural logarithm. i^r , i^d and i^{shadow} represent the policy interest rate, the interest rate on the deposit facility and the shadow short interest rate, respectively. EQUITY is the ratio equity on total assets. LCR is the liquidity coverage ratio, computed as total liquid assets on total liquid liabilities. SIZE is the natural logarithm of banks' total assets in millions of dollars. All bank control variables are collected at each annual closing date. RGDPG denotes the real GDP growth rate for each country. GDP/capita is the real GDP per capita expressed as natural logarithm. MC is the Herfindahl index and describes the concentration of European banking markets. STOCK INDEX is the stock market index per country, normalised at 100 in 2005. MPI is a macroprudential index.

rate and central banks' interest rates) are relatively higher than those obtained with our asymmetric Z-score (see Table 1.3). This means that the regime changes earlier than with the asymmetric Z-score, i.e., between the 2003-2006 period and after the beginning of 2008 for the main refinancing rate and the deposit facility rate. Second, the impact of the monetary policy tools is much lower compared to that obtained with the asymmetric Z-score. The unrealistic assumption of a normal distribution for the ROA, on which the traditional formula of the Z-score is based, does not only account for the asymmetry of the distribution but it also leads to much lower kurtosis than is the case in practice. Consequently, the traditional Z-score is often much higher than the asymmetric measure.

We complement our analysis with the Loans-to-Assets ratio, as an alternative measure of bank risk. One may suppose that loans are the part of a bank's assets that can be the most affected by a crisis event. Thus, the higher this ratio is, the more vulnerable a bank is. The results are presented in Table 1.4 and show that our qualitative results remain unchanged. Every time monetary policy eases above a certain threshold, the Loans-to-Assets ratio rises sharply, increasing bank risk. The estimate confirms the nonlinear relationship between monetary policy and risk of banks. The other explanatory variables have the expected sign. In particular, a tightening of prudential policy reduces the share of credit in bank balance-sheets.

1.5.2 Driven region of the main results: advanced vs. emerging Europe

It is quite interesting to determine which region of Europe drives our main findings. Since European central banks conducted different monetary policies and to different extents in Western and Eastern European countries, and since the European banks were also affected in different ways, we decided to divide our country sample into two sub-samples, i.e., advanced Europe and emerging Europe. The first sub-sample comprises Austria, Denmark, Finland, Greece, Ireland, Italy, the Netherlands, Norway, Spain, Sweden, Switzerland,

and the United Kingdom, and the second sub-sample includes Croatia, the Czech Republic, Hungary, Poland, Romania, and Slovakia. We thus run Equation 1.6 for each of the two sub-samples, and the results are presented in Table 1.5 and Table 1.6. We can confirm without any ambiguity that our main results are mostly driven by the behaviour of banks and the monetary policy stance in advanced European countries, since the thresholds remain statically significant only for this region of Europe and take values very close to those of the global sample (see Table 1.3). The effects of the monetary instruments are also similar, especially during the crisis period (λ_1 for interest rates and λ_2 for CBA), leading to the same conclusions as for the global sample. Indeed, the strengthening of QE is associated with the worsening of Western European banks' capitalisation with respect to the distribution of their ROA ratio. In the same period, the market value of these banks was too low with respect to their indebtedness, such that their DD decreased. Moreover, the impact of other variables explains also our global results. The findings for Eastern European banks are very different: most of the thresholds are not statistically significant and most of the coefficients change, especially for the Z-score. The impact of monetary policy instruments is also found to be different (see Table 1.6). All of this allows us to conclude that our main findings are mostly driven by the results obtained for Western European banks. One must also mention that the sample of Eastern European banks is much smaller, which places these results into perspective.

1.5.3 Heterogeneity of the shadow interest rate across the Euro Area countries

The shadow rate computed and applied in our main estimations is the same for all countries that are members of the Euro zone. Although the monetary policy is the same for all these countries, its effects may be very different. Since the shadow interest rate expresses the effects of a monetary policy stance, it can be computed separately for each country using the interest rates on the interbank market and sovereign debt market, which reflect

Table 1.5: Dynamic panel threshold estimations, nonlinearity between monetary policy indicators and bank risk-taking: Advanced Europe

	Z-score				Distance to Default			
	i^r	i^d	i^{shadow}	CBA	i^r	i^d	i^{shadow}	CBA
Threshold estimate	3.22***	0.05***	3.15***	10.97	3.84***	2.95***	3.45***	11.76***
95% confidence interval	[2.27 ; 3.46]	[-0.11 ; 0.13]	[3.07 ; 3.16]	[10.82 ; 11.00]	[3.69 ; 3.88]	[2.94 ; 2.98]	[3.40 ; 3.47]	[11.34 ; 11.77]
<i>Regime-dependent coefficients</i>								
λ_1	0.076*** (0.018)	0.283*** (0.013)	0.643*** (0.031)	-0.002 (0.043)	0.261*** (0.016)	0.653*** (0.077)	0.334*** (0.033)	-2.403*** (0.190)
λ_2	0.015 (0.010)	0.048*** (0.005)	-0.009* (0.005)	-0.026 (0.041)	0.025 (0.016)	-0.029 (0.052)	-0.003 (0.030)	-2.331*** (0.183)
<i>Regime-independent coefficients: Impact of covariates</i>								
$Risk_{t-1}$	-0.146** (0.070)	-0.132* (0.008)	-0.123** (0.070)	-0.170** (0.070)	0.450*** (0.052)	0.480*** (0.052)	0.470*** (0.045)	0.339*** (0.045)
$EQUITY_{t-1}$	0.017** (0.008)	0.015* (0.008)	0.017** (0.008)	0.019** (0.008)	0.112*** (0.032)	0.099*** (0.032)	0.094*** (0.032)	0.119*** (0.032)
LCR_{t-1}	-6.60e-4 (0.001)	-4.24e-4 (0.001)	-7.50e-4 (0.001)	-5.14e-4 (0.001)	0.014*** (0.004)	0.014*** (0.004)	0.014*** (0.004)	0.015*** (0.004)
SIZE	-0.174*** (0.053)	-0.230*** (0.051)	-0.174*** (0.051)	-0.147*** (0.057)	0.387** (0.192)	0.076 (0.187)	-0.069 (0.186)	1.029*** (0.207)
MC	1.383 (0.863)	0.609 (0.875)	1.087 (0.865)	2.245*** (0.881)	-20.307*** (3.074)	-21.000*** (3.125)	-23.579*** (3.125)	-6.418** (3.183)
RGDPG	0.012** (0.005)	0.013** (0.005)	0.014** (0.005)	0.011** (0.006)	0.130*** (0.022)	0.112*** (0.022)	0.135*** (0.022)	0.090*** (0.022)
GDP/capita	0.087 (0.132)	0.095 (0.130)	0.140 (0.132)	0.050 (0.139)	-0.393 (0.489)	-1.069** (0.479)	-0.172 (0.503)	1.310** (0.566)
STOCK INDEX	0.002*** (4.47e-4)	0.002*** (4.63e-4)	0.001*** (4.43e-4)	0.001*** (4.44e-4)	-0.004*** (0.001)	-0.005*** (0.001)	-0.006*** (0.001)	-0.006*** (0.001)
MPI	-0.019 (0.016)	-0.021 (0.016)	0.002 (0.016)	-0.023 (0.017)	0.225* (0.123)	0.381*** (0.121)	0.458*** (0.120)	0.294*** (0.064)
δ_1	2.624** (1.330)	3.189** (1.322)	2.105 (1.335)	3.144** (1.363)	1.081 (4.673)	12.308*** (4.334)	4.684 (4.587)	5.228 (4.273)
Obs.	1526	1526	1526	1526	1526	1526	1526	1526

Notes: λ_1 and λ_2 are the coefficients estimated for each regime. The DD is the Distance to Default and describes the distance of banks' balance-sheet structure from a structure that corresponds to the default event: the higher the DD, the lower the bank risk. The Z-score is in logarithm and describes the capitalisation profile of banks with respect to the distribution of their returns: the higher the Z-score, the lower the bank risk. CBA denotes central banks' total assets expressed in natural logarithm. i^r , i^d and i^{shadow} represent the policy interest rate, the interest rate on the deposit facility and the shadow short interest rate, respectively. EQUITY is the ratio equity on total assets. LCR is the liquidity coverage ratio, computed as total liquid assets on total liquid liabilities. SIZE is the natural logarithm of banks' total assets in millions of dollars. All bank control variables are collected at each annual closing date. RGDPG denotes the real GDP growth rate for each country. GDP/capita is the real GDP per capita expressed as natural logarithm. MC is the Herfindahl index and describes the concentration of European banking markets. STOCK INDEX is the stock market index per country, normalised at 100 in 2005. MPI is a macroprudential index.

Table 1.6: Dynamic panel threshold estimations, nonlinearity between monetary policy indicators and bank risk-taking: Emerging Europe

	Z-score				Distance to Default			
	i^r	i^d	i^{shadow}	CBA	i^r	i^d	i^{shadow}	CBA
Threshold estimate	1.25	0.75	-1.29	9.61	9.68	6.10	3.45***	11.52**
95% confidence interval	[1.00 ; 1.28]	[0.40 ; 0.94]	[-2.45 ; -1.06]	[0.60 ; 9.62]	[9.66 ; 11.44]	[4.25 ; 6.50]	[2.83 ; 3.46]	[11.44 ; 11.55]
<i>Regime-dependent coefficients</i>								
λ_1	0.541*** (0.186)	0.532*** (0.184)	0.187*** (0.058)	0.404*** (0.147)	-0.246*** (0.083)	-0.292*** (0.111)	-0.339*** (0.096)	-0.624 (0.537)
λ_2	0.050*** (0.018)	0.021 (0.029)	0.020* (0.011)	0.377*** (0.143)	0.028 (0.067)	0.048 (0.140)	0.054 (0.040)	-0.547 (0.531)
<i>Regime-independent coefficients: Impact of covariates</i>								
$Risk_{t-1}$	0.440* (0.278)	0.390 (0.287)	0.357 (0.282)	0.531* (0.057)	313*** (0.126)	0.309*** (0.128)	0.256** (0.125)	0.276** (0.129)
$EQUITY_{t-1}$	-0.001 (0.015)	0.017 (0.015)	0.021 (0.015)	-0.003 (0.016)	0.004 (0.062)	0.114** (0.054)	0.071 (0.054)	0.124** (0.062)
LCR_{t-1}	-0.001 (0.003)	2.23e-4 (0.003)	5.31e-4 (0.003)	0.001 (0.003)	0.013 (0.011)	0.004 (0.011)	0.005 (0.011)	0.002 (0.012)
SIZE	0.370*** (0.114)	0.326*** (0.114)	0.347*** (0.118)	0.361*** (0.115)	0.439 (0.425)	-0.033 (0.404)	-0.015 (0.414)	0.228 (0.418)
MC	-2.972 (2.834)	-0.160 (2.738)	-4.527 (2.924)	-4.065 (2.863)	-27.508*** (10.208)	-19.274** (9.955)	-24.188** (10.475)	-25.154** (10.294)
RGDPG	-0.008 (0.012)	0.006 (0.013)	0.007 (0.012)	-8.09e-4 (0.012)	0.104** (0.050)	0.120*** (0.050)	0.142*** (0.050)	0.130** (0.051)
GDP/capita	-0.600*** (0.191)	-0.409** (0.201)	-0.434** (0.191)	-1.113*** (0.300)	-4.775*** (0.845)	-3.972*** (0.775)	-3.073*** (0.732)	-3.200*** (1.147)
STOCK INDEX	0.002** (0.001)	3.31e-4 (0.001)	0.001*** (0.001)	0.001 (0.001)	0.012*** (0.004)	0.011** (0.004)	0.018*** (0.005)	0.010** (0.004)
MPI	-0.166*** (0.056)	-0.241*** (0.052)	-0.241*** (0.054)	-0.261*** (0.047)	-0.090 (0.208)	-0.135 (0.198)	0.095 (0.201)	-0.219 (0.176)
δ_1	3.264** (1.914)	2.172 (2.015)	2.451 (1.924)	4.470** (2.066)	43.960*** (7.335)	38.980*** (7.176)	29.417*** (6.724)	35.876*** (7.627)
Obs.	238	238	238	238	238	238	238	238

Notes: λ_1 and λ_2 are the coefficients estimated for each regime. The DD is the Distance to Default and describes the distance of banks' balance-sheet structure from a structure that corresponds to the default event: the higher the DD, the lower the bank risk. The Z-score is in logarithm and describes the capitalisation profile of banks with respect to the distribution of their returns: the higher the Z-score, the lower the bank risk. CBA denotes central banks' total assets expressed in natural logarithm. i^r , i^d and i^{shadow} represent the policy interest rate, the interest rate on the deposit facility and the shadow short interest rate, respectively. EQUITY is the ratio equity on total assets. LCR is the liquidity coverage ratio, computed as total liquid assets on total liquid liabilities. SIZE is the natural logarithm of banks' total assets in millions of dollars. All bank control variables are collected at each annual closing date. RGDPG denotes the real GDP growth rate for each country. GDP/capita is the real GDP per capita expressed as natural logarithm. MC is the Herfindahl index and describes the concentration of European banking markets. STOCK INDEX is the stock market index per country, normalised at 100 in 2005. MPI is a macroprudential index.

country-level effects. Therefore, we computed a country-level shadow interest rate for all members of the Euro zone (see Figure 1.5).

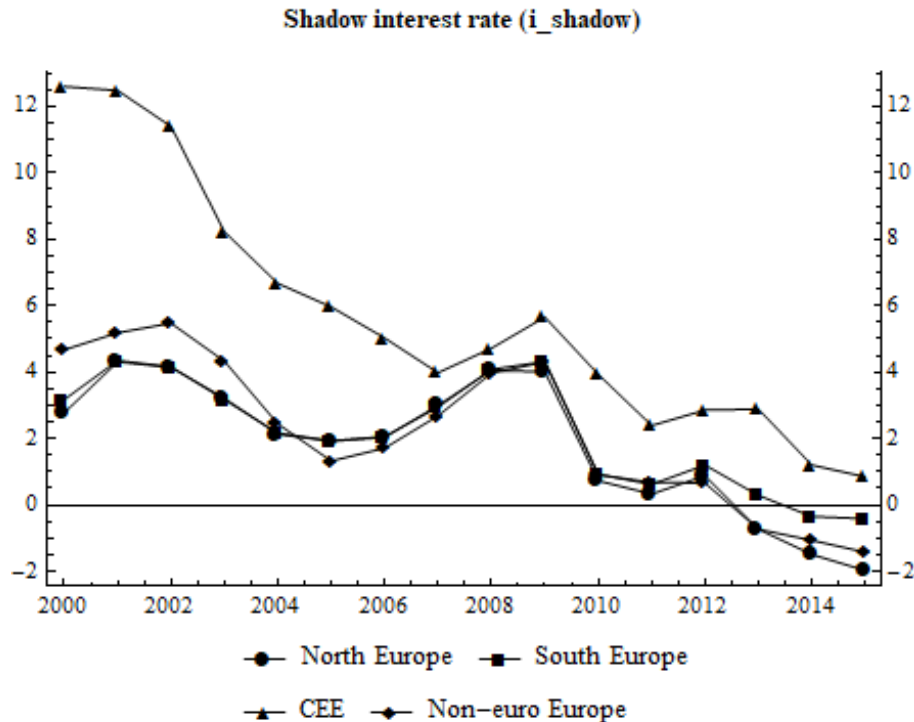


Figure 1.5: Evolution of country-level shadow interest rates (i^{shadow}). North Europe: Austria, Finland, France, Germany and the Netherlands. South Europe: Ireland, Italy and Spain. Central and Eastern Europe: Croatia, the Czech Republic, Hungary, Poland, and Slovakia. Non-Euro Area Europe: Denmark, Sweden, Switzerland and the United-Kingdom.

Since Greece has very low shadow interest rates (reaching -90%) and Romania very high (up to +90%), we decide to exclude these countries from our sample¹⁷. Figure 1.5 shows that although interest rates in Europe have similar trends, differences can be observed across countries. In particular, the shadow rate falls much more sharply in Euro Area countries than in other countries during the debt crisis. Countries whose banking systems are most affected by this crisis are experiencing the largest decline. The results presented in Table 1.7 are qualitatively very similar to those obtained with the same shadow rate for all members of the Euro zone (see Table 1.3), i.e., the thresholds are the same and all variables retain their signs. Thus, considering a country-level shadow interest rate does not change our main findings nor our conclusions.

¹⁷All estimates in Table 1.7 are performed without these two countries.

Table 1.7: Dynamic panel threshold estimations, nonlinearity between monetary policy indicators and bank risk-taking with country-level shadow rate

	Z-score				Distance to Default			
	i^r	i^d	i^{shadow}	CBA	i^r	i^d	i^{shadow}	CBA
Threshold estimate	2.27*	0.05***	2.44	10.81	3.22***	2.95***	3.59***	11.76***
95% confidence interval	[2.22 ; 2.39]	[-0.37 ; 0.13]	[2.00 ; 2.67]	[10.57 ; 10.82]	[3.21 ; 3.46]	[2.94 ; 2.98]	[3.48 ; 3.60]	[11.72 ; 11.77]
<i>Regime-dependent coefficients</i>								
λ_1	0.113*** (0.021)	0.589*** (0.102)	0.046*** (0.010)	0.020 (0.038)	0.812*** (0.081)	0.623*** (0.070)	0.328*** (0.036)	-2.316*** (0.181)
λ_2	0.031*** (0.009)	4.39e-4 (0.010)	0.015** (0.006)	0.006 (0.037)	0.219*** (0.046)	0.004 (0.046)	0.054** (0.028)	-2.228*** (0.173)
<i>Regime-independent coefficients: Impact of covariates</i>								
$Risk_{t-1}$	-0.201*** (0.067)	-0.159** (0.066)	-0.167*** (0.065)	-0.167** (0.066)	0.422*** (0.048)	0.470*** (0.047)	0.491*** (0.040)	0.339*** (0.042)
$EQUITY_{t-1}$	-0.001 (0.007)	-0.004 (0.007)	-0.002 (0.008)	-0.004 (0.008)	0.139*** (0.031)	0.158*** (0.031)	0.135*** (0.032)	0.159*** (0.031)
LCR_{t-1}	-0.001* (9.89e-4)	-0.001 (9.84e-4)	-0.001 (9.92e-4)	-0.001 (9.91e-4)	0.013*** (0.003)	0.013*** (0.003)	0.014*** (0.003)	0.013*** (0.003)
SIZE	-0.094** (0.047)	-0.129*** (0.047)	-0.103** (0.047)	-0.122** (0.052)	0.233 (0.174)	0.231 (0.173)	-0.030 (0.175)	0.973*** (0.191)
MC	2.354*** (0.825)	1.815** (0.840)	1.904** (0.852)	3.087*** (0.838)	-23.419*** (3.093)	-21.399*** (3.075)	-25.626*** (3.206)	-6.461** (3.141)
RGDPG	-0.001 (0.005)	-0.002 (0.005)	-7.87e-4 (0.005)	-0.001 (0.005)	0.125*** (0.022)	0.108*** (0.021)	0.126*** (0.023)	0.088*** (0.061)
GDP/capita	-0.165* (0.100)	-0.203** (0.100)	-0.129 (0.100)	-0.094 (0.106)	-1.710*** (0.404)	-1.670*** (0.403)	-1.381*** (0.409)	0.959** (0.446)
STOCK INDEX	0.002*** (4.28e-4)	0.002*** (4.33e-4)	0.002*** (4.19e-4)	0.001*** (4.19e-4)	-0.003*** (0.001)	-0.005*** (0.001)	-0.005*** (0.001)	-0.006*** (0.001)
MPI	-0.023 (0.014)	-0.020 (0.014)	-0.010 (0.015)	-0.037** (0.021)	0.056 (0.056)	0.021 (0.056)	0.127** (0.058)	0.238*** (0.061)
δ_1	4.747*** (1.024)	5.589*** (1.024)	4.512*** (1.039)	4.264*** (1.056)	16.641*** (3.661)	16.647*** (3.611)	16.534*** (3.726)	8.106** (3.679)
Obs.	1666	1666	1666	1666	1666	1666	1666	1666

Notes: λ_1 and λ_2 are the coefficients estimated for each regime. As Greece presents very negative i^{shadow} we drop Greek banks from the sample for the regressions of i^{shadow} . The DD is the Distance to Default and describes the distance of banks' balance-sheet structure from a structure that corresponds to the default event: the higher the DD, the lower the bank risk. The Z-score is in logarithm and describes the capitalisation profile of banks with respect to the distribution of their returns: the higher the Z-score, the lower the bank risk. CBA denotes central banks' total assets expressed in natural logarithm. i^r , i^d and i^{shadow} represent the policy interest rate, the interest rate on the deposit facility and the shadow short interest rate, respectively. EQUITY is the ratio equity on total assets. LCR is the liquidity coverage ratio, computed as total liquid assets on total liquid liabilities. SIZE is the natural logarithm of banks' total assets in millions of dollars. All bank control variables are collected at each annual closing date. RGDPG denotes the real GDP growth rate for each country. GDP/capita is the real GDP per capita expressed as natural logarithm. MC is the Herfindahl index and describes the concentration of European banking markets. STOCK INDEX is the stock market index per country, normalised at 100 in 2005. MPI is a macroprudential index.

1.6 Conclusion

We examine the effect of several monetary policy indicators on bank risk across the European banking sector over the period 2000-2015. This period allows us to capture the unconventional character of European monetary policy through negative interest rates and balance-sheet policy. Indeed, we use four monetary policy variables: the policy interest rate, the interest rate on the deposit facility, the shadow interest rate and the logarithm of central banks' total assets. Among these instruments, while the ZLB constrains the main refinancing interest rate, the deposit interest rate (Borio and Zabai, 2016) and the shadow interest rate capture UMP. Moreover, controlling for the evolution of central banks' balance-sheets accounts for QE policies. More precisely, we aim to investigate whether monetary authorities' instruments have a nonlinear effect on bank risk-taking behaviour. We rely on both the asymmetric Z-score and the DD, an accounting- and market-based bank risk measures, which provides complementary information.

We build our work on a dynamic panel model with threshold effect as introduced by Kremer et al. (2013). Indeed, as it is widely argued in the literature that bank risk has a lasting effect, this model permits us to take this dynamic feature into account and to mitigate potential endogeneity issues. In addition, this empirical methodology also allows testing the existence of nonlinearity.

The model provides interesting results when accounting for threshold effects. We find a nonlinear effect for both risk measures. The drop of central bank rates, or the rise in the monetary base, reflect riskier banks' behaviour. In line with the literature, this result suggests that the bank risk-taking channel was at play before the occurrence of the GFC. More importantly, our second contribution indicates that when interest rates are low and below the threshold, the negative relationship between bank risk measures and monetary policy is stronger. Accounting for the central banks' balance sheet policy indicates that additional liquidity encourages banks to take riskier positions. Their behaviour becomes

even riskier after the implementation of UMP. These findings are confirmed when (1) using the Loans-to-Assets ratio as a measure of risk, (2) using the traditional Z-score and (3) using the shadow short rate for each country as a monetary policy variable.

These results indicate that monetary policy does have an impact on European banks' risk-taking and that European monetary authorities should be concerned about this. They cannot set monetary conditions only on the basis of the final objectives of monetary policy. They must also take into account their effect on financial stability.

First, a too accommodating monetary policy can contribute to the accumulation of financial imbalances. Very recently, in mid-2019, a release from Banque de France (Juin 2019) points to a mild rebound of credit defaults in France. In the same token, S&P Global (2019) warns against a decline in the quality of credit over the next years in Europe. This new trend supports evidence-based policy-making in the research field. Second, difficulties that may arise in the banking industry should not be disregarded. The current compression of NIM may weaken banks' ability to generate profit and thus endanger financial stability via seeking alongside sources of profit. Prudential regulation, while reducing these risks, is not sufficient when monetary policy is too accommodating.

Against this background, the following chapter focuses on the growing crux concern evoked in the recent public debate, that is the adverse effect of the expansionary monetary policy on banks' profitability. Chapter 2 aims at investigating to what extent the low-interest rates environment hampers both banks' NIM and overall profitability. Additionally, being aware of the risk-taking channel pushes the analysis forward by disentangling the effect of risk from the effect of interest rates on bank profitability.

Appendix A

Chapter 1: Methodology to compute Macprudential Index (MPI)

This appendix provides details on the construction procedure of the regulation indicator used in the empirical analysis. We rely on the results of Cerutti et al. (2017) who analyse a recent survey, which includes detailed information on macroprudential policies in 119 countries. This survey is called the Global Macroprudential Policy Instruments (GMPI) and was carried out by the IMF's Monetary and Capital Department during 2013-2014. The authors focus on 12 different macroprudential instruments: LTV ratio caps (LTV_CAP), debt-to-income ratio (DTI), time-varying/dynamic loan-loss provisioning (DP), general countercyclical capital buffer/requirement (CTC), leverage ratio (LEV), capital surcharges on SIFIs (SIFI), limits on interbank exposure (INFER), concentration limits (CONC), limits on foreign currency loans (FC), FX and/or countercyclical reserve requirement (RR_REV), limits on domestic currency loans (CG) and levy/tax on financial institutions (TAX). They assign to each instrument the number of 1 if it was implemented, 0 otherwise. The MPI index is the sum of the scores on all 12 policies. Hence, the higher the MPI, the stricter is the regulation.

Appendix B

Chapter 1: Duan estimation

approach to compute the Distance to Default

Unlike the bank's assets V_t , the equity market values S_t are observed every trading day. Given the book value of bank debt, Equations (2) and (4) represent a one-to-one relationship between asset values and equity prices, which allows for the estimation of the state variable V_t . The asset value is computed daily through Equation (2), where the debt value, D_p , is constant during month p . The maturity of debt T is equal to one year ($T = 1$), and estimations are made on a six-month rolling window.

Let m denotes the number of months in our entire sample and n_j the number of days within the estimation window j , where $j = p - 5$ and $p = [6, \dots, m]$. We therefore express the time series of n_j daily observations within the estimation window j of the bank's market capitalisation by $\{S_{1,j}, \dots, S_{n_j,j}\}$, considering 260 trading days per year. For each trading day of a given month p and of the last five months, we compute the implicit market value of the bank's assets using month p 's level of debt. For this month p , we then estimate the expected return and the volatility of the bank's asset returns. Finally, we roll the estimation window forward by one month and estimate all unknown

model parameters, μ_V and σ_V , for all months of our sample period, except for the first five months. The DD is also computed for each month - specifically, for the last trading day of the month.

Duan and Yu (1994) and Duan (2000) develop a maximum likelihood estimator of the model parameters μ_V and σ_V , which is maximized considering the values of the banks' assets:

$$L_{S,j}(\mu_V, \sigma_V) = -\frac{n_j - 1}{2} \ln \left(\frac{2\pi\sigma_V^2}{260} \right) - \sum_{i=2}^{n_j} \ln \hat{V}_{i,j}(\sigma_V) - \sum_{i=2}^{n_j} \ln(N(\hat{d}_{i,j}(\sigma_V))) - \frac{260}{2\sigma_V^2} \sum_{i=2}^{n_j} \left[\ln \left(\frac{\hat{V}_{i,j}(\sigma_V)}{\hat{V}_{i-1,j}(\sigma_V)} \right) - \frac{(\mu_V - \frac{1}{2}\sigma_V^2)}{260} \right]^2, \quad (\text{B.1})$$

for each trading day i of the estimation window j using Equation (2) and where,

$$\hat{d}_{i,j}(\sigma_V) \equiv \frac{\ln \left(\frac{\hat{V}_{i,j}(\sigma_V)}{D_{p,j}} \right) + (r_{i,j} + \frac{1}{2}\sigma_V^2)(1 - t_{i,p})}{(\sigma_V \sqrt{1 - t_{i,p}})}, \quad (\text{B.2})$$

$\hat{V}_{i,j}(\sigma_V)$ determined from equation (2), which is slightly transformed to take into account the rolling window procedure:

$$S_{i,j} = \hat{V}_{i,j}(\sigma_V) N \left(\hat{d}_{i,j}(\sigma_V) \right) - D_{p,j} e^{-r_{i,j}(1-t_{i,j})} N \left(\hat{d}_{i,j}(\sigma_V) - \hat{d}_{i,j}(\sigma_V) \sqrt{1 - t_{i,p}} \right). \quad (\text{B.3})$$

For both equations $p = [1, \dots, m]$. For all days i belonging to month p , $D_{p,j}$ is constant and $t_{i,p} = \frac{(i'-1)}{260}$ where $i' = [1, \dots, np]$ has a one-to-one relationship with i , and np is the number of trading days within month p .

To compute the parameters μ_V and σ_V , an iterative optimization procedure is applied. Using the expected asset returns and asset return volatilities of the first approach as the starting values for μ_V and σ_V , respectively, and given data on the values of equity, $S_{i,j}$, and debt, $D_{p,j}$, Equation (B.3) is solved to yield the sample of bank asset values, $\hat{V}_{i,j}$. Equation (B.1) is then used to find the values of $\hat{\mu}_V$ and $\hat{\sigma}_V$ that maximize this likelihood function. These two parameters are computed for each estimation window, and as we roll

this window forward by one month, we obtain monthly estimations for annual values of $\hat{\mu}_V$ and $\hat{\sigma}_V$ for the entire sample except for the first five months.

Because the amount of debt is known only for the end of month, the DD is estimated monthly on an annual basis with the end-of-month asset value:

$$DD_{n_j,j} = \frac{\ln\left(\frac{\hat{V}_{n_i,j}(\sigma_V)}{D_{p,j}}\right) + \left(\mu_V - \frac{1}{2}\sigma_V^2\right)(1 - t_{n_p,p})}{\sigma_V \sqrt{1 - t_{n_p,p}}}. \quad (\text{B.4})$$

Unlike much of the literature that employs a risk-free interest rate, we consider the debt interest rate r_i to be specific to each bank i . Even if in the case of economy-wide troubles, banks are subject to the same conditions on the market, and the effects on their own economic and financial situation could be and are, in most cases, different. Employing own interest rate for each bank allows us to account for each bank's debt and its evolution and to be more precise regarding its risk.

Appendix C

Chapter 1: Yield curve and shadow interest rates' extreme values

Table 1.8: Yield curve and shadow interest rates' extreme values (2000-2015)

Countries	Daily yield curve data		Daily i^{shadow} value	
	Min	Max	Min	Max
Austria	-0.22	5.53	-1.99	5.11
Croatia	0.35	21.65	-5.77	27.60
Czech Republic	0.125	6.85	-5.38	5.34
Denmark	-0.60	6.93	-3.79	6.57
Finland	-0.23	5.85	-11.37	5.64
France	-0.90	6.26	-6.36	5.02
Germany	-0.44	6.23	-4.17	5.06
Greece	-0.22	9.43	-78.74	10.70
Hungary	1.34	15.10	1.17	14.61
Ireland	-0.22	7.75	-2.00	6.93
Italy	-0.22	7.29	-2.20	5.40
Netherlands	-0.22	5.78	-0.99	5.40
Norway	0.57	9.13	0.40	10.40
Poland	1.33	21.75	1.33	19.95
Romania	0.38	81.19	-9.28	85.98
Slovak Republic	1.97	14.25	1.83	12.11
Spain	-0.32	14.70	-3.62	5.65
Sweden	-0.65	6.02	-4.67	4.45
Switzerland	-3.60	4.57	-12.98	3.46
United-Kingdom	0.04	6.56	-7.65	6.72

Chapter 2

Interest rates and European bank profitability: Have central banks gone off the rails?¹⁸

Main European policy interest rates have been trending downwards for almost a decade now, presenting a challenging environment for banks where, in some countries, nominal interest rates are negative¹⁹. Indeed, as put into perspective in Chapter 1, to fight against slack economic growth and to respect the targeting inflation objective, many central banks have drastically lowered their policy interest rates and backstopped illiquid institutions. As previously explored, these (un)conventional monetary conditions have raised great concerns about the bank risk-taking channel. While this prevailing environment affects banks' incentives to take on more risk, profitability is the ultimate goal. It is a useful indicator to measure *inter alia* the stability and soundness of the banking industry. In this second chapter, we therefore propose to explore the nexus between low interest rates and profitability, while accounting for the level of risk.

¹⁸Part of this chapter is published in *Research in International Business and Finance*, 2020, vol. 51, issue C.

¹⁹As outlined in Chapter 2, subsection 1.3.2, the central banks of Sweden and Switzerland have set negative policy interest rates since 2015.

Analysing this relationship is essential for two main motivations. First, it is a predominant vector to ensure financial stability. While individual bank risk awakes attention concerning financial stability, today, banks must challenge the low-interest rate environment, which is especially predominant in Europe and Japan where interest rates fall below zero. Second, there is a need to shape appropriate policy recommendations. Policymakers face great concerns and criticisms when cutting interest rates in negative territory because of its adverse effects on banks' profitability (see Gros et al., 2016; Blot and Hubert, 2019).

As sketched out in the introduction of Chapter 1, the effect of low and persistent interest rates on banks' overall return is not clear. On the one hand, while financial institutions do pay attention to their NIM, that is the difference between interests they charge and the ones they pay but not the level of interest rates *per se*, a relaxation of monetary policy is often expected to erode NIM because banks are loathed or simply constrained to lower their interest rates on deposits (see further subsection 2.2.1). On the other hand, a reduction of interest rates stimulates banks' lending through two complementary monetary mechanisms: the drive up of banks' net worth since assets are of longer maturity than liabilities, and the strengthening of potential borrowers' creditworthiness through the improvement of asset value and business prospect.

All in all, even though NIM declines, in the short run, banks benefit from valuation gains on securities and, indirectly, from a lesser burden in non-performing loans as borrowers' debt decreases (see Altavilla et al., 2017). However, in the long run, it is not sure whether these benefits, offsetting the cut in the NIM, allow to increase (or maintain) profitability. It is worth mentioning that financial institutions may also seek other sources of profit by modifying their risk perception, playing on their lending volume or increasing their non-interest income. These effects may vary between banks, due to different interest rates' exposure, the degree of maturity transformation and risk management.

More specifically, banks' prudential behaviours are likely to modify the studied relation through risk/return arbitrages. In perspective of a compression of their NIM, banks could

be encouraged to shift their business away from the loan segment to trading activities. As such, they could engage in higher-yielding businesses to meet a minimum level of profitability and stakeholders' requirements (Baumol, 1962). In this respect and in light of the results outlined in Chapter 1, our work accounts for the level of risk in order to grasp such an effect when exploring the relation between interest rates and profit. In particular, the riskiness of universal banking model is mostly impacted by the credit risk since banks' assets are composed of about 50 to 70% of loans. As the literature focuses primarily on credit risk when studying risk-taking behaviours, our study aims to complement it in two ways. First, the analysis goes beyond the appraisal of credit risk by considering variables such as the loan-loss-provisions-on-gross-loans and the equity-on-net-loans ratios, which reflect the bank quality of management. Our study aims at adding extra information regarding the effect of banks' prudential behaviour, grasping banks' approach toward risk management. Second, the use of the Z-score makes it possible to capture a broader risk, namely the risk of insolvency, which is a direct consequence of the banks' risk management.

To explore the effect of these different variables on bank profitability, we use the OLS fixed effect estimation method. However, we also rely on the General Method of Moments estimators (Arellano and Bover, 1995; Blundell and Bond, 1998) to account for the dynamic nature of bank profitability and to mitigate the potential endogeneity issues our regression may face. In a first step, we assess the overall effect of policy interest rates and prudential behaviour indicators on profitability. In a second step, we investigate whether the relationship between the level of targeted interest rates and return is conditional to banks' prudential behaviour. Finally, we simultaneously examine the effects of prudential behaviour on bank profitability under different interest rate regimes.

Unsurprisingly, we find the central banks' main instrument being positively correlated with the NIM. When exploring this effect under different policy interest rate regimes, the lower the interest rate, the stronger the result. However, our results do not permit us to conclude that the conduct of monetary policy have impaired bank overall profitability. In

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fact, it turns out that at its lowest level (i.e., when policy interest rates are close to the ZLB), a decline of the policy interest rate increases profit. A decline in NIM seems to be mainly offset by increases in non-interest incomes. Our findings are very similar to the recent strand of literature focusing on European countries (see, *inter alia* Lopez et al., 2011; Altavilla et al., 2017). Finally, they reveal that the positive effect of policy interest rates on profitability is reduced when banks adopt a more prudent risk-taking behaviour.

The remainder of the chapter is arranged as follows. In the following section, we describe the different transmissions channels when exploring the relationship between interest and profit and present the related literature. Then, in Section 2.3, to provide the reader with an overview, we introduce stylised facts on European data with regard to the evolution of interest rates and profitability indicators. We describe the data and variables and explain the econometric methodology used in Section 2.3 and comment on our results in Section 2.4. In order to validate our results, Section 2.5 presents robustness checks. Finally, Section 2.6 summarises our main findings and conclude.

2.1 The effects of interest rates on profitability: What does the literature state?

This section first describes the different channels through which interest rates can influence bank profitability. Overall, low interest rates are often expected to undermine bank profitability and thus, their resilience. However, while the effects of interest rates on the NIM are fairly explicit, the effects of interest rates on overall profitability are less obvious. The section will also evidence that the prudential behaviour of a firm should not be disregarded when examining the relationship between interest rates and bank profitability.

The section wraps up presenting empirical analysis. Pieces of evidence from the literature report findings with regard to the effect of the interest rates on the NIM and overall

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profitability, as well as findings with regard to the relationship between risk-taking and profit as the bank risk dimension is a crucial element to be accounted for.

2.1.1 Transmission channels

Low interest rates mainly affect profitability through the NIM. Two components are capable of squeezing bank NIM: the level of interest rates received and the level of interest rates paid. The first one highly depends on monetary policy. Cut in central banks' policy interest rates put pressure on market rates, that is the rate a bank can receive when lending to its counterparts. Also, a cut in the central banks' deposit facility interest rate reduces the interest rate a bank receives when depositing funds at the central bank. It is worth mentioning that not only prolonged low interest rates are likely to flatten the yield curve, but also massive liquidity injections. Such actions affect NIM through lower yields on assets, which by nature have longer maturities than liabilities (Claessens et al., 2017; Committee on the Global Financial System, 2018).

The second component refers to interest rates paid by banks, that is deposit interest rates. As a result of a drop in perceived interest rates, banks may not be willing to lower their interest rates on several types of deposits and liabilities accordingly. Two rationales are put forward: depositors are able to shift to cash-form savings and the bank bears the risk of losing clients. Furthermore, although market rates are negative (see further subsection 2.2.1), banks are constrained by the ZLB; they cannot adjust their deposit rates in negative territory either because they are legally constrained or simply because it would make no economic sense since it would mean that customers would have to pay the banks to hold their money.

While the effects on NIM are hardly questionable and have a detrimental impact on banks' overall profitability, there are several factors that can mitigate these negative effects. Put differently, the effect of a low-interest rate environment does not always lead to lower overall profitability for banks.

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In fact, banks immediately benefit from valuation gains on the securities they hold when interest rates decrease. Banks can also indirectly benefit from relief on non-performing loans since borrowers' debt burden diminishes (see Altavilla et al., 2017). Moreover, in the same vein as the financial accelerator mechanism (Bernanke et al., 1999) described in section 1.1, lower interest rates are likely to have a positive effect on the net worth of economic agents. This, in turn, may influence banks' behaviour in granting more loans, since higher net worth would improve the capacity of some economic agents to meet banks' requirements when they borrow. Such a mechanism could boost the lending volume. Nevertheless, these two factors may only provide a one-off effect or short-term offsets; if interest rates do not fall further, gains on the valuation of assets are no longer recorded, and a decrease in borrowers' net worth depends heavily on the extent to which the decline in interest rates is associated with better economic prospects for households and businesses.

In addition, banks' behaviour vis-à-vis risk-taking, lending volume and other adjustable banking variables is capable of offsetting adverse effects on the NIM in order to meet a minimum level of profitability and shareholders' requirements (Baumol, 1962). In this respect, banks may engage in riskier activities. Evidence from Chapter 1 shows that financial institutions may increase their risk-taking to compensate for the loss in the NIM. By way of example, a low-interest rate environment can trigger a search for yield by engaging in the purchase of riskier assets and issuing riskier loans. On top of shaping the risk characteristics of loans, banks may also leverage and raise their lending volume (echoing the above-mentioned financial accelerator mechanism). As mentioned in section 1.1, Adrian and Shin (2010) provide theoretical evidence that banks target a pre-defined leverage ratio. Finally, banks can adjust other banking variables, such as cutting costs or increasing non-interest income (e.g., fees and commissions), although such decisions to offset a lower NIM are in practice limited in a fiercely competitive environment.

2.1.2 Empirical findings

Investigating the critical role of interest rates in determining profitability is knowing a particular awareness due to the prevalence of the low-interest rate environment. Before the GFC, studying the effect of interest rates on bank profitability was mainly considered as a “by-product” (Borio et al., 2017, p.3). The above rationale explains why empirical evidence on the topic remains relatively limited.

Demirgüç-Kunt and Huizinga (1999) is among the first studies to relate bank profitability to macroeconomic indicators, and in particular real interest rates. Running their research on 80 countries from 1988 to 1995, they highlight that higher real interest rates are associated with higher interest margins and profitability, which is especially true for developing countries where deposits are remunerated below market interest rates.

More recently, Albertazzi and Gambacorta (2009) focus on 10 major advanced countries, including both Euro Area members and Anglo-Saxon countries. Their results suggest a positive relation between net interest income and the yield curve. They also find a positive relation between loan loss provisions and the short-term interest rate. Similarly, Bolt et al. (2012) consider a cross-country analysis of 19 developed countries and corroborate the findings highlighted by Albertazzi and Gambacorta (2009). Moreover, English (2002) explore the effect of market interest rate risk – by inspecting its volatility – on the NIM of 10 industrialised countries. He finds that banks have been fairly successful in limiting the exposure of their NIM to market interest rates. Focusing on the United-kingdom, Alessandri and Nelson (2014) explain that, in response to higher interest rates, banks raise their lending rates, although they reduce their lending volume because of strengthening in their lending standards.

All the same, paying particular attention to the effect of the low-interest rate environment on bank profit has gained prominence in recent literature. The principal finding is that persistently low-interest rates weigh on bank net interest income (Weistroffer, 2013; Genay and Podjasek, 2014; Bikker and Vervliet, 2017; Borio et al., 2017; Claessens et al.,

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2017). More particularly, Borio et al. (2017) account for non-linear effects and demonstrate the existence of an inverted U-shape. In other words, the impact of interest rates on banks' NIM is much stronger at lower levels.

Although there is a consensus on the effect of interest rates on NIM, its impacts on profitability are more controversial. Indeed, Bikker and Vervliet (2017) find that American banks succeed in maintaining their overall profit by lowering provisioning. Weistroffer (2013) focuses on the Japanese banking system and argues that low-interest rate environment has galvanised banks to shift their portfolios over the time towards investments in securities and to have a higher reliance on non-interest income, allowing them to maintain profits. A more recent study conducted by Lopez et al. (2018) compares banks in different jurisdictions across Japan and Europe with positive and negative interest rates from 2010 to 2016. Results exhibit minimal impacts on overall profitability despite a fall of the NIM. They conclude that banks succeed in making up with higher non-interest income and benefit from the effect of lower interest rates on their assets' value. Altavilla et al. (2017) reach very similar conclusions for the Euro Area and add that monetary policy conditions have contributed to offset adverse impacts on the NIM by alleviating loan loss provisions.

By contrast, Borio et al. (2017) focus on advanced countries and find a positive linkage between short-interest rates and ROA. They specify that higher interest rates increase loan loss provisions via a growing burden of debt services and harm securities' valuation. Similarly, Claessens et al. (2017) conduct a cross-country analysis and provide evidence that low-interest rates reduce overall bank profit. Genay and Podjasek (2014) are in line with the previous findings. However, their analysis entails that as long as low interest rates result in better economic outcomes, their net effects on banks' profitability may become positive.

Furthermore, although research in the field of bank profitability has gained prominent momentum in the aftermath of the GFC, the effect of bank risk on profitability is yet

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under-researched in Europe. While the relationship between the level of bank capitalisation – which can be considered as a cushion to cover risky assets – and profitability is well-documented in the literature (see for instance, Demirgüç-Kunt and Huizinga, 1999; Athanasoglou et al., 2008; Barth et al., 2013), fewer studies have focused on the effect of credit risk and, especially, market and insolvency risks on profitability across the European banking system. The conclusions drawn in the literature with regard to the effect of bank risk on profitability do not reach consensus and make this area worth studying. Also, evidence highlighted in Chapter 1 with respect to the existence of the risk-taking channel of European banks reinforces the motivation for including a proxy of the level of risk when examining the relationship between interest rates and profitability.

The level of risk can be another determinant of banks' profitability through the well-known risk/return relationship. In theory, engaging in riskier activities implies higher earnings. However, depending on the type of risk the bank has engaged in, several factors could undermine profitability. According to Boffey and Robson (1995) and Giesecke (2002), although banks face different risks, credit risk is by far the most significant risk. The profitability is likely to decline if bank management fails to collect qualitative loans, thus facing a higher hazard rate or even defaulting on loans. In this perspective, there are high incentives to believe that poor asset quality reduces bank profitability as far as it constrains banks' pool loanable funds. As such, it requires reliable measurements and efficient management to a greater extent than any other risks. Among the variables employed to evaluate credit risk, the loan loss provisions and the non-performing loans are the most encountered in the literature (Alshatti, 2015; Bhattarai, 2016; Bikker and Vervliet, 2017; Trad et al., 2017, among others). For instance, Alshatti (2015) and Bhattarai (2016) respectively focus on Jordanian banks over 2005-2013 and on Nepali banks over 2010-2015, and report a negative correlation between non-performing loans and bank profitability. By contrast, Buchory (2015) concludes that in Indonesia, non-performing loans have a positive and significant impact on the ROA. Unlike Islam and Nishiyama (2016), who do

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not find any evidence of an effect of loan loss provisions on South Asian bank profitability, Vong and Chan (2009), Ozili (2015) and Ozili (2017) opine that this variable adversely affects bank profitability respectively in Macao, Nigeria and more generally in Africa.

In the same vein, other works rely on the use of financial ratios. Dietrich and Wanzenried (2011) and Tarus et al. (2012) employ the loan-loss-provisions-to-total-loans ratio and find opposite results. The first work focuses on Switzerland and find negative or insignificant results, while the second one concludes that in Kenya, this ratio positively affects the net interest rate. Abbas et al. (2019) run a comparative study between the US and Asian banks and conclude that the loans-loss-provisions-to-risk-loans ratio hampers profitability in the same manner in both banking industries. Finally, Ekinici (2016) assesses the effect of credit risk through an industrial index in Turkey from 2002 to 2015 and reports a negative relationship with profitability. On a general note, the above-mentioned studies are in line with the analysis of the banking determinants of profitability using panel fixed effects estimates or the Arellano-Bond Generalised Methods of Moments (GMM) estimator.

In addition, market risk and, more broadly, insolvency risk indicators are also used – albeit in a few analyses. For example, Boadi et al. (2016) employ the Z-score as a measure of bank insolvency on a panel of 114 Ghanaian banks and conclude that more resilient banks improve their profitability. Koutsomanoli-Filippaki and Mamatzakis (2009) relies on the DD and is one of the few studies to focus on the European banking market over the period 1998 to 2006. Their sample includes 251 listed banks. The panel-VAR analysis shows that in most cases, risk causes inefficiency. The reverse relation is not refuted but presents weaker evidence. In his study, (Ekinici, 2016) also considers the foreign exchange rate risk, but the impact of the latter is not significant.

2.2 Do feeble net interest margins replicate bad overall profitability in Europe?

This section offers insights, through stylised facts, on the evolution of European banks' profitability, the key variable of this chapter. This latter encompasses visual representations, for each country of our sample, of both the NIM through the analysis of its components and the overall profitability pictured by financial indicators. Against this background, we present graphical pieces of evidence on banks' reluctance to cut deposit interest rates or banks' constraint to set negative interest rates. While earnings from interests decrease, this reluctance weighs on bank NIM. Also, despite a compression of the NIM, overall profitability has now reached its pre-crisis level in almost all countries.

2.2.1 Bank interest rates: A disconnection between earnings and payments

Prior to 2008, data collected and presented in Figure 2.1 exhibit, for most of the countries of our sample, a "textbook case". The interest rates paid by banks (i.e., the deposit rates for households and non-financial corporations, corresponding to the solid red and blue lines, respectively) are lower than both the interest rates that banks receive when depositing money at the central bank funds overnight (i.e., the deposit facility rate, referring to the dashed black line) and the one that bank can obtain when lending to other banks overnight (i.e., EONIA, that is the solid black line). During the crisis, the spread between the previous two interest rates faded out. While the evolution of deposit interest rates for households and businesses is identical in almost all countries (except Denmark, where the deposit rate for non-financial corporations is negative), the evolution of the deposit facility rate and the overnight bank interest rate varies. As such, two groups stand out.

In the first group, the spread between the interest rates paid by banks and the ones

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they receive has become negative. This is the case for almost all countries of our sample, that is Euro Area countries, Bulgaria, the Czech Republic, Norway, Sweden, Switzerland, and the United-Kingdom. In Sweden and Switzerland, one may note the deep fall of both the deposit facility rate and the overnight bank interest rate, which have reached a very negative territory. By contrast, in Norway and the United-Kingdom, the latter interest rates are still positive. In most of these countries, the inversion of the two types of interest rates occurred even prior the implementation of a zero or negative interest rate policy, which was globally introduced after the European sovereign crisis.

For the second group of countries, which mainly concerns the CEE countries of our sample that still pursue an autonomous monetary policy (i.e. Croatia, Hungary, Poland and Romania), the difference between bank interest rates received and paid has been considerably reduced, but is not negative. In other words, the evolution between these two types of interest rates in these countries seems to be delayed compared to the first group of European countries.

Hence, the core business of a financial institution, which mainly refers to accepting deposits from both households and corporates and depositing the proceeds at the central bank or lending it to other banks, is now resulting in losses in many countries under investigation. More importantly, this disconnection between earnings and payments issuing from bank interest rates results from banks' unwillingness or incapacity to cut their deposit interest rates. A subzero nominal rate or a nominal rate close to zero might encourage households and corporations to accumulate cash, shrinking therefore banks' balance sheet. Also, sufficiently negative interest rates might be perceived as an adverse signal, expressing the central bank's distress.

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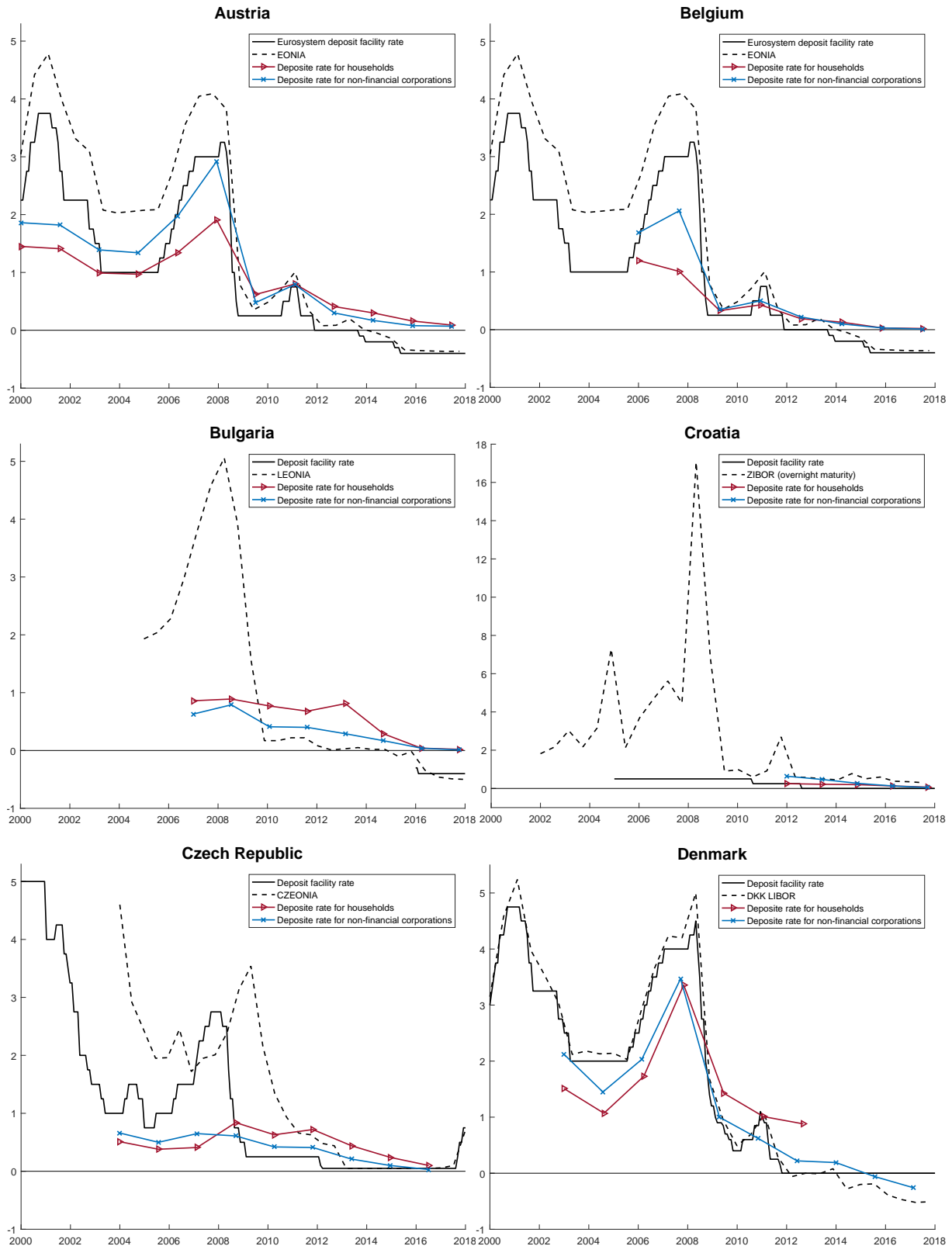


Figure 2.1: The different components of the NIM – a cross-country analysis. For European Union (EU) countries, data on the deposit interest rates for households and corporates are retrieved from the MFI Interest Rate Statistics of the ECB Statistical Data Warehouse. For Norway and Switzerland, these data are extracted from their central bank’s open databases. For all countries, data on deposit facility interest rates and bank overnight interest rates come from DataStream and/or their central bank’s open databases.

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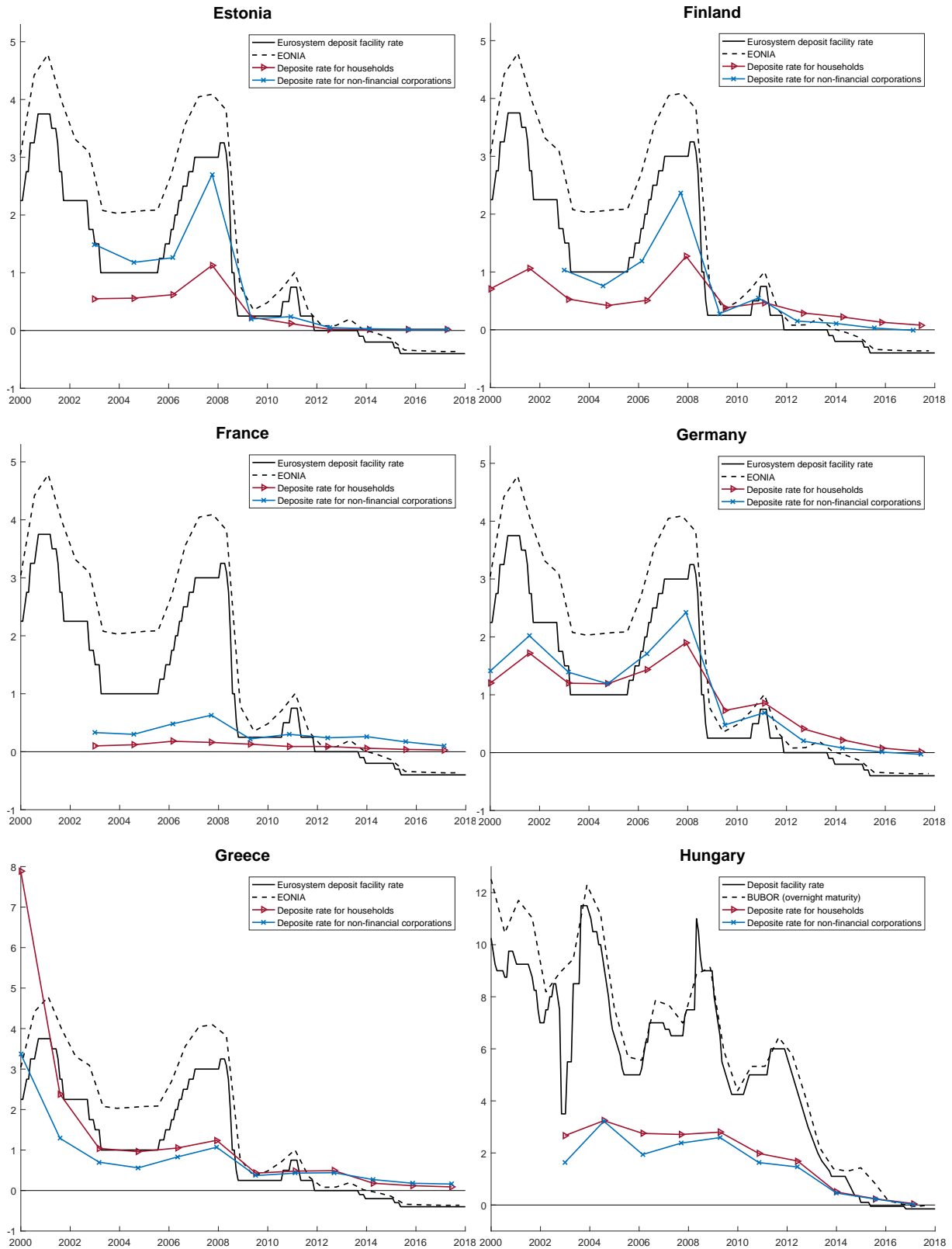


Figure 2.1 (continued): The evolution of the different components of the NIM – a cross-country analysis. For EU countries, data on the deposit interest rates for households and corporates are retrieved from the MFI Interest Rate Statistics of the ECB Statistical Data Warehouse. For Norway and Switzerland, these data are extracted from their central bank's open databases. For all countries, data on deposit facility interest rates and bank overnight interest rates come from DataStream and/or their central bank's open databases.

2.2 Do feeble net interest margins replicate bad overall profitability in Europe?

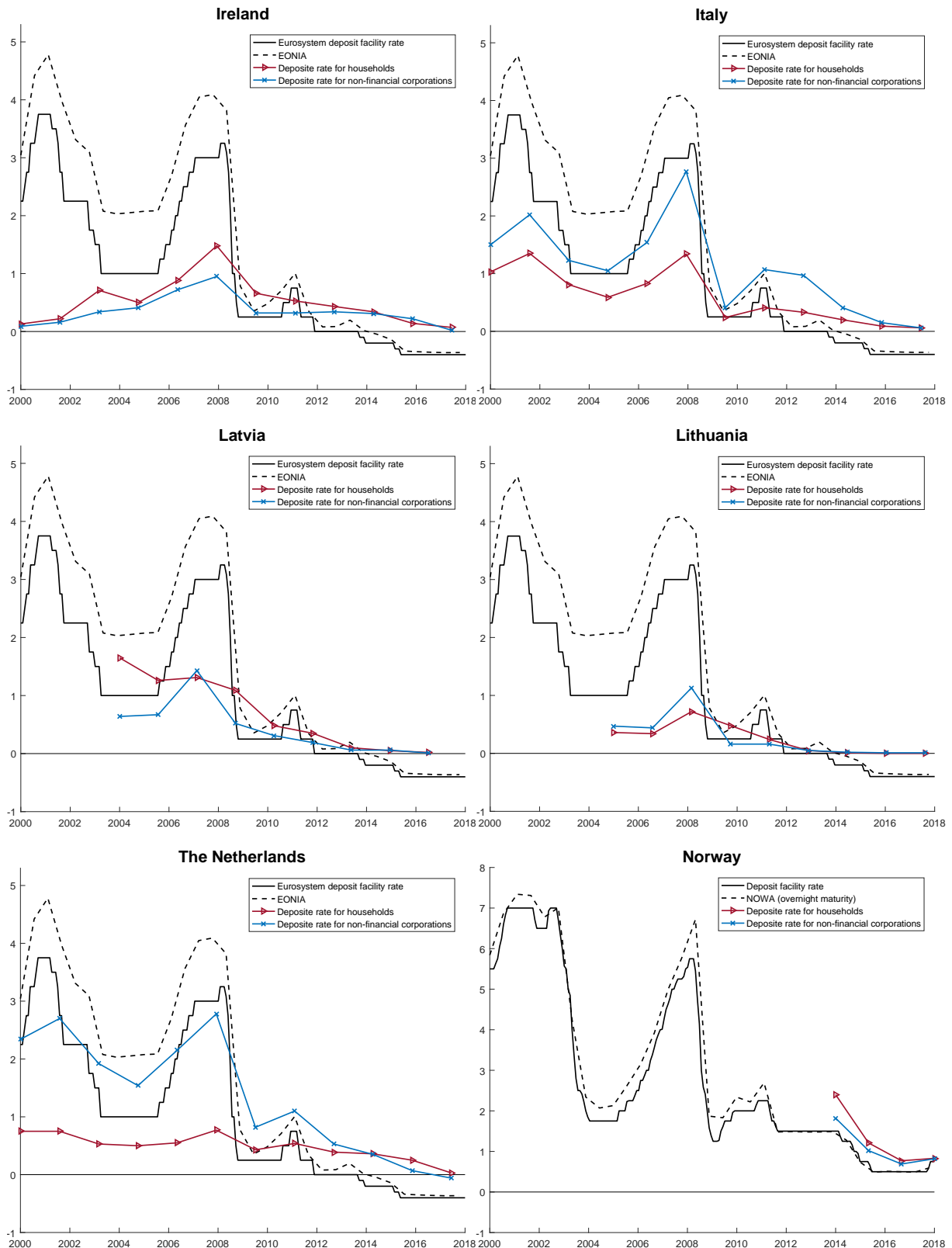


Figure 2.1 (continued): The evolution of the different components of the NIM – a cross-country analysis. For EU countries, data on the deposit interest rates for households and corporates are retrieved from the MFI Interest Rate Statistics of the ECB Statistical Data Warehouse. For Norway and Switzerland, these data are extracted from their central bank’s open databases. For all countries, data on deposit facility interest rates and bank overnight interest rates come from DataStream and/or their central bank’s open databases.

2.2 Do feeble net interest margins replicate bad overall profitability in Europe?

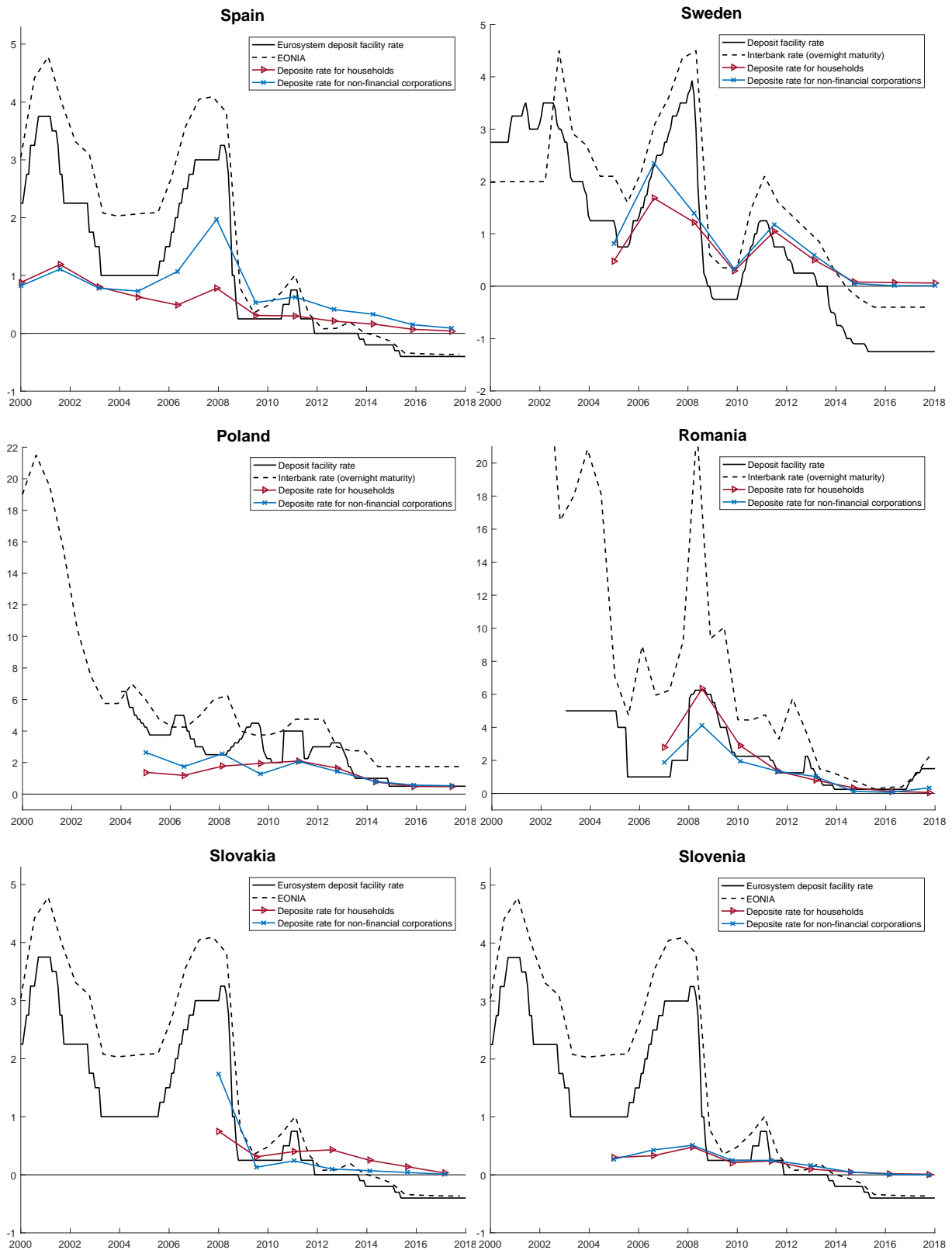


Figure 2.1 (continued): The evolution of the different components of the NIM – a cross-country analysis. For EU countries, data on the deposit interest rates for households and corporates are retrieved from the MFI Interest Rate Statistics of the ECB Statistical Data Warehouse. For Norway and Switzerland, these data are extracted from their central bank’s open databases. For all countries, data on deposit facility interest rates and bank overnight interest rates come from DataStream and/or their central bank’s open database.

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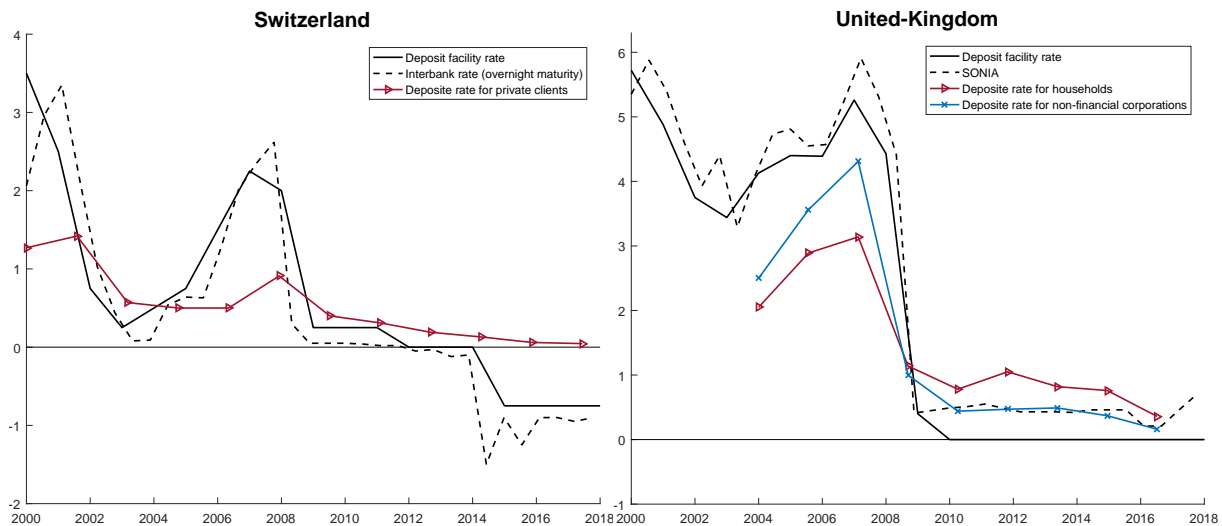
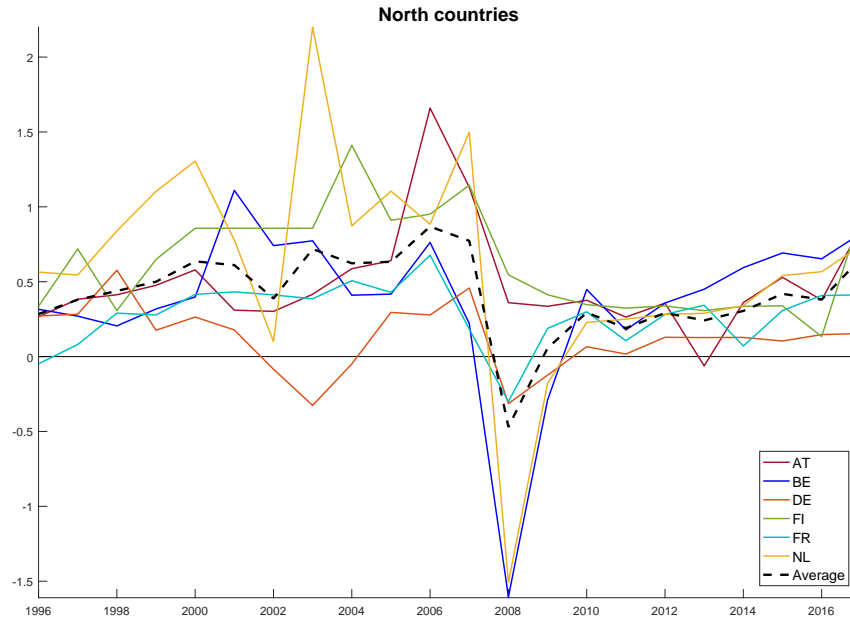


Figure 2.1 (continued): The evolution of the different components of the NIM – a cross-country analysis. For EU countries, data on the deposit interest rates for households and corporates are retrieved from the MFI Interest Rate Statistics of the ECB Statistical Data Warehouse. For Norway and Switzerland, these data are extracted from their central bank’s open databases. For all countries, data on deposit facility interest rates and bank overnight interest rates come from DataStream and/or their central bank’s open database.

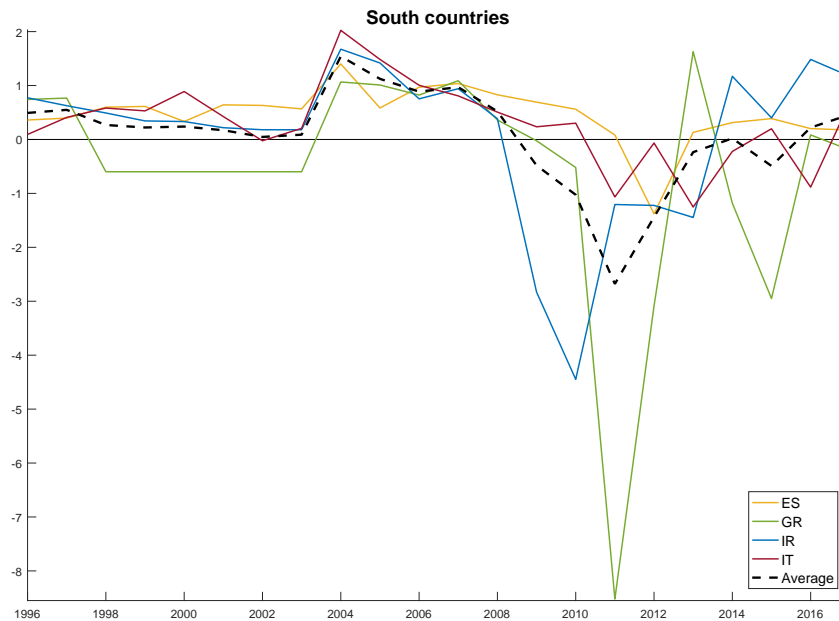
2.2.2 Overall profitability: A return to the pre-crisis level

Figure 2.2 and Figure 2.3 provide information on the evolution of the ROA and the Return on Equity (ROE). The ROA and the ROE are respectively computed as the ratio between net income and total assets and the ratio between net income and total equity. Data are collected from BankScope and are aggregated for each country of our sample. In addition, the two figures offer a cross-region analysis. It is worth stressing that these two financial ratios follow a very close pattern. The difference between ROA and ROE stems from the leverage effect, which appear to be constant in the banking industry (see section 1.1, Adrian and Shin, 2010).

2.2 Do feeble net interest margins replicate bad overall profitability in Europe?



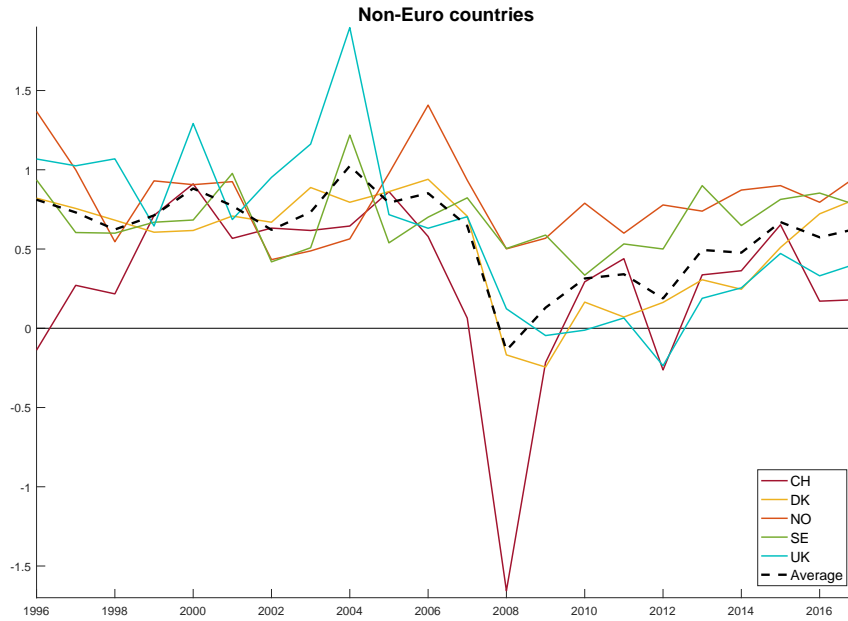
(a)



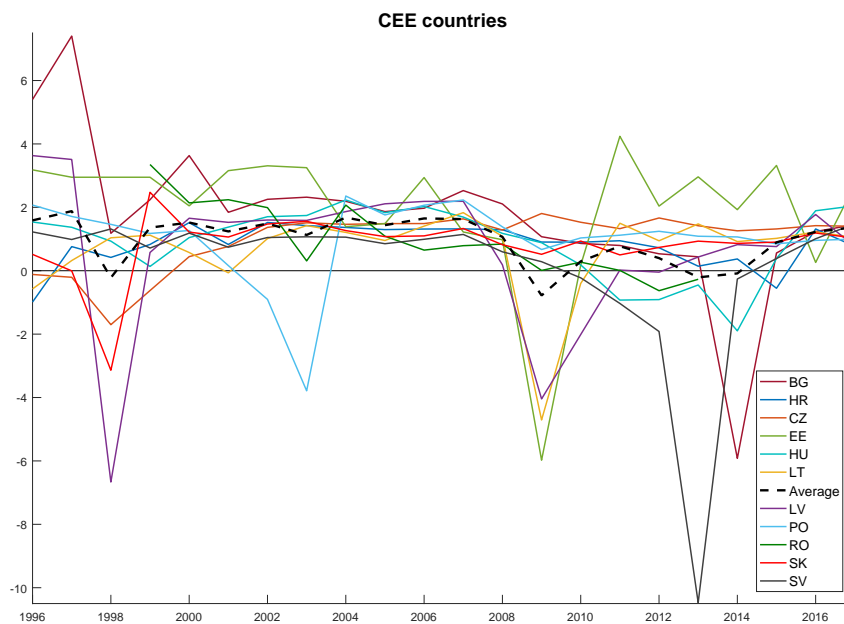
(b)

Figure 2.2: Evolution of the Return-on-Assets ratios. North Europe: Austria, Belgium, Finland, France, Germany and the Netherlands. South Europe: Greece, Ireland, Italy and Spain. Central and Eastern Europe: Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia. Non-euro Europe: Denmark, Norway, Sweden, Switzerland and the United-Kingdom. The data are collected from Bankscope. We rely on unconsolidated data as, throughout the analysis, we are interested in the banks' individual behaviour. In addition, the use of consolidated data when including several European countries may hide important information at the national level. For each country, return variables are first aggregated on the country level.

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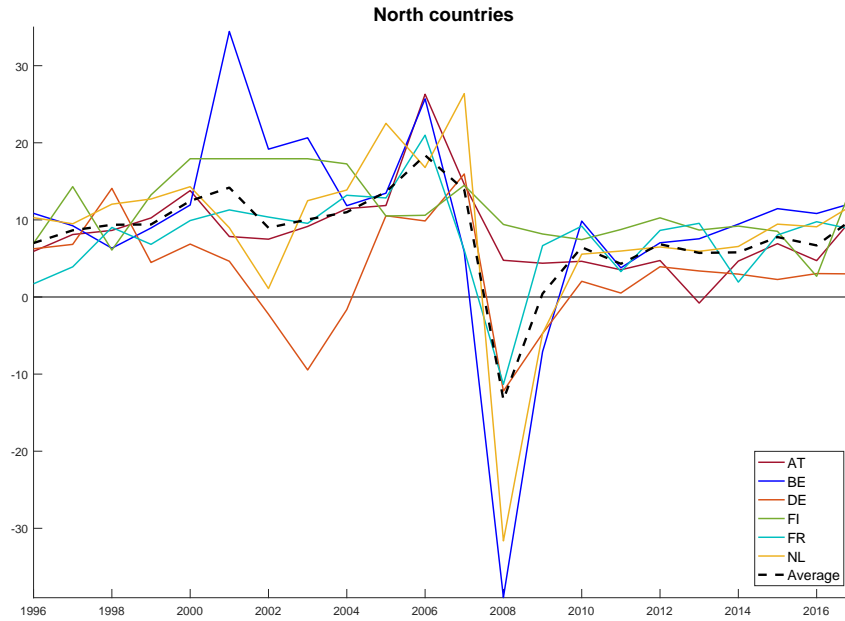
(c)



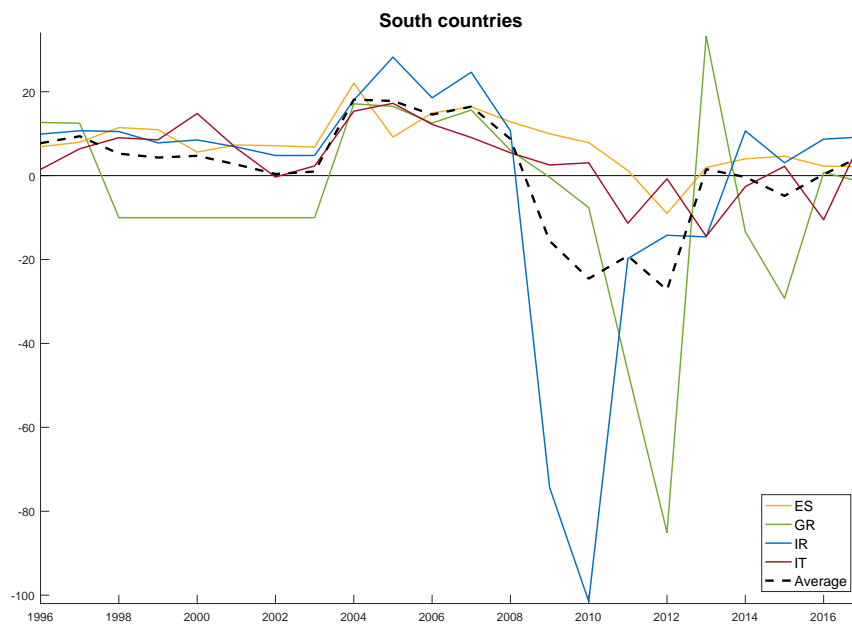
(d)

Figure 2.2 (continued): Evolution of the Return-on-Assets ratio. North Europe: Austria, Belgium, Finland, France, Germany and the Netherlands. South Europe: Greece, Ireland, Italy and Spain. Central and Eastern Europe: Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia. Non-euro Europe: Denmark, Norway, Sweden, Switzerland and the United-Kingdom. The data are collected from Bankscope. We rely on unconsolidated data as, throughout the analysis, we are interested in the banks' individual behaviour. In addition, the use of consolidated data when including several European countries may hide important information at the national level. For each country, return variables are first aggregated on the country level.

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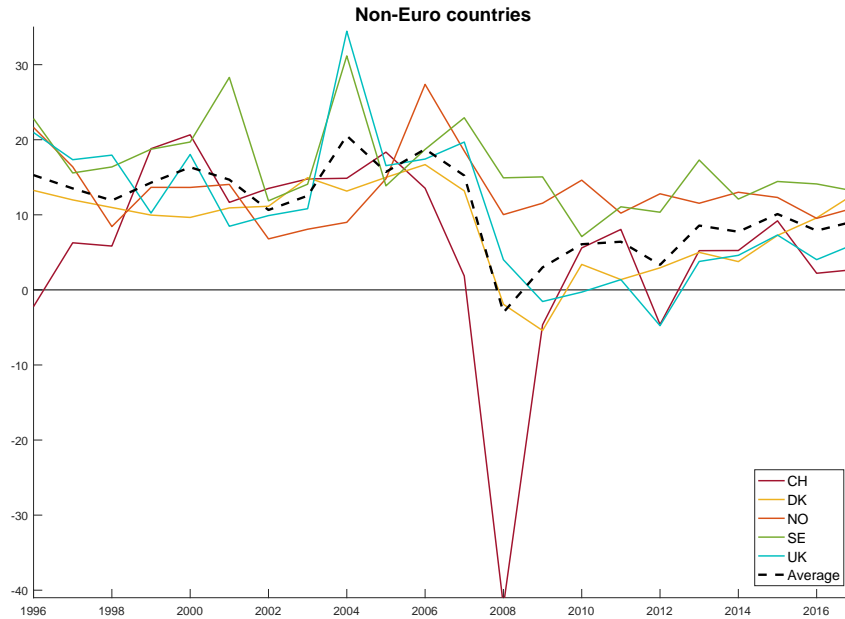
(a)



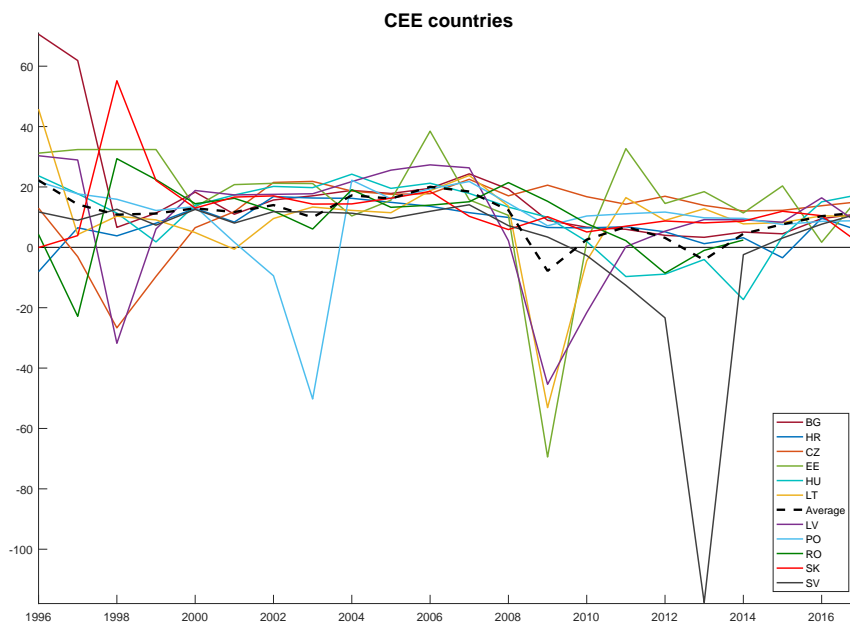
(b)

Figure 2.3: Evolution of the Return-on-Equity ratios. North Europe: Austria, Belgium, Finland, France, Germany and the Netherlands. South Europe: Greece, Ireland, Italy and Spain. Central and Eastern Europe: Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia. Non-euro Europe: Denmark, Norway, Sweden, Switzerland and the United-Kingdom. The data are collected from Bankscope. We rely on unconsolidated data as, throughout the analysis, we are interested in the banks' individual behaviour. In addition, the use of consolidated data when including several European countries may hide important information at the national level. For each country, return variables are first aggregated on the country level.

2.2 Do feeble net interest margins replicate bad overall profitability in Europe?



(c)



(d)

Figure 2.3 (continued): Evolution of the Return-on-Equity ratios. North Europe: Austria, Belgium, Finland, France, Germany and the Netherlands. South Europe: Greece, Ireland, Italy and Spain. Central and Eastern Europe: Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia. Non-euro Europe: Denmark, Norway, Sweden, Switzerland and the United-Kingdom. The data are collected from Bankscope. We rely on unconsolidated data as, throughout the analysis, we are interested in the banks' individual behaviour. In addition, the use of consolidated data when including several European countries may hide important information at the national level. For each country, return variables are first aggregated on the country level.

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Over the last years and in almost all countries, the overall profitability converged and reached its pre-crisis level or even higher levels. This feature is particularly salient for northern and non-euro countries, which experienced similar trends for both ROA and ROE. The performance of their banking sectors recovered swiftly from the financial crisis and were mildly affected by the European sovereign debt crisis compared to other regions.

Norway, Sweden, and Finland to a lesser extent, represent an exception. Norwegian financial institutions were barely exposed to the American subprimes. Their resilience resulted from lessons learnt during the earlier banking crisis (1987-1993). In fact, the Financial Surveillance Authorities in Norway have surveyed and regulated banks very carefully. Overall, the Norwegian economy better withstands the recession due to its dependency to oil, for which the demand did not collapse. By the same token, Sweden and Finland are examples of countries that have been through the GFC unscathed, but without benefits from petrol revenues. Although these two countries were hardly hit by the international downturn, the solid banking system permitted to escape from a domestic financial crisis. Similarly to Norway, the Swedish and Finnish governments enacted a number of measures strengthening the banking sector, such as reforms improving the risk management.

On the other side of the spectrum, due to substantial exposures to the US market, Belgium, Ireland, Switzerland and the Netherlands registered an analogous and sharp decline of their financial ratios as soon as the crisis erupted. The top banks in Switzerland (UBS and Credit Suisse) and Belgium (Fortis and Dexia) were among the most vulnerable foreign institutions. In the Dutch and Irish economies, the low profitability is most likely attributed to a high exposure to systemic risks (Masselink and Van Den Noord, 2009). Even though the burgeoning scrutiny regarding Irish largest banks' balance sheet recorded considerable exposures in the UK, the country did not experience an immediate steep cut of its profitability indicators. Because of high exposures to the "ticking time bomb" of the housing market, the financial turmoil hit Ireland on an unprecedented scale with a

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lag of five months.

This lag effect is observed in the southern countries overall. For instance, in August 2007, Spanish financial institutions, unlike its counterparts, did not feature massive losses, nor require heavy recapitalisation. Lis and Garcia-Herrero (2013) explain that the positive profitability registered before 2011 (see Figure 2.2 (b) and Figure 2.3 (b)) results from the implementation of a dynamic provisioning system, that is the use of a cyclical capital buffer. Nevertheless, in late 2009, the *Cajas* started to face difficulties via credits granted to real-estate developers that bankrupted and via a limited access to the wholesale banking market, failing to roll over their debts. In the aftermath of the GFC, the southern European region suffered tremendously from the contagious effects issued from the disclosure on the Greek incapacity to pay back its debt. In Greece, the banking system registered its lowest profitability in 2011 and 2012, reaching a ROA at -8.5% and a ROE at -85%.

The evolution of profitability in CEE countries presents discrepancies (see Figure 2.2 (d) and Figure 2.3 (d)). This European region did not follow a similar pattern and contended drawbacks from various crises. At the beginning of the period, while Latvia, Slovakia, the Czech Republic, and Bulgaria were experiencing a boom fuelled by a surge credit growth steered by western European inflows, the Asian crisis triggered reluctant behaviours from international investors to finance emerging markets with unsound banking systems. In the early 2000s, Poland faced low profitability mainly driven by bank restructurings. The new wave of massive foreign capital investments fed competition forcing domestic banks to overhaul (Mikolajczyk and Miklaszewska, 2009). The financial crisis hit CEE bank profitability in a very disparate manner. The CEE banking sector itself was a crux channel of transmission since more than 50% of the industry is owned by Western European banks. The slowdown of the economy in the northern countries, coupled with the implementation of the new regulatory framework, coerced Western banks to restrict their lending in CEE countries. Some banking systems mitigated this severe side effect.

2.3 Presentation of the variables used for a panel sample of 445 banks

For instance, the Polish case featured a healthy banking system with profitable, liquid and capitalised domestic banks. The bank PKO BP, the largest player on the Polish banking market, performed counter-cyclical measures, such as supporting lending. Finally, we can observe that Slovenia, Bulgaria, and Hungary to a lesser extent, deeply suffered from the sovereign debt crisis.

This section pictures the miscellaneous evolution, across the group of countries under investigation, of the two financial ratios, the ROA and ROE. In a nutshell, the stylised facts presented above suggest that, despite lower NIM and disparate historical evolution of the overall profitability indicators, all banking systems in our sample are capable, over the very recent years, of diversifying their sources of profit. In other words, it seems that banks shift their traditional source of profit to alongside activities.

2.3 Presentation of the variables used for a panel sample of 445 banks

This section offers the reader a detailed description of the sample and the variables used to best exploit the question at the core of this analysis. Therefore, we first provide an overview of the sample regarding both the distribution and market shares of banks across the different countries under investigation. This is essential to ensure the representativeness of our sample in each country.

Second, this section presents the different variables used to assess the relationship between interest rates and profit, while accounting for the level of risk. To guarantee the robustness of our results, we rely on three dependant variables, namely, the ROA, the ROE, and the NIM. To control for other factors that can potentially influence the relationship, we describe in the first step the key variables grasping the level of risk and, more broadly, banks' prudential behaviour. In the second step, we provide a description of the bank and country characteristics, which are crucial to disentangle the different effects

of interest rates and prudential behaviour on bank profitability.

Finally, Table 2.2 provides a summary statistic of all the variables introduced in the model. The table exhibits very disparate features across banks and countries accounted for in our analysis.

2.3.1 Sample description

Our study focuses on 26 European countries, including countries with different monetary authorities, thus covering a variety of regimes, countries belonging to the European monetary union, exchange rate peggers, and inflation targeters. This sample allows us to study the broad effect of bank risk and low policy interest rates on European banks' profitability. More specifically, including countries with a variety of monetary policy regime allows for more variability in the empirical analysis. In other words, restricting our analysis to the Euro Area only, would not permit variations in the central bank's main tool. In this respect, we focus on countries where interest rates entered negative at different points in time and similar countries where interest rates did not go negative. Nonetheless, this requires the introduction of fixed effects over time and by country to take into account the specificity of countries, such as different monetary and economic conditions.

By contrast with the first chapter, our data set is not constrained by listed banks. That is why our data covers a more substantial number of countries. However, our data set is limited in the sense that to obtain consistent values for the Z-score, which depends on past values, we drop banks with less than ten continuous observations on the time sample. Our data covers about 445 banks²⁰ and spans from 1999 to 2015 (see Table 2.1).

As in subsection 1.4.1, Figure 2.4 provides information on the market shares of European banks in terms of total assets in each country of our sample and on average over the period 1999-2015. Unsurprisingly, our data cover a higher market share than in the first Chapter (which was around 50%). On average, our sample covers 70% of banks' total

²⁰Banks refer to commercial, holding, cooperative, saving and multi-lateral governmental banks and specialised governmental credit institutions and data are not consolidated.

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Table 2.1: Countries and number of banks included in the sample

	List of countries	# of banks	Monetary authority
1	Austria	19	ECB
2	Belgium	7	ECB
3	Bulgaria	21	Balgarska Narodna Banka
4	Croatia	7	Hrvatska Narodna Banka
5	The Czech Republic	15	Česká Národní Banka
6	Denmark	25	Nationalbanken
7	Estonia	6	ECB
8	Finland	2	ECB
9	France	15	ECB
10	Germany	34	ECB
11	Greece	7	ECB
12	Hungary	14	Magyar Nemzeti Bank
13	Ireland	2	ECB
14	Italy	32	ECB
15	Latvia	15	ECB
16	Lithuania	6	ECB
17	The Netherlands	16	ECB
18	Norway	31	Norges Bank
19	Poland	29	Narodowy Bank Polski
20	Romania	21	Banca Națională a României
21	Slovakia	15	ECB
22	Slovenia	14	ECB
23	Spain	16	ECB
24	Sweden	8	Sveriges Riksbank
25	Switzerland	33	Swiss National Bank
26	The United-Kingdom	35	Bank of England
	Total	445	

Notes: Author's elaboration.

market shares over the period considered. In addition, as in chapter 1, our representative Finnish banks have a low market share (11% of the country's total market share). As previously outlined, this low percentage is explained by the presence of Nordea Bank, a Swedish bank that holds an important market share in the Finnish banking landscape.

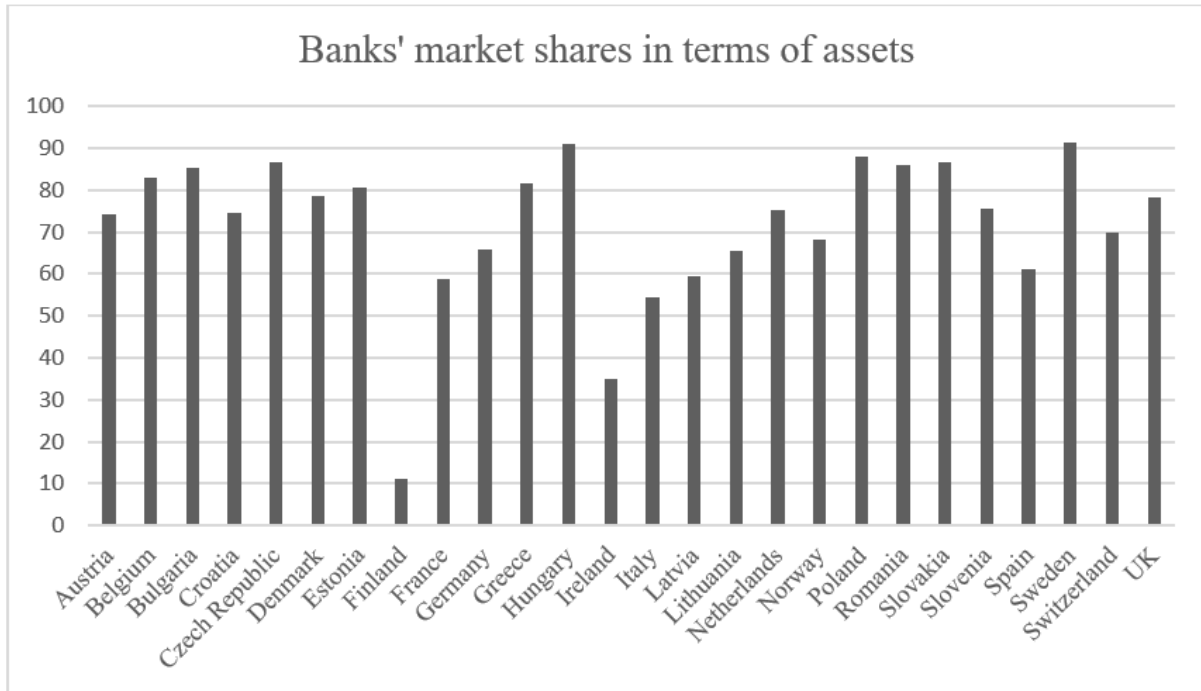


Figure 2.4: European banks' market shares in terms of total assets in each country of our sample and in average for the period 1999-2015. The figure is built from unconsolidated data. We rely on unconsolidated data as, throughout the analysis, we are interested in the banks' individual behaviour. In addition, the use of consolidated data when including several European countries may hide important information at the national level. *Source:* authors' computations based on data extracted from BankScope and Fitch Connect.

2.3.2 Bank profitability: the dependent variable

We rely on standard and reliable indicators to determine banks' profitability, that is ROA and ROE, denoted as the ratio of net profits to average total assets and the ratio of net profits to average total equity, respectively. These financial ratios have been used in many studies to proxy bank profitability (Dietrich and Wanzenried, 2011; Fayed, 2013; Jawadi et al., 2014; Boadi et al., 2016; Trad et al., 2017). Relying on two ratios also ensures robustness. To further explore the effect of low policy interest rates on banks' profitability, we include the NIM in our set of indicators (Borio et al., 2017; Claessens et al., 2017).

2.3.3 Bank prudential behaviour and policy interest rate: Key variables

As credit risk is the most critical risk banks may face (Alshatti, 2015; Gilchrist and Mojon, 2014), we decide to rely on two financial ratios which reflect the way banks manage this risk. We also consider insolvency risk directly arising from banks' risk management. Even though the literature on this issue did not give yet so much prominence to this type of risk, the GFC has shown the limits of the traditional banking system and revealed a soar in insolvency risk. Thus, given the several drawbacks highlighted in subsection 1.2.3, we consistently rely on the asymmetric Z-score, whose traditional form is the widely used accounting-based risk measure in the banking literature (Laeven and Levine, 2009; Delis et al., 2012; Ramayandi et al., 2014; Boateng and Nguyen, 2015; Trad et al., 2017, among others). It is worth recalling that the measure represents the inverse probability of insolvency, i.e., the lower the Z-score, the higher the risk, and it expresses the inability of a bank to repay its debt and financial obligation because of bankruptcy.

Two financial ratios

As it is explained and validated in Bikker and Hu (2001) and Bikker and Metzmakers (2005), higher exposure to lending activity entails lower margins when loans become riskier. An increase of credit risk directly hits profits since provisioning for expected loan losses is deducted from it. In the same vein, Gros et al. (2016) argue that a large share of non-performing loans may play an outstanding role in explaining European low bank profitability. Accordingly, the analysis aims at controlling for this bank characteristic by accounting for loan loss provisions on gross loans (LLP) and total equity on net loans (ENL)²¹. On the one hand, the ENL ratio can be seen as a forward-looking indicator of risk since it reflects policy decisions prior to the revelation of loan performance (as net loans

²¹The analysis is initially intended to include non-performing loans; however, given the low data points for non-performing loans, the model considers instead the two financial ratios cited above.

do not mirror loans quality). On the other hand, the LLP ratio is a backwards-looking indicator of risk and proxy decisions to be taken when loans turn out to be dodgy. These ratios are considered as proper financial ratios to assess banks' financial vulnerability and resilience to financial shocks (Trad et al., 2017).

The asymmetric Z-score

As explained in Chapter 1 (see subsection 1.2.1), Lapteacru (2016) demonstrates that the use of a flexible distribution to shape the distribution of banks' ROA is more appropriate than the normal distribution. Indeed, the author explains that – because it is very flexible – the stable distribution allows the best consideration of ROA distribution shapes, thus providing more consistent estimates of the Z-score. In this respect, we employ the Z-score to proxy insolvency risk as defined in Chapter 1, subsection 1.2.1.

Policy interest rate

Our analysis focuses on an observable monetary policy variable that describes the evolution of monetary policy across Europe, that is the policy interest rate (i^r) calculated as an average of retrieved monthly data. The period on which we focus – from 1999 to 2015- considers pre- and post-crisis years, allowing us to grab the full evolution of the low-interest rates environment. It is also important to mention that for countries that joined the Euro Area during the sample period²², we consider the national policy interest rate before their Euro Area accession while we consider the ECB policy interest rate after.

2.3.4 Bank and country control variables

We control for a set of both bank- and country-specific factors which are well-known to influence bank profitability.

At the bank level, We include the equity to total assets ratio (EQUITY) that controls for banks capitalisation. A high level of capital may act as a buffer in case of adverse

²²Greece (2001), Slovenia (2007), Slovakia (2009), Estonia (2011), Latvia (2014), Lithuania (2015).

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developments and may help to maintain the level of profitability during an economic slowdown (Athanasoglou et al., 2008). Moreover, since the Basel Accord may shape the level of capital as a percentage of risk-weighted assets, Iannotta et al. (2007) find that banks with a higher level of capitalisation could yield higher returns.

We introduce banks' total assets to control for banks' size (SIZE). According to the literature, bank size is expected to have a positive effect on profitability due to the economies of scale a larger bank may generate (Trujillo-Ponce, 2013; Athanasoglou et al., 2008). In their analysis, Demirgüç-Kunt and Huizinga (1999) and Borio et al. (2017) corroborate this positive relationship between bank size and profitability. However, given the period and panel sample, this effect may vary. For instance, in its Financial Stability Review, the ECB (2015) concludes on a negative relationship explaining that larger banks are more complex and costly. Furthermore, Athanasoglou et al. (2008) and Trujillo-Ponce (2013) suspect a nonlinear relationship between size and profitability, but do not find any evidence of such an effect.

The non-interest income-over-total-income ratio (DIVERSIFICATION) controls for diversification and reflects incomes generated by fees and commissions and trading activities. There is no strict consensus about the impact of diversification on profitability. Elsas et al. (2010) suggest that non-interest income yields higher returns and enhances bank profitability while the Demirgüç-Kunt and Huizinga (1999) and ECB (2015) find an opposite result. Finally, identifying three different business models via balance-sheet compositions, Roengpitya et al. (2014) deduces that bank performance varies markedly across business models and over time.

The ratio of total loans over total assets (LENDING) is essential to catch the relative lending size. An extensive loan portfolio induces higher net interest income. However, this latter is also subject to credit risk (Demirgüç-Kunt and Huizinga, 1999; ECB, 2015). Some studies find that, on average, lending has a positive effect on profit, although lending is found to be procyclical (Bikker and Metzmakers, 2005).

2.3 Presentation of the variables used for a panel sample of 445 banks

Finally, we decide to introduce a measure of concentration at the bank level (MS) computed as the market share in terms of assets of each bank divided by banks' total assets of the country where the bank belongs.

Since we are using a panel data analysis, it is necessary to control for country-specific characteristics. As such, we also include a measure of concentration, but at the country-level. Market concentration (MC) is measured by the Herfindahl-Hirschman index and controls for the banking market structure. No clear relationship has been found between market concentration and profitability. On the one hand, a high concentration is expected to increase profits because banks have greater market power and might be able to charge higher interest rates for loans and lower for deposits (Goddard et al., 2004). On the other hand, Berger (1995) and Athanasoglou et al. (2008) find a weak and negative relationship and argue that bank concentration is not overwhelming important in explaining profitability.

We include the real GDP growth (RGDPG) to control for the business cycle. This latter has a procyclical effect on the profitability via lending activity and provisioning (Demirgüç-Kunt and Huizinga, 1999; Bikker and Hu, 2001).

Finally, we introduce a variable controlling for the percentage change in average consumer price (INFLATION), which also exhibits and controls for the effect stemming from the business cycle. Most empirical studies assert that there is a positive effect of inflation on profit, but its coefficient is difficult to interpret.

2.3.5 At first glance, what does the data portrait?

Table 2.2 provides summary statistics. Data cover banks with very different profiles. First of all, the negative profitability corresponds to CEE countries (especially Bulgaria and Slovenia) where the GFC hit these countries even stronger. As expected, the country where insolvency risk is the highest, namely with the lowest Z-score, is Greece. The negative values of ENL and LLP are also associated with CEE countries. This first

2.3 Presentation of the variables used for a panel sample of 445 banks

overview of the data suggests that less cautious banks with respect to risk may be less profitable. The very high value associated with the policy interest rate observed in the table is attributed to the restrictive policy of the Romanian central bank. In 1999, the Romanian economy suffered from several bank failures and an economic slowdown, while many CEE countries experienced a period of robust growth and economic recovery. At the other side of the spectrum, the negative value of the policy interest rate mimics the recent extraordinary monetary actions undertaken by a few central banks and discussed in subsection 2.2.1.

In addition, the data show varied banking characteristics in terms of equity, size, lending, diversification and individual market concentration and disparate national banking markets when looking at concentration, real GDP growth and inflation. Note that, in line with previous results concerning the high policy interest rate, the very negative and high value of GDP growth corresponds to crisis events of the nineties in CEE transition economies and the very high and recent Irish economic boom, respectively. Again, the exceptionally high percentage change of inflation coincides with the crisis events of the nineties in Romania, while the negative one coincides with the post-crisis period when many countries have struggled with a low (even negative) inflation rate.

Data from our sample exhibits that in Europe, while NIM pursues a rapid and continued degradation, ROA and ROE heavily suffered from the GFC and recorded a sharp decline until recently. Indeed, the aggregated ROA and ROE over the entire sample have been increasing for the past few years (see Appendix D).

2.3 Presentation of the variables used for a panel sample of 445 banks

Table 2.2: Definition and descriptive statistics of the variables.

Variables	Description	Nr. of obs.	Mean (SD)	Min	Max	Source
<i>Profitability (π)</i>						
ROA	Return on Average Assets (%)	7100	0.59 (2.79)	-99.57	44.66	BankScope and Fitch Connect
ROE	Return on Average Equity (%)	7098	5.91 (31.39)	-1313.64	560	BankScope and Fitch Connect
NIM	Net Interest Margin (%)	7090	2.80 (2.64)	-16.94	48.47	BankScope and Fitch Connect
<i>Prudential behaviour (π)</i>						
$Z - score_{std}$	Z-score in logarithm estimated stable cumulative distribution function, Equation 1.1	7119	3.77 (4.02)	-0.77	1.73	BankScope, banks' annual reports and authors' computations
ENL	Equity on net loans (%)	7056	27.92 (60.13)	-522.79	984.21	BankScope and Fitch Connect
LLP	Loan loss provisions on gross loans (%)	6914	1.31 (3.22)	-66.67	55	BankScope and Fitch Connect
<i>Interest rate</i>						
i^r	Annual policy interest rate computed as an average of monthly interest rates	7537	3.53 (4.44)	-0.75	35	DataStream and central banks' annual reports
<i>Bank control (B)</i>						
EQUITY	Equity-to-total-assets ratio (%)	7190	10.37 (9.94)	-3.93	98.78	BankScope and Fitch Connect
SIZE	Size of banks, expressed as banks' total assets in thousand billions of USD	7190	0.094 (0.30)	4.58e-06	3.8	BankScope and Fitch Connect
DIVERSIFICATION	Non-interest income over total income (%)	7094	37.33 (36.10)	-1465.02	662.68	BankScope and Fitch Connect
LENDING	Total loans over total assets (%)	7104	55.84 (49.97)	-70.09	1637.98	BankScope and Fitch Connect
MARKET SHARE	Individual market power, computed as the market share in terms of assets divided by banks' total assets of each country (%)	7190	4.41 (7.79)	1.40e-3	74.94	BankScope and Fitch Connect
<i>Country control (C)</i>						
MC	Market concentration, computed with Herfindahl index	7565	0.081 (0.05)	0.02	0.41	DataStream and authors' computation
RGDPG	Real GDP growth rate (%)	7565	2.09 (3.02)	-14.81	26.28	DataStream
INFLATION	Percent change of average consumer prices	7565	2.91 (4.46)	-1.68	45.8	FMI database

Notes: This table defines our variables and reports summary statistics.

2.4 A twofold approach: Fixed effect estimator and dynamic panel estimations

This section encompasses two steps. As regards the database's structure, the first step introduces fixed effect panel estimations. The second step proposes dynamic panel estimations, a more appropriate methodology regarding the dynamic nature of bank profitability and the endogeneity issues the regression may face. Among dynamic panel regressions, we run simple regressions to examine the overall effects of policy interest rates on bank profitability while controlling for the level of bank risk. Then, we investigate whether the relationship between prudential behaviour and profitability is conditional to the level of the interest rates. Finally, while keeping variables proxying bank prudential behaviour in our regressions, we especially analyse the impact of the policy interest rates on profitability at different levels. This section also comments the obtained results.

2.4.1 Fixed effect estimator

The estimated regressions use panel data to measure banks' soundness in terms of profitability. As a first step of our empirical analysis, we run a general model using the fixed effect estimator:

$$\begin{aligned} \pi_{i,j,t} = & \alpha_0 + \alpha_1 PB_{i,j,t} + \alpha_2 i_t^r + \alpha_3 \sum_{k=0}^5 B_{i,j,t} + \alpha_4 \sum_{k=0}^3 C_{j,t} \\ & + \eta_i + \theta_t + \epsilon_{i,j,t}. \end{aligned} \quad (2.1)$$

Equation 2.1 assesses the ability of banks to generate profits ($\pi_{i,j,t}$) when accounting for the set of variables described previously. More precisely, $\pi_{i,j,t}$ is a set of financial indicators to measure bank profitability, namely ROA, ROE, and NIM, for the bank i in the country j and for the year t . In the right-hand side of the equation, we therefore introduce the two key independent variables: the policy interest rate ($i_{j,t}^r$) and the banks' prudential

2.4 A twofold approach: Fixed effect estimator and dynamic panel estimations

behaviour ($PB_{i,j,t}$). $PB_{i,j,t}$ breaks down into two types of variables, two financial ratios (ENL and LLP) and the insolvency risk ($Zscore_{std}$). We also control for bank- and country-specific characteristics (respectively, $B_{i,j,t}$ and $C_{j,t}$). η_i is the unobserved bank-specific effect, θ_t is the time (year) dummy²³ and $\epsilon_{i,j,t}$ is an error term. Although we run further robustness checks, the robustness of results is reinforced by employing the set of various financial indicators to measure bank profitability. Fixed effect estimator is an appropriate method when using panel data²⁴ since it accounts for heterogeneity across banks. Indeed, unobserved bank-specific characteristics are arbitrarily correlated with the observed explanatory variables (Baltagi, 2008).

Results are presented in Table 2.3 and Table 2.4. Turning out to the variable of primary interest, we observe that the policy interest rate is highly significant in all regressions where time fixed effect is not accounting for, indicating that relaxation of monetary policy negatively affects banks' profit. This finding corroborates the idea that banks are reluctant to lower their interest rates on deposits. However, once time fixed effects are included in the regressions (see Equation 2.1), the effect of i^r on banks' overall profit fades away, while, as expected, it remains significant for NIM. Such results are not surprising. As introduced in the first section of the Chapter, while the effect of the policy rate is expected to be positive on the NIM, its effect on overall profitability indicators is likely to be uncertain. The effect of interest rates on profit thus needs to be further investigated.

²³The joint test (*testparm* command in Stata) to see if the dummies for all years are equal to 0 rejects the null hypothesis, which suggests that the model needs to include time dummies.

²⁴The Hausman test rejects the null hypothesis, implying that the fixed effect estimation method is preferred (to the random effect estimation method).

Table 2.3: The effect of the Z-score and policy interest rates on bank profitability (*Fixed effect estimation method*)

Variables	ROA		ROE		NIM	
	(1)	(2)	(1)	(2)	(1)	(2)
$Z - score_{std}$	1.449*** (0.491)	1.419*** (0.506)	10.550 (7.122)	10.265 (7.694)	0.573** (0.380)	0.615*** (0.374)
i^r	0.059*** (0.021)	-0.016 (0.030)	0.944*** (0.231)	0.081 (0.262)	0.133*** (0.019)	0.083*** (0.374)
EQUITY	0.007 (0.022)	0.012 (0.022)	0.081 (0.104)	0.127 (0.108)	0.047*** (0.008)	0.045*** (0.374)
SIZE	-0.158 (0.105)	-0.168** (0.128)	-5.245*** (1.705)	-4.951*** (1.853)	-0.479*** (0.107)	-0.142** (0.374)
LENDING	0.001 (0.002)	0.000 (0.002)	0.009 (0.008)	0.005 (0.008)	-0.003*** (0.001)	-0.002*** (0.374)
DIVERSIFICATION	-0.001 (0.002)	-0.001 (0.002)	0.003 (0.023)	0.001 (0.023)	-0.007*** (0.003)	-0.007*** (0.374)
MS	2.794* (1.740)	1.604 (21.627)	-14.636 (20.152)	-29.227 (21.424)	4.367*** (1.124)	3.098*** (1.374)
RGDPG	0.134*** (0.010)	0.126*** (0.018)	1.733*** (0.243)	1.920*** (0.417)	0.030*** (0.007)	0.037*** (0.374)
MC	0.010 (0.017)	0.011 (0.018)	0.278 (0.252)	0.295 (0.255)	-0.028*** (0.016)	-0.031*** (0.374)
INFLATION	-0.036 (0.027)	0.008 (0.029)	-0.229 (0.295)	0.321 (0.309)	0.046** (0.030)	0.076*** (0.374)
CONST.	0.942*** (0.220)	-1.104** (0.448)	-8.830 (7.578)	-6.203 (7.813)	0.220 (0.213)	2.208 (0.374)
Total observations	6994	6994	6992	6992	6992	6992
Time fixed effects	No	Yes	No	Yes	No	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.31	0.33	0.19	0.21	0.75	0.75

Notes: Heteroscedastic robust t-statistics are in parentheses. ***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. Time (years) dummies are not reported.

Table 2.4: The effect of LLP, ENL and policy interest rates on bank profitability (*Fixed effect estimation method*)

Variables	ROA				ROE				NIM			
	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
LLP	-0.276*** (0.052)	-0.271*** (0.052)			-2.697*** (0.755)	-2.618*** (0.748)			-0.007 (0.020)	-0.009 (0.021)		
ENL			0.004 (0.005)	0.004 (0.005)			-0.011 (0.014)	-0.012 (0.014)			1.5e-4 (0.001)	-3.4e-4 (0.001)
i^r	0.054*** (0.018)	-0.008 (0.025)	0.034 (0.026)	0.043 (0.035)	0.767*** (0.249)	-0.139 (0.203)	0.787*** (0.257)	-0.162 (0.310)	0.134*** (0.019)	0.086*** (0.027)	0.124*** (0.018)	0.080*** (0.027)
EQUITY	0.032*** (0.014)	0.037*** (0.013)	0.017 (0.022)	0.024 (0.021)	0.256* (0.154)	0.309** (0.158)	0.236* (0.151)	0.290** (0.156)	0.059*** (0.009)	0.056*** (0.010)	0.055*** (0.009)	0.053*** (0.010)
SIZE	-0.194*** (0.103)	-0.209*** (0.118)	-0.199*** (0.106)	-0.271*** (0.130)	-5.830*** (1.757)	-5.153*** (1.727)	-5.583*** (1.725)	-5.324*** (1.896)	-0.477*** (0.107)	-0.129* (0.128)	-0.501*** (0.106)	-0.199*** (0.128)
LENDING	-0.001 (0.001)	-0.002 (0.001)	0.001 (0.003)	0.001 (0.003)	-0.009 (0.011)	-0.012 (0.011)	-0.001 (0.011)	-0.005 (0.011)	-0.003*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)	-0.002*** (0.001)
DIVERSIF.	0.001 (0.001)	4.9E-4 (0.001)	0.002 (0.002)	0.002 (0.002)	0.011 (0.022)	0.009 (0.022)	4.0E-4 (0.024)	-0.003 (0.024)	-0.006*** (0.003)	-0.006** (0.003)	-0.006*** (0.003)	-0.006*** (0.003)
MS	0.008 (0.014)	0.010 (0.015)	0.016 (0.017)	0.020 (0.019)	0.254 (0.253)	0.273 (0.256)	0.289 (0.255)	0.313 (0.260)	-0.028* (0.016)	-0.031*** (0.015)	-0.025*** (0.016)	-0.028*** (0.015)
RGDPG	0.077*** (0.011)	0.079*** (0.017)	0.138*** (0.011)	0.138*** (0.138)	1.213*** (0.250)	1.352*** (0.207)	1.745*** (0.247)	1.864*** (0.429)	0.030*** (0.008)	0.038*** (0.009)	0.030*** (0.007)	0.039*** (0.009)
MC	2.230** (1.354)	1.244 (1.337)	3.128* (1.725)	2.153 (1.667)	-14.174 (20.816)	-30.217 (20.860)	-20.627 (21.321)	-35.643* (22.513)	3.905*** (1.154)	2.638*** (1.095)	3.940*** (1.097)	2.867*** (1.064)
CPI	-0.002 (0.018)	0.033** (0.019)	-0.017 (0.031)	0.025 (0.033)	0.149 (0.358)	0.690** (0.391)	-0.135 (0.313)	0.444 (0.337)	0.055* (0.030)	0.086*** (0.030)	0.052**** (0.029)	0.080*** (0.030)
CONS.	-0.533** (0.257)	-0.135 (0.298)	-0.738*** (0.268)	-0.592* (0.330)	-1.173 (2.150)	1.369 (3.157)	-2.988 (2.153)	-2.766 (3.416)	0.451*** (0.153)	1.226*** (0.212)	0.521**** (0.157)	1.221*** (0.205)
Total observations	6865	6865	7000	7000	6863	6863	6998	6998	6863	6863	6998	6998
Time fixed effects	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.41	0.421	0.27	0.29	0.24	0.26	0.19	0.21	0.76	0.76	0.77	0.78

Notes: Heteroscedastic robust t-statistics are in parentheses. ***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. Time (years) dummies are not reported.

2.4 A twofold approach: Fixed effect estimator and dynamic panel estimations

Furthermore, more resilient banks likely increase their overall profits. In Table 2.3, the Z-score indicates that a lower insolvency risk instils confidence in the banking sector and increases profits, which is mainly confirmed by ROA. Coefficients associated with ROE lack robustness. In line with Boadi et al. (2016), this result backs that stability in the banking sector promotes bank profitability. In the end, banks' prudential behaviour does not seem to affect NIM since outcomes indicate weak significance (i.e., for the Z-score) or non-significant coefficients (i.e., for LLP and ENL in Table 2.4). The results associated with LLP in Table 2.4 are in line with expectations and literature (Bikker and Hu, 2001; Alhadab and Alsahawneh, 2016; Mustafa et al., 2012). In some detail, 1% increase of LLP is associated with about 0.270 percentage point of decrease in the ROA. As profit is calculated by deducing credit loss provisions from net profits, an outstanding share of loan loss provisions necessarily diminishes overall bank profitability. Also, the effect is stronger on ROE because it does not take into account the higher risk associated with high bank leverage and the potential impact of leverage regulation (Dietrich and Wanzenried, 2011). ROE seems also more sensitive than the ROA to prudential behaviour indicators since shareholders may pay greater attention to default risk. Nevertheless, ENL does not provide evidence that higher capital and/or a cut in net loans are costly for European banks when inspecting all profit indicators.

When we look at the control variables at the bank level, we notice that they are mainly significant for the NIM. In particular, other things being equal, a higher share of equity and a larger market share have a positive effect on the NIM. Conversely, SIZE, LENDING and DIVERSIFICATION exhibit a negative relationship with the NIM. However, when looking at the overall profitability, only SIZE has a significant negative impact.

Country-level variables indicate that an increase in the real GDP growth leads to an improvement in both the NIM and the overall bank profitability. The effect of MC is ambiguous as the sign of the relationship varies according to the employed dependent variable. Finally, in line with many studies, our results present a positive relationship

between inflation and profit.

In order to further validate our first results, we deepen our research question by applying a different methodology. Even though the OLS estimation may be suitable regarding the structure of the panel data set, a dynamic panel estimation is more appropriate to account for the dynamic nature of profit and to sort out the endogeneity problem the regression may encounter.

2.4.2 Bank profitability persistence: Dynamic panel estimations

Bank profitability is most likely characterised by a dynamic behaviour. Unlike the previous estimator, the methodology described thereafter accounts for this feature. Nevertheless, assessing a dynamic relationship requires taking precaution with regard to three endogeneity issues: the inclusion of the lagged dependent variable as a regressor, the potential reverse causality and omitted variable bias. While the first is inherent in the choice of the estimation, the second and third questions of endogeneity are specific to the model we want to apply. Against this background, the GMM defined by the Arellano and Bover (1995) and Blundell and Bond (1998) estimators resolve those issues.

Therefore, these estimators allow us to evaluate several effects on profitability. In a first model, we investigate the overall effect of both bank's prudential behaviour and policy interest rates on bank profit. Then, in a second model, we further exploit whether the relationship between the prudential behaviour and profit is conditional to a certain level of interest rates. More importantly, in a last model, we scrutinise the effect of the policy interest rates at different levels.

The section thus presents the results issued from the three models and the three dependent variables denoting bank profitability. It is worth stressing that the results associated with prudential behaviour indicators are in line with the previous findings assessing with fixed estimators. Furthermore, although the first outcome indicates that a loosening of monetary policy is more likely to harm bank profitability, the in-depth

exploration of the effect of policy interest rates at various levels displays more interesting conclusions regarding banks' behaviour in a low-interest rate environment.

2.4.2.1 Methodology

The empirical literature strongly suggests considering the dynamic nature of bank profitability in the estimations (i.e., the lagged dependent variable is treated as an explanatory variable). Indeed, many authors (Athanasoglou et al., 2008; Berger et al., 2009; Dietrich and Wanzenried, 2011; Hoffmann, 2011, among others) support that bank profitability tends to persist over time. Thus, in the first step, we adopt the following estimation²⁵:

$$\begin{aligned} \pi_{i,j,t} = & \alpha_0 + \alpha_1 \pi_{i,j,t-1} + \alpha_2 PB_{i,j,t} + \alpha_3 i_{j,t}^r + \alpha_4 \sum_{k=0}^5 B_{i,j,t} \\ & + \alpha_5 \sum_{k=0}^3 C_{j,t} + \theta_t + \epsilon_{i,j,t}, \end{aligned} \tag{2.2}$$

where the coefficient α_1 captures the level of persistence of bank profitability. If α_1 is between 0 and 1, profits display persistence. In other words, profit will more slowly return to its average level. Furthermore, if α_1 is close to zero, the speed of adjustment is high, and persistence is low. By contrast, if this coefficient is close to 1, the speed of adjustment is sluggish, and the persistence is important.

The dynamic panel bias resulting from the correlation between the lagged dependent variable and the error term makes the fixed effect estimations inconsistent. Besides, Equation 2.2 might face other endogeneity issues caused by potential reverse causality regarding some bank profitability determinants and/or by omitted variable bias. Bikker and Metzmakers (2005), Hoffmann (2011) and Trujillo-Ponce (2013) argue that a loop of causality exists between bank characteristics and profitability. García-Herrero et al. (2009) show that more profitable banks are more likely to increase their level of equity

²⁵One may note that only time fixed effects are included in the estimations. For estimation purposes and as explained in Roodman (2009), the system GMM transforms the model into first differences, thus removing these fixed effects.

2.4 A twofold approach: Fixed effect estimator and dynamic panel estimations

by transforming a part of their profit into reserves. Also, the more profitable banks tend to have more resources for advertising, which in turn has a positive effect on their size. Since our sample includes many advanced countries, whose economy have been markedly affected by the GFC, particular attention might be addressed to another potential reverse causality between bank profitability and the policy interest rate. Policymakers could have tried to contain the crisis through cuts in interest rates by looking beforehand at – among other things – indicators of bank soundness (Claessens et al., 2017). Consequently, all bank characteristics, bank risk measures and the policy interest rate are treated as endogenous variables in our regressions. As the inverse causality between country-specific variables and profitability is less evident in the literature or considered marginal (and especially with the NIM), all macroeconomic variables are treated as exogenous.

Given all these arguments, we decide to apply the GMM using the Arellano and Bover (1995) and Blundell and Bond (1998) estimators. The difference GMM method transforms exogenous regressors in first differences which are instrumented by themselves, while endogenous variables (also transformed in first differences) are instrumented by their own lags in level, allowing to solve the endogeneity problems. However, Arellano and Bover (1995) explain that regressors in level can be weak instruments for first-differences equations. As such, the authors have shown that difference GMM can be improved by relying on system GMM. The latter completes first-differences equations with equations in level. Lagged levels of endogenous regressors and lags of first-differenced regressors are respectively used as instruments for difference and level equations. To test for the validity of our instruments, we build our decision on the Hansen test which, according to Roodman (2009) and Kripfganz (2017), is more appropriate than the Sargan test when relying on a system GMM²⁶. Moreover, we use the robust and two-step estimator, which allows to make “the Windmeijer (2005) finite-sample correction to the reported standard errors in two-step estimation, without which those standard errors tend to be severely

²⁶Building our decision on the Sargan test would imply that we assume a strong hypothesis of homoscedasticity and absence of serial correlation in the error term.

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downward biased" (Roodman, 2009, p.1).

In a second step, we investigate whether the relationship between prudential behaviour and profitability is conditional to the level of the interest rates. Therefore, we include an interaction term between prudential behaviour and interest rates:

$$\begin{aligned} \pi_{i,j,t} = & \alpha_0 + \alpha_1\pi_{i,j,t-1} + \alpha_2PB_{i,j,t} + \alpha_3i_{j,t}^r + \alpha_4i_{j,t}^r * PB_{i,j,t} \\ & + \alpha_5 \sum_{k=0}^5 B_{i,j,t} + \alpha_6 \sum_{k=0}^3 C_{j,t} + \theta_t + \epsilon_{i,j,t}. \end{aligned} \quad (2.3)$$

Lastly, we specifically explore the effect of the policy interest rate on profitability under different regimes. In the same vein as Borio and Hofmann (2017), who include a dummy variable when interest rates are low, we create four dummy variables. For instance, the first dummy variable, Q_1 , takes the value of 1 when the value of the policy interest rate is in the first quartile of the country-by-country distribution. Hence, we integrate four interaction terms between i^r and a dummy Q_l , where $l = [1, \dots, 4]$. Therefore, the estimation becomes:

$$\begin{aligned} \pi_{i,j,t} = & \alpha_0 + \alpha_1\pi_{i,j,t-1} + \alpha_2PB_{i,j,t} + \alpha_3i_{j,t}^r + \alpha_4i_{j,t}^r * Q_l \\ & + \alpha_5B_{i,j,t} + \alpha_6C_{j,t} + \theta_t + \epsilon_{i,k,t}. \end{aligned} \quad (2.4)$$

2.4.2.2 Policy interest rates, prudential behaviour and profit

Table 2.5 presents the results for Equation 2.2. The estimations catch the persistence of bank profit. The dynamic panel estimations show that a loosening of monetary policy through a decrease in the policy interest rate hits profitability. This result remains significant when accounting for the lag of the dependent variable and including time dummies in the regressions. Claessens et al. (2017) explain that European banks still have a low share of non-interest income in their revenues. However, in the face of lower profits, banks have increased fees such as management costs.

Table 2.5: The effects of policy interest rates and prudential behaviour on profitability (*Dynamic panel estimation method*)

Variables	ROA			ROE			NIM		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
π_{t-1}	0.636*** (0.109)	0.194*** (0.059)	0.519*** (0.104)	0.472*** (0.106)	0.360*** (0.117)	0.481*** (0.158)	0.636*** (0.055)	0.713*** (0.078)	0.623*** (0.076)
$Z - score_{std}$	2.188* (1.279)			42.719*** (17.668)			-0.408 (0.517)		
LLP		-0.217** (0.114)			-3.093*** (1.191)			-0.035 (0.059)	
ENL			0.002 (0.002)			0.004 (0.022)			-5.22e-4 (0.001)
i^r	0.056** (0.025)	0.102*** (0.037)	0.072*** (0.028)	0.651** (0.296)	0.692** (0.378)	0.885*** (0.345)	0.131*** (0.030)	0.141*** (0.039)	0.128*** (0.032)
EQUITY	0.025 (0.026)	-0.039 (0.035)	-0.045 (0.036)	-0.574** (0.265)	-0.037 (0.316)	-0.289 (0.295)	-0.006 (0.016)	0.035* (0.021)	-2.42e-4 (0.019)
SIZE	-0.391* (0.243)	0.188 (0.353)	0.275 (0.272)	-8.402*** (2.997)	-3.019 (2.733)	-3.833 (4.643)	-0.138 (0.366)	-0.379 (0.330)	-0.115 (0.296)
LENDING	-0.009*** (0.002)	0.003 (0.002)	9.78e-7 (0.002)	-0.021 (0.033)	-0.048** (0.023)	-0.024 (0.030)	8.00e-4 (0.001)	-0.002 (0.001)	9.56e-5 (0.001)
DIVERSIFICATION	0.008*** (0.002)	-0.010 (0.013)	-0.011 (0.016)	0.319*** (0.095)	0.213*** (0.082)	0.306*** (0.102)	-0.014** (0.007)	-0.005 (0.006)	-0.013** (0.007)
MS	0.044 (0.033)	-0.032 (0.045)	-0.051 (0.038)	0.482 (0.417)	0.033 (0.349)	0.170 (0.693)	-0.009** (0.031)	0.036 (0.040)	-0.014 (0.036)
RGDPG	0.071*** (0.009)	0.073*** (0.013)	0.095*** (0.010)	0.848*** (0.102)	0.426*** (0.372)	0.795*** (0.120)	0.046*** (0.008)	0.024* (0.013)	0.042*** (0.009)
MC	-1.696 (1.627)	0.037 (0.026)	0.028 (0.025)	6.398 (19.473)	0.187 (0.227)	-0.040 (0.255)	2.920** (1.339)	0.001 (0.014)	0.034** (0.017)
INFLATION	-0.071*** (0.023)	-0.065* (0.035)	-0.085*** (0.027)	-0.282 (0.271)	-0.160 (0.388)	-0.480** (0.255)	-0.049** (0.023)	-0.064*** (0.024)	-0.046* (0.026)
CONST.	-1.658** (0.915)	0.754 (0.643)	0.753 (0.651)	-38.557*** (13.553)	-0.731 (2.900)	-1.748 (3.660)			
Total observations	6573	6458	6577	6570	6455	6574	6568	6453	6572
Nr. of instruments	68	52	52	84	44	92	59	43	51
AR(1) (p-value)	0.000	0.000	0.000	0.037	0.040	0.036	0.000	0.000	0.000
AR(2) (p-value)	0.303	0.375	0.473	0.425	0.473	0.420	0.922	0.835	0.946
Hansen test (p-value)	0.482	0.370	0.392	0.603	0.780	0.589	0.420	0.596	0.396

Notes: Heteroscedastic robust t-statistics are in parentheses. ***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. AR(1) and AR(2) are the tests for first and second-order autocorrelation and Hansen is the test for over-identifying restrictions. The results associated with tests of exogeneity of instruments are not reported but validate our instruments. Time (years) dummies are not reported and dropped from regressions when they do not bring any additional information. Note that the constant in the estimations may disappear because of time fixed effects. The command “collapse” is used to limit the number of instruments.

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In line with (Claessens et al., 2017), it seems that a weaker NIM has a tremendous negative impact on the overall profitability of banks, but the increase of bank fees as well as valuation gains in securities held by banks may mitigate this adverse effect and explain the lower impact on ROA. A breakdown in the financial leverage might explain the fact that the ROE shrinks much more after a fall in policy interest rates.

The results regarding prudential behaviour indicators are similar to those obtained with fixed effect panel estimations. The Z-score and LLP display that more cautious banks are associated with higher overall profits (i.e., ROA and ROE). In line with our previous results, banks' financial resilience does not affect NIM.

Bank characteristics have various effects. The effect of EQUITY is ambiguous according to the measure of profitability and lacks significance. Our results for SIZE are similar to Martynova et al. (2015), who indicate that big and high profitable banks took greater risk through substantial exposures to market risk. Thus, when the crisis erupted these same banks registered essential losses. LENDING has a relatively slight and negative effect on ROA. Finally, a greater DIVERSIFICATION is likely to enhance the overall profitability but reduces NIM since higher diversification corresponds to an increase of non-interest income. MS is only significant for NIM but has a slightly negative impact.

Country control variables present consistent results. A vigorous GDP growth improves profit. INFLATION turns now to be negatively related to bank profitability. Lastly, MC displays a positive relationship between bank concentration and NIM. That is, the higher the concentration on the banking sector, the greater the net interest income is. A large market share allows financial institutions to charge a higher interest rate.

2.4.2.3 Prudential behaviour and profit: A relationship conditional upon the level of interest rate

In this section, we examine whether the relationship between prudential behaviour and profitability is conditional to the policy interest rates. Table 2.6 presents the outcome of

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Equation 2.3. The coefficients associated with i^r and PB take a different meaning when we introduce interaction terms. For instance, the sole coefficient associated to PB (α_2 in Equation 2.3) would be now interpreted as the unique effect of the prudential behaviour indicators on profitability when $i^r = 0$. The inclusion of the interaction terms changes these coefficients and provides two main pieces of information: one is related to the sign of the interaction term and the other is related to the overall effect of the variables that were used to compute the interaction terms.

The significance of interaction terms means that the effect of prudential behaviour on profitability depends on the values of the policy interest rate. In particular, our results reveal that the interaction terms are negative and significant for the Z-score. This indicates that the positive effect of the Z-score on the profitability is less strong when the policy interest increases. In the same vein, the negative effect of LLP and ENL on the NIM is less strong when the policy interest increases. The interaction terms associated with LLP and ENL lack of statistical significance for ROA and ROE.

We have also computed the overall impact of i^r and PB in Table 2.6. With regard to the overall effect of prudential behaviour, conclusions remain unchanged: the coefficients associated with the Z-score is still positive, indicating that the lower the insolvency risk, the higher the profit; the negative coefficients associated with LLP reflect a detrimental effect on profitability; and the coefficients associated with ENL lack statistical significance. The overall effect of the policy interest rate is positive and significant for the regressions (2) and (3). In short, less cautious banks in terms of risk are less profitable, and a lower policy interest rate harms banks' soundness in terms of return. However, for the Z-score (1), we observe that the total effect of i^r reverses and becomes harmful for the overall profitability (i.e., ROA and ROE) when controlling for the interaction between prudential behaviour and the monetary policy instrument. The next section, with the decomposition of the policy interest rate into four regimes, may shed light on this interesting result.

Table 2.6: The effects of policy interest rates and prudential behaviour on profitability

Variables	ROA			ROE			NIM		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
π_{t-1}	0.385*** (0.132)	0.214*** (0.063)	0.345*** (0.075)	0.498*** (0.172)	0.367*** (0.100)	0.329*** (0.140)	0.626*** (0.079)	0.615*** (0.079)	0.563*** (0.078)
$Z - score_{std}$	5.626*** (1.930)			94.450*** (38.504)			0.819 (0.719)		
LLP		-0.179** (0.092)			-2.703** (1.309)			-0.093** (0.046)	
ENL			-0.001 (0.004)			-0.037 (0.044)			-0.001 (0.003)
i^r	0.841** (0.391)	0.087*** (0.028)	0.140*** (0.045)	13.173* (7.443)	1.764*** (0.659)	0.764** (0.375)	0.337*** (0.116)	0.140*** (0.053)	0.129*** (0.046)
$i^r * PB$	-1.172** (0.548)	0.007 (0.007)	-9.4e-5 (7.48e-4)	-18.419** (10.006)	0.087* (0.056)	0.013 (0.012)	-0.254* (0.144)	0.037** (0.020)	-6.87e-4* (4.08e-4)
EQUITY	0.012 (0.034)	-0.048 (0.031)	0.005 (0.042)	-0.369 (0.338)	-0.502*** (0.209)	-0.629*** (0.198)	0.029* (0.016)	-0.616 (0.418)	0.071 (0.053)
SIZE	-0.386 (0.304)	0.230 (0.338)	0.109 (0.562)	-8.429* (4.921)	-9.691*** (4.111)	-2.892 (4.246)	-0.207 (0.200)	0.022 (0.364)	0.002 (0.452)
LENDING	-0.001 (0.003)	0.004** (0.002)	-0.003 (0.004)	0.007 (0.035)	0.028** (0.014)	0.003 (0.038)	-0.001 (0.001)	0.001 (0.001)	-0.004 (0.003)
DIVERSIFICATION	-0.013 (0.015)	-0.012 (0.009)	-0.022 (0.017)	0.226 (0.153)	0.283 (0.148)	0.313*** (0.092)	-0.011* (0.006)	-0.005 (0.006)	-0.012 (0.011)
MS	0.037 (0.034)	-0.036 (0.041)	-0.017 (0.073)	0.755 (0.569)	1.075 (0.495)	-0.138 (0.633)	0.017 (0.025)	-0.043 (0.047)	-0.013 (0.065)
RGDPG	0.108*** (0.016)	0.082*** (0.013)	0.096*** (0.014)	1.323*** (0.253)	0.774*** (0.197)	1.030*** (0.143)	0.029*** (0.008)	0.058*** (0.018)	0.032*** (0.013)
MC	-0.0149 (0.020)	0.041* (0.026)	0.016 (0.043)	0.238 (0.221)	-0.038 (0.248)	0.143 (0.210)	1.519 (1.128)	0.059** (0.026)	0.010 (0.040)
INFLATION	0.008 (0.029)	-0.079*** (0.027)	-0.128*** (0.052)	0.653 (0.511)	-1.488** (0.722)	-0.821** (0.367)	-0.050** (0.021)	-0.141** (0.073)	-0.002 (0.041)
CONST.	-3.602** (1.612)	0.824* (0.488)	1.054 (0.660)	-38.557*** (13.553)	18.346* (10.747)	-1.748 (3.660)	0.124 (0.380)	0.514 (0.364)	0.826** (0.401)
Total effect of i^r	-0.330**	0.094***	0.140***	-5.245**	1.851***	0.778**	0.083*	0.178***	0.128***
Total effect of PB	4.454***	-0.172**	-0.001	76.031***	-2.615**	-0.024	0.565	-0.055*	-0.002
Total observations	6573	6458	6577	6570	6577	6574	6568	6453	6572
Nr. of instruments	82	76	31	37	21	112	73	46	37
AR(1) (p-value)	0.000	0.000	0.000	0.050	0.000	0.036	0.001	0.001	0.001
AR(2) (p-value)	0.390	0.354	0.438	0.449	0.669	0.729	0.898	0.851	0.943
Hansen test (p-value)	0.747	0.360	0.288	0.347	0.433	0.378	0.274	0.289	0.231

Notes: Heteroscedastic robust t-statistics are in parentheses. ***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. AR(1) and AR(2) are the tests for first and second-order autocorrelation and Hansen is the test for over-identifying restrictions. The results associated to tests of exogeneity of instruments are not reported but validate our instruments. Time (years) dummies are not reported and dropped from regressions when they do not bring any additional information. Note that the constant in the estimations may disappear because of time fixed effects. The lines reporting the total effect of i^r and PB are computed by summing the coefficients respectively associated with i^r and $i^r * PB$ and PB and $i^r * PB$. The command “collapse” is used to limit the number of instruments.

2.4.2.4 The effect of policy interest rate on profit under different monetary policy regimes

Finally, we investigate whether the policy interest rate at different levels has a variable effect on profitability. This methodology is also able to catch potential thresholds. We thus compute a country-by-country quartile distribution for i^r and include four dummy variables to control for different policy interest rate regimes. Results are summarised in Table 2.7, Table 2.8 and Table 2.9, respectively for the Z-score, LLP and ENL.

First of all, the effect of all prudential behaviour indicators – when significant – have the expected signs: the less cautious the bank, the lower the profitability. Moreover, ENL becomes significant when looking into overall profitability, providing evidence that capital requirement is marginally costly for European banks. Although a rise in equity impairs the overall profitability and especially ROE, the effect is rather low and not often significant in our regressions. This effect may also be explained by the recent strengthening in banking regulation which compels banks to expand their equity level. We also notice that the effect of ENL – as the Z-score and LLP – on NIM is insignificant.

Focusing on the effect of the policy interest rate at different monetary policy regimes reveals interesting results. When policy interest rates are particularly low (Q1), the effect of i^r becomes negatively correlated with both ROA and ROE (the sign reverses and becomes strong and positive when turning to the higher regime Q2). Although the results for NIM are expected, because low policy interest rates directly affect bank profit margin by compressing it, the effect of low policy interest rates on overall profitability becomes less obvious when i^r is in the first quartile of the country-by-country distribution. Controlling for the periods when policy interest rates are low shows that banks succeed in increasing overall profitability despite a reduction of their net interest income (this is in line with the recent evolution of ROA and ROE, see Appendix D).

Table 2.7: Profitability, Z-score and policy interest rate regimes

Variables	ROA				ROE				NIM			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
π_{t-1}	0.350* (0.217)	0.501*** (0.122)	0.465*** (0.137)	0.600*** (0.108)	0.235*** (0.217)	0.508*** (0.102)	0.586*** (0.099)	0.627*** (0.081)	0.713*** (0.087)	0.567*** (0.108)	0.640*** (0.045)	0.616*** (0.065)
$Z - score_{std}$	3.673* (2.392)	2.529* (1.458)	3.037** (1.620)	2.426** (1.210)	-35.490 (28.185)	37.768*** (14.989)	43.284** (18.781)	53.016*** (16.766)	0.127 (0.860)	-0.374 (0.833)	-0.197 (0.587)	-0.556 (0.515)
i^r	0.014 (0.040)	0.044 (0.036)	-0.062 (0.052)	0.115** (0.051)	-2.605*** (0.830)	0.603** (0.280)	-0.269 (0.603)	0.825*** (0.302)	0.235*** (0.217)	0.171*** (0.064)	0.104*** (0.030)	0.135*** (0.030)
$i^r * Q_i$	-0.460*** (0.187)	0.058* (0.034)	0.020 (0.023)	-0.040 (0.027)	-1.487** (0.808)	0.189 (0.230)	0.582** (0.287)	0.148 (0.234)	0.160*** (0.053)	0.031 (0.037)	0.022* (0.014)	0.022 (0.017)
EQUITY	-0.035 (0.062)	-4.82e-4 (0.024)	0.024 (0.032)	0.028* (0.016)	0.143 (0.208)	-0.506** (0.243)	-0.541* (0.323)	-0.231 (0.170)	0.042** (0.018)	0.063*** (0.022)	-0.002 (0.015)	0.004 (0.017)
SIZE	-0.343 (0.488)	-0.180 (0.194)	-0.205 (0.324)	-0.051 (0.211)	-16.466*** (4.100)	-6.692*** (2.719)	-8.157*** (3.377)	-5.293 (3.584)	-2.81e-8 (4.02e-7)	8.17e-9 (3.73e-7)	-1.86e-7 (2.38e-7)	-3.34e-8 (2.57e-7)
LENDING	7.15e-5 (0.004)	-0.001 (0.001)	-0.008*** (0.002)	-0.003** (0.001)	-0.015 (0.027)	-0.021 (0.031)	-0.016 (0.034)	-0.003 (0.022)	-0.002 (0.002)	-0.002 (0.002)	1.74e-4 (0.001)	3.17e-4 (0.001)
DIVERSIFICATION	0.011 (0.018)	0.006 (0.010)	0.008 (0.007)	0.003 (0.011)	-0.524 (0.279)	0.291*** (0.079)	0.255* (0.157)	0.049 (0.056)	-0.010 (0.007)	-0.017** (0.009)	-0.009* (0.006)	-0.017** (0.007)
MS	3.72e-4 (0.066)	0.020 (0.030)	0.006 (0.046)	0.016 (0.030)	2.044*** (0.524)	0.375 (0.349)	0.611 (0.503)	0.532 (0.472)	0.012 (0.050)	0.007 (0.042)	-8.63e-4 (0.028)	-0.018 (0.032)
RGDPG	0.096*** (0.016)	0.075*** (0.009)	0.094*** (0.017)	0.067*** (0.008)	1.694*** (0.304)	0.851*** (0.105)	1.014*** (0.136)	0.830*** (0.116)	0.018*** (0.005)	0.019*** (0.005)	0.046*** (0.008)	0.043*** (0.009)
MC	0.024 (0.039)	0.529 (1.376)	-0.002 (0.018)	-0.652 (1.286)	-1.009*** (0.318)	0.075 (0.176)	-0.063 (0.243)	-0.123 (0.171)	-0.001 (0.022)	0.395 (2.126)	0.024** (0.011)	0.023* (0.012)
INFLATION	-0.032 (0.035)	-0.317 (0.284)	0.021 (0.034)	-0.085*** (0.029)	1.720*** (0.626)	-0.317 (0.284)	0.142 (0.485)	-0.731*** (0.329)	-0.102*** (0.035)	-0.081* (0.044)	-0.028 (0.022)	-0.028 (0.020)
CONST.	-2.679 (2.091)	-2.105* (1.212)	0.124 (0.380)	-2.054** (1.038)	0.350* (0.217)	-34.586*** (11.622)	-37.319** (16.082)	-40.995*** (13.340)	0.340 (0.916)	1.097 (0.954)	0.586*** (0.099)	0.340 (0.916)
Total effect of i^r	-0.446**	0.102*	-0.042	0.074***	-4.093***	0.792**	0.312	0.973***	0.283**	0.203***	0.126***	0.112***
Total observations	6573	6573	6573	6573	6570	6570	6570	6570	6568	6568	6568	6568
Nr. of instruments	40	76	82	76	37	76	40	49	22	22	64	64
AR(1) (p-value)	0.008	0.000	0.000	0.000	0.012	0.039	0.044	0.051	0.000	0.000	0.000	0.001
AR(2) (p-value)	0.798	0.431	0.437	0.279	0.312	0.386	0.325	0.252	0.945	0.772	0.953	0.730
Hansen test (p-value)	0.836	0.216	0.415	0.225	0.397	0.152	0.154	0.216	0.783	0.664	0.347	0.371

Notes: Heteroscedastic robust t-statistics are in parentheses. ***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. AR(1) and AR(2) are the tests for first and second-order autocorrelation and Hansen is the test for over-identifying restrictions. The results associated with tests of exogeneity of instruments are not reported but validate our instruments. Time (years) dummies are not reported and dropped from regressions when they do not bring any additional information. The line reporting the total effect of i^r is computed by summing the coefficients associated to i^r and $i^r * Q_i$. The command “collapse” is used to limit the number of instruments.

Table 2.8: Profitability, LLP and policy interest rate regimes

Variables	ROA				ROE				NIM			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
π_{t-1}	0.170*** (0.057)	0.164*** (0.064)	0.426*** (0.105)	0.163*** (0.065)	0.208*** (0.028)	0.245 (0.195)	0.225 (0.188)	0.353*** (0.126)	0.687*** (0.085)	0.554*** (0.114)	0.658*** (0.055)	0.615*** (0.074)
LLP	0.200* (0.120)	0.262* (0.148)	-0.249** (0.122)	-0.210* (0.129)	-1.892** (0.899)	-3.059** (1.373)	-3.129*** (1.094)	-3.201*** (1.209)	0.014 (0.095)	0.032 (0.084)	0.046 (0.069)	0.045 (0.064)
i^r	0.079*** (0.033)	0.115*** (0.045)	0.049** (0.025)	0.115** (0.051)	1.258** (0.561)	1.087*** (0.352)	-0.269 (0.603)	1.101** (0.547)	0.172*** (0.066)	0.135** (0.066)	0.159** (0.074)	0.207*** (0.075)
$i^r * Q_i$	-0.299*** (0.085)	0.128*** (0.047)	0.010 (0.015)	-0.015 (0.035)	-4.425*** (1.049)	0.430** (0.218)	0.582** (0.287)	-0.361 (0.349)	0.073 (0.109)	0.089** (0.044)	0.002 (0.031)	-0.068 (0.062)
EQUITY	-0.057 (0.042)	-4.82e-4 (0.024)	-0.043 (0.042)	-0.044 (0.038)	-0.324 (0.210)	-0.435* (0.267)	-0.292 (0.262)	-0.098 (0.298)	0.043 (0.031)	0.054* (0.028)	-0.006 (0.026)	-0.011 (0.022)
SIZE	-2.36e-7 (6.67e-7)	1.01e-7 (6.52e-7)	4.22e-7 (2.77e-7)	-1.07e-7 (6.18e-7)	-1.3e-4*** (4.07e-6)	-5.45e-6* (3.40e-6)	-9.8e06*** (3.74e-6)	-2.47e-6 (3.15e-6)	-1.86e-7 (3.68e-7)	-1.16e-7 (3.20e-7)	3.85e-7 (2.93e-7)	4.23e-7* (2.66e-7)
LENDING	0.001 (0.002)	0.003 (0.002)	0.027 (0.018)	0.002 (0.002)	0.017 (0.014)	-0.021 (0.019)	-0.016 (0.034)	-0.041** (0.020)	-0.003 (0.002)	-0.003 (0.002)	0.001 (0.001)	0.002* (0.001)
DIVERSIFICATION	-0.010 (0.009)	-0.014 (0.010)	-0.002 (0.012)	-0.022* (0.013)	0.301** (0.142)	0.298*** (0.063)	0.332*** (0.068)	0.261*** (0.069)	-0.007 (0.006)	-0.007 (0.006)	-0.025** (0.011)	-0.026** (0.012)
MS	0.003 (0.079)	-0.029 (0.074)	-0.076* (0.043)	-0.114 (0.419)	1.462*** (0.492)	0.283 (0.411)	0.767* (0.434)	0.532 (0.472)	0.018 (0.044)	0.003 (0.041)	-0.060 (0.044)	-0.069** (0.038)
RGDPG	0.076*** (0.016)	0.073*** (0.020)	0.060*** (0.018)	0.078*** (0.018)	0.887*** (0.179)	0.460*** (0.170)	0.422*** (0.167)	0.413*** (0.157)	0.026 (0.019)	0.037*** (0.015)	0.056*** (0.012)	0.059*** (0.012)
MC	0.022 (0.036)	0.044 (0.042)	0.068* (0.039)	0.031 (0.037)	-0.268 (0.253)	0.149 (0.225)	-0.027 (0.231)	-0.123 (0.171)	0.002 (0.020)	0.003 (0.021)	0.039* (0.023)	0.041** (0.020)
INFLATION	-0.056* (0.031)	-0.070* (0.040)	-0.043 (0.033)	-0.100*** (0.042)	-0.937* (0.577)	-0.258 (0.276)	-0.129 (0.282)	-0.289 (0.317)	-0.092*** (0.038)	-0.030 (0.038)	-0.066 (0.049)	-0.043 (0.043)
CONST.	-0.945** (0.443)	1.011** (0.512)	0.659 (0.560)	1.288** (0.526)	15.621*** (5.554)	-2.447 (2.955)	-4.474* (2.432)	1.083** (0.509)	0.340 (0.916)	1.097 (0.954)	0.817** (0.418)	0.340 (0.916)
Total effect of i^r	-0.220***	0.243***	0.060**	0.134***	-3.166***	1.518***	0.803**	0.740**	0.245*	0.224***	0.162***	0.138**
Total observations	6458	6458	6458	6458	6455	6455	6455	6570	6453	6453	6453	6453
Nr. of instruments	40	40	58	40	22	94	94	49	37	37	37	37
AR(1) (p-value)	0.000	0.000	0.000	0.000	0.019	0.066	0.058	0.046	0.000	0.000	0.006	0.008
AR(2) (p-value)	0.395	0.482	0.202	0.311	0.781	0.989	0.325	0.518	0.906	0.929	0.471	0.399
Hansen test (p-value)	0.324	0.338	0.378	0.287	0.819	0.432	0.288	0.291	0.180	0.128	0.177	0.165

Notes: Heteroscedastic robust t-statistics are in parentheses. ***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. AR(1) and AR(2) are the tests for first and second-order autocorrelation and Hansen is the test for over-identifying restrictions. The results associated with tests of exogeneity of instruments are not reported but validate our instruments. Time (years) dummies are not reported and dropped from regressions when they do not bring any additional information. The line reporting the total effect of i^r is computed by summing the coefficients associated to i^r and $i^r * Q_i$. The command “collapse” is used to limit the number of instruments.

Table 2.9: Profitability, ENL and policy interest rate regimes

Variables	ROA				ROE				NIM			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
π_{t-1}	0.308*** (0.076)	0.336*** (0.082)	0.359*** (0.074)	0.311*** (0.078)	0.233*** (0.036)	0.527*** (0.110)	0.403*** (0.145)	0.344*** (0.130)	0.636*** (0.116)	0.443*** (0.125)	0.655*** (0.065)	0.553*** (0.124)
ENL	-0.003* (0.001)	-0.007 (0.019)	-0.002* (0.001)	-0.016 (0.023)	-0.029** (0.014)	-3.059** (1.373)	0.012 (0.036)	-3.201*** (1.209)	-0.003 (0.003)	0.002 (0.002)	1.61e-4 (0.001)	-8.59e-4 (0.001)
i^r	0.089** (0.041)	0.138*** (0.055)	0.113*** (0.042)	0.196** (0.093)	0.862* (0.470)	0.800*** (0.335)	0.958** (0.446)	1.264*** (0.436)	0.204*** (0.078)	0.242*** (0.076)	0.074** (0.032)	0.135*** (0.042)
$i^r * Q_i$	-0.288*** (0.078)	0.190*** (0.058)	0.005 (0.019)	-0.045 (0.052)	-3.870*** (0.867)	0.130 (0.255)	-0.094 (0.229)	0.096 (0.230)	0.127 (0.139)	0.106*** (0.037)	0.035** (0.015)	-0.022 (0.021)
EQUITY	-0.005 (0.040)	-0.022 (0.046)	-0.007 (0.040)	-0.011 (0.037)	-0.073 (0.194)	-0.245 (0.250)	-0.445* (0.273)	-0.391 (0.301)	0.032 (0.022)	0.029 (0.034)	-0.006 (0.020)	0.001 (0.021)
SIZE	1.80e-7 (7.49e-7)	4.43e-7 (6.76e-7)	-1.14e-7 (6.23e-7)	1.56e-7 (5.14e-7)	-6.84e-6 (4.86e-6)	-2.36e-6 (3.77e-6)	-4.65e-6 (4.04e-6)	1.59e-6 (5.20e-6)	-1.86e-7 (3.68e-7)	8.71e-8 (2.91e-7)	-2.27e-7 (1.94e-7)	-1.09e-7 (2.14e-7)
LENDING	-0.002 (0.004)	-5.24e-4 (0.004)	-0.005 (0.004)	-0.001 (0.004)	-3.12e-4 (0.014)	-0.024 (0.028)	-0.012 (0.029)	-4.97e-4 (0.002)	-0.002 (0.002)	-0.003 (0.002)	3.86e-4 (0.001)	5.24e-4 (0.001)
DIVERSIFICATION	-0.014 (0.015)	-0.024 (0.016)	-0.014 (0.013)	-0.034* (0.021)	-0.191** (0.101)	0.298*** (0.073)	0.322*** (0.092)	0.237*** (0.077)	-0.010* (0.005)	-0.038*** (0.010)	-0.025** (0.011)	-0.019** (0.008)
MS	-0.035 (0.092)	-0.050 (0.082)	0.003 (0.078)	-0.018 (0.062)	0.729 (0.585)	-0.047 (0.561)	0.193 (0.632)	-0.624 (0.727)	-0.007 (0.026)	-0.032 (0.039)	7.91e-4 (0.020)	-0.019 (-0.024)
RGDPG	0.102*** (0.013)	0.104*** (0.015)	0.091*** (0.013)	0.101*** (0.013)	1.139*** (0.128)	0.815*** (0.120)	0.805*** (0.139)	0.918*** (0.113)	0.027*** (0.011)	0.048*** (0.010)	0.047*** (0.007)	0.045*** (0.009)
MC	0.023 (0.044)	0.038 (0.049)	0.007 (0.044)	0.022 (0.039)	-0.229 (0.263)	-0.018 (0.194)	-0.027 (0.231)	0.167 (0.205)	0.018 (0.013)	0.033 (0.021)	0.027** (0.012)	0.031** (0.015)
INFLATION	-0.089*** (0.037)	-0.122*** (0.050)	-0.109*** (0.039)	-0.146*** (0.056)	-0.916* (0.506)	-0.488* (0.303)	-0.398 (0.302)	-0.779*** (0.271)	-0.095*** (0.039)	-0.090*** (0.038)	-0.011 (0.023)	-0.009 (0.029)
CONST.	1.044* (0.602)	989* (0.583)	0.659 (0.560)	1.457** (0.694)	11.223*** (4.143)	-6.271** (3.178)	-6.324** (3.169)	-2.344 (0.529)	0.340 (0.916)	2.085*** (0.405)	0.817** (0.418)	1.180*** (0.490)
Total effect of i^r	-0.199***	0.329***	0.118***	0.150***	-3.007***	0.931**	0.864***	1.360***	0.332*	0.349***	0.109***	0.112***
Total observations	6577	6577	6577	6577	6574	6574	6574	6574	6572	6572	6572	6572
Nr. of instruments	31	31	31	31	31	85	103	122	37	37	64	64
AR(1) (p-value)	0.000	0.000	0.000	0.000	0.019	0.066	0.034	0.036	0.000	0.018	0.000	0.001
AR(2) (p-value)	0.633	0.659	0.507	0.378	0.687	0.342	0.533	0.612	0.805	0.402	0.977	0.658
Hansen test (p-value)	0.176	0.322	0.448	0.185	0.120	0.215	0.396	0.152	0.349	0.276	0.308	0.167

Notes: Heteroscedastic robust t-statistics are in parentheses. ***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. AR(1) and AR(2) are the tests for first and second-order autocorrelation and Hansen is the test for over-identifying restrictions. The results associated with tests of exogeneity of instruments are not reported but validate our instruments. Time (years) dummies are not reported and dropped from regressions when they do not bring any additional information. The line reporting the total effect of i^r is computed by summing the coefficients associated to i^r and $i^r * Q_i$. The command “collapse” is used to limit the number of instruments.

2.4 A twofold approach: Fixed effect estimator and dynamic panel estimations

This result echoes subsection 2.2.2 where we have previously observed that banks succeeded in recovering their pre-crisis level of returns. In fact, although the lowest Q1 regime corresponds to the most recent period of our sample year, that is when central banks conducted very accommodating policy, close to the ZLB, banks may have anticipated the further fall in policy interest rates and compelled them to rely on other sources of profit. For instance, they could have reoriented their core business towards other, more remunerative activities such as investing in riskier assets to inflate overall profit. Banks could have also increased their commissions or invest in riskier assets to inflate overall profit. Finally, such an anticipation could have encouraged them to rethink their strategy by, *inter alia*, engaging in a higher lending volume. Shamshur and Weill (2019) shows that improved efficiency through cost minimisation is passed on to the lending rate. As such, banks could have tried to reduce their costs in order to transfer this gain into the cost of borrowing, which could have contributed to increasing the volume of loans and maintain their profitability.

Moreover, another interesting result is that our model grasps that the most harmful effect of the policy interest rate on profitability occurs when i^r is the lowest (i.e., when i^r is in Q2 for ROA and ROE and Q1 for NIM). We also obtain consistent findings for all regressions with NIM because the positive coefficients of the total effect of i^r are becoming greater when following the downward trend of the policy interest rate. In other words, the regressions show that a drop in i^r compresses margins since the impact of the key interest rate on NIM is becoming stronger and stronger when this latter drops.

Our conclusion is in line with Lopez et al. (2018) and Altavilla et al. (2017) who focus *inter alia* on European banks. Indeed, on a general note, the authors find that easing monetary policy is not associated with lower profits. In this context, the authors specify that although a cut in the policy interest rate adversely affects the NIM, accommodative monetary conditions have fostered overall profits. More specifically, the positive impact on loan loss provisions and non-interest income offset the negative one on the NIM.

2.5 Robustness of findings

This section introduces different robustness checks. We first present our model augmented by a regulation index at the country level. We perform panel fixed effect estimations only, since we prefer to control for all types of fixed effects: bank, country and year fixed effects²⁷. However, the index is still accounted for in the following robustness check, which performs both types of estimations. Indeed, we then build a monetary policy gap indicator replacing the policy interest rate in both fixed effects estimations and dynamic estimations while taking into account the regulation index. Finally, we present results when using winsorizing data. Unlike previous estimations, both estimation methods cluster standard errors at the bank level and account for time fixed effects. Fixed effect estimations additionally account for country and bank fixed effects.

2.5.1 Are results alike in the presence of a regulation index?

As the banking regulation became more stringent in the aftermath of the GFC, one may wonder if precedent outcomes, and mainly results associated with prudential behaviour, still held in the presence of bank regulation. Against this background, we build and introduce in the regressions a regulation index as prudential behaviour is suspected to be driven by the regulatory environment that prevails in each country (Laeven and Levine, 2009; Barrell et al., 2010; Ramayandi et al., 2014). The construction of this variable is based on the Bank Regulation and Supervision Databases from the World Bank, built by Barth, Caprio and Levine and conducted in 1999, 2003, 2007 and 2011 (see Appendix F for the methodology used to compute the index). As there are four different waves of the survey, it is assumed that the index is the same for the 3-4 years following the time of information. The index varies between 0 and 1 and the closer to 1, the stricter.

Our index indicates a minimum value (0.264) in 2001 for Germany, where regulation

²⁷The use of the system GMM eliminates individual fixed effects. In addition, the inclusion of too many fixed effects absorbs the effects and makes most of them statistically not significant.

was deemed to be particularly relaxed before the GFC. For example, unlike in almost all countries in our sample, in Germany the sources of funds to be used as capital were not subject to verification by the authorities before the financial crisis of 2008. Moreover, unlike other countries, the German banking authority did not hold directors legally liable for false or misleading information. The maximum value (0.651) is observed in Hungary in 2007. According to Barth et al. (2013), Hungary is one of the few countries to have eased global restrictions on banking activities after the financial crisis. Overall, we distinguish three different patterns. For many countries, the second and third waves of the survey indicate a relaxation of the regulatory index before and during the run-up of the crisis. For the second group of countries²⁸, the index slightly increased over the years. Finally, for Norway, Spain, Switzerland and the United Kingdom, the last survey conducted in 2011 highlights a softening of regulations.

Further, we perform panel fixed effect estimations accounting for the clustering of standard errors to correct for potential heterogeneity within individuals. We also include country, bank and year fixed effects to correct for heterogeneity between the different groups and years. The regression becomes:

$$\begin{aligned} \pi_{i,j,t} = & \alpha_0 + \alpha_1 PB_{i,j,t} + \alpha_2 \hat{v}_{j,t}^r + \alpha_3 \sum_{k=0}^5 B_{i,j,t} + \alpha_4 \sum_{k=0}^3 C_{j,t} + \alpha_5 RSI_{j,t} \\ & + \eta_i + \psi_j + \theta_t + \epsilon_{i,j,t}, \end{aligned} \quad (2.5)$$

where $RSI_{j,t}$ denotes the regulation and supervision index in each country j and for each year t and η_i and ψ_j respectively stand for bank and country fixed effects.

Table 2.10 presents the results. When completing the estimations with RSI, the results still hold. In particular, the Z-score, LLP and ENL reflect the same results as in Table 2.3 and Table 2.4, that is more resilient banks register a higher profit. The policy interest rate does not influence overall profitability but the NIM, corroborating our previous findings.

²⁸That is Bulgaria, Denmark, France, Germany, Italy, Latvia, Lithuania and the Netherlands.

Table 2.10: Profitability, prudential behaviour and monetary policy in presence of regulation index (*Fixed effects estimations*)

Variables	ROA			ROE			NIM		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
$Z - score_{std}$	1.545*** (0.554)			10.584 (8.681)			0.662* (0.418)		
LLP		-0.272*** (0.054)			-2.626*** (0.784)			-0.010 (0.022)	
ENL			0.004 (0.005)			-0.012 (0.015)			-3.136E-4 (7.441E-4)
i^r	-0.018 (0.030)	-0.011 (0.027)	-0.045 (0.036)	0.009 (0.271)	-0.196 (0.317)	-0.228 (0.322)	0.087*** (0.028)	0.090*** (0.028)	0.083*** (0.028)
EQUITY	0.007 (0.024)	0.038*** (0.014)	0.020 (0.022)	0.125 (0.118)	0.328** (0.170)	0.297* (0.170)	0.045*** (0.009)	0.057*** (0.011)	0.054*** (0.010)
SIZE	-0.129 (0.135)	-0.200* (0.124)	-0.235* (0.138)	-4.574** (1.981)	-4.863*** (2.051)	-4.925*** (2.024)	-0.177 (0.138)	-0.168 (0.139)	-0.228* (0.128)
LENDING	6.625E-4 (0.002)	-0.002 (0.001)	6.154 (0.003)	0.003 (0.009)	-0.014 (0.012)	-0.007 (0.012)	-0.002 (0.001)	-0.002** (0.001)	-0.002* (0.001)
DIVERSIFICATION	-9.318E-4 (0.002)	6.098E-4 (0.001)	0.002 (0.003)	0.001 (0.024)	0.010 (0.023)	-0.002 (0.026)	-0.007*** (0.003)	-0.006*** (0.003)	-0.006*** (0.003)
MS	0.009 (0.019)	0.009 (0.015)	0.018 (0.020)	0.275 (0.266)	0.258 (0.269)	0.296 (0.271)	-0.028* (0.016)	-0.028* (0.016)	-0.025* (0.016)
RGDPG	0.128*** (0.019)	0.080*** (0.018)	0.140*** (0.019)	1.943*** (0.433)	1.363*** (0.424)	1.884*** (0.446)	0.037*** (0.009)	0.038*** (0.010)	0.040*** (0.009)
MC	1.621 (1.711)	1.169 (1.403)	2.165 (1.764)	-30.638 (22.502)	-32.817 (23.264)	-37.909 (3.780)	3.149*** (1.094)	2.651** (1.137)	2.951*** (1.111)
INFLATION	0.008 (0.030)	0.034* (0.020)	0.024 (0.034)	0.330 (0.321)	0.697* (0.407)	0.449 (0.350)	0.076*** (0.030)	0.085*** (0.031)	0.080*** (0.030)
RSI	1.129** (0.583)	0.489 (0.587)	1.035* (0.610)	18.771*** (7.692)	13.322* (7.666)	18.421*** (7.785)	-1.205*** (0.454)	-1.305*** (0.450)	-1.277*** (0.441)
CONST.	-1.605*** (605)	-0.350 (0.436)	-0.985 (0.463)	-14.736* (8.331)	-4.779 (4.954)	-11.018** (5.409)	1.463*** (0.384)	1.819*** (0.293)	1.797*** (0.293)
Total observations	6866	6734	6867	6864	6732	6865	6864	6732	6865
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Std. Err. Adjusted at the bank level	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.33	0.42	0.3	0.21	0.26	0.21	0.76	0.77	0.78

Notes: Heteroscedastic robust t-statistics are in parentheses. ***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. Country, bank and time (years) dummies are not reported. The standard errors are clustered at the bank level.

2.5.2 The monetary policy gap as monetary policy indicators

In a second robustness check, we decide to validate our findings by using an alternative indicator of the main variable of interest (i.e. the policy interest rate). We build an alternative monetary policy indicator, referring to the monetary policy gap. Relying on both panel fixed effects and dynamic panel estimation methods, we replace the policy interest rate in the regressions by this indicator while accounting for the regulation index.

As a first step, we compute the Taylor (1993) rule for the Euro Area and each other country of our sample as follows:

$$i = r^* + \pi^* + 1.5(\pi - \pi^*) + 0.5y, \quad (2.6)$$

where i is the nominal policy rate, r^* defines the long-run or real equilibrium rate of interest, π is the current period inflation rate, π^* is the central bank's inflation target, and y is the current period output gap. We use the price consumer index and the output gap data²⁹ to proxy π and y , respectively. For π^* , we use inflation targets from each central bank³⁰.

At last, following Taylor (1993), the calibration of the real equilibrium rate is linked to the estimates of the trend of the output growth. Specifically, applying the Hodrick–Prescott filter, the long-run level of the real interest rate is equal to the estimate of the trend growth rate of the real GDP.

As a second step, we build the monetary policy gap indicator, MP_{gap} . The latter is defined as the absolute difference between the policy interest rate and the Taylor rule, meaning that the indicator accounts for the distance between the two. The greater the distance, the more accommodative or restrictive is the monetary policy. Under the investigated period, central banks are deemed to be more accommodative than what a Taylor rule

²⁹Data are retrieved from the OECD and IMF databases.

³⁰Information about inflation targets is retrieved from each central bank official website. Note that for some central banks, inflation targets may vary during the period.

would suggest. This has been confirmed before the financial crisis and more generally over the whole studied period in all European regions (see Appendix E). From this perspective, we would expect the effect of such an indicator to be negatively related to the NIM since, in light of our data, an increase in the monetary policy gap is more likely to capture a more accommodative monetary policy and thus harms the NIM.

Table 2.11 and Table 2.12 present results when replacing i^r by MP_{gap} . The findings associated with MP_{gap} are consistent with previous conclusions. On the one hand, the positive coefficients for the overall profitability (coefficients are more significant for ROE) reveal that when the policy interest rate moves away from the Taylor rule, the overall profitability increases. Fixed effect estimations confirm this finding although the results are significant at a 10% level. In dynamic panel regressions for overall profitability (see Table 2.12), the variable MP_{gap} lacks significance. With regard to the uncertain overall effect of the policy interest rate on the ROA and ROE when breaking down interest rate regimes, this outcome is not surprising. On the other hand, for the NIM, coefficients are negative and highly significant. A higher distance between i^r and the Taylor rule reduces banks' net interest income.

Table 2.11: Profitability, prudential behaviour and monetary policy gap (*Fixed effects estimations*)

Variables	ROA			ROE			NIM		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
$Z - score_{std}$	1.553*** (0.552)			10.819 (8.710)			0.702* (0.423)		
LLP		-0.272*** (0.055)			-2.637*** (0.785)			-0.010 (0.022)	
ENL			0.004 (0.005)			-0.013 (0.015)			-3.57E-4 (0.001)
MP_{gap}	0.051** (0.024)	0.031* (0.018)	0.038* (0.021)	0.444* (0.248)	0.483* (0.286)	0.517* (0.292)	-0.028* (0.016)	-0.037** (0.016)	-0.025* (0.015)
EQUITY	0.007 (0.024)	0.038*** (0.014)	0.020 (0.022)	0.129 (0.117)	0.333** (0.169)	0.307* (0.171)	0.045*** (0.010)	0.058*** (0.011)	0.055** (0.010)
SIZE	-0.088 (0.138)	-0.175 (0.125)	-0.193 (0.139)	-4.169** (1.967)	-4.509** (2.057)	-4.423** (2.022)	-0.201 (0.144)	-0.191 (0.146)	-0.246* (0.135)
LENDING	0.001 (0.002)	-0.002 (0.001)	0.001 (0.003)	0.003 (0.008)	-0.014 (0.012)	-0.008 (0.012)	-0.002* (0.001)	-0.003** (0.001)	-0.002** (0.001)
DIVERSIFICATION	-0.001 (0.002)	0.001 (0.001)	0.002 (0.003)	0.001 (0.024)	0.009 (0.023)	-0.002 (0.026)	-0.007** (0.003)	-0.006** (0.003)	-0.006** (0.003)
MS	0.007 (0.020)	0.009 (0.016)	0.017 (0.020)	0.260 (0.266)	0.246 (0.270)	0.278 (0.272)	-0.027* (0.016)	-0.027* (0.015)	-0.024 (0.015)
RGDPG	0.127*** (0.018)	0.079*** (0.018)	0.141*** (0.019)	1.930*** (0.434)	1.350*** (0.428)	1.883*** (0.447)	0.035*** (0.010)	0.036*** (0.010)	0.037*** (0.009)
MC	1.570 (1.700)	1.132 (1.397)	2.134 (1.773)	-31.578 (22.166)	-33.219 (22.978)	-38.907* (23.553)	3.064*** (1.101)	2.502** (1.149)	2.818** (1.116)
INFLATION	-0.036 (0.030)	0.007 (0.023)	-0.028 (0.031)	0.051 (0.273)	0.265 (0.291)	-0.024 (0.288)	0.148*** (0.039)	0.165*** (0.038)	0.148*** (0.039)
RSI	1.110* (0.582)	0.481 (0.589)	0.973 (0.618)	19.145** (7.751)	13.012* (7.630)	18.341** (7.878)	-0.986** (0.447)	-1.069** (0.441)	-1.059** (0.435)
CONST.	-1.609*** (0.597)	-0.360 (0.431)	-1.040** (0.447)	-14.554* (8.348)	-4.851 (5.068)	-11.085** (5.429)	1.568*** (0.376)	1.942*** (0.283)	1.915*** (0.281)
Total observations	6892	6756	6891	6890	6754	6889	6890	6754	6889
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Std. Err. Adjusted at the bank level	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.282	0.377	0.244	0.154	0.202	0.147	0.744	0.753	0.763

Notes: Heteroscedastic robust t-statistics are in parentheses. ***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. Country, bank and time (years) dummies are not reported. The standard errors are clustered at the bank level.

Table 2.12: Profitability, prudential behaviour and monetary policy gap (*Dynamic panel estimations*)

Variables	ROA			ROE			NIM		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
π_{t-1}	0.414*** (0.140)	0.377*** (0.131)	0.439*** (0.082)	0.356*** (0.109)	0.213*** (0.030)	0.848*** (0.247)	0.581*** (0.045)	0.571*** (0.086)	0.564*** (0.068)
$Z - score_{std}$	-2.444 (3.023)			44.961** (20.031)			-0.124 (0.499)		
LLP		-0.125 (0.131)			-1.806* (1.047)			-0.091 (0.062)	
ENL			0.011 (0.010)			0.150 (0.424)			-8.15E-5 (0.003)
MP_{gap}	-0.074 (0.075)	-0.092 (0.072)	-0.087 (0.053)	1.310** (0.535)	1.208 (0.839)	1.424 (0.871)	-0.168*** (0.036)	-0.094*** (0.028)	-0.090*** (0.027)
EQUITY	-0.094 (0.061)	-0.107** (0.053)	-0.108* (0.056)	-0.307 (0.247)	-0.348 (0.224)	0.041 (0.768)	0.002 (0.007)	-0.025 (0.024)	-0.006 (0.018)
SIZE	0.457 (0.821)	0.559 (0.699)	0.547 (0.493)	-7.662** (3.277)	-13.276*** (4.384)	-6.573 (7.240)	-0.050 (0.149)	-0.108 (0.343)	-0.009 (0.237)
LENDING	-0.007 (0.006)	0.002 (0.004)	0.002 (0.005)	-0.021 (0.031)	0.017 (0.018)	0.015 (0.077)	0.001 (0.001)	0.001 (0.001)	0.000 (0.001)
DIVERSIFICATION	-0.018 (0.038)	-0.002 (0.007)	-0.017 (0.014)	0.109 (0.073)	-0.265* (0.138)	-0.106 (0.315)	-0.016*** (0.005)	-0.006 (0.006)	-0.010* (0.006)
MS	-0.117 (0.115)	-0.133 (0.095)	-0.116* (0.066)	0.816* (0.479)	1.469*** (0.509)	0.396 (0.954)	-0.030 (0.019)	-0.037 (0.044)	-0.035 (0.028)
RGDPG	0.153*** (0.030)	0.140*** (0.027)	0.171*** (0.026)	0.871*** (0.205)	1.111*** (0.296)	1.303*** (0.472)	0.069*** (0.011)	0.056*** (0.015)	0.064*** (0.013)
MC	7.434 (6.320)	8.225 (5.698)	5.881* (3.210)	-20.607 (18.949)	-56.518* (29.716)	-57.993 (46.789)	3.742*** (1.057)	5.483*** (2.073)	4.054*** (1.459)
INFLATION	0.028 (0.059)	0.067 (0.058)	0.036 (0.041)	-0.601 (0.458)	-0.315 (0.579)	-0.865 (0.604)	0.164*** (0.029)	0.142*** (0.029)	0.115*** (0.025)
RSI	1.874** (0.795)	1.588* (0.924)	1.417* (0.765)	-3.702 (5.673)	1.142 (6.794)	-7.837 (8.409)	0.449 (0.282)	0.503 (0.395)	0.409 (0.334)
CONST.	3.567 (3.214)	0.539 (0.405)		-31.607** (15.851)				0.927** (0.375)	
Total observations	6464	6347	6465	6461	6344	6462	6459	6342	6460
Nr. of instruments	36	52	60	100	36	36	68	44	52
AR(1) (p-value)	0.001	0.000	0.000	0.050	0.025	0.050	0.000	0.000	0.000
AR(2) (p-value)	0.805	0.328	0.422	0.588	0.505	0.213	0.668	0.632	0.974
Hansen test (p-value)	0.403	0.280	0.498	0.141	0.273	0.570	0.344	0.141	0.252

Notes: Heteroscedastic robust t-statistics are in parentheses. ***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. AR(1) and AR(2) are the tests for first and second-order autocorrelation and Hansen is the test for over-identifying restrictions. The results associated with tests of exogeneity of instruments are not reported but validate our instruments. Time (years) dummies are not reported. Note that the constant in the estimation may disappear because of time fixed effects. The command “collapse” is used to limit the number of instruments.

2.5.3 Evidence from winsorization

At last, we also use the winsorization method as a robustness check as Table 2.2 exhibits extreme values in our sample. The winsorization method transforms the data by limiting the extreme values to alleviate the effect of possible outliers. To this end, we remove the first and ninety-ninth percentile from the distribution of all our variables.

Table 2.13 and Table 2.14 present the results. Fixed effect estimations display very similar results as in subsection 2.4.1. First, when controlling for time fixed effects in the regression, the effect of the policy interest rate on overall profitability (i.e., ROA and ROE) is insignificant. However, its effect on the NIM remains positive, but slightly stronger. Second, the effects of indicators of banks' prudential behaviour are of the same sign and magnitude. Finally, control variables present very similar effects.

Results associated to dynamic panel estimations in Table 2.14 also present similar findings. When examining the effect of prudential behaviour indicators, the associated signs are consistent throughout our analysis. In addition, the positive effect of the policy interest rate on the NIM remains highly significant. Yet, the effect of the policy interest rate on overall profitability is not as clear-cut as in subsection 2.4.2. The lack of significance when using the winsorization method reveals that our findings in subsection 2.4.2 regarding the relationship between the overall profitability indicators and the key interest rate is most likely driven by extreme (and negative) values of overall profitability that occur during the 2008 financial crisis. First, this result is consistent with the results obtained from the fixed panel estimate and confirms the complex assessment of the effect of the key interest rate on overall profit. It cannot therefore be concluded that the conduct of monetary policy is detrimental to bank profitability. Second, while we acknowledge that this conclusion requires a deeper analysis, these results support our findings that further breaks down the effect of the policy rate, especially when we assess the effect of the policy interest rate at the lowest regimes (i.e., Q1 and Q2) since extreme values most likely occur during regime Q3.

Table 2.13: Winsorization: profitability, prudential behaviour and monetary policy (*Fixed effects estimations*)

Variables	ROA			ROE			NIM		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
$Z - score_{std}$	0.919*** (0.353)			10.415** (4.181)			0.573** (0.275)		
LLP		-0.339*** (0.025)			-3.426*** (0.256)			0.024* (0.013)	
ENL			0.000 (0.002)			0.005 (0.011)			0.001 (0.001)
i^r	-0.019 (0.024)	-0.003 (0.023)	-0.022 (0.024)	-0.105 (0.203)	0.007 (0.189)	-0.128 (0.204)	0.106*** (0.026)	0.113*** (0.026)	0.107*** (0.026)
EQUITY	0.022** (0.009)	0.026*** (0.009)	0.031*** (0.009)	0.056 (0.061)	0.114* (0.064)	0.123* (0.071)	0.045*** (0.007)	0.051*** (0.008)	0.046*** (0.008)
SIZE	-0.177 (0.179)	-0.191 (0.167)	-0.213 (0.179)	-7.816*** (2.262)	-7.833*** (2.212)	-8.160*** (2.252)	-0.035 (0.158)	-0.012 (0.159)	-0.055 (0.155)
LENDING	0.012*** (0.003)	0.006** (0.003)	0.012*** (0.003)	0.071*** (0.026)	0.017 (0.026)	0.069** (0.028)	0.004 (0.004)	0.004 (0.004)	0.006* (0.004)
DIVERSIFICATION	0.001 (0.002)	0.003 (0.002)	0.002 (0.002)	0.019 (0.026)	0.034 (0.025)	0.019 (0.026)	-0.027*** (0.002)	-0.027*** (0.002)	-0.026*** (0.002)
MS	0.028* (0.015)	0.025* (0.013)	0.031** (0.015)	0.426*** (0.147)	0.390*** (0.135)	0.432*** (0.148)	-0.027 (0.017)	-0.028* (0.017)	-0.027 (0.017)
RGDPG	0.109*** (0.014)	0.046*** (0.013)	0.113*** (0.014)	1.186*** (0.143)	0.545*** (0.136)	1.213*** (0.143)	0.044*** (0.009)	0.051*** (0.009)	0.045*** (0.009)
MC	0.009 (0.013)	0.016 (0.012)	0.009 (0.013)	-0.117 (0.115)	-0.060 (0.111)	-0.122 (0.116)	0.039*** (0.010)	0.038*** (0.010)	0.040*** (0.010)
INFLATION	0.042** (0.019)	0.038** (0.017)	0.039** (0.018)	0.371** (0.187)	0.348** (0.174)	0.326* (0.184)	0.049*** (0.016)	0.048*** (0.016)	0.048*** (0.016)
CONST.	-1.687*** (0.353)	-0.420 (0.267)	-1.298*** (0.262)	-9.102** (3.881)	4.480* (2.478)	-3.453 (2.543)	1.253*** (0.385)	1.468*** (0.342)	1.447*** (0.329)
Total observations	6994	6865	7000	6992	6863	6998	6992	6863	6998
Country fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bank fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Std. Err. Adjusted at the bank level	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.335	0.472	0.338	0.318	0.444	0.319	0.803	0.808	0.810

Notes: Heteroscedastic robust t-statistics are in parentheses. ***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. Country, bank and time (years) dummies are not reported. The standard errors are clustered at the bank level.

Table 2.14: Winsorization: profitability, prudential behaviour and monetary policy (*Dynamic panel estimations*)

Variables	ROA			ROE			NIM		
	(1)	(2)	(3)	(1)	(2)	(3)	(1)	(2)	(3)
π_{t-1}	0.607*** (0.133)	0.507*** (0.097)	0.798*** (0.109)	0.606*** (0.106)	0.549*** (0.102)	0.703*** (0.098)	0.806*** (0.096)	0.783*** (0.100)	0.737*** (0.073)
$Z_s core_{std}$	0.633 (0.778)			12.919** (6.204)			-0.014 (0.557)		
LLP		-0.262*** (0.068)			-2.321*** (0.840)			0.023 (0.100)	
ENL			0.026*** (0.010)			-0.027 (0.031)		-0.001 (0.003)	
i^r	-0.038 (0.044)	-0.029 (0.032)	0.080 (0.049)	-0.216 (0.328)	-0.545* (0.328)	-0.589 (0.369)	0.140** (0.059)	0.116* (0.062)	0.077*** (0.027)
EQUITY	0.004 (0.028)	0.001 (0.023)	-0.097*** (0.037)	-0.229 (0.190)	-0.064 (0.175)	0.133 (0.183)	0.020 (0.018)	0.032 (0.022)	0.005 (0.014)
SIZE	0.118 (0.564)	0.064 (0.399)	0.516 (0.362)	-6.538* (3.658)	-4.269 (3.285)	-3.533 (4.843)	0.196 (0.312)	0.070 (0.349)	0.140 (0.242)
LENDING	0.012 (0.010)	0.011 (0.007)	0.025** (0.010)	0.024 (0.081)	0.099 (0.080)	0.002 (0.081)	0.005 (0.006)	0.003 (0.007)	0.004 (0.005)
DIVERSIFICATION	0.024** (0.011)	0.027*** (0.009)	0.008 (0.008)	0.283*** (0.103)	0.305*** (0.095)	0.230** (0.097)	-0.006 (0.007)	-0.006 (0.008)	-0.008 (0.006)
MS	-0.009 (0.048)	-0.018 (0.034)	-0.065** (0.032)	0.449 (0.322)	0.315 (0.298)	0.249 (0.386)	-0.014 (0.029)	-0.003 (0.031)	-0.028 (0.019)
RGDPG	0.068*** (0.014)	0.046*** (0.014)	0.093*** (0.015)	0.648*** (0.132)	0.405*** (0.143)	0.676*** (0.144)	0.038*** (0.011)	0.026 (0.017)	0.033*** (0.009)
MC	-0.002 (0.020)	0.024* (0.012)	0.029* (0.016)	-0.114 (0.116)	-0.020 (0.122)	-0.200 (0.147)	0.010 (0.015)	0.002 (0.015)	0.020* (0.011)
INFLATION	0.045 (0.034)	0.053** (0.023)	-0.045 (0.039)	0.405 (0.254)	0.765*** (0.259)	0.533* (0.283)	-0.096** (0.040)	-0.051 (0.032)	-0.003 (0.022)
CONST.		-1.076* (0.624)	-1.760** (0.731)	-20.766** (8.523)	-8.998 (6.622)			-0.226 (0.510)	
Total observations	6573	6458	6577	6570	6455	6574	6568	6453	6572
Nr. of instruments	35	75	35	51	51	43	35	35	43
AR(1) (p-value)	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
AR(2) (p-value)	0.168	0.117	0.252	0.420	0.584	0.222	0.288	0.321	0.264
Hansen test (p-value)	0.418	0.474	0.274	0.339	0.640	0.380	0.510	0.330	0.167

Notes: Heteroscedastic robust t-statistics are in parentheses. ***, ** and * are statistical significances at 0.01, 0.05 and 0.10 level, respectively. AR(1) and AR(2) are the tests for first and second-order autocorrelation and Hansen is the test for over-identifying restrictions. The results associated with tests of exogeneity of instruments are not reported but validate our instruments. Time (years) dummies are not reported. Note that the constant in the estimation may disappear because of time fixed effects. The command “collapse” is used to limit the number of instruments.

2.6 Conclusion

We examine the effect of banks' prudential behaviour and the policy interest rate on banks' NIM and overall profitability, i.e., the ROA and the ROE, across the European banking sector from 1999 to 2015. This period allows us to capture the downward trend of the policy interest rate. To proxy banks' prudential behaviour, we rely on two financial ratios, equity on net loans (ENL) and loan loss provisions on gross loans (LLP), which grasp bank management of the risk, and an accounting-based insolvency risk measure, the asymmetric Z-score, which reflects a distance to a default state. We build our estimations on the GMM to take into account the dynamic feature of bank profitability and to overcome endogeneity issues, which may be present in our regressions.

This Chapter provides evidence that less cautious banks in terms of risk are associated with lower returns. A higher Z-score enhances profits and corroborates the idea that financial stability promotes profitability. Our results also indicate that the negative effect of insolvency risk, in particular, is less strong when the policy interest rate increases. This result is consistent with our findings regarding the existence of a risk-taking channel in Europe. Moreover, this Chapter highlights that the recent evolution of monetary policy plays a critical role in bank net interest income since the main central bank's instrument pushes NIM downwards. However, its effect on overall bank profitability is not clear and does not allow us to conclude that the conduct of monetary policy impairs bank overall profitability (i.e., ROA and ROE) as our results obtained from the dynamic panel estimations seem to be driven by extreme values that occur during the financial crisis.

When shifting the attention on the effect of policy interest rates under different regimes, the results reveal that despite compression of the NIM following the downward trend of the policy interest rate, banks succeed in increasing their overall profitability, but only at the lower regime (i.e., when the policy interest is close to the ZLB). Above this threshold, the effect of the European central banks' primary tool is becoming more

harmful when the key interest rate is dropping. Hence, banks' ability to generate profits from their traditional activity is eroded by persistently low-interest rates. Nevertheless, banks may have anticipated such a reduction in their NIM and may generate profit from other sources such as fees and commissions or trading activity or from revamping their management strategy by increasing their lending volume. Thus, our results can only suggest that "too low for too long" interest rates alter European banks' business model by encouraging them to engage in alongside activity. Perhaps, such a policy would make the policy interest rate a less efficient tool by impeding the bank lending channel and/or threatening financial stability via encouraging banks to engage in riskier investments.

In fact, both the ECB and the IMF have recently flagged that low bank profit, combined with other risks, could be a potential critical challenge on the long run to ensure financial stability (European Central Bank Banking Supervision, 2018; International Monetary Fund, 2018). As a low-interest rates environment is an uncontrollable obstacle for financial institutions, this study supports the implementation of actions to "clean up" banks' balance sheets with a high share of loan loss provisions. This is in line with Andersson et al. (2017) who state that in high-loan loss provisions countries, costs associated with loan impairments remain a critical driver of low bank profits. It should also be recalled that the recent introduction of the EBA guidelines is in line with such recommendation, as it aims to reduce the amount of non-performing loans held by banks.

Among the other vulnerabilities, the ECB and the IMF have identified the rapid development of house prices, households' indebtedness and the growth of mortgage lending as potential threats to financial stability. Nevertheless, these institutions have not anticipated the recent outbreak of the pandemic, which is likely to pose an additional and major challenge. In this respect, the subsequent Chapter proposes to explore the role of macroprudential policy in the event of an exogenous shock similar to the COVID-19 pandemic affecting households' capacity to pay off their loans.

Appendix D

Chapter 2: Bank profitability

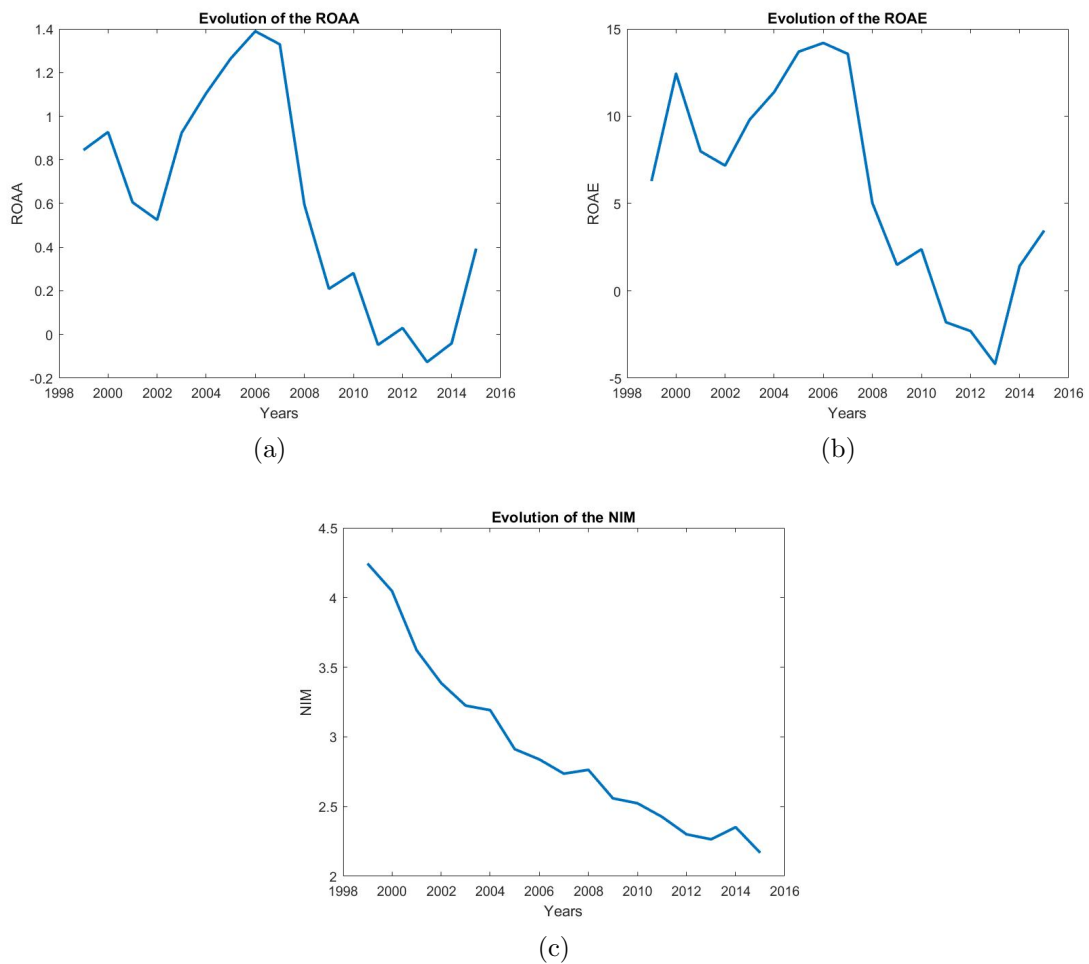


Figure 2.5: Bank profitability: the evolution of the ROA, ROE and the NIM

Appendix E

Chapter 2: Taylor rule and policy interest rates

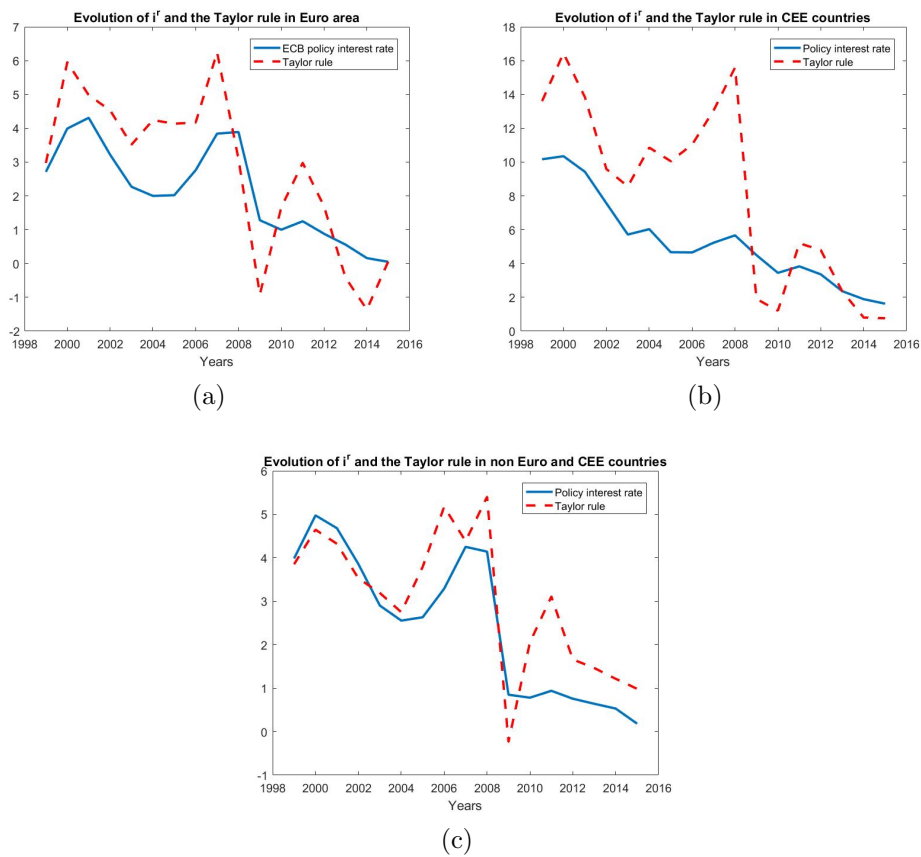


Figure 2.6: Policy interest rates and Taylor rules in the Euro Area, in the CEE countries and both non-Euro and non-CEE countries¹

¹CEE countries includes Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia, Slovenia. Non Euro and CEE countries refer to Denmark, Norway, Sweden, Switzerland and United-Kingdom.

Appendix F

Chapter 2: Construction of bank regulation and supervision index

This appendix provides details on the construction procedure of the bank regulation and supervision indicator used in the empirical analysis. We rely on data coming from four Bank Regulation and Supervision Data bases from the World Bank, built by Barth, Caprio and Levine and conducted in 1999, 2003, 2007 and 2011. Each survey contains approximately 300 questions divided into several sub-sections corresponding to different aspects of bank regulation and supervision, namely entry requirement on the banking market, ownership structure, capital adequacy, banking activity, external audit requirement, internal management, liquidity, depositor protection scheme, provisioning, information disclosure, discipline and supervisory structure. However, questions in each survey may vary, thus, it is necessary to analyse the information brought in each new survey in order to keep the same information for each index in the time. Hence, we build 12 indicators IND_i ($i=1, \dots, 12$). Since many questions require yes/no answers, we assign 1 when the answer expresses an enforcement of the banking regulation. Then, we aggregate all the relevant answers to each of the 12 indicators. We construct two main indicators: the Barriers to Entry Index (BEI) composed of the initial capital index (0.4), the foreign entry index (0.4) and the permission activity index (0.2) and the Stability Regulation and

Supervision Index (SRSI) corresponding to the aggregation of the overall capital index (0.25), the ownership index (0.05), the audit requirement index (0.05), the liquidity stringency index (0.1), the deposit insurance index (0.1), the provisioning stringency index (0.1), the market discipline index (0.15), the supervisory power index (0.15) and the supervisory structure index (0.05). To make all these indicators comparable across years and countries, they are normalised: $\overline{IND}_i = (IND_{i,t} - \min IND_i) / (\max IND_i - \min IND_i)$. Values are ranged between 0 and 1. Finally, we present in parenthesis the weight of each index in the composition of BEI and SRSI, equally weighted in the composition of the whole Banking Regulation and Supervision Index (BRSI). See the tables below for more information.

Table 2.15: Construction of regulatory variables for survey I (1999)

Variables	Range	Quantification	Questions
Barriers to entry			
Initial capital index	1-6	For (1): answer between 0 and 1 For (2)-(4): yes=1, no=0 For (5)-(6): yes=0, no=1	(1) Minimum capital entry requirement ³¹ (2) Is information on source of funds for capital required? (3) Are the sources of funds to be used as capital verified by authorities? (4) Are law enforcement authorities consulted? (5) Can assets other than cash/govt. securities be used to increase capital? (6) Can borrowed funds be used?
Foreign entry index			n.a.
Permission activity index	1-8	For all questions: yes=1, no=0	(1) Legal submissions required for banking license: (a) Draft by-laws (b) Intended organization chart (c) First 3-year financial projections (d) Financial information on shareholders (e) Background/experience of future directors (f) Background/experience of future managers (g) Sources of funds in capitalization of new bank (h) Intended market differentiation of new bank
Stability regulation index			
Overall capital index	1-9	For (1): answer between 0 and 1 For (2): if answer is < 0.75 = 1, 0 otherwise For (3)-(7): yes=1, no=0	(1) Minimum capital-asset ratio requirement (%) ³² (2) What fraction of revaluation gains is allowed as part of capital? (3) Is it risk-weighted in line with Basle guidelines? (4) Does the ratio vary with a bank's credit risk? (5) Does the ratio vary with market risk? (6) Is subordinated debt allowable as part of capital? (7) Before minimum capital adequacy is determined, which items are deducted from capital: (a) Market value of loan losses not realized in accounting books? (b) Unrealized losses in securities portfolios? (c) Unrealized foreign exchange losses?
Ownership index	1-4	For (1): yes=1, no=0 For (2)&(3): yes=0, no=1 For (4): unrestricted=0, permitted=0.25, restricted=0.75 and prohibited=1	(1) Is there a maximum percentage of capital that can be owned by single owner? (2) Can related parties own capital in a bank? (3) Can non-bank financial firms own shares in banks? (4) Regulatory restrictiveness of ownership by non-financial firms of banks
Audit requirement index	1-3	For all questions: yes=1, no=0	(1) Is an external audit compulsory? (2) Are there specific requirements for the extent of audit? (3) Are auditors licensed or certified?

³¹Minimum capital entry requirement is given in local currency. Thus, we converted all these data in millions of dollars. We assigned 1 to the highest minimum capital entry requirement to have values between 0 and 1. The final index may vary since the exchange rate is not the same for the whole period.

³²We assigned 1 to the highest minimum capital-asset ratio requirement to have values between 0 and 1.

Table 2.15 (Continued): Construction of regulatory variables for survey I (1999)

Variables	Range	Quantification	Questions
Liquidity stringency index	1-5	For (1)&(2): yes=1, no=0 For (3)&(4): if a minimum exists/reserves are remunerated=1, 0 otherwise For (5): if a precise description is given=1, if no such requirement=0	(1) Are there guidelines for asset diversification? (2) Are banks prohibited from making loans abroad? (3) Minimum liquidity requirement (4) What interest is paid on reserves? (5) What assets satisfy liquidity or reserve requirements?
Deposit insurance index	1-5	For (1)-(4): yes=1, no=0 For (5): if banks=1, 0 otherwise	(1) Is there an explicit deposit insurance scheme? (2) Is there a limit per person? (3) Does deposit insurance authority make the decision to intervene a bank? (4) Can deposit insurance agency take legal action against bank directors/officials? (5) Is it funded by the government, banks or both?
Provisioning stringency index	1-5	For (1)&(2): yes=1, no=0 For (3): answers are in percentage, we range value between 0 and 1 (example 45=0.45 or 100=1)	(1) Is there a formal definition of "non-performing loan"? (2) If one loan is non-performing, are other loans of a multiple-loan customer classified as non-performing? (3) Minimum required provisioning of loans as they become: (a) Substandard (b) Doubtful (c) Loss
Market discipline index	1-9	For (1)-(6): yes=1, no=0 For (7): yes=0, no=1	(1) Are consolidated accounts covering bank and any non-bank financial subsidiaries required? (2) Are off-balance sheet items disclosed to public? (3) Must banks disclose risk management procedures to public? (4) Are directors legally liable for erroneous/misleading information? (5) Do regulations require credit ratings for commercial banks? (6) Which bank activities are rated?: (a) Bonds (b) Commercial papers (c) Other (7) Does income statement contain accrued but unpaid interest/principal while loan is non-performing?

Table 2.15 (Continued): Construction of regulatory variables for survey I (1999)

Variables	Range	Quantification	Questions
Supervisory power index	1-14	For all questions: yes=1, no=0	(1) Are off-balance sheet items disclosed to supervisors? (2) Is auditor's report given to supervisory agency? (3) Can supervisors meet external auditors to discuss report without bank approval? (4) Are auditors legally required to report misconduct by managers/directors to supervisory agency? (5) Can legal action against external auditors be taken by supervisor for negligence? (6) Can supervisors force banks to change internal organizational structure? (7) Can the supervisory agency order directors/management to constitute provisions to cover actual/potential losses? (8) Can the supervisory agency suspend director's decision to distribute: (a) Dividends (b) Bonuses (c) Management fees (9) Can the supervisory agency supersede bank shareholder rights and declare bank insolvent? (10) Regarding bank restructuring & reorganization, can supervisory agency or any other govt. agency do the following: (a) Supersede shareholder rights (b) Remove and replace management (c) Remove and replace directors
Supervisory structure index	1-3	For (1): yes=1, no=0 For (2): yes=0, no=1 For (3): if the answer contains the parliament=1, 0 otherwise	(1) Is there more than one supervisory body? (2) Are supervisors legally liable for their actions? (3) To whom are supervisors accountable?

Table 2.16: Construction of regulatory variables for survey II (2002)

Variables	Range	Quantification	Questions
Barriers to entry			
Initial capital index	1–5	For (1): answer between 0 and 1 For (2)&(3): yes=1, no=0 For (4)&(5): yes=0, no=1	(1) Minimum capital entry requirement ³³ (2) Is it legally required that applicants submit information on the source of funds to be used as capital? (3) Are the sources of funds to be used as capital verified by the regulatory/supervisory authorities? (4) Can the initial disbursement or subsequent injections of capital be done with assets other than cash or government securities? (5) Can initial disbursement of capital be done with borrowed funds
Foreign entry index	1–3	For all questions: yes=1, no=0	(1) Are foreign entities prohibited from entering through: (a) Acquisition (b) Subsidiary (c) Branch
Permission activity index	1–8	For all questions: yes=1, no=0	(1) Legal submissions required for banking license: (a) Draft by-laws; (b) Intended organization chart (c) First 3-year financial projections (d) Financial information on shareholders (e) Background/experience of future directors (f) Background/experience of future managers (g) Sources of funds in capitalization of new bank (h) Intended market differentiation of new bank
Stability regulation index			
Overall capital index	1–9	For (1): answer between 0 and 1 For (2): if answer is $\geq 0.75=1$, 0 otherwise For (3)–(7): yes=1, no=0	(1) Minimum capital-asset ratio requirement (%) ³⁴ (2) What fraction of revaluation gains is allowed as part of capital? (3) Is it risk-weighted in line with Basle guidelines? (4) Does the ratio vary with a bank's credit risk? (5) Does the ratio vary with market risk? (6) Is subordinated debt allowable as part of capital? (7) Before minimum capital adequacy is determined, which items are deducted from capital: (a) Market value of loan losses not realized in accounting books? (b) Unrealized losses in securities portfolios? (c) Unrealized foreign exchange losses?
Ownership index	1–4	For (1): yes=1, no=0 For (2)&(3): yes=0, no=1 For (4): unrestricted=0, permitted=0.25, restricted=0.75 and prohibited=1	(1) Is there a maximum percentage of bank capital that can be owned by a single owner? (2) Can related parties own capital in a bank? (3) Can non-financial firms own shares in commercial banks? (4) Can non-bank financial firms own commercial banks?
Audit requirement index	1–3	For all questions: yes=1, no=0	(1) Is an external audit a compulsory obligation for banks? (2) Are specific requirements for the extent or nature of the audit spelled out? (3) Are auditors licensed or certified?

³³Minimum capital entry requirement is given in local currency. Thus, we converted all these data in millions of dollars. We assigned 1 to the highest minimum capital entry requirement to have values between 0 and 1. The final index may vary since the exchange rate is not the same for the whole period.

³⁴We assigned 1 to the highest minimum capital-asset ratio requirement to have values between 0 and 1.

Table 2.16 (Continued): Construction of regulatory variables for survey II (2002)

Variables	Range	Quantification	Questions
Liquidity stringency index	1–4	For (1)–(3): yes=1, no=0 For (4): yes=0, no=1	(1) Are there explicit, verifiable, and quantifiable guidelines regarding asset diversification? (2) Are banks prohibited from making loans abroad? (3) Do these reserves earn any interest? (4) Are banks allowed to hold reserves in foreign denominated currencies or other foreign denominated instruments?
Deposit insurance index	1–5	For (1)–(4): yes=1, no=0 For (5): if banks=1, 0 otherwise	(1) Is there an explicit deposit insurance scheme? (2) Is there a limit per person? (3) Does deposit insurance authority make the decision to intervene a bank? (4) Can deposit insurance agency take legal action against bank directors/officials? (5) Is it funded by the government, banks or both?
Provisioning stringency index	1–5	For (1)&(2): yes=1, no=0 For (3): answers are in percentage, we range value between 0 and 1 (example 45=0.45 or 100=1)	(1) Is there a formal definition of "non-performing loan"? (2) If one loan is non-performing, are other loans of a multiple-loan customer classified as non-performing? (3) Minimum required provisioning of loans as they become: (a) Substandard (b) Doubtful (c) Loss
Market discipline index	1–9	For (1)–(6): yes=1, no=0 For (7): yes=0, no=1	(1) Are consolidated accounts covering bank and any non-bank financial subsidiaries required? (2) Are off-balance sheet items disclosed to public? (3) Must banks disclose risk management procedures to public? (4) Are directors legally liable for erroneous/misleading information? (5) Do regulations require credit ratings for commercial banks? (6) Which bank activities are rated?: (a) Bonds (b) Commercial papers (c) Other (7) Does income statement contain accrued but unpaid interest/principal while loan is non-performing?

Table 2.16 (Continued): Construction of regulatory variables for survey II (2002)

Variables	Range	Quantification	Questions
Supervisory power index	1-14	For all questions: yes=1, no=0	(1) Are off-balance sheet items disclosed to supervisors? (2) Is auditor's report given to supervisory agency? (3) Can supervisors meet external auditors to discuss report without bank approval? (4) Are auditors legally required to report misconduct by managers/directors to supervisory agency? (5) Can legal action against external auditors be taken by supervisor for negligence? (6) Can supervisors force banks to change internal organizational structure? (7) Can the supervisory agency order directors/management to constitute provisions to cover actual/potential losses? (8) Can the supervisory agency suspend director's decision to distribute: (a) Dividends (b) Bonuses (c) Management fees (9) Can the supervisory agency supersede bank shareholder rights and declare bank insolvent? (10) Regarding bank restructuring & reorganization, can supervisory agency or any other govt. agency do the following: (a) Supersede shareholder rights (b) Remove and replace management (c) Remove and replace directors
Supervisory structure index	1-3	For (1): yes=1, no=0 For (2): yes=0, no=1 For (3): if the answer contains the parliament=1, 0 otherwise	(1) Is there more than one supervisory body? (2) Are supervisors legally liable for their actions? (3) To whom are supervisors accountable?

Table 2.17: Construction of regulatory variables for survey III (2007)

Variables	Range	Quantification	Questions
Barriers to entry			
Initial capital index	1–5	For (1): answer between 0 and 1 For (2)&(3): yes=1, no=0 For (4)&(5): yes=0, no=1	(1) Minimum capital entry requirement ³⁵ (2) Is it legally required that applicants submit information on the source of funds to be used as capital? (3) Are the sources of funds to be used as capital verified by the regulatory/supervisory authorities? (4) Can the initial disbursement or subsequent injections of capital be done with assets other than cash or government securities? (5) Can initial disbursement of capital be done with borrowed funds?
Foreign entry index	1–4	For all questions: yes=1, no=0	(1) Are foreign entities prohibited from entering through: (a) Acquisition (b) Subsidiary (c) Branch (d) Joint-venture
Permission activity index	1–8	For all questions: yes=1, no=0	(1) Legal submissions required for banking license: (a) Draft by-laws (b) Intended organization chart (c) First 3-year financial projections (d) Financial information on shareholders (e) Background/experience of future directors (f) Background/experience of future managers (g) Sources of funds in capitalization of new bank (h) Intended market differentiation of new bank
Stability regulation index			
Overall capital index	1–10	For (1): answer between 0 and 1 For (2): if answer is < 0.75 = 1, 0 otherwise For (3)–(8): yes=1, no=0	(1) What is the minimum capital to asset ratio requirement? ³⁶ (2) What fraction of revaluation gains is allowed as part of capital? (3) Is this ratio risk weighted in line with the 1988 Basle guidelines? (4) Does the minimum ratio vary as a function of an individual bank's credit risk? (5) Does the minimum ratio vary as a function of market risk? (6) Does the minimum ratio vary as a function of operational risk? (7) Is subordinated debt allowable as part of regulatory capital? (8) Before minimum capital adequacy is determined, which of the following are deducted from the book value of capital?: (a) Market value of loan losses not realized in accounting books? (b) Unrealized losses in securities portfolios? (c) Unrealized foreign exchange losses?
Ownership index	1–4	For (1): yes=1, no=0 For (2)&(3): yes=0, no=1 For (4): unrestricted=0, permitted=0.25, restricted=0.75 and prohibited=1	(1) Is there a maximum percentage of bank capital that can be owned by a single owner? (2) Can related parties own capital in a bank? (3) Can non-financial firms own shares in commercial banks? (4) If any voting shares can be owned by non-financial firms, what are the limits?

³⁵Minimum capital entry requirement is given in local currency. Thus, we converted all these data in millions of dollars. We assigned 1 to the highest minimum capital entry requirement to have values between 0 and 1. The final index may vary since the exchange rate is not the same for the whole period.

³⁶We assigned 1 to the highest minimum capital-asset ratio requirement to have values between 0 and 1.

Table 2.17 (Continued): Construction of regulatory variables for survey III (2007)

Variables	Range	Quantification	Questions
Audit requirement index	1–5	For all questions: yes=1, no=0	<ol style="list-style-type: none"> (1) Is an external audit a compulsory obligation for banks? (2) Are auditing practices for banks in accordance with international auditing standards? (3) Is it required by the regulators that bank audits be publicly disclosed? (4) Are specific requirements for the extent or nature of the audit spelled out? (5) Are auditors licensed or certified?
Liquidity stringency index	1–5	For (1)–(4): yes=1, no=0 For (5): yes=0, no=1	<ol style="list-style-type: none"> (1) Are there explicit, verifiable, and quantifiable guidelines regarding asset diversification? (2) Are banks limited in their lending to single or related borrowers? (3) Are banks required to hold either liquidity reserves or any deposits at the Central Bank? (4) Do these reserves earn any interest? (5) Are banks allowed to hold reserves in foreign denominated currencies or other foreign denominated instruments?
Deposit insurance index	1–8	For (1)–(7): yes=1, no=0 For (8): if banks=1, 0 otherwise	<ol style="list-style-type: none"> (1) Is there an explicit deposit insurance protection system? (2) Do deposit insurance fees charged to banks vary based on some assessment of risk? (3) Is there a limit per person? (4) Is there formal coinsurance, that is, are depositors explicitly insured for less than 100% of their deposits? (5) Does the deposit insurance authority make the decision to intervene a bank? (6) Does the deposit insurance authority by itself have the legal power to cancel or revoke deposit insurance for any participating bank? (7) Can the deposit insurance agency/fund take legal action for violations against laws, regulations, and bylaws (of the deposit insurance agency) against bank directors or other bank officials? (8) Is it funded by the government, the banks, or both ?
Provisioning stringency index	1–5	For (1)&(2): yes=1, no=0 For (3): answers are in percentage, we range value between 0 and 1 (example 45=0.45 or 100=1)	<ol style="list-style-type: none"> (1) Is there a formal definition of a "nonperforming loan"? (2) If a customer has multiple loans and one loan is classified as non-performing, are the other loans automatically classified as non-performing? (3) Minimum required provisioning of loans as they become: (a) Substandard (b) Doubtful (c) Loss
Market discipline index	1–9	For (1)–(6): yes=1, no=0 For (7): yes=0, no=1	<ol style="list-style-type: none"> (1) Are financial institutions required to produce consolidated accounts covering all bank and any non-bank financial subsidiaries (including affiliates of common holding companies)? (2) Are off-balance sheet items disclosed to the public? (3) Must banks disclose their risk management procedures to the public? (4) Are bank directors legally liable if information disclosed is erroneous or misleading? (5) Do regulations require credit ratings for commercial banks? (6) Which bank activities are rated?: (a) Bonds (b) Commercial papers (c) Other (7) Does accrued, though unpaid, interest/principal enter the income statement while the loan is still non-performing?

Table 2.17 (Continued): Construction of regulatory variables for survey III (2007)

Variables	Range	Quantification	Questions
Supervisory power index	1-14	For all questions: yes=1, no=0	(1) Are off-balance sheet items disclosed to supervisors? (2) Do supervisors get a copy of the auditor's report? (3) Does the supervisory agency have the right to meet with external auditors to discuss their report without the approval of the bank? (4) Are auditors required by law to communicate directly to the supervisory agency any presumed involvement of bank directors or senior managers in illicit activities, fraud, or insider abuse? (5) Can legal action against external auditors be taken by supervisor for negligence? (6) Can supervisors force banks to change internal organizational structure? (7) Can the supervisory agency order directors/management to constitute provisions to cover actual/potential losses? (8) Can the supervisory agency suspend director's decision to distribute: (a) Dividends (b) Bonuses (c) Management fees (9) Can the supervisory agency supersede bank shareholder rights and declare bank insolvent? (10) Regarding bank restructuring & reorganization, can supervisory agency or any other govt. agency do the following: (a) Supersede shareholder rights (b) Remove and replace management (c) Remove and replace directors
Supervisory structure index	1-4	For (1): yes=1, no=0 For (2): yes=0, no=1 For (3): if the answer contains the parliament=1, 0 otherwise For (4): if the answer is yes and is < 4 years=1, 0 otherwise	(1) Are there multiple Bank Supervisory Agencies/Superintendencies? (2) Can individual supervisory staff be held personally liable for damages to a bank caused by their actions or omissions committed in the good faith exercise of their duties? (3) To whom are the supervisory bodies responsible or accountable? (4) Does the head of the supervisory agency (and other directors) have a fixed term?

Table 2.18: Construction of regulatory variables for survey IV (2011)

Variables	Range	Quantification	Questions
Initial capital index	1–4	For (1)&(2): yes=1, no=0 For (3)&(4): yes=0, no=1	(1) Does the minimum capital entry requirement vary depending on the nature of the banking businesses that are licensed? (2) Are the sources of funds to be used as capital verified by the regulatory/supervisory authorities? (3) Can the initial disbursement or subsequent injections of capital be done with assets other than cash or government securities? (4) Can initial capital contributions by prospective shareholders be in the form of borrowed funds?
Foreign entry index	1–4	For all questions: yes=1, no=0	(1) Are foreign entities prohibited from entering through: (a) Acquisition (b) Subsidiary (c) Branch (d) Joint-venture
Permission activity index	1–9	For all questions: yes=1, no=0	(1) Which of the following are legally required to be submitted before issuance of the banking license?: (a) Draft bylaws (b) Intended organizational chart (c) Structure of Board (d) Market / business strategy (e) Financial projections for first three years (f) Financial information on main potential shareholders (g) Background/experience of future Board directors (h) Background/experience of future senior managers (i) Source of funds to be used as capital
Stability regulation index			
Overall capital index	1–11	For (1): answer between 0 and 1 For (2): if answer is $\geq 0.75=1$, 0 otherwise For (3)–(5): yes=1, no=0 ³⁷	(1) What was the minimum required risk-based regulatory capital ratio as of end of 2010? (2) What fraction of revaluation gains is allowed as part of capital? (3) Do you use the Basel II regime as of end of 2010 ? (4) Which risks are covered by the current regulatory minimum capital requirements in your jurisdiction?: (a) Credit risk (b) Market risk (c) Operational risk (5) Are the following items deducted from regulatory capital?: (a) Goodwill (b) Deferred tax assets (c) Intangibles (d) Unrealized losses in fair valued exposures (e) Investment in the capital of certain banking, financial and insurance entities which are outside the scope of consolidation

³⁷We assigned 1 to the highest minimum capital-asset ratio requirement to have values between 0 and 1.

Table 2.18 (Continued): Construction of regulatory variables for survey IV (2011)

Variables	Range	Quantification	Questions
Ownership index	1–4	For (1): yes=1, no=0 For (2): yes=0, no=1 For (3)&(4): (a)=0, (b)=0.25, (c)=0.5 and (d)=1	(1) Is there a maximum percentage of a bank's equity that can be owned by a single owner? (2) Can related parties own capital in a bank? (3) Can non-financial firms own voting shares in commercial banks?: (a) Non-financial firm may own 100% of the equity in a commercial bank (b) Non-financial firm may own 100% of the equity in a commercial bank, but prior authorization or approval is required (c) Limits are placed on ownership of banks by non-financial firms, such as maximum percentage of a commercial bank's capital or shares (d) Non-financial firms cannot own any equity investment in a commercial bank (4) Can non-bank financial firms own voting shares in commercial banks?: (a) Non-bank financial firm may own 100% of the equity in a commercial bank (b) Non-bank financial firm may own 100% of the equity in a commercial bank, but prior authorization or approval is required (c) Limits are placed on ownership of banks by non-bank financial firms, such as maximum percentage of a commercial bank's capital or shares (d) Non-bank financial firms cannot own any equity investment in a commercial bank
Audit requirement index	1–5	For all questions: yes=1, no=0	(1) Is an audit by a professional external auditor required for all commercial banks in your jurisdiction? (2) Does the external auditors have to obtain a professional certification or pass a specific exam to qualify as such? (3) Are specific requirements for the extent or nature of the audit spelled out? (4) Are banks required to promptly report to the banking supervisor any change of external auditor and the reasons for the change? (5) Are banks required to nominate more than one external auditor? (6) Do laws or regulations require auditors to conduct their audits in accordance with International Standards on Auditing (ISA)?
Liquidity stringency index	1–5	For (1)–(4): yes=1, no=0 For (5): yes=0, no=1	(1) Are banks limited in their lending to a single borrower or a group of inter-related borrowers? (2) Are there any regulatory rules or supervisory guidelines regarding asset diversification? (3) Are banks prohibited from making loans abroad? (4) Are Central Bank reserve and/or deposit required in your jurisdiction? (5) Are banks required to hold reserves in foreign currencies or other foreign-denominated instruments?

Table 2.18 (Continued): Construction of regulatory variables for survey IV (2011)

Variables	Range	Quantification	Questions
Deposit insurance index	1–8	For all questions: yes=1, no=0	<p>(1) Is there an explicit deposit insurance protection system for commercial banks?</p> <p>(2) Does the deposit insurance authority by itself have the legal power to cancel or revoke deposit insurance for any participating bank?</p> <p>(3) Can the deposit insurance agency/fund take legal action for violations against laws, regulations, and bylaws (of the deposit insurance agency) against bank directors or other bank officials?</p> <p>(4) Is there formal coinsurance, i.e. are all depositors explicitly insured for less than 100% of their deposits?</p> <p>(5) Do deposit insurance fees/premiums charged to banks vary based on some assessment of risk?</p> <p>(6) Were insured depositors wholly compensated (to the extent of legal protection) the last time a bank failed?</p> <p>(7) Have you introduced changes to your deposit protection system as a result of the global financial crisis?</p> <p>(8) Is funding provided by banks?</p>
Provisioning stringency index	1–5	For (1)&(2): yes=1, no=0 For (3): answers are in percentage, we range value between 0 and 1 (example 45=0.45 or 100=1)	<p>(1) Do you have an asset classification system under which banks have to report the quality of their loans and advances using a common regulatory scale?</p> <p>(2) If a customer has multiple loans and advances and one of them is classified as non-performing, are all the other exposures automatically classified as non-performing as well?</p> <p>(3) Minimum required provisioning of loans as they become: (a) Substandard (b) Doubtful (c) Loss</p>
Market discipline index	1–7	For (1)–(4): yes=1, no=0 For (5): yes=0, no=1	<p>(1) Are banks required to prepare consolidated accounts for accounting purposes?</p> <p>(2) Do banks disclose to the public: (a) Full audited financial statements (b) Off-balance sheet items (c) Governance and risk management framework</p> <p>(3) Are bank directors legally liable if information disclosed is erroneous or misleading?</p> <p>(4) Are commercial banks required by supervisors to have external credit ratings?</p> <p>(5) Does accrued, though unpaid, interest/principal enter the income statement while the loan is non-performing?</p>

Table 2.18 (Continued): Construction of regulatory variables for survey IV (2011)

Variables	Range	Quantification	Questions
Supervisory power index	1–14	For all questions: yes=1, no=0	<p>(1) Do supervisors receive a copy the auditor’s report on the financial statements?</p> <p>(2) Are auditors required to communicate directly to the supervisory agency any presumed involvement of bank directors or senior managers in illicit activities, fraud, or insider abuse?</p> <p>(3) Does the supervisor have the powers to take actions against the bank?</p> <p>(4) Are off-balance sheet items disclosed to supervisors?</p> <p>(5) Indicate whether the following enforcement powers are available to the supervisory agency: (a) Require banks to constitute provisions to cover actual or potential losses (b) Withdraw the bank’s license (c) Require banks to reduce/restructure their operations and adjust their risk profile (d) Require banks to reduce or suspend dividends to shareholders (e) Require banks to reduce or suspend bonuses and other remuneration to bank directors and managers (f) Suspend or remove bank directors (g) Suspend or remove managers</p> <p>(6) Does the banking supervisor have the right to meet with the external auditors and discuss their report without the approval of the bank?</p> <p>(7) Does bank supervisor have the powers to perform the following problem bank resolution activities?: (a) Declare insolvency (b) Supersede shareholders’ rights</p>
Supervisory structure index	1–4	<p>For (1): yes=1, no=0</p> <p>For (2): yes=0, no=1</p> <p>For (3): if the answer contains the parliament=1, 0 otherwise</p> <p>For (4): if the answer is yes and is < 4 years=1, 0 otherwise</p>	<p>(1) Are there multiple Bank Supervisory Agencies/Superintendencies?</p> <p>(2) Can individual supervisory staff be held personally liable for damages to a bank caused by their actions or omissions committed in the good faith exercise of their duties?</p> <p>(3) To whom is the supervisory agency legally responsible or accountable?</p> <p>(4) Does the head of the supervisory agency have a fixed term?</p>

Chapter 3

Macroprudential policy revamp in times of pandemic: Flexible tools to combat “extraordinary” shocks³⁸

The outbreak of the COVID-19 has pushed governments across the world to put their economies in medically-induced comas for several months. Adverse consequences arising from such an exogenous shock affect the real economy and are likely to spread to the financial sector. In Europe, De Moura Fernandes (2020) estimates a dramatic rise of insolvencies in the coming months and until mid-2021. The ECB is currently studying the establishment of a “bad bank” to which some hundred billion euros of risky loans would be transferred. Meanwhile, the EBA encourages national authorities to make full use of the flexibility embedded within the existing regulatory framework. For instance, the capital and liquidity buffers are designed to absorb losses and ensure continuous credit flows when the economy is stricken. In addition, to foster lending, the ECB’s banking supervision has endorsed a greater flexibility in the prudential rulebook by recently deciding that banks could meet their capital requirements, as laid down in Pillar 2 of the Basel III requirements, with instruments other than Tier 1 capital such as additional Tier 1 or

³⁸This Chapter is co-authored by Ibrahima Sangaré.

Tier 2 instruments. Also, to weather COVID-19, the ECB has relaxed the bank leverage regulation by excluding certain exposures to the central bank from their leverage ratio.

Our work aims to explore such actions in the Euro Area. Given the expected deterioration in the ability of households and firms to pay off their debts, we contribute to the recent literature by examining a loosening of macroprudential policy in the event of an exogenous shock such as the COVID-19 pandemic. We assume that the latter shock dramatically affects both households and businesses' capacity to repay their loans, which in turn is passed on to risk premia. However, at the same time, easing macroprudential tools should not alter financial stability. Prior to the outbreak of the pandemic, neither the ECB nor the European Systemic Risk Board had identified systemic risks, but the two institutions have pushed for close monitoring of financial stability when combining risks associated to property prices rise, private indebtedness, and new lending driven by the low-yield environment (Darvas and Pichler, 2018; International Monetary Fund, 2018).

Since mid-2014, residential valuation has steadily increased. In both the Euro Area and the EU, house prices skyrocketed by 4.2% over the second quarter of 2019 compared with the second quarter of 2018 (Eurostat, 2019). This trend is tightly synchronised with loan origination (see Figure 3.1). While mortgage loans have grown at a moderate pace, Adalid and Falagiarda (2018) show that, when exploring both loan repayments and loan origination, the former has dragged down net loan growth via its long-lasting effects. Overall, in the Euro Area, newly granted loans with a floating rate are trending downward; however, in some countries, an essential share of outstanding mortgages hold is of an adjustable-rate, exposing households to interest rate risk (Bouyon, 2017). Additionally, in the event of a housing bust, a heavy private debt burden is likely to aggravate a recession (Glick and Lansing, 2010; Mian and Sufi, 2014; Jordà et al., 2016). Although the average households debt in percentage of income in the Euro area has appeared to level off, its amount reached 97.5% in 2018 (Lo Duca et al., 2019).

In the light of these recent evolution, the European Central Bank (2019) had warned

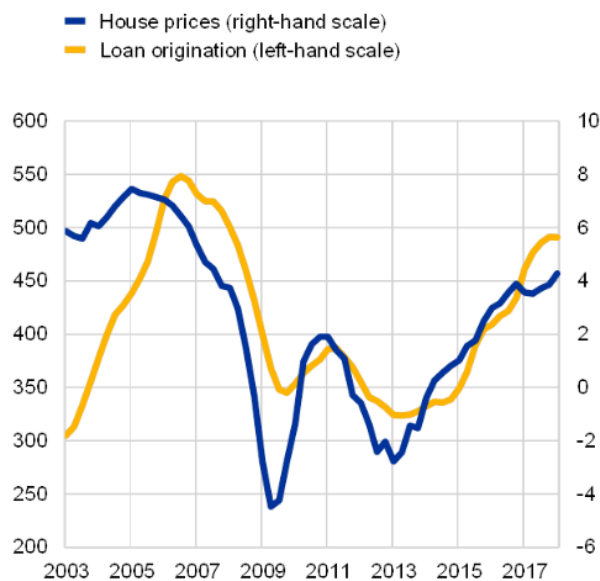


Figure 3.1: House prices (right scale) and loan origination (left scale) in the Euro area. House prices are expressed in percentage changes and loan origination correspond to accumulated 12-month flows in EUR billions.

Source: ECB.

against unexpected deteriorations in market conditions, as well as tighter financial conditions through both availability and cost of borrowing. This is of particular relevance in a time of the pandemic; worsened market conditions could adversely affect households' and businesses' capacity to repay their debts and, in turn, jeopardise banks' soundness, especially in countries with important exposures to housing market.

Furthermore, as discussed in Chapter 2, the low-interest-rate environment poses a challenge to structural banks' profitability and is at the core of monetary policy guidance debate. Chapter 2 presents empirical evidence in both the growing empirical literature and the results that persistently low-interest rates adversely affect NIM and hamper banks' traditional core business (see *inter alia* Lopez et al., 2011; Borio et al., 2017; Claessens et al., 2017). When focusing on the linkage between low profitability and financial stability, the European Central Bank (2019) points to undesirable consequences that could arise from low ROE, which mainly ranges between 8% and 10% (see Figure 3.2). As such, low profitability is a major concern from a financial stability perspective, as it hinders capital raising and thus, limits the build-up of buffers. To compensate for the squeeze on

margins, banks engage in large lending volumes. Although the coronavirus crisis can be expected to dampen lending activity, banks are holding a large stock of mortgages, much of which could be exposed to the risk of default.

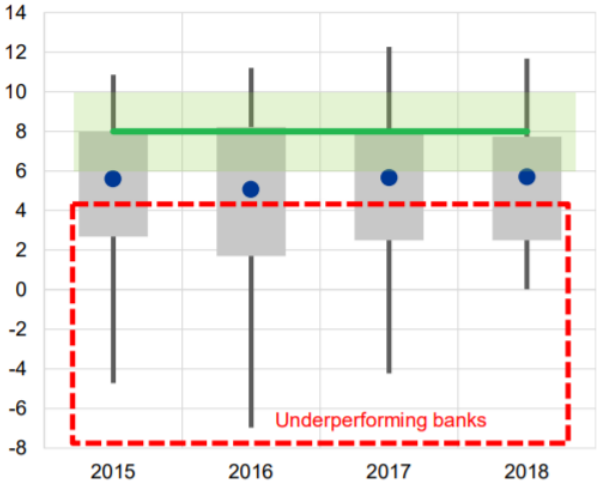


Figure 3.2: Distribution of bank Return-on-Equity (in percentage) in the Euro area. The green shaded area represents an indicative target range of 6-10% ROE based on survey-based evidence on banks’ medium and long-term targets, as well as cost of equity estimates. The red rectangle represents the cohort of underperforming banks, i.e. those which recorded a below-median ROE in at least three years between 2015 and 2018

Source: ECB supervisory data and ECB calculations.

Financial stability challenges thus appear as twofold. First, while the rapid growth of mortgage and business loans was mitigated by the health crisis, the evolution of housing prices is uncertain and the high level of household and corporate indebtedness is bound to be aggravated, raising the risk of an increase in loan defaults. Second, the banking industry’s performance amid the low-yield environment could be even worsened by a slack economy and an upsurge in payment defaults. Therefore, these two vulnerabilities require close monitoring. On July 2019, the IMF issued that “macroprudential policies should be used more actively to manage financial vulnerabilities in both housing and corporate sectors” (International Monetary Fund, 2018, p.23). More particularly, while capital-based instruments are best suited to tame risks stemming from high level of private indebtedness and overvalued house prices, borrower-based instruments are found to be effective in correcting risks related to household indebtedness, demand for mortgages and

worsening of credit conditions (Lo Duca et al., 2019).

European authorities responsible for financial stability devoted important efforts to tackle the huge deviations and imbalances experienced during the financial crisis by designing macroprudential policies on both supply and demand sides. On the bank side, authorities enforced the Capital Requirement Directive IV and the Capital Requirement Regulation packages which transpose the Basel III global standards on bank capital into a legal European framework. On the demand side, given the major role played by the residential real estate market during the GFC, the European Commission published, in 2014, a Directive related to consumer mortgage credit agreements (Directive 2014/17/EU) aiming to define a common “responsible lending policy” among European Member States. This Directive introduces complementary tools, such as the LTV ratio, deemed as the most efficient macroprudential tool to correct house prices (International Monetary Fund, 2013). However, as explained in the introduction, by its very nature, the Directive may lead room to Member States to adapt these tools³⁹.

Unlike stringent regulations on bank’s capital aiming to strengthen the banking system, no standardised restrictions are legally enshrined across the Euro Area regarding borrower-based measures. The main reasons lie in the lack of harmonisation regarding the definition of hazard ratios and in the disparate commercial practices (Couailler et al., 2018). Table 3.1 reports that, despite different definitions of the ratio, a number of countries have introduced this tool at the national level. By contrast, in other countries, constraints on credits are still left to the discretion of financial institutions, which may lead to divergent terms and conditions when issuing loans. Beyond the heterogeneous use across the Euro Area, imposing an LTV cap – and more generally any type of regulation – hits the problem of coverage. The jurisdiction to which the instrument applies, highly matters for its effect. In the absence of common rules, deteriorated market conditions

³⁹Despite this positive progress in drafting demand-side policies, in November 2016, the (European Systemic Risk Board) ESRB issued eight warnings, whose five concerned Euro Area countries (Austria, Belgium, Finland, Luxembourg and the Netherlands), that medium-term vulnerabilities in the real estate sector coupled with households’ indebtedness may be a source of systemic risk.

in one country could adversely impact financial stability and spread to the economies of neighbouring countries, as was the case during the financial crisis and shortly afterwards during the sovereign debt crisis.

Table 3.1: LTV caps officially notified to the ESRB by country in the Euro Area

	Countries	National authority	LTV cap	Type of legislation
1	Austria	Oesterreichische Nationalbank	80%	Recommendation
2	Cyprus	Central Bank of Cyprus	70% (80% for first time buyers)	National law
3	Estonia	Eesti Pank	85% (90% if state guaranteed)	National law
4	Finland	Finanssivalvonta	85% (95% if first time buyers)	National law
5	Ireland	Central Bank of Ireland	80% (90% if first time buyers)	National law
6	Latvia	Latvias Banka	90% (95% if state guaranteed)	National law
7	Lithuania	Lietuvos bankas	85%	National law
8	The Netherlands	Rijksoverheid	100%	National law
9	Portugal	Banco de Portugal	90% (80% for other than own and permanent residence 100% for properties held by banks and for property financial leasing agreements)	Recommendation (based on the “comply or explain” principle)
10	Slovakia	Národná banka Slovenska	90% Share of new loans with LTV > 80% cannot exceed 20%	National law
11	Slovenia	Banka Slovenije	80%	Recommendation

Notes: authors’ elaboration on collected information by the ESRB. Note that Bank of Finland (2018) recently endorsed this measure in order to mitigate the households indebtedness risk, as the lion’s share of domestic borrowing includes mortgage loans, and the limit is on the loan-to-collateral, rather than the LTV. In Belgium, France, Germany, Greece, Italy, Luxembourg, Malta and Spain, no LTV regulation is currently available in the national policy toolkit.

Against this background, our work aims at assessing the effectiveness of easing macroprudential instruments in the event of an exogenous shock such as the pandemic, while accounting for financial vulnerabilities. This study involves two steps.

Before to introduce our theoretical model, in a first step, we provide empirical evidence. In the view of the vulnerabilities identified by the ECB and the IMF, we focus on households' capacity to repay their mortgage loans. Using panel VAR analysis, we study the propagation of an exogenous shock, which rises up risk premia on newly issued mortgages⁴⁰, through the economy and the banking system to determine its impact on financial stability. To further complement empirical evidence, we conduct an Interacted Panel VAR (IPVAR) analysis which, unlike the previous standard panel VAR, allows for the inclusion of the time-varying level of macroprudential policy. Such a model enables the exogenous variable, namely the level of macroprudential policy, to interact with other variables and therefore to study macroprudential policy at a low level (i.e., when macroprudential conditions are relaxed) and at a high level (i.e., when macroprudential conditions are tight).

In a second step, we embed a DSGE model which further explores the role of macroprudential policy in the Euro Area. The model features two types of households and a housing sector. We also present a competitive banking sector constrained by regulatory capital requirements which closely mimic the way prudential policy is conducted. Furthermore, our model introduces collateral constraints. Only households are financially constrained when borrowing but both firms and impatient households are subject to a collateral. Nevertheless, both mortgage and business loans can default. In particular, such a model assesses the extent to which the relaxation of capital and/or borrower-based tools can mitigate the risks resulting from an exogenous shock such as the Covid-19 epidemic and foster the economy.

Our work encourages policymakers to make the most of macroprudential flexibility. Both our empirical and theoretical models demonstrate that an ease scenario of macro-

⁴⁰Given the available data, our analysis focuses solely on an increase in risk premia on mortgages.

prudential policy helps mitigate the adverse effects stemming from the health shock on risk premia. In particular, empirical findings show that an easing scenario of macroprudential policy prevent the economy from experiencing a “mortgage crunch”, and the economy is not necessarily recessionary. Furthermore, the DSGE model, which unlike the empirical model focuses on both mortgages and corporate loans, shows that relaxing the LTV ratio is more effective than relaxing the Capital Requirement Ratio (CRR). A higher LTV ratio helps alleviate negative effects by specifically containing the fall in corporate lending. Banks compensate their mortgage cut by both issuing relatively more corporate loans and lowering interest rates on these loans. Such measures have a positive effect on consumption, production and banks’ expected returns, which in turn increase their capital.

In the next section, we present an overview of the related literature. Then, we provide, in Section 3, stylised facts and empirical evidence. In Section 4, we introduce the DSGE model and in Section 5, we present its calibration. In Section 6, we comment on our results. Finally, we summarise our main findings and conclude in Section 7.

3.1 Related literature

Our study is related to several strands of the literature. First, it is linked to manifold papers that feature the role of housing as collateral constraints as introduced in Iacoviello (2005). This latter differentiates between impatient (borrower) and patient (lender) households and create a collateral constraint faced by borrowers (i.e. impatient households and entrepreneurs). This collateral is tied to the physical value of capital or house, implying that they cannot borrow more than a fraction of their capital or housing stock. Although Iacoviello (2005), or other papers as Iacoviello and Neri (2010) (an extension of the previous model), Lambertini et al. (2017) and Pataracchia et al. (2013), feature a collateral constraint in their model, they do not explicitly represent financial intermediaries. As financial frictions originate from households, saving households endorse the role of lenders.

Nevertheless, because of the prominent role of banks, as depicted during the GFC, few papers introduce them and aim at explaining the magnitude of the GFC when implementing financial shocks. For instance, Gerali et al. (2010) focus on the Euro Area banking system's characteristics. Consequently, the authors consider frictions directly arising from an imperfectly competitive banking sector but they do not consider any default at the borrower level. Iacoviello (2015) allows borrowers to default and introduces banks that are financially constrained when collecting deposits, as in Gertler and Kiyotaki (2010) and Gertler and Karadi (2011). However, in Gerali et al. (2010) and Iacoviello (2015), the authors do not focus on the efficiency of macroprudential tools. The LTV ratio is not considered as a tool able to mitigate financial instability, but only as a collateral constraint, and the interaction between the demand- and supply-side measures is not explored. Hence, we try to fill this gap by embedding an explicit banking sector subject to a regulatory capital requirement and by imposing an exogenous LTV ratio. Finally, we aim at considering the interaction between both borrower and capital based measures.

Consequently, our work is also related to a second growing strand of the literature which covers the use of macroprudential instruments. With this respect, modelling financial intermediaries becomes of great importance when focusing on the role of macroprudential regulations for financial stability⁴¹. Numerous papers analyse the performance of regulatory tools through a general equilibrium framework incorporating a banking sector and a collateral constraint. The two most frequently referred macroprudential tools are the capital requirement and the LTV. In Angelini et al. (2011), banks should respect an exogenous capital-to-asset target imposed by a regulator. They also consider the use of the LTV ratio. Depending on the shock that hits the economy, the set of prudential tools yields very different benefits. In “normal time”, i.e. when the economic cycle is predomi-

⁴¹Except for studies that exclusively explore the use of the LTV rule. Indeed, the capital requirement ratio needs to be directly initiated at the bank level while the LTV ratio is designed to household lending or either entrepreneurs or even to both. Hence, in many papers (Lambertini et al., 2017; Mendicino and Punzi, 2014; Alpanda and Zubairy, 2017, among others) introducing borrowing constraints *à la* Iacoviello (2005), patient households endorse the role of lender. Overall, the effectiveness of the LTV ratio in achieving its ultimate goal, that is financial stability, is unanimously agreed.

nantly driven by supply shocks, setting a countercyclical capital requirement ratio brings only marginal benefits over a “monetary-policy-only” scenario. Nonetheless, when the economy is hit by a financial shock, benefits become significant. Using a similar framework and relying on the same set of instruments, Suh (2011) embeds a twofold financial accelerator mechanism *à la* Bernanke and Woodford (2008), i.e. on both entrepreneur and borrowing household contracts. Though, the LTV rule is designed to be specific only to borrowing households. Given different shocks, the capital requirement ratio appears as more effective to mitigate the volatility of output and inflation. The LTV ratio underperforms as credits shift to the business sector.

Besides the nature of shocks, Catalán and Ganapolsky (2014) prescribe the use of an adjusting capital requirement ratio according to the phase of the business cycle. Regulator should tighten the ratio in anticipation of a recession but loosen it at the onset of the recession. In contrast to Catalán and Ganapolsky (2014), who find that macroprudential policy is not able to “lean” against the expansionary phase of the cycle, Christensen et al. (2011) suggest that relying on a strong countercyclical capital requirement ratio is markedly efficient to stabilise the cycle when financial shocks explain a non-negligible part of economic fluctuations. Agénor et al. (2013) confirms the previous work by considering two different instruments, a countercyclical bank capital requirement rule and a credit-augmented interest rate rule. They find that these regulations are optimal for mitigating economic instability if monetary policy struggles to respond to a high deviation of inflation from its target.

Other studies focus on the LTV ratio. In addition to the LTV, Mendicino and Punzi (2014) and Lambertini et al. (2017) use an interest rate rule responding to financial variable changes and find that, given different shocks, introducing the LTV ratio is welfare improving and helps stabilise the financial cycle. In the same vein, Rubio and Carrasco-Gallego (2014), who only implement an LTV rule, come to the same conclusion. Alpanda and Zubairy (2017) compare the performance of monetary policy, housing-related tax

policies and the LTV rule in reducing households' debt burden. Although monetary policy is able to reduce the stock of mortgage debts, it leads to an increase of the Debt-to-Income ratio, a tightening in regulatory tools is more efficient. All in all, few papers focus on the optimality of macroprudential tools (Mendicino and Punzi, 2014; Rubio and Carrasco-Gallego, 2014), as well as the examination of bank's reactions to the combination of both borrower- and capital-based measures into a general equilibrium framework (see for instance Benes et al., 2016).

Third, our work fits in the literature on DSGE models that incorporate financial frictions between the borrower and the lender. Only in the last decade, the works by Kiyotaki and Moore (1997) and Bernanke and Woodford (2008) paved the way to a flourishing literature which introduces such frictions. Unlike these two studies, where frictions emanate from entrepreneurs, Goodfriend and McCallum (2007), Gertler and Kiyotaki (2010) and Gertler and Karadi (2011) introduce financial frictions that directly arise from financial intermediaries. In our work, frictions originate from both impatient households and firms and take the form of credit defaults. In the aftermath of the GFC, numerous studies explore the importance of the interaction between macroeconomic conditions affecting bank's asset default and the financial system. After the European debt crisis, some papers stress the importance of the channels at play between the sovereign risk and the bank's soundness (see for example Gunn and Johri, 2013; Faia, 2017).

However, our work rather belongs to the stream of literature focusing on credit default. A sub-strand of this literature focuses on the role of mortgages in explaining the financial crisis. To this end, they embed mortgage default into DSGE models with two types of households, allowing financially constrained households to default (Forlati and Lambertini, 2011; Punzi and Rabitsch, 2016; Bekiros et al., 2017; Nookhwun and Tsomocos, 2017; Ricci and Tirelli, 2017; Wickens, 2017). By contrast, another sub-strand rather investigates the importance of the relationship between financial and real shocks in driving business cycles. Therefore, they exclusively implement defaults on corporate lending

(Agénor et al., 2013; Takamura, 2013; Hristov and Hülsewig, 2017). Unlike the mentioned studies above, a handful of papers expand the default to both mortgage and corporate lending. In particular, Suh (2011) implements the financial accelerator mechanism in both household and business contracts. The firm’s idiosyncratic shock hits the project value, while in our work, this latter directly arises from idiosyncratic productivity shock. Unlike most models in previous literature, we allow credit defaults to materialise on both mortgages and business loans, which have tangible consequences for banks’ balance sheet.

3.2 Evidence from the Euro Area data

This section first puts into perspective, through stylised facts, the evolution of the different key vulnerabilities identified in the Euro Area over the last two decades and prior to the onset of the pandemic. Second, the section introduces a panel VAR analysis. The model assesses to what extent an exogenous shock – such as the pandemic – to mortgage spread, directly disrupting households’ indebtedness sustainability, affects macroeconomic and banking variables in the Euro Area over the period 2003Q2-2019Q2. Finally, this section wraps up presenting an IPVAR, which complements the analysis by accounting for the time-varying role of macroprudential policy as an exogenous variable. In particular, this model allows comparing the role of a loose and a tight macroprudential policy on both macroeconomic and banking responses in the event of a shock on the mortgage spread.

3.2.1 Evolution of the vulnerabilities flagged prior to the outbreak of the pandemic

Figure 3.3 offers *prima facie* evidence from the Euro Area regarding key variables of our analysis and whose developments were flagged as potential vulnerabilities by both the ECB and the IMF before the effects of the COVID-19. Since the magnitude of the effects of the pandemic is still highly uncertain and our work does not aim to forecast them, the

stylised facts presented below provide a first step towards understanding the evolution of the variables identified as likely to undermine financial stability. We voluntarily include the financial crisis because it is the starting point for explaining the evolution of these variables and gives indications of the extent of a crisis phenomenon.

Over the last years, two intertwined banking phenomena are fairly striking. Expectedly, as discussed in Chapter 2, the first one is the sharp fall in bank profits in the wake of the financial crisis (see Figure 3.3c) and the second is the persistent decline in the bank lending rate for house purchases from the end of 2008 (see Figure 3.3d). Figure 3.3c and Figure 3.3d presents these variables for the whole banking sector in the European Union. Their evolution follows the one of the policy interest rate (see Figure 3.3d, which experienced continuous cuts and hit the ZLB in 2016 (see Figure 3.3d). Similarly to Figure 2.2 and Appendix D in Chapter 2, which both exhibit the evolution of ROA and ROE of our bank sample (by regions and for the whole sample, respectively), the figure shows that bank profitability deteriorated sharply in 2007-2008 and reached its bottom at nearly 0% in 2011.

As discussed in the previous Chapter, lower policy interest rates mechanically hinder banks' NIM and thus, affect the bank's core traditional business. However, despite the low-yield environment, from 2011 onwards, the evolution of bank profitability has kept on increasing. Banks might therefore be encouraged to soften their lending standards and engage in large lending volumes (see, *inter alia*, Dell'Ariccia and Marquez, 2006; Jiménez et al., 2009; Maddaloni and Peydró, 2011). At the same time, banks could have anticipated the continued fall in interest rates by revamping and improving their efficiency (i.e. minimising costs). Such a gain could have been transferred to the cost of borrowing (Shamshur and Weill, 2019), which can in turn increase the volume of loans.

Figure 3.3e pictures that despite a slow GDP growth and a slacker or even declining pace of household indebtedness, lending for house purchase has kept on increasing. As previously mentioned, mortgage loans growth is slightly pulled down by loan repayments

3.2 Evidence from the Euro Area data

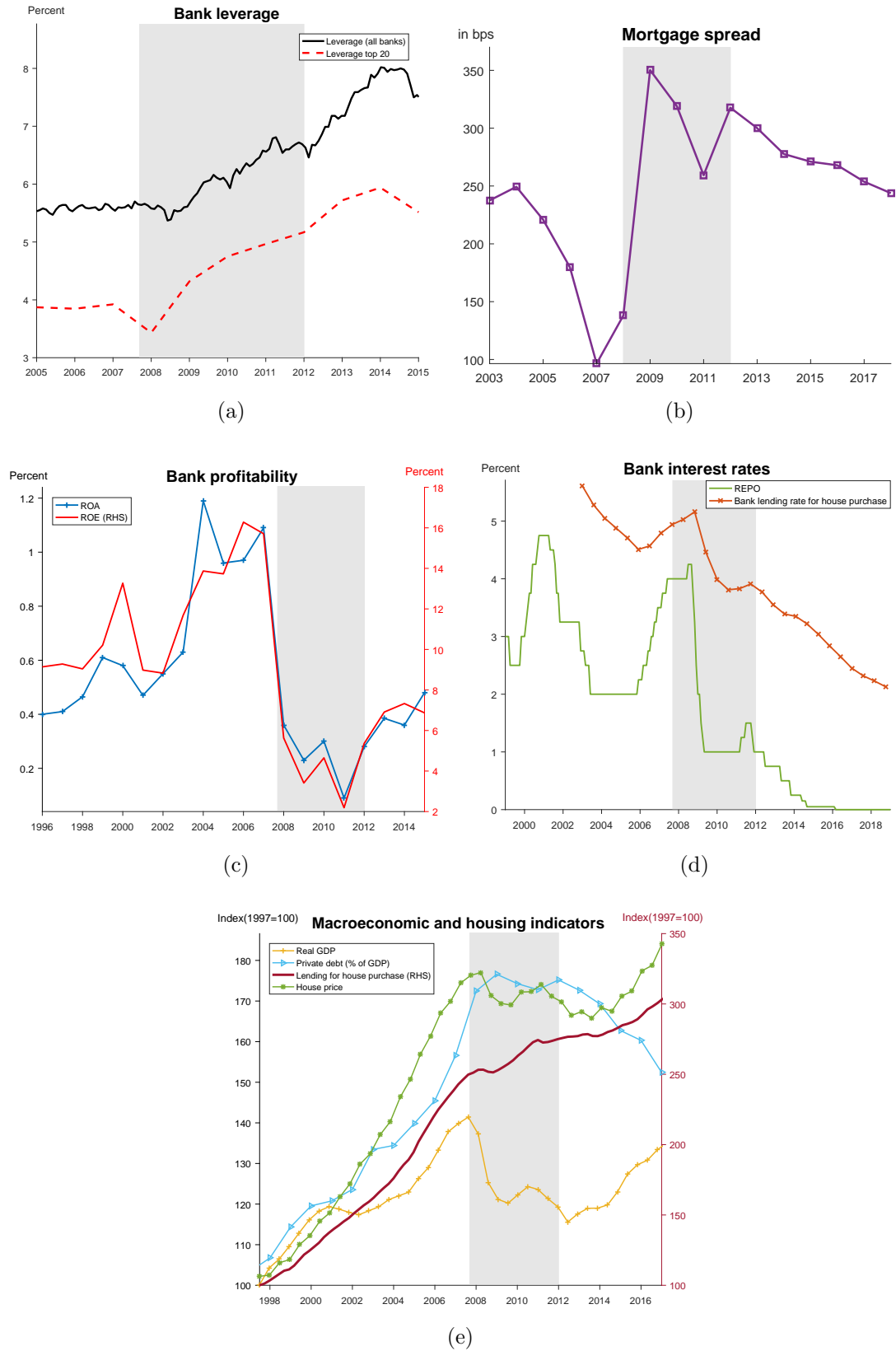


Figure 3.3: Empirical evidences. See Appendix G for data description.

(Adalid and Falagiarda, 2018), but the level of loan origination does not fade away (see Figure 3.1) and has recently fuelled house prices. It is worth mentioning that the level of house prices has recovered from its level registered during the financial crisis, and as of 2016, the annual growth rate outreached the long-term average (Battistini et al., 2018).

In the view of these developments, two questions remain pending when examining i) the leverage ratio (see Figure 3.3a) and ii) the mortgage spread, defined as the difference between the bank lending rate to households (for house purchase) and EONIA (see Figure 3.3b). First of all, the leverage ratio has increased and then levelled off over the most recent period. It therefore suggests that the transposition of the Basel III requirements in 2014 has proven to be somehow successful by coercing banks to increase their level of capital (e.g., banks must, *inter alia*, comply with a 3% minimum requirement for the leverage ratio, to which a surcharge for systemic bank is added). Second, while the mortgage spread has kept pace with bank interest rates, its decline has not been as pronounced. As a result, banks might have succeeded to slow down this spread by maintaining the level of the bank lending rate on house purchases and/or the interbank rate. However, although the latest observations displayed in Figure 3.3b have reached their pre-crisis levels, the pandemic's effects are expected to fuel it. The subsequent subsection assesses the effect of such a shock on key macroeconomic and banking variables.

3.2.2 The effects of a shock to mortgage spread on the Euro Area: A Panel VAR analysis

In what follows, we investigate empirical evidence. In order to better grasp the role of macroprudential policy, we propose a step-by-step analysis. In this first step, the VAR analysis aims to capture the effects of an exogenous shock to mortgage spreads on macroeconomic and banking variables, particularly those variables that have been identified as threats to financial stability. Such a shock reflects an increase in risk premia; however, given the availability of data, we were compelled to focus only on mortgages, excluding

business loans. The next subsection will complement the analysis by investigating the effects of macroprudential policy when the latter is accommodative and restrictive.

For the sake of consistency with the DSGE model, we opt for a VAR methodology that allows for the implementation of shocks and treats all variables as endogenous. In particular, we rely on a 1-lag⁴² quarter Euro Area panel VAR. Due to the changing composition of the Euro Area and thus, unavailability of data for the countries entering lately in the monetary union, we account for the 11 core countries⁴³ for which our data span the period from 2003Q2 to 2019Q2. Any other alternative method presents caveats for our analysis. For instance, a quarterly Euro Area VAR presents too few observations and would therefore lack robustness. A monthly Euro Area VAR is not consistent with the DSGE's time frequency. Given the relatively small number of countries and the medium time dimension, the least squares dummy variable estimator is the most consistent (Nickell, 1981; Bun and Kiviet, 2006). To this purpose, we follow the methodology developed by Cagala and Glogowsky (2014) enabling for unobserved individual country heterogeneity within our sample by introducing fixed effects. Finally, the standard errors of the Impulse Response Functions (IRF) and the confidence intervals are generated by the use of bootstrap.

The 1-lag quarter Euro Area VAR includes six variables, namely the real GDP growth (GDP), bank lending margin (LM), mortgage spread (MS), bank capital growth (K), housing prices evolution (HP) and the growth rate of newly issued loans for house purchase⁴⁴ (LH^n) (see Appendix H for further details). In order to explore the effect of a shock on the households' repayment capacity, we examine an orthogonalised shock to mortgage spread. Estimating a positive shock to mortgage spread stems from the demand-

⁴²The optimal number of lag is selected by relying on several information criteria: the likelihood criteria, the Akaike's information criterion, the Schwarz's Bayesian information criterion, and the Hannan and Quinn information criterion.

⁴³That is Austria, Belgium, France, Finland, Germany, Italy, Ireland, Luxembourg, the Netherlands, Portugal and Spain.

⁴⁴In the empirical model, we only account for lending to households. Newly granted loans to corporate for house purchases is not available.

side and reflects a deterioration in financial conditions, causing an immediate effect on households' repayment capacity. Mortgage spread is defined as the difference between the bank interest lending rate to households for house purchases of each country of our sample and the EONIA. According to Kanngiesser et al. (2017), relying on the mortgage spread presents several advantages as it captures repricing in assets after a shock on the bank supply, accounts for the level of monetary policy and catches the bank's capacity to generate income from mortgage activity. We also introduce the bank lending margin to grasp bank profitability⁴⁵. Such indicator for bank profitability is also consistent with the DSGE model.

Our baseline model can be specified as follows:

$$Y_{i,t} = C_i + A_i(L_i)Y_{i,t} + \epsilon_{i,t}, \quad (3.1)$$

where $i = 1, \dots, N$ and $t = 1, \dots, T$ are indexes of country and time, respectively, $Y_{i,t}$ is a vector (6×1) of the endogenous variables (GDP, LM, MS, K, HP, LH^n), C_i is a vector of country specific intercepts, $A_i(L_i)$ is a matrix polynomial in the lag operator specific to each country, and $\epsilon_{i,t}$ is a vector of idiosyncratic errors. It is often assumed that the vector of residuals is independent and identically distributed, but this assumption is likely to fail since the variance-covariance matrix of errors is in practice not diagonal. In this respect, it is important to isolate the shock on one of the VAR errors by decomposing the residuals so that they become orthogonal. The variables should thus be ordered based on their degree of exogeneity to have a recurrent causal order (Sims, 1980).

Therefore, the key shock is identified using a standard Cholesky decomposition which ensures the orthogonalisation of the shocks. Ordering macroeconomic variables before financial blocks is standard in the literature (see for instance, Kanngiesser et al., 2017; Leroy and Lucotte, 2019). This suggests that financial variables react promptly to real

⁴⁵Relying on the ROA and ROE would have been more appropriate to grasp overall profitability; however, available data only starts in 2007. Such a timeframe considerably reduces our data points.

shocks. The remaining variables are ordered as follows: lending margin, mortgage spread, bank capital, house prices, and newly loans for house purchase. We consider that mortgage spreads react contemporaneously to lending margin as the deposit rate (a component of the lending margin) adjusts more sluggishly. As those two variables are also capable of capturing the effect of monetary policy, we assume that central banks respond swiftly to contemporaneous movement in output. Furthermore, we follow, among others, Iacoviello (2005) who considers that house prices react almost instantaneously to monetary policy announcements and we accordingly order house prices below the three previous variables. The assumption of a shift in lending after a change in monetary policy is consistent with Gerali et al. (2010) and Gertler and Kiyotaki (2010). In Nookhwun and Tsomocos (2017), whose work is closer to ours, new loans for house purchase are ordered below the mortgage spread because they consider that a shock to the latter variable is more likely to immediately exert pressure on lending activities and, thus, on bank's balance sheet than vice versa. Finally, we assume that banks adjust their bank lending volumes after a change in bank capital. An increase in the regulatory CRR allows banks to grant a larger amount of loans. In other words, bank capital reacts with a lag to a shock on newly issued loans (for house purchase). While the ordering of the first three variables is less controversial, we are aware that establishing a proper ordering of the last three variables is subject to discussion in the literature. However, modifying the order of these variables does not qualitatively alter the results.

Figure 3.4 first shows that our IRF need a long period of time before returning to their stationary level. This can be explained by the inclusion of data covering the GFC. The results highlight that in the short run, a positive shock to the mortgage spread squeezes housing prices, mirroring difficulties that households face in paying back their loans, which in turn may affect housing demand and thus prices. At the same time, a decrease in newly issued loans could be expected; however, the impact of the shock on the latter variable is not significant. Nevertheless, a positive shock to the mortgage spread shapes the bank

lending margin. This phenomenon may indicate that banks more than compensate the rise in mortgage rates by reducing interest rates on other types of loans. It also confirms bank's reluctance to reduce their deposit rates while bank lending interest rates drop as a result of a reduction in the policy rate (see section 2.2). The central bank may respond to the shock by promptly lowering its key interest rate, avoiding an economic downturn on the short-run. Although our model features a lower bank lending margin, its effect on bank's overall profitability is uncertain. This, combined with the lack of significant effect on the volume of bank lending (for house purchase), does not suggest a decline in bank capital.

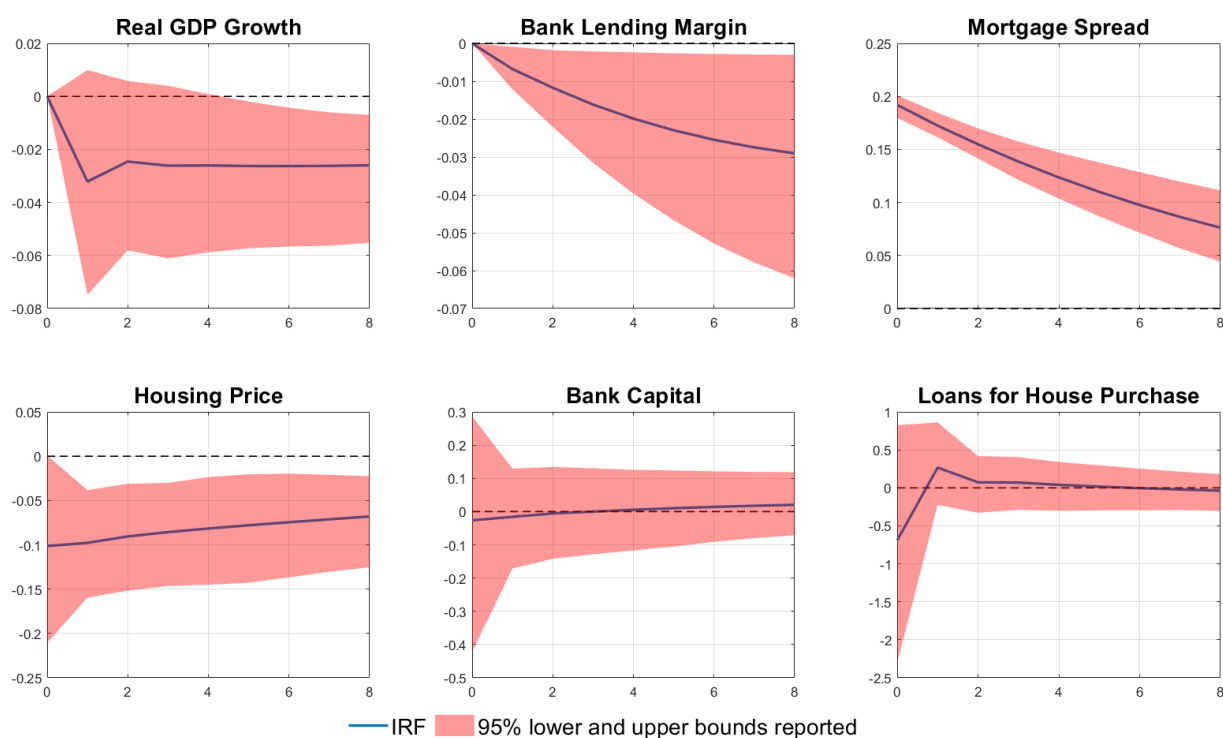


Figure 3.4: Panel VAR evidences – Mortgage spread shock. The figure displays IRF of the variable of interest to a standard deviation shock to mortgage spread.

It is important to note that macroprudential policy has played a major role over the surveyed period. The period under investigation encompasses the introduction of the Basel III requirements, which is key to supporting the findings regarding bank capital and mortgage lending. Banks were coerced to engage in a deleveraging process and a

strengthening of their core capital. Against this background, the following section aims at further examining these results by accounting for the time-varying level of macroprudential policy and also allows disentangling the outcomes associated with a loosened macroprudential scenario from those arising from a tightened macroprudential policy scenario.

3.2.3 The role of macroprudential policy in the event of a mortgage spread: An Interacted Panel VAR analysis

To further complement our analysis, it is key to test the implication of macroprudential policy, whose more binding role may have affected the considered variables over the sample period under consideration.

Similar to what is done in the literature (see for instance Altunbas et al., 2012; Akinci et al., 2013; Claessens et al., 2013; Bruno et al., 2017; Cerutti et al., 2017), the variable is built via dummy-type indexes of macroprudential policy based on the MacroPrudential Policies Evaluation Database (MaPPED) (Budnik and Kleibl, 2018). More particularly, the database provides explicit coding for each macroprudential measure according to whether it can qualify as “tight” or “loosen”, or with an “unspecified/ambiguous direction”. Therefore, we assign a value of 1 when the macroprudential measure is considered “tight”, a value of -1 when the macroprudential measure is considered “loose”, and 0 otherwise. We thus use a macroprudential policy index, MPI_i , which cumulatively aggregates the number of prudential measures adopted over time in each country. In order to test the implication of this index in our model, we introduce the Interacted Panel VAR (IPVAR) methodology which, unlike the standard panel VAR, allows to explicitly account for the time-varying level of macroprudential policy, acting as an exogenous factor on macroeconomic and banking responses to a mortgage spread shock.

In particular, we follow Towbin and Weber (2013) and Sá et al. (2014) and obtain the

following reduced structural form⁴⁶ for our model:

$$Y_{i,t} = \sum_{j=1}^N C_i \Delta_{j,i} + \sum_{j=1}^N \sum_{l=1}^L A_{j,l} \Delta_{j,i} Y_{i,t-l} + C_i^t MPI_{i,t} + \sum_{l=1}^L A_l^t MPI_{i,t} Y_{i,t-l} + \epsilon_{i,t}, \quad (3.2)$$

where, as in Equation 3.1, $Y_{i,t}$ is the 6×1 vector of explanatory variables, C_i is the 6×1 vector of country-specific intercepts, $A_{j,l}$ is a squared matrix ($q \times q$) of autoregressive coefficients up to lag L , $\Delta_{j,i}$ is a constant and is used as an indicator for each country; when $i = j$, $\Delta_{j,i} = 1$, $\Delta_{j,i} = 0$ otherwise.

The interaction term, $MPI_{i,t}$, which captures the time-varying level of macroprudential policy and could affect the transmission of shocks, intervenes both in level and interaction in each of the equations. It affects the dynamic relationship between the endogenous variables via A_l and the level of the variables via C_i . As explained in Sá et al. (2014), the effect of $MPI_{i,t}$ on both the intercept and the slope of the model (namely C_i and A_l , respectively) is homogeneous across countries in order to preserve the same degree of freedom. In our specification, we allow all the autoregressive coefficients of the VAR system to interact with the level of macroprudential policy. Finally, $\epsilon_{i,t}$ is a vector of residuals assumed to be uncorrelated across countries and normally distributed with a zero mean.

After the estimation of the IPVAR, as we are interested in the role of macroprudential policy, we compare the IRF of a mortgage spread shock when macroprudential policy is loose and tight. Such a specification is possible by replacing the structural characteristics of $MPI_{i,t}$ with the first and fourth quintiles of the variable's distribution in order to obtain a loose and tight macroprudential policy, respectively (see for example Leroy and Lucotte, 2019). For the same shock, we thus obtain two matrices of different estimated coefficients depending on the level of macroprudential policy. As detailed in Towbin and

⁴⁶The model can also be written in a recursive-form where the left side of the equation is multiplied by a lower triangular matrix. As a result, the error terms are, by construction, uncorrelated between the equations, thereby making it possible to estimate the VAR system of equations using OLS. At the same time, the zero-restrictions, imposed on the impact matrix, are similar to the standard panel VAR. As such the ordering of the variables remains the same as in the previous section.

Weber (2013), the impulse functions are inferred by a bootstrap procedure and Figure 3.5 depicts a 95% confidence interval.

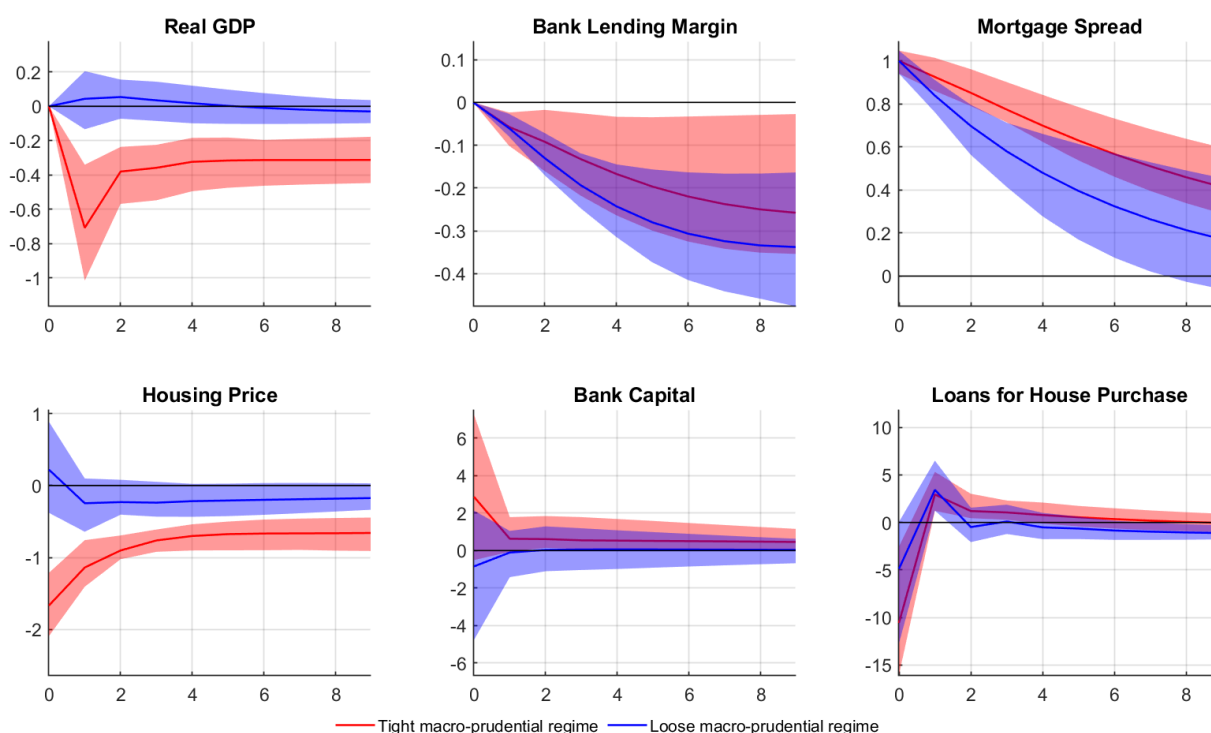


Figure 3.5: Interacted Panel VAR – Mortgage spread shock. The figure displays IRF of the variable of interest to a one-percentage-point shock to mortgage spread.

Figure 3.5 shows that a mortgage spread shock under a loose macroprudential regime alleviates more swiftly than under a tight macroprudential regime. This indicates that banks increase their mortgage interest rates disproportionately in the context of stricter prudential requirements. Under a tight macroprudential regime, our results show that house prices respond promptly to a shock on mortgage spread. This could signal an increase of defaulted loans, which reflects a decline in demand and thus exerts pressure on house prices. Unsurprisingly, newly issued loans for house purchase decline abruptly in the short run. When macroprudential measures are relaxed, newly granted loans for house purchase are not affected, but a higher number of loans can default and thus affects bank lending margins even more severely. Bank capital seems stable and may mirror an uncertain effect of the shock on banks' overall profitability although the NIM falls.

3.3 A general equilibrium framework featuring housing collateral constraint, financial frictions and macroprudential instruments

As outlined in Chapter 2, over the last few years, the low-interest rate environment has undermined banks' lending margin but not the overall profitability *per se*. It is no surprise that real GDP declines rapidly and sharply under a tight macroprudential policy scenario. The relatively larger increase in the mortgage rate under a strict prudential policy scenario may induce households to curb their consumption to pay off their mortgages, which may also explain such a sharp fall in the GDP in the short term.

Although the results obtained in the previous panel VAR cannot be fully compared with the ones obtained with the IPVAR, because the magnitude of the shock is not similar, the inclusion of macroprudential policy, and more specifically, the loosening of macroprudential policy reveals interesting findings. Our model suggests that under a tight macroprudential policy regime loans for house purchase are severely affected by the shock, while an easing of macroprudential policy helps mitigate the fall of newly issued mortgages. In addition, bank capital does not seem to play a role in the issuance of new mortgages.

3.3 A general equilibrium framework featuring housing collateral constraint, financial frictions and macroprudential instruments

We consider a DSGE model with a housing sector, a borrowing constraint, and corporate and mortgage defaults. Two groups of households populate the economy, each group having a unit mass: patient households and impatient households. Patient households are savers and have higher discount factors than those of impatient households who are borrowers ($\beta_P > \beta_I$).

This heterogeneity in agents' discount factors generates positive fund flows in equilibrium: patient households make positive deposits and do not borrow, while impatient households borrow a positive amount of loans. Patient households consume, work and

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accumulate capital and housing. Impatient households consume, work and accumulate housing. As impatient households are considered to be borrowers, they are constrained by having to collateralise the value of their house (financial friction) and by the occurrence of default.

We introduce a monopolistically competitive banking sector *à la* Gerali et al. (2010). Banks intermediate the funds that flow from patient households to impatient households and to corporate sector. Banks issue loans to impatient households and firms by collecting deposits from patient households and accumulating their own capital out of reinvested profits. They are facing the risks of defaults from the two types of borrowers (i.e. impatient households and firms).

A second financial friction is introduced in the model by assuming that banks are subject to a risk weighted capital requirement constraint that translates into an exogenous target for the leverage ratio, deviation from which implies a quadratic cost.

On the production side, monopolistically competitive intermediate-goods-producing firms produce heterogeneous intermediate goods using physical capital, bought from capital goods producers, and labour supplied by households against sticky wages *à la* Rotemberg (1984). They borrow from banks in order to cover their costs of working capital. The prices of intermediate goods are also set in a staggered fashion *à la* Rotemberg (1984). Final goods-producing firms, who bundle intermediate goods into final goods, capital, and housing producers, operate in perfectly competitive markets.

Finally, a passive government covers its expenditures by levying lump-sum taxes on households and collecting the share of defaulting entities' wealth seized that accrues to the government's insolvency agency. The monetary authority follows a standard Taylor-type interest rate rule.

3.3 A general equilibrium framework featuring housing collateral constraint, financial frictions and macroprudential instruments

3.3.1 Heterogeneous households

The economy is composed of two types of agents: patient and impatient households. The only difference between these agents is that the discount factor for impatient households (β_I) is lower than the one for patient households (β_P). Both types of households derive utility from consumption, $c_{z,t}$, housing services, $h_{z,t}$, and the number of worked hours, $n_{z,t}$, and have an identical utility function which corresponds, in real term, to:

$$\begin{aligned} & E_0 \sum_{t=0}^{\infty} \beta_z^t E_0 \{U(c_{z,t}, h_{z,t}, n_{z,t})\} \\ & = E_0 \sum_{t=0}^{\infty} \beta_z^t \left[A_{c,t}(1-a) \ln(c_{z,t} - a.C_{z,t-1}) + A_{h,t} \chi_h \ln(h_{z,t}) - \frac{n_{z,t}^{1+\phi}}{1+\phi} \right], \end{aligned} \quad (3.3)$$

where $z = [I, P]$ with I and P respectively standing for impatient (borrowers) and patient (savers) households. The current individual consumption depends on the lagged smoothed aggregated consumption, $a.C_{z,t-1}$, where the parameter a denotes the degree of habit formation in consumption for non-durable goods. The parameter χ_h is the weight on housing services and ϕ is the labour substitution elasticity. $A_{c,t}$ and $A_{h,t}$ are two preference shocks respectively embedded on consumption and housing demands and both follow an AR(1) process as below:

$$\ln(A_{c,t}) = \rho_c \ln(A_{c,t-1}) + \varepsilon_{c,t}, \quad (3.4)$$

$$\ln(A_{h,t}) = \rho_h \ln(A_{h,t-1}) + \varepsilon_{h,t}. \quad (3.5)$$

3.3.1.1 Patient households

The representative patient household i maximises his expected utility (Equation 3.3) being subject to the following real budget constraint:

$$\begin{aligned} & c_{P,t} + q_{h,t}(h_{P,t} - h_{P,t-1}) + d_t + q_{k,t}(k_t - (1 - \delta_k)k_{t-1}) \\ & = w_{P,t-1}n_{P,t-1} + \frac{R_{t-1}}{\Pi_t}d_{t-1} - T_{P,t} + \Lambda_t + Div_t + \frac{r_{K,t-1}k_{t-1}}{\Pi_t}, \end{aligned} \quad (3.6)$$

3.3 A general equilibrium framework featuring housing collateral constraint, financial frictions and macroprudential instruments

where $q_{h,t}$ and $q_{k,t}$ are the respective prices for housing stock, $h_{P,t}$, and physical capital, k_t , which depreciates at the rate δ_k . Patient households receive the wage rate $w_{P,t}$ for supplying hours of work and earn r_{t-1} on the last period risk-free deposit, d_{t-1} , and $r_{K,t-1}$, the rental rate on the physical capital that they own, which depend on gross inflation, $\Pi_t = \frac{P_t}{P_{t-1}}$. They receive a profit Λ_t from both intermediate consumption and capital good producers and a dividend Div_t from monopolistically competitive banks. Finally, they pay a lump-sum tax, $T_{P,t}$, to the government.

The first order conditions derived from the maximisation problem of patient households with respect to $c_{P,t}$, $h_{P,t}$, d_t and k_t are summarised as:

$$U_{P,t}^c q_{h,t} = U_{P,t}^h + \beta_P E_t [U_{P,t+1}^c q_{h,t+1}], \quad (3.7)$$

$$U_{P,t}^c = \beta_P E_t \left[U_{P,t+1}^c \frac{R_t}{\Pi_{t+1}} \right], \quad (3.8)$$

$$U_{P,t}^c q_{k,t} = \beta_P E_t \left[U_{P,t+1}^c \left(\frac{r_{K,t}}{\Pi_{t+1}} + q_{k,t+1} (1 - \delta_k) \right) \right], \quad (3.9)$$

where $U_{P,t}^c$, $U_{P,t}^h$ and $U_{P,t}^n$ are respectively the individual household marginal utilities with respect to consumption, housing and the number of worked hours.

3.3.1.2 Impatient households subject to a collateral

The representative impatient household faces, expressed in real terms, the following borrowing constraint:

$$R_{I,t}^L l_{I,t} \leq m_h q_{h,t} h_{I,t}, \quad (3.10)$$

where m_h denotes the LTV ratio sets by the prudential authority.

In $t + 1$, each impatient household are facing an idiosyncratic shock to its house

3.3 A general equilibrium framework featuring housing collateral constraint, financial frictions and macroprudential instruments

value ω_{t+1} , which follows a uniform distribution⁴⁷ with the lower and upper bounds, $(\underline{\omega}, \bar{\omega})$. The shock ω_t is *i.i.d.* and it has positive support with cumulative distribution, $F(x_t) \equiv \text{prob}(\omega_t \leq x)$, with mean $\mu_{\omega,t}$, variance σ_{ω}^2 , and density function $f(\omega_t)$.

The borrower is solvent if only $\omega_{t+1} \geq \tilde{\omega}_{t+1}$ where $\tilde{\omega}_{t+1}$ is the threshold or cutoff point such that, in nominal terms:

$$R_{I,t}^L L_{I,t} = \tilde{\omega}_{t+1} E_t Q_{h,t+1} h_{I,t}. \quad (3.11)$$

Default occurs when the expected value of house at $t + 1$ falls short of the amount that needs to be repaid, that is when $\omega_{t+1} Q_{h,t+1} h_{I,t} < R_{I,t}^L L_{I,t}$.

From Equation 3.10 and Equation 3.11, the cutoff point is determined endogenously:

$$\tilde{\omega}_{t+1} = m_h \frac{Q_{h,t}}{E_t Q_{h,t+1}}. \quad (3.12)$$

The default threshold is therefore driven by the LTV ratio and the deviation of the nominal house price from expectations. When default occurs, households cannot repay the loan and the bank seizes $\omega_{t+1} Q_{h,t+1} h_{I,t}$. Bank pays the fraction $1 - \mu_I$ of what is seized to the government's insolvency agency. Let's define $1 - \mu_I = \Theta \in [0, 1]$. Therefore, in the case of non-default, borrower would earn:

$$\begin{aligned} & \int_{\tilde{\omega}_{t+1}}^{\bar{\omega}} [\omega_{t+1} Q_{h,t+1} h_{I,t} - R_{I,t}^L L_{I,t}] f(\omega_{t+1}) d\omega_{t+1} \\ &= \int_{\tilde{\omega}_{t+1}}^{\bar{\omega}} [\omega_{t+1} Q_{h,t+1} h_{I,t} - \tilde{\omega}_{t+1} Q_{h,t+1} h_{I,t}] f(\omega_{t+1}) d\omega_{t+1} \\ &= \int_{\tilde{\omega}_{t+1}}^{\bar{\omega}} [\omega_{t+1} Q_{h,t+1} h_{I,t} f(\omega_{t+1}) d\omega_{t+1} - \tilde{\omega}_{t+1} \int_{\tilde{\omega}_{t+1}}^{\bar{\omega}} Q_{h,t+1} h_{I,t} f(\omega_{t+1}) d\omega_{t+1}] \\ &= \int_{\tilde{\omega}_{t+1}}^{\bar{\omega}} [(\omega_{t+1} - \tilde{\omega}_{t+1}) f(\omega_{t+1}) d\omega_{t+1}] Q_{h,t+1} h_{I,t}. \end{aligned} \quad (3.13)$$

⁴⁷Each impatient household faces an identical uniform distribution.

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Furthermore, the average real earning of the bank (net of agency costs) is:

$$\begin{aligned}
& (1 - \Theta) \int_{\underline{\omega}}^{\tilde{\omega}_{t+1}} \omega_{t+1} Q_{h,t+1} h_{I,t} f(\omega_{t+1}) d\omega_{t+1} + \int_{\tilde{\omega}_{t+1}}^{\bar{\omega}} R_{I,t}^L L_{I,t} f(\omega_{t+1}) d\omega_{t+1} \\
&= (1 - \Theta) \int_{\underline{\omega}}^{\tilde{\omega}_{t+1}} \omega_{t+1} Q_{h,t+1} h_{I,t} f(\omega_{t+1}) d\omega_{t+1} + \int_{\tilde{\omega}_{t+1}}^{\bar{\omega}} \tilde{\omega}_{t+1} Q_{h,t+1} h_{I,t} f(\omega_{t+1}) d\omega_{t+1} \quad (3.14) \\
&= R_{I,t}^L L_{I,t}.
\end{aligned}$$

Let's $\int_{\underline{\omega}}^{\tilde{\omega}_{t+1}} \omega_{t+1} f(\omega_{t+1}) d\omega_{t+1} = G_{t+1}(\tilde{\omega}_{t+1})$ and $\int_{\underline{\omega}}^{\tilde{\omega}_{t+1}} f(\omega_{t+1}) d\omega_{t+1} = F_{t+1}(\tilde{\omega}_{t+1})$ be respectively the expected house value accrued to the bank when default occurs and the probability of default. The Equation 3.14, as the bank participation constraint, can be written in nominal terms as:

$$R_{I,t}^L L_{I,t} = \Phi(\tilde{\omega}_{t+1}) Q_{h,t+1} h_{I,t},$$

where $\Phi(\tilde{\omega}_{t+1}) = (1 - \Theta) G_{t+1}(\tilde{\omega}_{t+1}) + \tilde{\omega}_{t+1} \int_{\tilde{\omega}_{t+1}}^{\bar{\omega}} f(\omega_{t+1}) d\omega_{t+1}$.

At time t , the nominal budget constraint of the representative impatient household is defined as:

$$\begin{aligned}
& p_t c_{I,t} + Q_{h,t} h_{I,t} = W_{I,t-1} n_{I,t-1} + L_{I,t} - p_t T_{I,t} \\
& + \int_{\tilde{\omega}_{t+1}}^{\bar{\omega}} \left[\omega_t Q_{h,t} h_{I,t-1} - R_{I,t-1}^L L_{I,t-1} \right] f(\omega_t) d\omega_t \\
\Leftrightarrow & p_t c_{I,t} + Q_{h,t} h_{I,t} + \int_{\tilde{\omega}_{t+1}}^{\bar{\omega}} R_{I,t-1}^L L_{I,t-1} f(\omega_t) d\omega_t = W_{I,t-1} n_{I,t-1} \\
& + L_{I,t} - p_t T_{I,t} + \left[1 - \int_{\underline{\omega}}^{\tilde{\omega}_{t+1}} \omega_t f(\omega_t) d\omega_t \right] Q_{h,t} h_{I,t-1}, \quad (3.15)
\end{aligned}$$

Using Equation 3.11 and Equation 3.14 in Equation 3.15 yields:

$$\begin{aligned}
& p_t c_{I,t} + Q_{h,t} h_{I,t} + R_{I,t-1}^L L_{I,t-1} \\
&= W_{I,t-1} n_{I,t-1} + L_{I,t} - p_t T_{I,t} + [1 - \Theta G_t(\tilde{\omega}_t)] Q_{h,t} h_{I,t-1},
\end{aligned}$$

3.3 A general equilibrium framework featuring housing collateral constraint, financial frictions and macroprudential instruments

and in real term:

$$\begin{aligned} c_{I,t} + q_{h,t}h_{I,t} + \frac{R_{I,t-1}^L}{\Pi_t}l_{I,t-1} \\ = w_{I,t-1}n_{I,t-1} + l_{I,t} - T_{I,t} + [1 - \Theta G_t(\tilde{\omega}_t)]q_{h,t}h_{I,t-1}. \end{aligned} \quad (3.16)$$

The impatient household maximises Equation 3.3 subject to the budget constraint (Equation 3.16) and the bank participation constraint (Equation 3.14). The first order conditions with respect to $c_{I,t}$, $h_{I,t}$, $l_{I,t}$ and $\tilde{\omega}_{t+1}$ are:

$$U_{I,t}^c q_{h,t} = U_{I,t}^h + \beta_I E_t \left[U_{I,t+1}^c [1 - \Theta G_{t+1}(\tilde{\omega}_{t+1})] q_{h,t+1} \right] + \Lambda_{t+1} \Phi(\tilde{\omega}_{t+1}) q_{h,t+1} \Pi_{t+1}, \quad (3.17)$$

$$U_{I,t}^c = \beta_I E_t \left[U_{I,t+1}^c(i) \frac{R_{I,t}^L}{\Pi_{t+1}}, \right] + \Lambda_{t+1} R_{I,t}^L \quad (3.18)$$

$$\Lambda_{t+1} \Phi'(\tilde{\omega}_{t+1}) \Pi_{t+1} = \beta_I E_t \left[U_{I,t+1}^c \Theta G'_{t+1}(\tilde{\omega}_{t+1}) \right], \quad (3.19)$$

where Λ_{t+1} is the Lagrange multiplier with respect to the bank participation constraint at $t + 1$.

3.3.1.3 Wage setting by the union labour

It is assumed that labour services are heterogeneous across households within each group, granting them pricing power when setting their own wage. This latter is agreed one period in advance and becomes effective in $t + 1$. Competitive labour intermediaries (also called unions or labour packers) aggregate these tiered labour services into one homogeneous labour service and then, rent them to good producers. Hence, the union provides the following labour demand facing each household i of both types $z \in [I, P]$:

$$n_{z,t}(i) = \left(\frac{W_{z,t}(i)}{W_{z,t}} \right)^{-\varepsilon_w} n_t, \quad (3.20)$$

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where $n_{z,t} = \left[\int_0^1 n_{z,t}^{\frac{\varepsilon_w - 1}{\varepsilon_w}}(i) di \right]^{\frac{\varepsilon_w}{\varepsilon_w - 1}}$ is the aggregate labour and $W_{z,t} = \left[\int_0^1 W_{z,t}^{1 - \varepsilon_w}(i) di \right]^{\frac{1}{1 - \varepsilon_w}}$, the aggregate nominal wage. ε_w denotes the stochastic elasticity of substitution for the different types of labour. At the end of the period t , labour packers and intermediate good producers agree a contract specifying the amount of working hours needed in $t + 1$ to produce intermediate goods. Producers choose labour hours each period. In contrast, nominal wage setting is decided in the current period and becomes effective in $t + 1$. This latter is indeed paid in a subsequent period, which is not necessarily the next one. In this approach, each household gives up the right to determine working hours when signing the nominal wage contract (Gray, 1978; Bénassy, 1995; Cho and Cooley, 1995; Hristov and Hülsewig, 2017, among others).

The labour union sets nominal wages in order to maximise each type of household's revenue subject to demand of labour packers (Equation 3.20) and wage adjustment cost, covered by charging each member a lump-sum fee. Thus, the intertemporal maximisation problem for each type of labour is:

$$\max_{W_{z,t}(i), n_{z,t}(i)} E_0 \sum_{t=0}^{\infty} \beta_z^t \left(\lambda_{z,t} \left[\frac{W_{z,t-1}(i)}{p_{t-1}} \frac{p_{t-1}}{p_t} n_{z,t-1}(i) - \frac{\zeta_z}{2} \left(\frac{W_{z,t}(i)}{W_{z,t-1}(i)} - 1 \right)^2 \frac{W_{z,t}}{p_t} \right] - \frac{\chi_n n_{z,t}^{1+\gamma}(i)}{1+\gamma} \right),$$

$$\text{s.t. } n_{z,t-1}(i) = \left(\frac{W_{z,t-1}(i)}{W_{z,t-1}} \right)^{-\phi} n_{t-1},$$

where ζ_z describes the wage adjustment cost parameter, γ is the inverse of Frisch elasticity and λ_t is the Lagrange multiplier of the budget constraint. Solving the previous maximisation programme yields the following first-order conditions with respect to $n_{z,t}(i)$ and $W_{z,t}(i)$:

$$\chi_n n_{z,t}^\gamma(i) = \beta_z E_t \left[\lambda_{z,t+1} \frac{W_{z,t}(i)}{p_t} \frac{p_t}{p_{t+1}} - mrs_{z,t+1}(i) \right], \quad (3.21)$$

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$$\begin{aligned}
\zeta_z \lambda_{z,t} \left(\frac{W_{z,t}(i)}{W_{z,t-1}(i)} - 1 \right) \frac{W_{z,t}}{p_t} \frac{1}{W_{z,t-1}(i)} &= \beta_z E_t \left[\lambda_{z,t+1} \left[\frac{n_{z,t}(i)}{p_{t+1}} \right. \right. \\
&+ \left. \left. \zeta_z \left(\frac{W_{z,t+1}(i)}{W_{z,t}(i)} - 1 \right) \frac{W_{z,t+1}}{p_{t+1}} \left(\frac{W_{z,t+1}(i)}{(W_{z,t}(i))^2} \right) \right] \right. \\
&\left. - \phi mrs_{z,t+1}(i) \left(\frac{W_{z,t}(i)}{W_{z,t}} \right)^{-\phi-1} \frac{n_{z,t}}{W_{z,t}} \right], \tag{3.22}
\end{aligned}$$

where $mrs_{z,t}$ denotes the marginal rate of substitution. Therefore, in a symmetric equilibrium, the following expression determines the evolution of the gross nominal wage inflation for both patient and impatient households:

$$\begin{aligned}
\zeta_z (\Pi_{z,t}^W - 1) \Pi_{z,t}^W &= \zeta_z \beta_z E_t \left[\frac{\lambda_{z,t+1}}{\lambda_{z,t}} (\Pi_{z,t+1}^W - 1) \frac{(\Pi_{z,t+1}^W)^2}{\Pi_{t+1}} \right] \\
&+ E_t \left[(1 - \phi) \beta_z \frac{\lambda_{z,t+1}}{\lambda_{z,t}} \frac{n_{z,t}}{\Pi_{t+1}} + \frac{\phi \chi_n n_{z,t}^{\gamma+1}}{\lambda_{z,t} w_{z,t}} \right], \tag{3.23}
\end{aligned}$$

where $\Pi_{z,t}^W = \frac{W_{z,t}}{W_{z,t-1}}$ is the nominal wage inflation. Further, note that the real wage evolves as:

$$w_{z,t} = \frac{w_{z,t-1} \Pi_{z,t}^W}{\Pi_t}. \tag{3.24}$$

3.3.2 Firms' behaviour in the production chain

3.3.2.1 Final good producers

Final good producers operate under perfect competition, buy differentiated intermediate goods, $j \in [0, 1]$, which are bundled into final goods, y_t , via the Dixit-Stiglitz aggregator:

$$y_t = \left[\int_0^1 \left(\varepsilon_t^{\frac{1}{\xi_t}}(j) y_t^{\frac{\xi_t-1}{\xi_t}}(j) \right) dj \right]^{\frac{\xi_t}{\xi_t-1}}, \tag{3.25}$$

where ξ_t denotes the stochastic elasticity of substitution between the various types of goods and as in Agénor et al. (2013) and Hristov and Hülsewig (2017), $\varepsilon_t(j)$ is the share associated with the output level of good j . For each intermediate good, the final good

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firm yields the following demand equation:

$$y_t(j) = \varepsilon_t(j) \left(\frac{p_t(j)}{p_t} \right)^{-\xi_t} y_t, \quad (3.26)$$

where $p_t(j)$ is the price of the intermediate good j and p_t is the aggregate price of final goods set as:

$$p_t = \left[\int_0^1 \left(\varepsilon_t(j) p_t^{1-\xi_t}(j) \right) dj \right]^{\frac{1}{1-\xi_t}}. \quad (3.27)$$

3.3.2.2 Intermediate good producers

Intermediate good producers operate under monopolistic competition and are indexed by $j \in [0, 1]$. The intermediate good firm j relies on the following technology:

$$y_{t+1}(j) = A_{F,t+1} \varepsilon_{t+1}(j) k_t^\alpha(j) \left[n_{I,t}^\eta(j) n_{P,t}^{1-\eta}(j) \right]^{1-\alpha} \equiv \varepsilon_{t+1}(j) \tilde{y}_{t+1}(j). \quad (3.28)$$

where α is the share of capital in the whole production, η is the share of impatient households in the labour input and $n_{I,t}(j)$ and $n_{P,t}(j)$ stand for labour supplied by impatient and patient households, respectively. $A_{F,t+1}$ is an aggregate productivity shock and $\varepsilon_{t+1}(j)$ is an idiosyncratic productivity shock. At the end of the period t , to cover their costs of working capital, intermediate good firms borrow from banks the following real loan volume:

$$l_{F,t}(j) = r_{K,t} k_t(j) + w_{I,t} n_{I,t}(j) + w_{P,t} n_{P,t}(j). \quad (3.29)$$

In line with Agénor et al. (2013) and Hristov and Hülsewig (2017) and similarly to the households' idiosyncratic shock, it is assumed that $\varepsilon_{t+1}(j)$ is serially correlated and drawn from a uniform distribution⁴⁸ with $(\underline{\varepsilon}, \bar{\varepsilon})$ the lower and upper bounds.

Each intermediate producer j seeks to minimise expected real production cost for the period $t + 1$. Accordingly, at the end of the period t , capital and labour services, both

⁴⁸Intermediate good producers face an identical uniform distribution.

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technologically constrained by the production function, are optimally chosen. Therefore, this minimisation problem spells out the following Lagrangian:

$$\begin{aligned} \min_{k_t(j), n_t(j)} \quad & E_{\varepsilon_{t+1}(j)|t} \sum_{t=0}^{\infty} \beta^t \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \left[\frac{r_{K,t} R_{F,t}^L k_t(j)}{\Pi_{t+1}} + \frac{w_{P,t} R_{F,t}^L n_{P,t}(j)}{\Pi_{t+1}} + \frac{w_{I,t} R_{F,t}^L n_{I,t}(j)}{\Pi_{t+1}} \right. \\ & \left. - mc_{t+1}(j) \left(A_{F,t+1} \varepsilon_{t+1}(j) k_t^\alpha(j) \left[n_{I,t}^\eta(j) n_{P,t}^{1-\eta}(j) \right]^{1-\alpha} \right. \right. \\ & \left. \left. - y_{t+1}(j) \right) \right], \end{aligned} \quad (3.30)$$

where the expectation operator, $E_{\varepsilon_{t+1}(j)|t}$, captures the expectations at the end of the period t regarding the idiosyncratic productivity shock, $\varepsilon_{t+1}(j)$. Note that this latter's distribution function is identical across producers and time invariant since by assumption $\varepsilon_t(j)$ is *i.i.d.* $mc_{t+1}(j)$ denotes the Lagrange multiplier. In addition, $y_{t+1}(j)$ and $mc_{t+1}(j)$ depend stochastically on the idiosyncratic shock. Solving the minimisation problem entails the following input demands for labour and capital:

$$\frac{r_{K,t} R_{F,t}^L}{\Pi_{t+1}} = \alpha \frac{\tilde{y}_{t+1}(j)}{K_t(j)} E_\varepsilon \left[mc_{t+1}(j) \varepsilon_{t+1}(j) \right], \quad (3.31)$$

$$\frac{w_{I,t} R_{F,t}^L}{\Pi_{t+1}} = (1 - \alpha) \eta \frac{\tilde{y}_{t+1}(j)}{n_{I,t}(j)} E_\varepsilon \left[mc_{t+1}(j) \varepsilon_{t+1}(j) \right], \quad (3.32)$$

$$\frac{w_{P,t} R_{F,t}^L}{\Pi_{t+1}} = (1 - \alpha)(1 - \eta) \frac{\tilde{y}_{t+1}(j)}{n_{P,t}(j)} E_\varepsilon \left[mc_{t+1}(j) \varepsilon_{t+1}(j) \right], \quad (3.33)$$

where E_ε refers to expectations over the distribution of $\varepsilon_{t+1}(j)$. Note that optimal demand factors, i.e. Equation 3.31, Equation 3.32 and Equation 3.33, depend on the expected inflation, $E_t[\Pi_{t+1}]$, which reflects the fact that nominal wages are determined at the beginning of the period. This identifies a channel of monetary policy transmission, though, this latter is conditional to a sufficiently persistent intervention from the central bank to induce shifts in expected inflation.

Thereafter, producers are assumed to be identical regarding optimal demand factors and price decisions. As a consequence, $E_\varepsilon \left[mc_{t+1}(j) \varepsilon_{t+1}(j) \right]$, the expected real marginal

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cost which is conditional on the distribution of possible idiosyncratic productivity levels, ε , is identical across firms. Further, for all producers:

$$\tilde{y}_t(j) = \tilde{y}_t, \quad \forall j,$$

with $\tilde{y}_t = A_{F,t} k_{t-1}^\alpha n_{t-1}^{1-\alpha}$, the aggregate production function.

In order to maximise their expected discounted real profit, each firm j sets the price of its good at the beginning of every period before the realisation of the idiosyncratic shock. Firms are subject to Rotemberg price-setting. As in Rotemberg (1984), it is assumed that price changes are costly, inducing the incorporation of quadratic adjustment costs. The dynamic problem of profit maximisation of the firm that adjusts its price in period t is:

$$\begin{aligned} \max_{p_t(j)} \quad & E_t \sum_{t=0}^{\infty} \beta^t \frac{\lambda_{P,t+1}}{\lambda_{P,t}} \left\{ E_\omega \left[\frac{p_t(j)}{p_t} \varepsilon_t(j) \left(\frac{p_t(j)}{p_t} \right)^{-\xi_t} y_t \right] - \frac{r_{K,t-1} R_{F,t-1}^L k_{t-1}(j)}{\Pi_t} \right. \\ & - \frac{w_{I,t-1} R_{F,t-1}^L n_{I,t-1}(j)}{\Pi_t} - \frac{w_{P,t-1} R_{F,t-1}^L n_{P,t-1}(j)}{\Pi_t} - \frac{\zeta_p}{2} \left(\frac{p_t(j)}{p_{t-1}(j)} - 1 \right)^2 y_t \\ & \left. + E_\omega \left[m_{c_t}(j) \left(\varepsilon_t(j) \tilde{y}_t(j) - \varepsilon_t(j) \left(\frac{p_t(j)}{P_t} \right)^{\xi_t} y_t \right) \right] \right\}, \end{aligned} \quad (3.34)$$

where ζ_p denotes the price adjustment cost parameter. The first order condition provides the following optimal price:

$$\begin{aligned} E_\omega \left[-\xi_t \varepsilon_t(j) \left(\frac{p_t(j)}{p_t} \right)^{-\xi_t-1} \frac{p_t(j)}{p_t} \frac{y_t}{p_t} + \varepsilon_t(j) \left(\frac{p_t(j)}{p_t} \right)^{-\xi_t} \frac{y_t}{p_t} \right. \\ \left. - \zeta_p \left(\frac{p_t(j)}{p_{t-1}(j)} - 1 \right) \frac{y_t}{p_{t-1}(j)} + \xi_t m_{c_t}(j) \varepsilon_t(j) \left(\frac{p_t(j)}{p_t} \right)^{-\xi_t-1} \frac{y_t}{p_t} \right] \\ + \zeta_p \beta E_t \left[\frac{\lambda_{P,t+1}}{\lambda_{P,t}} \left(\frac{p_{t+1}(j)}{p_t(j)} - 1 \right) y_{t+1} \left(\frac{p_{t+1}(j)}{p_t^2(j)} \right) \right] = 0. \end{aligned} \quad (3.35)$$

As a perfect symmetry is assumed across firms, they all choose an identical $k_t(j)$ and $n_t(j)$ thus they all fix the same price and, consequently, the index j can be dropped.

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Hence, the inflation rate is:

$$\begin{aligned} \zeta_p \Pi_t (\Pi_t - 1) = \zeta_p \beta E_t \left[\frac{\lambda_{P,t+1}}{\lambda_{P,t}} \Pi_{t+1} (\Pi_{t+1} - 1) \frac{y_{t+1}}{y_t} \right] + (1 - \xi_t) E_\varepsilon \left[\varepsilon(j) \right] \\ + \xi_t E_\varepsilon \left[mc_t(j) \varepsilon_t(j) \right]. \end{aligned} \quad (3.36)$$

Furthermore, intermediate good producer j defaults in period $t + 1$ if revenue after the occurrence of the idiosyncratic productivity shock is not enough to cover costs (the cost of borrowing plus the cost of price adjustment). Accordingly, defaults occur when:

$$p_{t+1}(j)y_{t+1}(j) < R_{F,t}^L L_{F,t}(j) + \frac{\zeta_p}{2} \left(\frac{p_{t+1}(j)}{p_t(j)} - 1 \right)^2 p_{t+1} y_{t+1} \quad (3.37)$$

or equivalently:

$$\varepsilon_{t+1}(j) \tilde{y}_{t+1}(j) < \frac{R_{F,t}^L L_{F,t}(j)}{p_{t+1}(j)} + \frac{\zeta_p}{2} \left(\frac{p_{t+1}(j)}{p_t(j)} - 1 \right)^2 \frac{p_{t+1} y_{t+1}}{p_{t+1}(j)}. \quad (3.38)$$

Similarly to impatient households, we identify the cutoff point, $\tilde{\varepsilon}_t$, below which intermediate good producer j defaults. We denote this cutoff point, i.e, the value of ε_t for which Equation 3.38 holds with equality, as follows:

$$\tilde{\varepsilon}_t = \frac{R_{F,t-1}^L l_{F,t-1}}{\Pi_t \tilde{y}_t} + \frac{\zeta_p}{2} (\Pi_t - 1)^2. \quad (3.39)$$

Note that since all firms set the same price in a symmetric equilibrium, the cutoff point is the same for all producers, that is $\tilde{\varepsilon}_t(j) = \tilde{\varepsilon}_t, \forall j$ ⁴⁹. Lastly, Equation 3.39 exhibits the Fisher debt deflation effect and enriches a new channel of monetary policy. Indeed, changes in the current inflation impacts the aggregate default probability because interest and loan repayments are fixed in nominal terms, one period in advance. Thus, a brutal increase in inflation mechanically declines the real debt burden (for instance see Christiano

⁴⁹As stated in Hristov and Hülsewig (2017), in the financial accelerator mechanism of Bernanke and Woodford (2008), banks would be aware of $\tilde{\varepsilon}_{t+1}$ when defining the loan contract, while in this framework, the knowledge of the cutoff point results from expectations.

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et al., 2010).

3.3.2.3 Capital good producers

Capital good producers operate under perfect competition and rent capital to intermediate good producers. In return, they receive payment at the end of the period t used to purchase investment goods. Capital accumulation evolves as:

$$k_t = (1 - \delta_K)k_{t-1} + \left[1 - \frac{\zeta_K}{2} \left(\frac{A_{K,t}i_{K,t}}{i_{K,t-1}} - 1 \right)^2 \right] i_{K,t}. \quad (3.40)$$

The capital at time t is equal to existing capital stocks, net of the depreciation costs, δ_K , and the new investments, $i_{K,t}$, net of investment adjustment cost. Finally, ζ_K denotes the business capital investment adjustment cost and $A_{K,t}$ denotes a shock on investment efficiency.

Capital producers maximise the following expected profit:

$$E_0 \sum_{t=0}^{\infty} \beta_P^t \lambda_{P,t} \left[q_{K,t} \left(i_{K,t} - \frac{\zeta_K}{2} \left(\frac{A_{K,t}i_{K,t}}{i_{K,t-1}} - 1 \right)^2 \right) - i_{K,t} \right], \quad (3.41)$$

Therefore, maximising Equation 3.41 with respect to $i_{K,t}$ gives the following first order condition:

$$\begin{aligned} & q_{K,t} \left[1 - \frac{\zeta_K}{2} \left(\frac{A_{K,t}i_{K,t}}{i_{K,t-1}} - 1 \right)^2 - \zeta_K \left(\frac{A_{K,t}i_{K,t}}{i_{K,t-1}} - 1 \right) \left(\frac{A_{K,t}i_{K,t}}{i_{K,t-1}} \right) \right] \\ & + \beta_P E_t \left[\frac{\lambda_{P,t+1}}{\lambda_{P,t}} \zeta_K q_{K,t+1} \left(\frac{A_{K,t+1}i_{K,t+1}}{i_{K,t}} - 1 \right) \left(\frac{i_{K,t+1}}{i_{K,t}} \right)^2 A_{K,t+1} \right] = 1. \end{aligned} \quad (3.42)$$

3.3.3 A competitive banking sector

A competitive banking sector extends loans to impatient households and intermediate goods producers, i.e., Non-Financial Corporations (NFCs), and collects deposits from patient households. Banks are subject to an adjustment cost. As in Gerali et al. (2010),

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we assume that the bank has a target τ for their capital-to-risk-weighted-assets ratio and pays a quadratic cost whenever it deviates from that target. The target can be interpreted as an exogenous regulatory capital requirement constraint that imposes the amount of own resources to hold. The existence of a cost for deviating from τ implies that bank leverage affects credit conditions in the economy. The expected profit of the representative bank is given by:

$$E_t[\Lambda_{B,t+1}] = E_t[R_{t+1}] - R_t D_t - \frac{\zeta_B}{2} \left(\frac{K_{B,t}}{RW_t} - \tau \right)^2 K_{B,t},$$

where $E_t[R_{t+1}]$ is the expected return from lending, ζ_B is the banking leverage adjustment cost, τ denotes the CRR target and RW_t denotes risk weighted assets.

In real terms, we obtain:

$$E_t[\Lambda_{B,t+1}^r] = E_t[R_{t+1}^r] - R_t d_t - \frac{\zeta_B}{2} \left(\frac{k_{B,t}}{RW_t} - \tau \right)^2 k_{B,t}, \quad (3.43)$$

Further, RW_t is given by:

$$RW_t = rw_{I,t} l_{I,t} + rw_{F,t} l_{F,t}, \quad (3.44)$$

with $rw_{I,t}$ and $rw_{F,t}$ being the regulatory risk weight on mortgage loans and the regulatory risk weight on corporate loans, respectively. Bank capital adequacy ratio is therefore expressed in percentage of a bank's risk weighted credit exposures. The bank's balance sheet at the end of the period t is:

$$l_t = d_t + k_{B,t}, \quad (3.45)$$

with $l_t = l_{I,t} + l_{F,t}$

Expected return from lending to impatient household i and intermediate good pro-

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ducer j is given, in nominal terms, by⁵⁰:

$$\begin{aligned}
E_t \left[R_{t+1}(i, j) \right] &= R_{I,t}^L L_{I,t}(i) - L_{I,t}(i) E_t \left(\frac{Q_{h,t+1} h_{I,t}(i)}{L_{I,t}(i)} \right) \\
&\int_{\underline{\omega}}^{\tilde{\omega}_{t+1}(i)} \left(\tilde{\omega}_{t+1}(i) - \mu_I \omega_{t+1}(i) \right) f(\omega_{t+1}(i)) d\omega_{t+1}(i) + R_{F,t}^L L_{F,t}(j) \\
&- L_{F,t}(j) E_t \left(\frac{P_{t+1}(j) \tilde{Y}_{t+1}(j)}{L_{F,t}(j)} \right) \int_{\underline{\varepsilon}}^{\tilde{\varepsilon}_{t+1}(j)} \left(\tilde{\varepsilon}_{t+1}(j) - \mu_F \varepsilon_{t+1}(j) \right) \\
&f(\varepsilon_{t+1}(j)) d\varepsilon_{t+1}(j).
\end{aligned} \tag{3.46}$$

When restating Equation 3.43 by using Equation 3.45, the representative bank's real expected profit becomes:

$$E_t[\Lambda_{B,t+1}^r] = E_t[R_{t+1}^r] - R_t(l_t - k_{B,t}) - \frac{\zeta_B}{2} \left(\frac{k_{B,t}}{r w_t} - \tau \right)^2 k_{B,t}, \tag{3.47}$$

The representative bank chooses the optimal loan supply to maximise its real expected profit (Equation 3.47) subjects to the balance sheet constraint (Equation 3.45), and the risk weighted assets (Equation 3.44). Solving the maximisation programme leads to the following first order conditions:

$$R_{I,t}^L = R_t - \zeta_B \left(\frac{k_{B,t}}{r w_t} - \tau \right) \left(\frac{k_{B,t}}{r w_t} \right)^2 r w_{I,t} + \rho_{I,t}^L, \tag{3.48}$$

$$R_{F,t}^L = R_t - \zeta_B \left(\frac{k_{B,t}}{r w_t} - \tau \right) \left(\frac{k_{B,t}}{r w_t} \right)^2 r w_{F,t} + \rho_{F,t}^L, \tag{3.49}$$

$\rho_{I,t}^L$ and $\rho_{F,t}^L$ are finance premia and are defined as:

$$\rho_{I,t}^L = E_t \left[\frac{\Pi_{t+1} q_{h,t+1} h_{I,t}}{l_{I,t}} \right] \int_{\underline{\omega}}^{\tilde{\omega}_{t+1}} \left(\tilde{\omega}_{t+1} - \mu_I \omega_{t+1} \right) f(\omega_{t+1}) d\omega_{t+1}, \tag{3.50}$$

$$\rho_{F,t}^L = E_t \left[\frac{\Pi_{t+1} \tilde{y}_{t+1}}{l_{F,t}} \right] \int_{\underline{\varepsilon}}^{\tilde{\varepsilon}_{t+1}} \left(\tilde{\varepsilon}_{t+1} - \mu_F \varepsilon_{t+1} \right) f(\varepsilon_{t+1}) d\varepsilon_{t+1}, \tag{3.51}$$

⁵⁰The demonstration is reported in Appendix I

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where $\tilde{y}_{t+1} = A_{F,t+1} k_t^\alpha n_t^{1-\alpha}$, $l_{I,t} = \frac{L_{I,t}}{p_t}$ and $l_{F,t} = \frac{L_{F,t}}{p_t}$.

Consistent with Basel III, risk weights are increasing functions of the default probability:

$$rw_{I,t} \equiv (1 - \chi_I)rw_I + \chi_I E_t \left(\frac{F_{t+1}(\tilde{\omega}_{t+1})}{F(\bar{\omega})} \right), \quad (3.52)$$

$$rw_{F,t} \equiv (1 - \chi_F)rw_F + \chi_F E_t \left(\frac{F_{t+1}(\tilde{\varepsilon}_{t+1})}{F(\bar{\varepsilon})} \right), \quad (3.53)$$

where χ_I and χ_F are respectively the sensitivity parameters of risk weights with respect to the mortgage and corporate expected probabilities of default; rw_I and rw_F are respectively the steady-state risk weight on mortgage and corporate lending and $F(\bar{\omega})$ and $F(\bar{\varepsilon})$ are respectively the steady-state mortgage and corporate loans' default frequencies.

Furthermore, bank's capital is accumulated out of reinvested profits, consequently:

$$k_{B,t+1}\Pi_{t+1} = (1 - \delta_B)k_{B,t} + \Lambda_{B,t}^r, \quad (3.54)$$

where the bank *ex-post* profit ($\Lambda_{B,t}^r$) is:

$$\Lambda_{B,t}^r = (\bar{r}_{I,t+1}^L - r_t)l_{I,t} + (\bar{r}_{F,t+1}^L - r_t)l_{F,t} + r_t k_{B,t} - \frac{\zeta_B}{2} \left(\frac{k_{B,t}}{rw_t} - \tau \right)^2 k_{B,t},$$

where $\bar{r}_{I,t+1}^L$ and $\bar{r}_{F,t+1}^L$ are the actual rates of return from mortgage and corporate lending after the occurrence of all shocks in $t + 1$. Hence:

$$\bar{r}_{I,t+1}^L = r_{I,t}^L - \rho_{I,t}^L, \quad (3.55)$$

$$\bar{r}_{F,t+1}^L = r_{F,t}^L - \rho_{F,t}^L. \quad (3.56)$$

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3.3.4 Monetary policy and market clearing

Monetary policy follows a Taylor rule of the following type:

$$R_t = R^{1-\phi_R} R_{t-1}^{\phi_R} \left(\frac{\Pi_t}{\bar{\Pi}} \right)^{\phi_{\Pi}(1-\phi_R)} \left(\frac{Y_t}{\bar{Y}} \right)^{\phi_Y(1-\phi_R)} A_{r,t}, \quad (3.57)$$

where R denotes the steady-state nominal interest rate. ϕ_R denotes the interest rate smoothing parameter. Respectively, ϕ_{Π} and ϕ_Y are the weight assigned to inflation and output targets, Π and Y . $A_{r,t}$ represents a monetary policy shock following an AR(1) process.

The market clearing condition in goods market is given by:

$$\begin{aligned} y_t = & C_t + i_{K,t} + G_t + \frac{\zeta_K}{2} \left(\frac{A_{K,t} i_{K,t}}{i_{K,t-1}} - 1 \right)^2 i_{K,t} + \frac{\zeta_P}{2} (\Pi_t - 1)^2 y_t \\ & + \frac{\zeta_{W_I}}{2} (\Pi_t^{W_I} - 1)^2 w_{I,t} + \frac{\zeta_B}{2} \left(\frac{k_{B,t-1}}{r w_{t-1}} - \tau \right)^2 \frac{K_{B,t-1}}{\Pi_t} \\ & + \frac{\zeta_{W_P}}{2} (\Pi_t^{W_P} - 1)^2 w_{P,t} + \delta_B \frac{k_{B,t-1}}{\Pi_t} - (1 - \mu_F) G_t (\tilde{\varepsilon}_t) \tilde{y}_t \end{aligned} \quad (3.58)$$

where the aggregate consumption is $C_t = c_{P,t} + c_{I,t}$ and the aggregate housing stock, in equilibrium, is $\bar{H} = h_{P,t} + h_{I,t} = 1$. Government spending is exogenous and represents a fraction of the steady state output:

$$G_t = A_{g,t} g \bar{Y}, \quad (3.59)$$

where $A_{g,t}$ is a shock on government spending, $g \in [0, 1]$ and \bar{Y} stands for the steady state output. It is assumed that at the beginning of the period, the government has no debt and each period, the budget is balanced, i.e. $G_t = T_t + IC_t$, where IC_t is a fraction of both real output of insolvent firms and real housing stock of insolvent households. This fraction covers insolvency proceeding cost, i.e. $IC_t = \int_{\underline{\omega}}^{\tilde{\omega}_t} \omega_t (1 - \mu_I) q_{h,t} h_{I,t-1} f(\omega_t) d\omega_t + \int_{\underline{\varepsilon}}^{\tilde{\varepsilon}_t} \varepsilon_t (1 - \mu_F) \tilde{y}_t f(\varepsilon_t) d\varepsilon_t$.

3.4 Calibration of the model based on Euro Area data

In order to simulate the model, we pick the values of model parameters from both the literature and Euro Area data.

We set the discount factor of patient households, β_P , at 0.999 in order to match the average annual real risk free interest rate of approximately 1%, which depicts a low-yield environment. The discount factor of impatient households, β_I , is endogenously determined at the steady state to be 0.941. The degree of habit formation in consumption, A , is set to the average estimates of 0.5 as in Lambertini et al. (2017). The capital share in output, α , is equal to 0.3. The share of impatient households' income in the labour income, η , is set to 0.4 as in Quint and Rabanal (2014) and in Punzi and Rabitsch (2016).

We pick the non-residential capital depreciation rate, δ_k , of 0.025 from standard literature (see Clerc et al., 2015; Hristov and Hülsewig, 2017, among others). The LTV ratio, m_h , is 0.7 consistent with Euro Area data and Gerali et al. (2010) and Quint and Rabanal (2014). The labour substitution elasticity, ϕ , and the goods substitution elasticity, ξ , are set respectively to 5 and 6, implying the steady-state markup of 25% and 20% respectively as in Chen and Columba (2016) and Hristov and Hülsewig (2017). The inverse of Frisch elasticity is $\gamma = 1$.

Consistent with Basel III requirements, we reasonably fix the instrument CRR, that is τ to 12%⁵¹. The parameters of adjustment costs related to the bank leverage (ζ_B), price (ζ_p), business capital (ζ_K) and both patient and impatient wages (ζ_{W_P} and ζ_{W_I}) are respectively set to 10, 20, 15 and 30. These values are broadly consistent with the literature (see Gerali et al. (2010) for ζ_B , Hristov and Hülsewig (2017) for ζ_p , ζ_{W_I} and ζ_{W_P} and Clerc et al. (2015) for ζ_K). The bank capital is supposed to depreciate at $\delta_B = 0.15$,

⁵¹Under Basel III, the total minimum capital adequacy ratio of Tier 1 and Tier 2, including the capital conservation buffer, is 12.5%.

3.4 Calibration of the model based on Euro Area data

which is slightly higher than the value of 0.1 in Gerali et al. (2010).

The regulatory risk weights on mortgage and corporate loans are respectively 0.04 and 0.08 as in Clerc et al. (2015). We assume that the sensitivities of the mortgage (χ_I) and corporate (χ_F) risk-weighted ratios to their respective defaults are similar to 0.5. The fractions of the actual house (μ_I) and output (μ_F) values seized by the bank in case of default are both set to 95% implying insolvency proceeding costs of 5%.

The weights of housing preference (χ_h) and labour disutility (χ_n) in the utility function are respectively 0.2 and 1, following Clerc et al. (2015). The mean of the expected idiosyncratic productivity shock, ε , is set to unity. The steady state values of the lower and upper bounds of the idiosyncratic housing value and productivity shocks are respectively $\omega_{inf} = 0.6$ and $\omega_{sup} = 1.4$ and $\varepsilon_{inf} = 0.7$ and $\varepsilon_{sup} = 1.3$, such that the model produces reasonable value. Therefore, the steady state values of the respective probabilities of default of mortgage and corporate sectors are 10% and 22%.

The ratio of public spending over GDP is 0.2 from Euro Area data. The monetary policy rule has a smoothing parameter of 0.8, a response to inflation about 2 and a response to output gap of 0.4, following Gerali et al. (2010).

Finally, we pick 0.8 as coefficients of the autoregressive parts of shocks. All the values used for the model parameters are summarised in Table 3.2.

3.4 Calibration of the model based on Euro Area data

Table 3.2: Calibration of the model parameters

Parameters	Description	Value
<i>Households</i>		
β_P	Patient household discount factor	0.999
A	Habit formation in consumption	0.5
α	Capital share in output	0.3
η	Share of impatient households' income in the labour income	0.4
δ_k	Non-residential capital depreciation rate	0.025
m_h	Loan-to-value ratio	0.7
ϕ	Labour substitution elasticity	5
ξ	Goods substitution elasticity	6
γ	Inverse of Frisch elasticity	1
ζ_{WP}	Wage adjustment cost for patient households	30
ζ_{WI}	Wage adjustment cost for impatient households	30
χ_h	Weight of housing in the utility	0.2
χ_n	Weight of labour in the utility	1
ω_{inf}	Lower bound of the idiosyncratic housing shock	0.6
ω_{sup}	Upper bound of the idiosyncratic housing shock	1.4
<i>Firms</i>		
ζ_p	Price adjustment cost	20
ζ_K	Business capital investment adjustment cost	15
ϵ_{inf}	Lower bound of the idiosyncratic productivity shock	0.7
ϵ_{sup}	Upper bound of the idiosyncratic productivity shock	1.3
<i>Banks</i>		
τ	Capital-to-risk weighted assets ratio	0.12
ζ_B	Banking leverage adjustment cost	10
δ_B	Depreciation rate of the bank capital	0.15
rw_I	Regulatory risk weight on mortgage loans	0.04
rw_F	Regulatory risk weight on corporate loans	0.08
χ_I	Sensitivity of the mortgage risk weighted ratio to risk	0.5
χ_F	Sensitivity of the corporate risk weighted ratio to risk	0.5
μ_I	Fraction of the house value seized by the bank in case of default	0.95
μ_F	Fraction of the output seized by the bank in case of default	0.95
Θ	Fraction of the house value seized to cover insolvency proceeding cost	0.05
<i>Monetary policy and market clearing</i>		
ϕ_R	Taylor rule smoothing coefficient	0.8
ϕ_Π	Taylor rule coefficient on inflation	2
ϕ_Y	Taylor rule coefficient on output	0.4
G	Government spending to GDP ratio	0.2
<i>Shocks and default rate</i>		
ρ_c	AR consumption preference shock	0.8
ρ_h	AR housing preference shock	0.95
ρ_B	AR banking capital shock	0.8
ρ_F	AR productivity shock	0.8
ρ_R	AR monetary policy shock	0.8
ρ_K	AR capital investment shock	0.8
ρ_G	AR government spending shock	0.8
$F_{t+1}(\tilde{\omega}_{t+1})$	Mortgage default rate (probability)	0.03
$F_{t+1}(\tilde{\epsilon}_{t+1})$	Corporate default rate (probability)	0.03

Source: authors' elaboration on collected Euro Area data from the literature.

3.5 How well does an easing macroprudential policy mitigate the effect of a shock to the spread of mortgages?

This section first presents the dynamic of the model when introducing a shock on both mortgage and corporate risk premia. In particular, we explore via our baseline model the impact of an exogenous shock, affecting the capacity of households and firms to repay their loans, on macroeconomic and banking behaviours. An exogenous shock such as the outbreak of the recent pandemic is likely to dramatically affect the capacity of agents to repay their loans, which in turn, can affect banks' ability to grant loans and, more generally, bank revenues. In this context, as a second step, we decide to investigate the extent to which the effect of an ease of both LTV and CRR requirements could help foster the economy without undermining the resilience of the banking system. While our baseline model accounts for macroprudential policies but does not modify their level when the rise in risk premia occurs, we explore the role of the macroprudential policy by embedding both a relaxed LTV ratio and a capital(-to-risk weighted) adequacy ratio.

3.5.1 Private sector finance premium shock

We assume that an exogenous reason like the coronavirus pandemic triggers an increase of both mortgage and corporate lending risk premia. Figure 3.6 shows the effects of a 1% positive shock to both household and corporate finance risk premia using the baseline calibration of the model. This shock initially translates into an increase in mortgage and corporate lending rates, depressing loans to households and corporates. As a result, bank capital falls, reflecting the decline in the bank expected profit as higher interest rates on mortgages and business loans do not offset the volume compression in lending. The rise of borrowers' interest rate on loans pushes impatient households to reduce their consumption

3.5 How well does an easing macroprudential policy mitigate the effect of a shock to the spread of mortgages?

fulfilling their mortgage obligations. Accordingly, aggregate consumption and output decline sharply. The lending spread shock generates a decrease in house demand from borrowers, leading to a fall of house price one quarter later. The probability (risk) of default reacts negatively to the shock, raising therefore the borrowing constraint and this fuels, in turn, the risk premium. In particular, the mortgage default risk increases, reflecting the deteriorated lending conditions and the depressed house prices. Note that this happens after a quick drop of the default risk at the impact with respect to its steady state level following the increase of house prices at the impact of the shock. The corporate default risk also increases as a result of output decline and tighter lending standards. These dynamics are consistent with the empirical findings presented in the first part of this work.

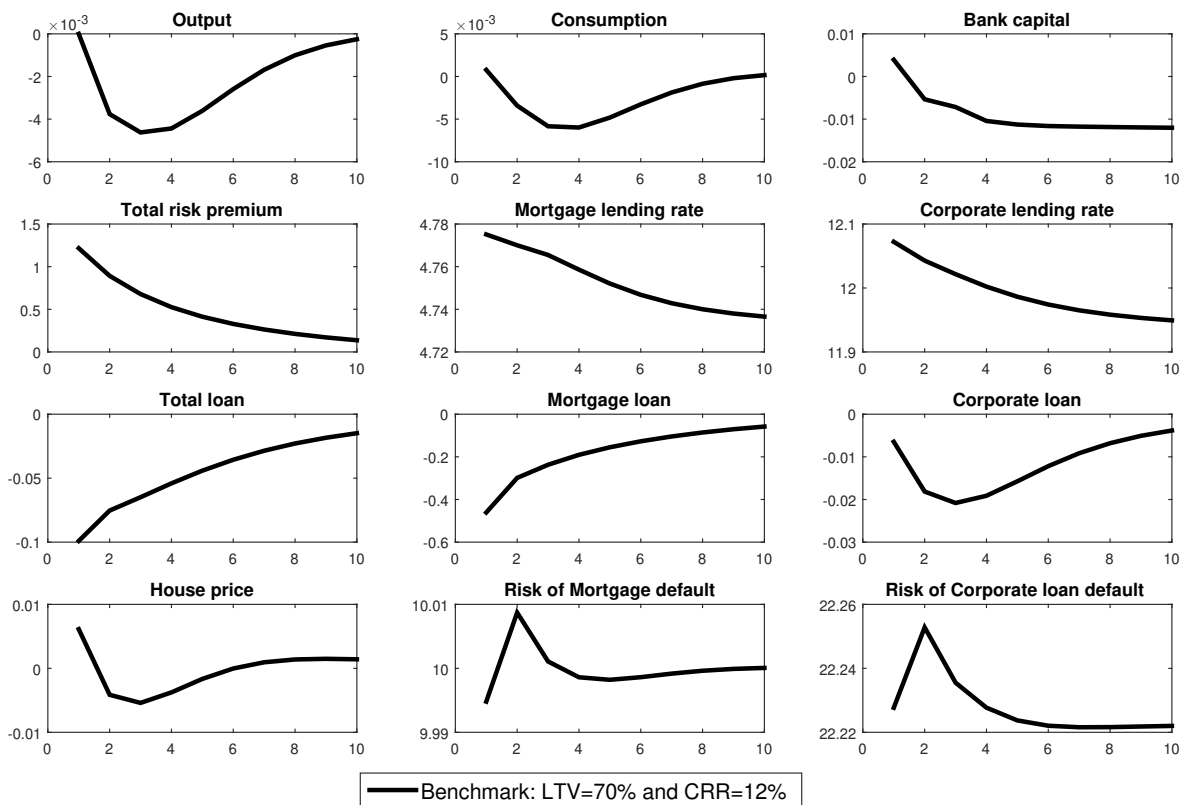


Figure 3.6: Mortgage and corporate finance premium shock

3.5 How well does an easing macroprudential policy mitigate the effect of a shock to the spread of mortgages?

3.5.2 The role of macroprudential policy

We assume that the macroprudential authority exogenously sets the value of both macroprudential instruments: LTV and bank capital requirement ratios. We perform a counterfactual analysis by varying the values of these instruments in order to account for the role of macroprudential policies when the risk premium contractionary shock occurs.

3.5.2.1 Relaxing the LTV ratio

We start by varying the LTV limit in order to show how their different values modify the effects of the spread shock. We compare two scenarios: a scenario of LTV about 70% (called the baseline scenario) against a scenario of higher LTV (90%; i.e., an LTV release scenario).

Figure 3.7 contrasts the effects of a 1% positive risk premium shock under the two policy scenarios. This shock differently affects the main variables depending on the policy scenario considered. As a direct impact of the shock, the probability of mortgage default becomes higher under high LTV scenario compared to the scenario with low LTV. The mortgage lending interest rate raises much more under the high LTV scenario relative to the low LTV case, since banks overreacts to mortgage loan demand (i.e., price effect). This drastically reduces mortgage loans compared to the low LTV case (i.e., quantity effects). Banks compensate their mortgage loan cuts by extending relatively more corporate loans and lower the lending interest rate on these loans compared to the low LTV scenario. As a result, the relative probability of corporate default increases in the short term. The aggregate loan decreases relatively more in the high LTV scenario as the rise in corporate loans is not enough to balance the fall in mortgage loans. However, the price effect seems to compensate the quantity effects, thus having a positive effect on bank expected profitability. Therefore, bank capital increases more under the scenario with a high LTV limit.

Furthermore, higher corporate loans imply a positive effect by increasing output and

3.5 How well does an easing macroprudential policy mitigate the effect of a shock to the spread of mortgages?

the firm's capital rental rate relative to the case of low LTV. As firms are owned by patient households, the latter consume relatively more in response to favourable rental rates, leading to a relative rise of aggregate consumption in the medium term which, in turn, contributes to increase output. Housing demand from savers is higher under the high LTV scenario compared to the low LTV case. This causes a relative higher house prices and contributes to raising relative output. Finally, loosening LTV prevents the output contraction in the wake of the shock.

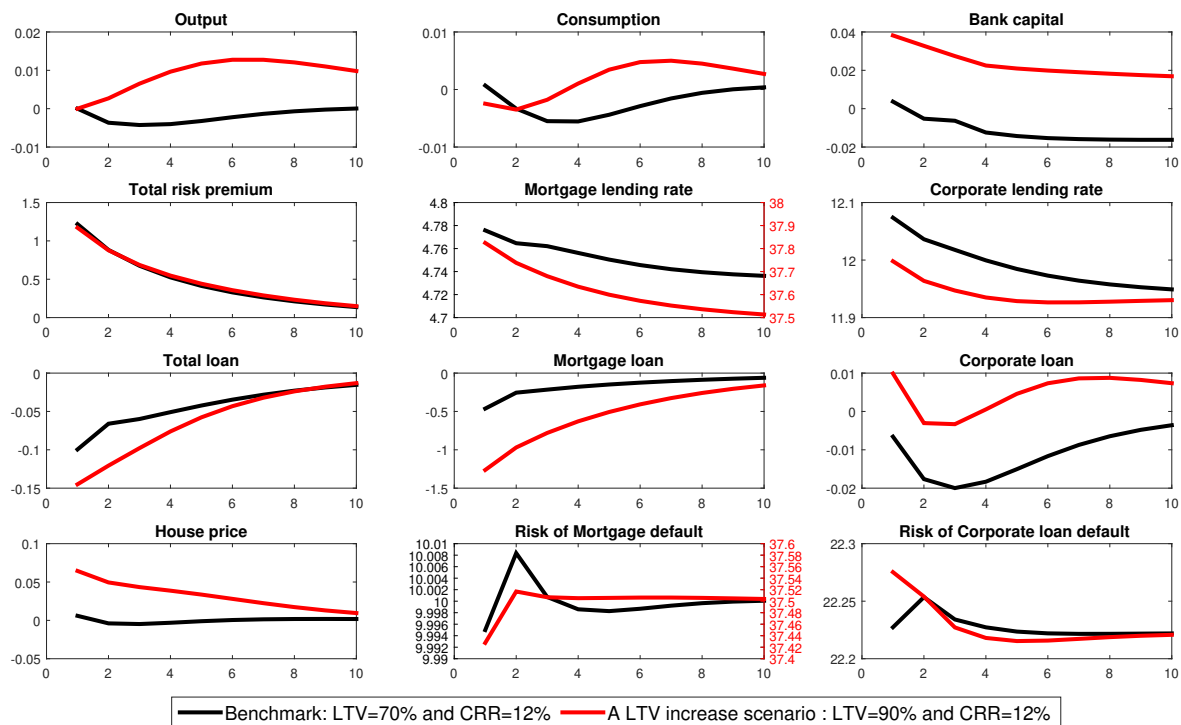


Figure 3.7: Mortgage and corporate finance premia shock with an LTV increase scenario. Note that the values of the mortgage rate and the mortgage default risk under a scenario of increasing LTV are displayed on the right-hand scale (in red).

3.5.2.2 Relaxing the capital(-to-risk weighted) adequacy ratio

We vary the value of CRR while keeping the LTV ratio as given by its benchmark value (70%). Then, we compare the outcomes of the model dynamic under a scenario with CRR=12% (benchmark scenario) and under a scenario with CRR=5% (macroprudential capital release scenario). Figure 3.8 compares the two policy scenarios under the effect of

3.5 How well does an easing macroprudential policy mitigate the effect of a shock to the spread of mortgages?

a 1% positive risk premium shock. In performing the comparison among the two policies, we increase the parameter of bank capital adjustment cost ζ_B ⁵² in order to better display the differences between variable dynamics.

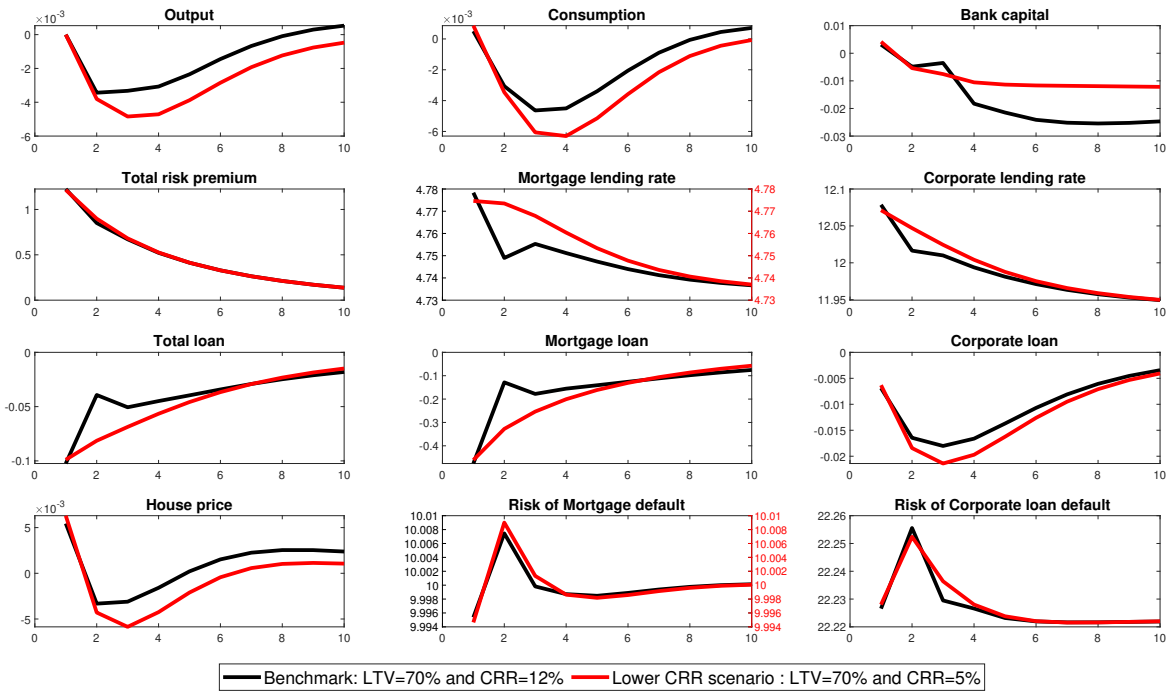


Figure 3.8: Mortgage and corporate finance premia shock with a CRR decrease scenario. Note that the values of the mortgage rate and the mortgage default risk under a scenario of increasing LTV are displayed on the right-hand scale (in red).

In response to this shock, both the bank corporate and mortgage lending interest rates increase relatively more in the low CRR case. As a result, loans to households and corporates and as well as aggregate loans decrease slightly more under the policy scenario with the low CRR compared to the one with the high CRR. The house prices pattern reflects the relative fall in loans in the policy scenario with the low CRR compared to the benchmark scenario. The risks of mortgage and corporate default accordingly increase slightly in the former scenario relative to the latter case. The contractionary effect of the shock is exacerbated by lowering the CRR. Specifically, consumption and output depress

⁵²Since IRFs are sensitive to the bank capital adjustment cost parameter, we decide in this scenario to increase its value so that we can better compare the IRFs from the baseline scenario with the IRFs from a lower CRF scenario. In the absence of such a change, the differences between the IRFs are very small. Results are presented for a value of $\zeta_B = 50$.

3.5 How well does an easing macroprudential policy mitigate the effect of a shock to the spread of mortgages?

more when CRR=5% compared to the case where it is set to 12%. Unlike an LTV increase scenario and despite a relaxation of the CRR, banks are cutting both their mortgages and corporate loans, which does not help stimulate the economy. In the short term, there are no noticeable differences between bank capital responses while in the medium term bank capital decreases less under the low CRR scenario. This relative increase in capital is due to the slight increase in mortgage and business lending rates, which offsets the decline in loan volumes and relatively increases profits.

The differences between the IRF of different variables under the two policy scenarios obviously depend on the bank capital adjustment cost parameter, which defines the sensitivity of the lending interest rates and of bank profits to the capital cost. In particular, these differences are increasing in the parameter of bank capital adjustment cost.

3.5.2.3 Relaxing both the LTV ratio and the capital(-to-risk weighted) adequacy ratio

In this policy experiment, we first assume that both borrower (LTV) and capital-based (CRR) macroprudential instruments were set to their loosened levels when the risk premium shock occurs (i.e., LTV =90% and CRR=5%). In Figure 3.9, we then compare this scenario with the one under which LTV and CRR are set to their baseline levels (i.e., LTV=70% and CRR=12%).

Figure 3.9 displays the effects of a 1% positive risk premium shock under these alternative policy scenarios. Figure 3.9 then reflects the combination of Figure 3.7 (i.e., relaxing LTV ratio) and Figure 3.8 (i.e., relaxing CRR). The results follow mostly the ones from changing only LTV as the differences between alternative policies in this case dominate much more than the ones stemming from comparing a tight CRR and a loosened CRR.

In particular, when both LTV and CRR are loosened, the effect of the risk premium shock is not necessarily recessionary. It is also worth mentioning that under this scenario, bank capital increases more than under an LTV increase scenario. Both the relaxation of

the LTV and CRR leads to a relatively higher level of profits and thus bank capital.

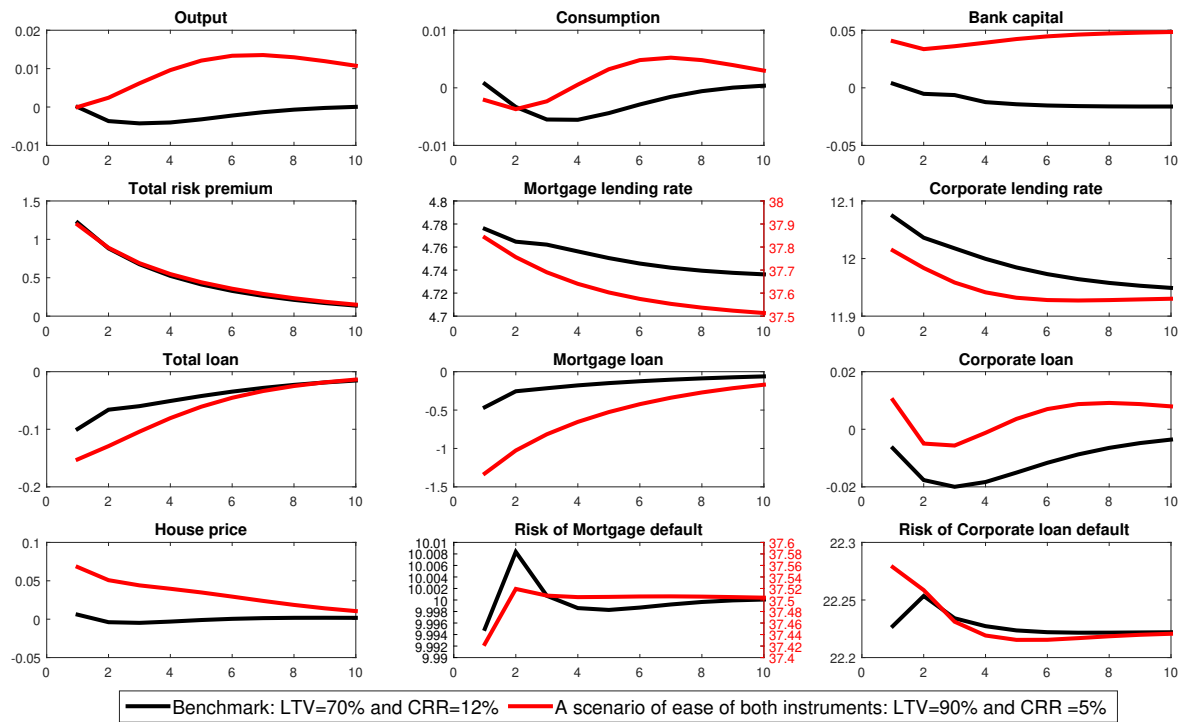


Figure 3.9: Mortgage and corporate finance premia shock with a scenario of ease of both instruments. Note that the values of the mortgage rate and the mortgage default risk under a scenario of increasing LTV are displayed on the right-hand scale (in red).

3.6 Conclusion

Faced with a health crisis, almost all European governments imposed an unprecedented halt in production and consumption. The consequences of such an economic shutdown spills over into the banking system, as losses due to payment defaults coupled with falls in asset prices threaten the financial stability. De Moura Fernandes (2020) forecasts a sharp rise of insolvencies across Europe in the second half of 2020 and in 2021. For instance, Italy and the United-Kingdom would be the most penalised countries with an increase in insolvency of about 37%. Over the past decade, in the name of macroprudential policy, banking authorities have increased resilience into their banking systems by compelling financial institutions to build up liquidity and capital buffers and adopt borrower-based

measures. Even if macroprudential policy is not front stage in this crisis, its flexibility must help the banking sector operate as a shock absorber. This time, banks are called to use their build-up to support the economy. At the same time, any changes in macroprudential rules should take into account the environment of low bank profitability and high private indebtedness.

In this context, our work focuses on the role of macroprudential policy in the Euro Area in the event of an exogenous shock similar to the coronavirus pandemic, which is expected to adversely affect households' and businesses' capacity to pay off their loans. We provide both empirical and theoretical pieces of evidence. We first introduce a panel VAR analysis of the core countries of the Euro Area. By simulating a shock on mortgage spread rates, we mimic the propagation of an exogenous shock immediately affecting households' capacity to repay their loans. To further complement our empirical findings, we also present an Interacted Panel VAR that allows for the inclusion of the time-varying level of macroprudential policy. Furthermore, such a model has the advantage to evaluate the role of the exogenous variable at high and low regimes. In other words, we are able to assess the role of macroprudential policy under both tight and loose regimes. Second, we explore the role of specific macroprudential measures, that is the CRR and the LTV, through a DSGE model calibrated on Euro Area data. In order to integrate these tools into the model, the latter presents heterogeneous households, a housing sector and a competitive banking sector, which closely reflects the way the capital-based requirement is imposed on financial institutions. In addition, our model differentiates collateral from borrowing constraint. Only impatient households are financially constrained when borrowing but both firms and impatient households are subject to a collateral. It is important to note that both mortgages and corporate loans can default.

Our findings encourage policymakers to make the most of macroprudential policy flexibility since this "tertiary" policy is able to mitigate or even counteract the side effects of the pandemic. More importantly, our model provides useful guidance on the specific

instruments to be used. Cutting the CRR is the most straightforward way to limit the amplifier effect of a shrink in the leverage ratio and many jurisdictions have relaxed capital requirements by reducing the countercyclical capital buffer. While relaxing such an instrument is likely to avoid any negative consequences, our model shows that it does not provide stimulus to the economy. By contrast, an easing of the LTV ratio is more effective in giving impetus to the activity. Although mortgage lending declines in the short term under an LTV facility scenario (due to a larger initial stock of mortgages in this scenario), which then leads to higher mortgage interest rates, banks compensate for this loss by issuing more business loans. This provides direct support to business production and capital leasing.

Appendix G

Chapter 3: Data description of stylised facts

Data	Unit	Source
Bank leverage defined as bank capital and reserves on total assets	Percent, monthly	MFI Balance Sheet of the ECB Statistical Data Warehouse, authors' computations
Equity-to-Total-Assets ratio for the 20 largest Euro Area banks in terms of assets	Percent, yearly	BankScope and Fitch Connect
Mortgage spread defined as the difference between the bank lending rate to households for house purchase (all maturity combined) and EONIA	In bps, quarterly	MFI Interest Rate Statistic of the ECB Statistical Data Warehouse and DataStream, authors' computations
Bank return-on-Asset	Percent, yearly	Consolidated Banking data of the ECB Statistical Data Warehouse
Bank return-on-Equity	Percent, yearly	Consolidated Banking data of the ECB Statistical Data Warehouse
ECB policy interest rate (repo)	Percent, monthly	Financial Market Data of the ECB Statistical Data Warehouse
Bank lending rate for house purchase (with an original maturity of over five years)	Percent, monthly	MFI Interest Rate Statistic of the ECB Statistical Data Warehouse
Lending for house purchase	Index Jan 1997=100, monthly	MFI Balance Sheet Statistics of the ECB Statistical Data Warehouse, authors' computation
House price	Index Q1 1997=100, quarterly	Eurostat
Real GDP	Index Q1 1997=100, quarterly	Eurostat, authors' computation
Private sector debt in % of GDP (changing Euro Area composition)	Simple average, percent, yearly	Eurostat

Appendix H

Chapter 3: Data description of the VAR analysis

Variable	Description and unit	Source
Bank capital and reserves	Outstanding amounts at the end of the period - Growth rate (in %)	MFI Balance Sheet of the ECB Statistical Data Warehouse, authors' computation
Loans for house purchase	Newly issued loans for house purchase over the period - Growth rate (in %)	MFI Balance Sheet Statistics of the ECB Statistical Data Warehouse, authors' computation
Mortgage spread	Difference between the bank lending rate to households for house purchase (all maturity combined) and EONIA (similar to Kangiesser et al., 2017) (in bps)	MFI Interest Rate Statistic of the ECB Statistical Data Warehouse and DataStream
Bank lending margin	Difference between the average of bank lending rate to households and non-financial corporations weighted by total loans for households and non-financial corporations and deposit rates (in bps)	Risk Assessment Indicators of the ECB Statistical Data Warehouse
House price	Index Q1 1997=100 - Growth rate (in %)	Eurostat, authors' computation
Real GDP	Growth rate (in %)	Eurostat
Macroprudential Policy Index	Based on the MaPPeD (Budnik and Kleibl, 2018), each macroprudential measure considered "tight" takes the value of 1, -1 when it is considered "loose", 0 otherwise. The variable is then a cumulative aggregation of all the the dummy-type indexes	Central Bank of Luxembourg, authors' computation.

Appendix I

Chapter 3: Bank's expected return from lending

Bank's expected return from lending to impatient household i and intermediate good producer j is given, in nominal terms, by:

$$\begin{aligned}
E_t \left[R_{t+1}(i, j) \right] &= \int_{\tilde{\omega}_{t+1}(i)}^{\bar{\omega}} R_{I,t}^L L_{I,t}(i) f(\omega_{t+1}(i)) d\omega_{t+1}(i) \\
&+ \int_{\underline{\omega}}^{\tilde{\omega}_{t+1}(i)} (1 - \Theta) \omega_{t+1} Q_{h,t+1} h_{I,t}(i) f(\omega_{t+1}(i)) d\omega_{t+1}(i) + \int_{\tilde{\varepsilon}_{t+1}(j)}^{\bar{\varepsilon}} R_{F,t}^L L_{F,t}(j) f(\varepsilon_{t+1}(j)) d\varepsilon_{t+1}(j) \\
&+ \int_{\underline{\varepsilon}}^{\tilde{\varepsilon}_{t+1}(j)} \left([1 - (1 - \mu_F)] P_{t+1}(j) Y_{t+1}(j) - \frac{\zeta_P}{2} \left(\frac{P_{t+1}(j)}{P_t(j)} - 1 \right)^2 P_{t+1} Y_{t+1} \right) f(\varepsilon_{t+1}(j)) d\varepsilon_{t+1}(j) \\
\\
E_t \left[R_{t+1}(i, j) \right] &= R_{I,t}^L L_{I,t}(i) - E_t \int_{\underline{\omega}}^{\tilde{\omega}_{t+1}(i)} \left[R_{I,t}^L L_{I,t}(i) - \left(\mu_I \omega_{t+1} Q_{h,t+1} h_{I,t}(i) \right) \right] f(\omega_{t+1}(i)) d\omega_{t+1}(i) \\
&+ R_{F,t}^L L_{F,t}(j) - E_t \int_{\underline{\varepsilon}}^{\tilde{\varepsilon}_{t+1}(j)} \left[R_{F,t}^L L_{F,t}(j) - \left(\mu_F P_{t+1}(j) Y_{t+1}(j) - \frac{\zeta_P}{2} \left(\frac{P_{t+1}(j)}{P_t(j)} - 1 \right)^2 P_{t+1} Y_{t+1} \right) \right] \\
&f(\varepsilon_{t+1}(j)) d\varepsilon_{t+1}(j) \\
\\
E_t \left[R_{t+1}(i, j) \right] &= R_{I,t}^L L_{I,t}(i) - \int_{\underline{\omega}}^{\tilde{\omega}_{t+1}(i)} \left(\tilde{\omega}_{t+1}(i) - \mu_I \omega_{t+1}(i) \right) Q_{h,t+1} h_{I,t}(i) f(\omega_{t+1}(i)) d\omega_{t+1}(i) \\
&R_{F,t}^L L_{F,t}(j) - E_t P_{t+1}(j) \tilde{Y}_{t+1}(j) \int_{\underline{\varepsilon}}^{\tilde{\varepsilon}_{t+1}(j)} \left(\tilde{\varepsilon}_{t+1}(j) - \mu_F \varepsilon_{t+1}(j) \right) f(\varepsilon_{t+1}(j)) d\varepsilon_{t+1}(j) \\
\\
E_t \left[R_{t+1}(i, j) \right] &= R_{I,t}^L L_{I,t}(i) - L_{I,t}(i) E_t \left(\frac{Q_{h,t+1} h_{I,t}(i)}{L_{I,t}(i)} \right) \int_{\underline{\omega}}^{\tilde{\omega}_{t+1}(i)} \left(\tilde{\omega}_{t+1}(i) - \mu_I \omega_{t+1}(i) \right) \\
&f(\omega_{t+1}(i)) d\omega_{t+1}(i) + R_{F,t}^L L_{F,t}(j) - L_{F,t}(j) E_t \left(\frac{P_{t+1}(j) \tilde{Y}_{t+1}(j)}{L_{F,t}(j)} \right) \int_{\underline{\varepsilon}}^{\tilde{\varepsilon}_{t+1}(j)} \left(\tilde{\varepsilon}_{t+1}(j) - \mu_F \varepsilon_{t+1}(j) \right) \\
&f(\varepsilon_{t+1}(j)) d\varepsilon_{t+1}(j)
\end{aligned}$$

General conclusion

The European banking institutional environment, mainly shaped by monetary policy and prudential policy, has been subject to profound changes over the first two decades of the 20th century. First marked by the financial crisis, and recently by the pandemic, central banks have no choice but to resort to unconventional measures to achieve their ultimate objective and support their economies. These actions brought the main policy interest rate to the Zero Lower Bound (ZLB) and led to massive liquidity injections. At the same time, European authorities have strengthened, mainly via the implementation of macroprudential tools, the prudential framework to reinforce banks' resilience in order to safeguard financial stability. Changes in the institutional environment aim at influencing banks' behaviour; however, under some circumstances, unintended effects arise.

Against this background, the goal of this thesis was to analyse the effects of both monetary and macroprudential policies on banks' behaviour. In particular, in response to the financial and health crisis, we have examined the extent to which the behaviour of European banks, in terms of risk, profit and resilience, has been affected by the advent of unconventional monetary policy (UMP) and macroprudential tools over the last two decades.

In the first Chapter, we explored the existence of the bank risk-taking channel in Europe through both conventional and unconventional monetary policy indicators: the policy interest rate, the interest rate on the deposit facility, the shadow interest rate and the central banks' total assets. We relied on a dynamic panel model with threshold effects as introduced by Kremer et al. (2013). We found evidence for nonlinear effects for both risk measures employed, namely the asymmetric Z-score, an accounting-based measure, and the Distance-to-Default (DD), a market-based measure, which provides complementary information. The cut of central bank rates and the rise in the monetary base reflect riskier

banks' behaviour. In line with the literature, this result confirms that the bank risk-taking channel was at play before the outburst of the financial crisis. More importantly, our work shows that below a certain threshold, the positive relationship between monetary policy interest rate indicators and risk measures becomes even stronger. Also, accounting for the central banks' balance sheet policy indicates that additional liquidity encourages banks to take riskier positions. These findings are of particular importance for monetary authorities since monetary conditions do not only have the intended effects on banks' behaviour and, more generally, on the economy but are also likely to distort their behaviour by encouraging them to search for more risk.

As the pursuit of additional risk stems directly from low returns, the purpose of Chapter 2 was to explore this issue. While accounting for bank's prudential behaviour, this Chapter put into perspective the relationship between the low interest rate environment and bank profitability. While the negative effect of low interest rates on net interest margins (NIM) may be evident, we also examined its ultimate effect on overall bank profitability - proxied by both the Return-on-Assets (ROA) and the Return-on-Equity (ROE) - as there is no clear evidence that low interest rates undermine ROA and ROE. Banks may seek other sources of profit. Our work provided empirical evidence that European banks that adopt prudential behaviour are associated with higher returns. Expectedly, the overall effect of policy interest rates squeezes NIM. Nevertheless, our results do not allow us to conclude that the effect of the policy interest rates has worsened bank profitability as our results obtained from the dynamic panel estimations seem to be driven by extreme values that occur during the financial crisis. Focusing on the effect of the key interest rate on profitability indicators under different regimes, our study reveals that under the lowest regime (i.e. close to the ZLB and under which our data do not include the extreme values recorded during the financial crisis), European banks manage to increase their overall profitability, despite the compression of the NIM which follows the downward trend of the key interest rate. This important result suggests that although the ability to generate profits from their traditional business is being eroded by the persistence of low interest rates, banks have appeared to slowly return to their pre-crisis profitability levels, most likely generating profits from other activities such as fees and commissions and trading activities or from engaging in greater lending volume. However, the outbreak of

the pandemic may halt this trend. The expected increase in loan defaults, combined with risks related to house prices and high private indebtedness, may pose further challenges to the financial sector's profitability.

In this context, Chapter 3 examined the role of macroprudential instruments in a turbulent banking institutional environment, marked by risks that could jeopardise financial stability. In some Euro Area economies, in addition to the widespread issue of low interest rates, banking sectors are highly exposed to the housing market in a context of rapidly rising house prices and increasing private indebtedness. Furthermore, the outbreak of the pandemic is expected to worsen the capacity of households and businesses to repay their loans. Therefore, in this last Chapter, we presented evidence, through both a panel VAR analysis and a DSGE model, that policy makers can make the most of the flexibility of macroprudential instruments in the event of an external shock such as the pandemic. We showed that relaxing macroprudential tools helps counteract adverse effects stemming from a shock capable of worsening households' and firms' capacity to pay off their loans. Moreover, while the panel VAR analysis accounts for a macroprudential policy as a whole, the DSGE more specifically focuses on two flexible macroprudential tools, namely the Capital Requirement Ratio (CRR) and the Loan-to-Value (LTV) ratio. The model reveals that relaxing the LTV ratio is more effective than relaxing the CRR in recovering from a shock that raises the risk premiums of mortgages and firms.

List of Acronyms

BEI	Barriers to Entry Index
BLS	Bank Lending Survey
BRSI	Banking Regulation and Supervision Index
CBA	Central Bank's Assets
CDS	Credit Default Swap
CEE	Central and Eastern Europe
COA	Capital-on-Assets
CRR	Capital Requirement Ratio
DD	Distance-to-Default
DSGE	Dynamic and Stochastic General Equilibrium
EBA	European Banking Authority
ECB	European Central Bank
EDF	Expected Default Frequency
ENL	Equity on Net Loans
EONIA	Euro OverNight Index Average
ESRB	European Systemic Risk Board
EU	European Union
GDP	Gross Domestic Product
GFC	Global Financial Crisis
GMM	Generalised Methods of Moments
GMPI	Global Macroprudential Policy Instruments
IMF	International Monetary Fund
IPVAR	Interacted Panel Vector AutoRegression
IRF	Impulse Response Functions

LLP Loan Loss Provisions on Gross Loans

LTV Loan-to-Value

MaPPED MacroPrudential Policies Evaluation Database

NFC Non-Financial Corporations

NIM Net Interest Margins

QE Quantitative Easing

ROA Return-on-Assets

ROE Return-on-Equity

SLM Shadow/Lower-bound term structure Model

SRSI Stability Regulation and Supervision Index

UMP Unconventional Monetary Policy

VAR Vector AutoRegression

ZLB Zero Lower Bound

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Title: Institutional environment and bank behaviour: The case of European banks

Abstract: We study two policies that are key to shaping the institutional environment and that can therefore influence banks' behaviour, namely monetary and macroprudential policies.

In the first Chapter, we evidence the existence of the bank risk-taking channel of (un)conventional monetary policy in Europe. We show that the latter is nonlinear, i.e., the effects of monetary policy interest rates (the total assets on the balance sheet of central banks) on banking risk are stronger below (above) a certain threshold.

The second Chapter mainly explores the nexus between the low interest rate environment and bank profitability. Our findings suggest that monetary policy's main instrument adversely affects net interest margins, but its effect on overall profitability is unclear. Nevertheless, when policy interest rates are particularly low, it seems that European banks succeed in increasing their profitability despite a compression of their net interest income.

In the third Chapter, we examine the role of macroprudential tools in a turbulent institutional environment. The outbreak of the COVID-19 is likely to worsen households' and businesses' capacity to pay off their debt. The Chapter bridges the gap between the flexible use of macroprudential tools and their yet unknown effects in the event of a shock to risk premia of mortgages and corporate loans. Our empirical and theoretical models corroborate that an ease scenario of macroprudential policy allows mitigating the adverse effects stemming from such a shock. In particular, the DSGE model shows preference for relaxing the Loan-to-Value ratio over the Capital Requirement Ratio.

Keywords: Monetary policy, Macroprudential policy, Bank risk, Bank profitability, COVID-19

Title: Environnement institutionnel et comportement des banques: Le cas des banques européennes

Abstract: Nous étudions deux politiques jouant un rôle clé dans l'évolution et la métamorphose du cadre institutionnel et qui sont donc à même d'influencer le comportement des banques, à savoir la politique monétaire et la politique macroprudentielle.

Dans le premier chapitre, nous mettons en évidence l'existence du canal de la prise de risque bancaire de la politique monétaire (non)conventionnelle en Europe. Nous démontrons que ce dernier est non linéaire, c'est-à-dire que les effets des taux d'intérêt de la politique monétaire (du total des actifs au bilan des banques centrales) sur le risque bancaire sont plus forts en-dessous (au-dessus) d'un certain seuil.

Le deuxième chapitre explore le lien entre l'environnement des taux d'intérêt bas et la rentabilité des banques. Nos résultats suggèrent que le principal outil de la politique monétaire a un effet négatif sur les marges d'intérêt nettes, mais que son effet sur la rentabilité globale n'est pas clair. Néanmoins, lorsque les taux d'intérêt directs sont particulièrement bas, il semble que les banques européennes parviennent à accroître leur rentabilité malgré une compression de leurs revenus d'intérêts nets.

Le troisième chapitre examine le rôle des outils macroprudentiels dans un environnement institutionnel turbulent. L'apparition de la COVID-19 est de nature à aggraver la capacité des ménages et des entreprises à rembourser leurs dettes. Le chapitre fait le lien entre l'utilisation flexible des instruments macroprudentiels et leurs effets encore inconnus en cas de choc sur les primes de risque des prêts hypothécaires et des prêts aux entreprises. Nos modèles empiriques et théoriques corroborent le fait qu'un scénario d'assouplissement des outils macroprudentiels permet d'atténuer les effets négatifs découlant d'un tel choc. En particulier, le modèle DSGE montre une préférence pour l'assouplissement du ratio prêt-sur-valeur au détriment du ratio d'adéquation des fonds propres.

Keywords: Politique monétaire, Politique macroprudentielle, Risque bancaire, Rentabilité bancaire, COVID-19
