
DOCUMENT
DE TRAVAIL
N° 602

A DGSE MODEL TO ASSESS THE POST-CRISIS REGULATION

OF UNIVERSAL BANKS

Olivier de Bandt and Mohammed Chahad

September 2016



A DGSE MODEL TO ASSESS THE POST-CRISIS REGULATION

OF UNIVERSAL BANKS

Olivier de Bandt and Mohammed Chahad

September 2016

Les Documents de travail reflètent les idées personnelles de leurs auteurs et n'expriment pas nécessairement la position de la Banque de France. Ce document est disponible sur le site internet de la Banque de France « www.banque-france.fr ».

Working Papers reflect the opinions of the authors and do not necessarily express the views of the Banque de France. This document is available on the Banque de France Website “www.banque-france.fr”.

A DSGE Model to Assess the Post Crisis Regulation of Universal Banks*

Olivier de Bandt[†]

Mohammed Chahad[‡]

*Comments by Eleni Iliopoulos as well as participants in the European Economic Association meeting (Toulouse, Aug. 2014) and the EBA 4th Research Conference (Nov. 2015) are gratefully acknowledged. The views expressed in the paper are those of the authors and do not necessarily correspond to those of the Banque de France or the Autorité de Contrôle Prudentiel et de Résolution

[†]Banque de France- Autorité de Contrôle Prudentiel et de Résolution (ACPR) and EconomiX-CNRS, University of Paris Ouest.
E-mail: olivier.debandt@acpr.banque-france.fr

[‡]Banque de France. E-mail: mohammed.chahad@banque-france.fr

Résumé

Le papier étudie la cohérence générale ainsi que l'impact sur le secteur financier et l'économie réelle des nombreuses réglementations bancaires qui ont été mises en place depuis la grande crise financière. Pour cela, nous développons un modèle DSGE de grande taille avec un secteur réel et un secteur financier et des actifs multi-périodes. Nous modélisons des banques universelles offrant des crédits et investissant dans des titres obligataires publics ou émis par les entreprises. Dans notre modèle, ces derniers ne sont émis que par les grandes entreprises tandis que les petites entreprises ne peuvent se financer que par des crédits bancaires..

Les principales conclusions sont : (i) la réglementation sur la liquidité, qui affecte la dynamique de la consommation privée, à des effets moins persistants que celle portant sur la solvabilité, qui affecte la distribution de crédit et l'investissement ; (ii) le modèle évalue dans quelle mesure le LCR peut inciter les banques à substituer des titres publics à des prêts aux entreprises ; (iii) les réglementations sur la liquidité et la solvabilité apparaissent comme étant complémentaires ; (iv) en revanche, celles du LCR et du NSFR sont plutôt substituables, même si les effets du dernier apparaissent plus modérés.

Mots-clés : Bâle III, ratio de solvabilité, ratios de liquidité, actifs multi-périodes, entreprises hétérogènes

JEL : D58, E3, E44, G21

Abstract

The paper assesses the overall consistency and impact, on both the financial sector and the real economy, of the numerous banking regulations that have been introduced in the aftermath of the Great Financial Crisis. For this purpose, we develop, within a multi-period asset framework, a large scale DSGE model with a real and a financial sector. Universal banks grant credit and invest also in corporate and sovereign bonds. Small companies are financed through bank loans only, while large corporate can also issue bonds.

The main findings of the paper are that: (i) the implementation of liquidity regulation which affects private consumption dynamics has a less persistent effect than solvency regulation that affects loan distribution as well as investment; (ii) the model assesses to what extent the Liquidity Coverage Ratio (LCR) may induce banks to substitute sovereign bonds to business loans; (iii) liquidity and solvency regulations appear to be complementary; (iv) the implementation of the LCR has qualitatively similar results as the NSFR, even if, quantitatively, the latter has a more moderate effect.

Keywords: Basel III, Solvency ratio, Liquidity ratios, Multi-period assets, Firms' heterogeneity.

JEL : D58, E3, E44, G21

Non Technical Summary

Following the Great Financial Crisis, the regulatory framework for banking has changed dramatically. At the international (Basel) level this included capital reform, announced in 2010 and completed in June 2011, and for the Liquidity Coverage ratio (LCR), finalisation in January 2013. These reforms, together with others (Net Stable Funding ratio (NSFR) and discussions on the separation of some market activities) will be implemented progressively. The issue of the effect on banks and the macroeconomy has therefore been raised, as well as the overall consistency of the whole framework and possibly unintended effects. However, no definite answer has been provided so far, as these effects are difficult to assess since they have taken place in a context of a slow post-crisis GDP growth and the very accommodative stance of monetary policy.

The new Basel III requirements triggered a first wave of studies in the wake of the initial regulatory proposals by the Basel Committee in order to assess the overall impact of the new regulatory constraints on the real economy. This included the Macroeconomic Assessment Group (MAG 2010a and MAG 2010b), for the evaluation of the economic benefits and costs of stronger capital and liquidity regulation in terms of their impact on output. In addition, Angelini et al. (2011) analysed the impact of the reforms, comparing the results of 13 different models, but many of them were not fully consistent general equilibrium models. On the other hand, Gerali et al. (2010) as well Darracq Paries et al. (2011) built Dynamic Stochastic General Equilibrium (DSGE) models with a detailed banking sector including a wholesale and a retail branch. However, they concentrated on the effect of the solvency ratio, without considering liquidity regulation. More recently, as surveyed by BCBS (2016), several papers revisited the conclusions of the MAG papers. First, new DSGE models have been introduced, featuring a more developed banking sector. Second, liquidity constraints have been investigated (Adrian and Boyarchenko, 2014; Covas and Driscoll, 2014). Third, empirical evidence have been put forward in order to assess the effects of country-specific experiences (UK, Netherlands). The general conclusion is that regulatory constraints have a short term negative effects on credit supply and GDP, usually of small magnitude and balanced by expected long term gains in terms of financial stability. However, there is less consensus regarding liquidity regulation. In addition, as stressed by Cechetti (2014), no definite conclusion has yet been reached ("the jury is still out") and the conclusions still differ across studies (De Nicolo, Gambacorta and Lucchetta, 2014).

With a little bit of hindsight as compared to the previous papers, and taking stock of the preliminary evidence observed so far, the aim of the paper is twofold. First to study the interactions between banking regulation and the macroeconomic environment. Second, to investigate further a few stylised facts of the post-crisis banking system as well as some outstanding issues that are little discussed in the literature. This includes (i) the calibration of the liquidity requirements, (ii) the interaction between capital and liquidity requirements, (iii) the interaction between both liquidity requirements, namely the LCR and the NSFR.

For this purpose, also in the view of assessing the effects of the implementation of the new regulations, we develop a large scale DSGE model which is calibrated using mainly euro area data and which includes a real and a financial sector dominated by a universal banking system. Banks grant long term credit but invest also in corporate and sovereign bonds. As we want to take better into account the impact of the regulatory constraints on both small and large firms, we introduce heterogeneity among producers distinguishing between SMEs and large corporate firms, the latter ones being able to issue bonds. This heterogeneity is also useful for a better

modeling of the regulatory constraints. In comparison to previous paper we achieve a very detailed assessment of the regulation as we introduce both capital and liquidity regulation (LCR and also NSFR) in a way close to the basel III complex definition. Such a rather detailed model, as compared to previous ones, while remaining tractable, is able to incorporate many relevant features of the European banking sector, notably the rise of alternative sources of finance for non financial corporations. One additional novelty of the paper is to introduce a multi-period asset and liability framework, following Benes and Lees (2010), instead of standard one period contracts. This allows a more adequate modelling of the actual regulation, notably regarding the NSFR.

The main findings of the paper are important regarding the interactions between the real and the financial sector.

First, in terms of the channels of transmission of the new regulations, we show that the implementation of liquidity regulation affects private consumption dynamics, and has less persistent effects than solvency regulation that affects loan distribution as well as investment. Such a differential effect of the regulation has, to our knowledge, never been highlighted before in the literature.

Second, the model assesses to what extent the Liquidity Coverage Ratio may induce banks to substitute sovereign bonds to business loans. Indeed, the dynamic of private investment suffers from a crowding out effect from public debt. One of the expected effects of the new LCR is the search for highly rated sovereign debt. Neglecting the sovereign bonds channel may therefore underestimate the transitory adverse effect of the introduction of LCR on real variables.

Third, regarding the various debates concerning possible substitution between liquidity and solvency regulation, which was the view held before Basel III (see Bonner and Hilbers (2015), for a survey of the literature), we uncover large complementarity: implementing simultaneously liquidity and solvency regulations has compounded effects.

Fourth, we show that the implementation of the LCR has qualitatively similar results as the NSFR, even if, quantitatively, the latter has a more moderate effect. In consequence, we find large positive externalities between the two liquidity ratios, and more particularly in the financial sector.

Controlling for various other macroeconomic and financial effects, we show that banking regulation contributed to the stylized facts mentioned above. Such a conclusion might bear on the continuing debate on the optimal calibration of the regulatory framework by the Basel Committee.

1 Introduction

Following the Great Financial Crisis that started in 2007 a general consensus emerged to conclude that the previous regulatory framework had failed to detect and prevent the build-up of excessive risk-taking in the financial sector. As a consequence a set of regulatory reforms has been put in place along several dimensions, regarding banks' solvency and -substantial innovation- liquidity, as well on banks' business models.

The regulatory agenda is still very dense and while the contours of solvency regulation in Basel III are broadly defined, the overall calibration is still under discussion. This includes that of the Net Stable Funding Ratio (NSFR) and the leverage ratios, as well as the relative risk weights of the different portfolios in the standardised approach for credit risk. However, at the same time, economists as well as the Basel Committee have questioned the overall consistency of the approach and its impact on credit distribution notably to SMEs. Regarding the Liquidity Coverage Ratio (LCR), under article 509 (1) of the Capital Requirement Regulation, that applied to the European Union, the EBA is requested to investigate annually whether "the general liquidity coverage regulation [...] is likely to have a material detrimental [...] on the economy and the stability of the supply of credit, with a particular focus on lending to SMEs [...]".

While in the long run, a tighter solvency and liquidity regulation helps increase the resilience of the banking sector, hence the financing of the economy, policy makers face a dilemma in the short run, as on the one hand restraining banks' leveraging and increasing liquidity helps reduce banking instability, but on the other hand, it may hamper the continuous flow of credit to the real economy.

Literature

There is an abundant literature on the implementation of Basel III regulation (see notably Cecchetti (2014); BCBS (2016)). However, most of the literature (macro models as well as empirical papers) focused mainly on the the overall impact of higher capital requirements on the real economy. They put forward the role of higher capital requirements in the increase in the banks' funding costs that result in a higher bank lending rates. The channel of the borrowing costs remains the most common transmission channel adopted in the literature. The Macroeconomic Assessment Group (MAG (2010b) and MAG (2010a)) conducted within this framework two studies on the economic benefits and costs of stronger capital and also liquidity regulation in terms of their impact on output. Angelini et al. (2011) implemented 13 different models in order to analyze the long-term economic costs of the new rules putting forward the potential increase in banks margins as well as the subsequent drop in production. Using a sample of 594 banks over the period 2006-2011, Sutorova and Tepy (2013) estimate that a 1 pp increase in the capital requirement makes European banks increase their lending rates by 2.8 bp to 18.8 bp in the long term, depending on the capital ratio taken into account (an increase in the common equity ratio having the largest impact). Using the elasticity of loans to the corresponding interest rates which have been estimated at -0.156%, a 1 pp increase in the common equity ratio would trigger a drop in banks loans level about 0.03%. A level much lower than what Bridges et al. (2015) find using a panel data set of UK-supervised banks. They evaluate the impact of a 1 pp increase in the capital requirement is about -3.5% on loan volumes with some heterogeneity depending on the type of loans considered: commercial real estate (CRE) loans and loans to households being more sensitive to the rise in capital requirements than other types of loans.

State-of-the-art macroeconomic models, namely DSGE models including a fully fledged banking sector should be the appropriate tool to answer such a question, more generally to assess the consistency of the regulatory changes and their effects on the real economy, as well as to point out to the relevant tradeoffs.

Within such a general equilibrium framework, Gerali et al. (2010) build a DSGE model with a detailed banking sector including a wholesale and a retail branch. Expanding on that DSGE model, Angelini and Gerali (2012) estimate the long term impact of a 1 pp increase in the capital requirement ranging from 0 bp to +31 bp on loan rates and from 0% to -1.96% on total loans. The overall impact on output is according to most papers limited ranging generally from almost no impact to about -0.30% as listed in BCBS (2016)).

Nonetheless, most of the macro models concentrate on the effect of the solvency ratio, without considering liquidity regulation. Indeed, liquidity presents more data and modeling challenges than capital, so that its impact is addressed by fewer models. Roger and Vlcek (2000) develop a DSGE model when the liquidity requirement is proxied by the amount of bank holdings of government securities in banks total assets. They find that a 25 pp increase in liquidity requirements over 2 years would trigger a long run 5 bp increase in lending spread when it would have no impact on the output in the long term. De Nicolo et al. (2014) develop a dynamic model of banks in a partial equilibrium framework to assess the impact of both capital and liquidity requirements. They show that liquidity requirements hamper maturity transformation, forcing banks to use retained earnings to increase bond holding rather than lending. They also found that liquidity requirements have significant impact on bank lending. Indeed, when they add a liquidity requirement to a capital requirement, the long run level of bank lending drops by more than 26%. Covas and Driscoll (2014) evaluate, within a partial equilibrium model, that the introduction of a liquidity requirement has a significantly negative effect on bank lending (-5.8%) while banks' holdings of securities increase by about 10%. But they also report that "the effects on lending and other banking variables are substantially larger in partial equilibrium analysis which takes prices as given". Indeed, they show that within a general equilibrium model, the introduction of a liquidity requirement should result in a 3.1% drop in banks lending and a 6.6% increase in their holdings of securities.

Since liquidity requirements are still new and had never been implemented in most countries before Basel III, the empirical literature on the impact of liquidity requirements are even more sparse. A few exceptions include the works of Bonner (2015) and Banerjee and Mio (2015) who study the effects of liquidity requirements imposed respectively in Netherlands and in the UK prior to Basel III. If there is some consensus between empirical and macro models about the significant effect of liquidity requirements on banks' holdings of high quality liquid assets (HQLA), there is no agreement about the impact of those requirements on banks' lending. As mentioned above, macro models tends to identify an impact of liquidity requirements on banks' lending. Similar result can be found in Bonner (2015) but not in Banerjee and Mio (2015) who find that banks lending remained nearly unchanged. Such a result is consistent with EBA's second LCR impact report based on QIS data (EBA (2014)). However, while major progress has been made since the crisis on the assessment of the impact of the micro-prudential regulation, most macro models are still unsatisfactory and more specifically with regard to liquidity requirements. Indeed, to our knowledge, all the macro models that incorporate liquidity requirements adopt very simple definitions of the liquidity constraint which mainly takes the form of a liquid to total assets ratio, the former being generally represented by sovereign bonds, a definition that is "quite distant from the complex measures introduced by the new rules" as attested by Angelini et al. (2011). Moreover, many other issues have not yet been clearly addressed in the literature. Among these outstanding issues, the impact of the calibration of the liquidity requirements has not yet been fully discussed. Also, the interaction between capital and liquidity requirements and more specifically between both liquidity requirements (LCR and NSFR) have not been clearly assessed (see BCBS (2016)).

For this purpose, we develop a large scale DSGE model of the euro area with a banking sector and credit frictions

a la Iacoviello (2005) and Gerali et al. (2010). The European banking system is dominated by the universal banking model: in many European countries, a few banks represent a very large part of total assets in the system as well as of provision of financial services. Therefore, we propose to model both investment and retail branches of a bank, which is a more accurate description of a bank than the distinction between wholesale and retail branches - an assumption that is common in the literature but omits a possible link with the real economy.

Investment banking in our model comes with the introduction of a (corporate) bond market. We find it relevant to match the increasing share of securities issuance in Europe. Debt issuance can be seen as a substitute to bank loans for large corporations. In that respect Europe is getting closer to the US. This is also a way to investigate further the role of investment banking in the crisis, as its failure (in particular Bear Stearns and Lehman Brothers) played a crucial role. We thus introduce a corporate bond market where large firms are able to issue bonds to fund a part of their expenses. Such a source of borrowing is not available to small and medium-sized enterprises (SMEs hereafter). We introduce this heterogeneity in the production sector in line with studies by Gertler and Gilchrist (1994), Gilchrist et al. (2010) among many others. Indeed, one key feature in the study of financial interaction with the real economy relies on the ability of borrowers to have access to different alternative sources of borrowing, or, more specifically, to the degree of substitutability between (private) bank credit and market funding. Still, the fixed costs of issuance of bonds as well as the disclosure requirements are, among other reasons, behind the fact that only large firms have access to the corporate market. Thus, the conditions in financial and credit markets would have different impacts depending on the economy structure. Giesecke et al. (2012) argue that "the Great Depression collapse of credit hit small and medium sized firms particularly hard since they did not have the same access to alternative forms of credit that a larger firm might". This result is consistent with the findings of Gertler and Gilchrist (1994) as well as Chari et al. (2007), although during the Great Financial Crisis, corporate banking catering the needs of large companies was the most severely hit (see notably Vinas (2015)).

We also enrich our model introducing several assets with different maturities. Indeed, liquidity matters come along with asset maturity concerns. Yet, standard General Equilibrium Models, which represent the main framework used to assess the effects of microprudential regulation effects, rely on the standard one period maturity assumption. An hypothesis that is consistent neither with the economic concept of liquidity, nor with its Basel III definitions. Thus, neglecting the maturity mismatches in the liquidity constraints definition, one may run the risk of omitting a large part of the dynamics of macroeconomic variables. For this reason, we choose to develop an economy where most of the assets have more than a one period maturity, using for this purpose the Benes and Lees (2010) framework which incorporates differences in asset maturity at the cost of a few additional state variables.

Main Findings and Structure of the Paper

The main finding of the paper is that the impact of the capital ratio differs from what will induce the implementation of the new Liquidity requirement. First, the implementation of liquidity regulation, which rather affects private consumption dynamics, has a less persistent effect than solvency regulation which affects loan distribution as well as investment. Second, implementing both regulations simultaneously has compounded macroeconomic effects. Third, regarding the various debates concerning possible substitution between liquidity and solvency regulation, which was the view held before Basel III (see Bonner and Hilbers, 2015, for a survey of the literature), we uncover large complementarity: implementing simultaneously liquidity and solvency

regulations has compounded effects. Fourth, we show that the implementation of the LCR has qualitatively similar results as the NSFR, even if, quantitatively, the latter has a more moderate effect. As a consequence, we find large positive externalities between the two liquidity ratios, and more particularly in the financial sector.

The paper is structured as follows. Section 2 provides an overview of the theoretical model where we mainly present each agent's objective function and the corresponding constraints. Section 3 deals with the calibration of the model when section 4 presents simulation results, drawing comparisons between the different types of Basel III regulations. Section 5 concludes and describes several directions for future research.

2 The model

The economy is mainly populated by households (indexed with ' w ') and two types of entrepreneurs (indexed with ' e ').¹ Households consume, work and accumulate savings in the form of banking deposits and sovereign bonds, while entrepreneurs produce intermediate goods using capital bought from specific capital-good producers and labor supplied by households. Entrepreneurs differ regarding their ability to have access to the bond market, large firms can issue corporate bonds, along with banking loans, to finance their activity while SMEs are limited to banking loans. We introduce nominal rigidities in both labor and goods market.

The economy is also characterized by the presence of a financial intermediary represented by a continuum of universal banks. Each bank collects households' deposits and interbank funds which form, together with its accumulated own capital, the total liabilities. On the asset side, banks supply loans to both kinds of entrepreneurs and purchase corporate bonds. The banking system faces three classes of frictions. First, banks face quadratic adjustment costs when changing their nominal interest rates generating imperfect short term pass-through of policy rate to bank deposit and lending rates. Second, they operate in a monopolistic competitive market which can amplify/attenuate the impact of some of their decisions. Third, banks face capital requirements as well as liquidity ones represented by the Basel III LCR and NSFR.

The question of the implementation of the new Basel III requirements has been recently investigated in the literature (Roger and Vlcek (2000), Gambacorta (2010) among others). However, as mentioned above, most of the models featuring bank liquidity generally "adopt very simple definitions (e.g. the ratio of cash and government bonds to total assets) for the bank liquidity, that are quite distant from the complex measures introduced by the new rules", (Angelini et al. (2011)). One reason behind this simplification is the use of standard DSGE models that are all based on one-period maturity assets the concept of liquidity - and more specifically both Basel III liquidity constraints (NSFR and LCR) - intrinsically presupposes a maturity mismatch between and within assets. One key feature of our model is that we develop an economy where most of the assets have more than a one period maturity. This allows us to assess much better the impact of the new Basel III liquidity constraints taking into account the maturity mismatch between the assets coupled with the heterogeneity in the productive sector as well as the different frictions in the model.

¹For some variables and parameters, a ' p ' and a ' g ' are added for SMEs and large firms.

Households

There is a continuum $h \in [0, 1]$ of infinitely-lived households, each representative household h maximizes its intertemporal utility function which is assumed to be of the form :

$$\mathcal{W}_t^{w,h} = \mathbb{E}_t \left[\sum_{i=0}^{\infty} \beta_w^i \left(\frac{1 - \eta^w}{1 - \sigma_c^w} \left(\frac{C_{t+i}^{w,h} - \eta^w \bar{C}_{t+i-1}^w}{1 - \eta^w} \right)^{1 - \sigma_c^w} - \frac{(N_{t+i}^h)^{1 - \sigma_n}}{1 - \sigma_n} \right) \right]$$

This utility function depends on consumption $C_t^{w,h}$ and hours worked N_t^h . The parameter σ_c represents the intertemporal elasticity of substitution and η^w measures the degree of external habit formation in consumption. Each period, the representative household has to optimize his utility function under the following budget constraint (in real terms):

$$C_t^{w,h} + D_t^{w,h} + T_t^{w,h} (1 + \mu_t^w) = \frac{W_t^h}{P_t} N_t^h + \frac{J_{t-1}^{D,w,h}}{\pi_t} + \frac{J_{t-1}^{T,w,h}}{\pi_t} + \mathcal{D}_t^{w,h} + \mathcal{F}_t^{w,h} \quad (1)$$

with $\pi_t = P_t/P_{t-1}$ the inflation factor.

The flow of expenditures includes current consumption $C_t^{w,h}$ and the new deposit flow $D_t^{w,h}$. Resources include wage earnings $\frac{W_t^h}{P_t} N_t^h$, dividends $\mathcal{D}_t^{w,h}$ from the different types of firms that all belong to households, non distortive transfers $\mathcal{F}_t^{w,h}$ and gross interest income on last previous deposits $\frac{J_{t-1}^{D,w,h}}{\pi_t}$ as well as on their financial investment in sovereign bonds $\frac{J_{t-1}^{T,w,h}}{\pi_t}$. Indeed, households have access to investments in the sovereign bond market through financial intermediaries facing transaction costs $T_t^{w,h} \mu^w$.

We consider a multi-period asset framework as in Benes and Lees (2010). The letter J_t^X refers to interests and (partial) principal repayments on all the assets X_{t-k} in which households invested k periods ago ($k \geq 0$). Thus, at time t , household h holds a stock of deposits and sovereign bonds noted SD_t^h and $ST_t^{w,h}$ respectively.

Adopting the Benes and Lees (2010) multi-period fixed-rate assets framework, we assume that the capital repayment required at each period is a constant proportion $(1 - \delta^X) \in [0, 1]$ of the residual outstanding amount SX_t of the asset X . Moreover, the interest payments are also due on this residual outstanding amount of the debt. These two assumptions involve a geometric repayment scheme that has two major practical advantages : First, the geometric distribution allows for simple recursive equations for most interest-related variables. Second, the average maturity of an asset can be calibrated using only one parameter, namely the parameter δ^X . For example, we can easily show that according to the Macaulay's duration definition, the average maturity d^X of the asset X is (at the steady-state) of the form $d^X = \frac{R}{R - \delta^X}$ where R is the discounting interest rate. Thus, choosing the adequate calibration for the parameters R and δ^X , we can set different maturities values for the different assets in the economy.

More practically, the sum of all repayments (in real terms) related to $X = (D, T^w)$ due at time t can be assessed as:

$$J_{t-1} = \sum_{k=1}^{\infty} \left(\underbrace{1 - \delta^X}_{\text{capital repayment part}} + \underbrace{\frac{R}{R - \delta^X}}_{\text{interest repayment part}} \right) \underbrace{(\delta^X)^{k-1} X_{t-k}}_{\text{Residual amount in 't' of the asset bought in 't-k'}} \frac{P_{t-k}}{P_{t-1}}$$

which can be rewritten recursively as :

$$J_t^X = \frac{\delta^X}{\pi_t} J_{t-1}^X + (1 - \delta^X + R_t^X) X_t$$

As well, the stock of assets held at time t is of the form :

$$SX_t = \sum_{k=0}^{\infty} (\delta^X)^k X_{t-k} \frac{P_{t-k}}{P_t} \iff SX_t = \frac{\delta^X}{\pi_t} SX_{t-1} + X_t$$

According to this framework, one saving unit will generate resource flows in the next period but also in the subsequent ones. Furthermore, the optimality condition states that the current period marginal utility of consumption (noted Λ_t , see the left hand side of equation (2)) must equal the discounted values of one unit saving benefits (the right hand side). We can thus write :

$$\begin{aligned} \Lambda_t &= \mathbb{E}_t \left\{ \beta_w \Lambda_{t+1} (1 - \delta^D + R_t^D) + \beta_w^2 \Lambda_{t+2} (1 - \delta^D + R_t^D) \delta^D + \beta_w^3 \Lambda_{t+3} (1 - \delta^D + R_t^D) (\delta^D)^2 + \dots \right\} \\ &= \beta_w (1 - \delta^D + R_t^D) \underbrace{\mathbb{E}_t \sum_{j=1}^{\infty} \left[\Lambda_{t+j} (\beta_w \delta^D)^{j-1} \right]}_{=\Gamma_t} \end{aligned} \quad (2)$$

Γ_t can be written recursively as $\Gamma_t = \Lambda_{t+1} + \beta_w \delta^D \Gamma_{t+1}$.

Also, and using the optimality condition equation (2), we know that $\Lambda_{t+1} = \beta_w (1 - \delta^D + R_{t+1}^D) \Gamma_{t+1}$.

Merging the two equations gives :

$$\mathbb{E}_t \left(\frac{\Lambda_t}{\Lambda_{t+1}} \frac{1}{\beta_w} \right) = (1 - \delta^D + R_t^D) \mathbb{E}_t \left(1 + \frac{\delta^D}{1 - \delta^D + R_{t+1}^D} \right)$$

The last equation represents a modified version of the standard Euler equation which indicates that the consumption growth path depends not only on the current period deposit rate but also on the next period expected value.

Labor Market

In the labor market, there is a continuum of unions $\iota \in [0, 1]$, each of which represents a certain type of labor. Unions differentiate the aggregated level of labor issued by households ($N_t^H = \int_0^1 N_t^h dh$) and sell its services in a monopolistically competitive market to a perfectly competitive firm which transforms it into an aggregate labor input using a CES technology function $N_t = \left(\int_0^1 (N_t^\iota)^{\frac{\nu_w - 1}{\nu_w}} d\iota \right)^{\frac{\nu_w}{\nu_w - 1}}$, where ν_w is the elasticity of substitution between differentiated labor services.

Unions set their wages on a staggered basis a la Rotemberg (1982) in the sense that, at each period, every union faces quadratic adjustment costs with indexation to a weighted average of lagged and steady-state inflation.

Under the assumption that workers have the ability to choose costlessly to work for small or large companies, the aggregate labor rate faced by each of these companies is unique (equal to w_t^e).

Production

Small Entrepreneurs (SMEs)

In the economy there is a continuum $i \in [0, 1]$ of small entrepreneurs (indexed by p) that maximize their specific consumption $C_t^{i,p}$ according to the following utility function :

$$\max \mathbb{E}_t \left\{ \sum_{j=0}^{\infty} \beta_p^j \frac{1 - \eta^p}{1 - \sigma_c^p} \left[\frac{C_{t+j}^{i,p} - \eta^p \bar{C}_{t+j-1}^i}{1 - \eta^p} \right]^{1 - \sigma_c^p} \right\} \quad (3)$$

Since small entrepreneurs are net borrowers in the model, the correspondent discount factor β_p is assumed to be strictly lower than β_w .

Each small entrepreneur chooses the optimal stock of physical capital $K_t^{i,p}$ and the desired amount of labor input $N_t^{i,p}$ that are combined to produce an intermediate output $Y_t^{i,e,p}$ according to a Cobb-Douglas production function.

$$Y_t^{i,e,p} = A_t (K_t^{i,p})^\alpha (N_t^{i,p})^{1-\alpha} \quad (4)$$

A_t represents total factor productivity shocks, supposed common to both small and large companies.

Small entrepreneurs maximize their own utility functions subject to an infinite sequence of real budget constraints :

$$C_t^{i,p} + \frac{J_{t-1}^{L^p,i}}{\pi_t} + w_t^e N_t^{i,p} + q_t^K K_t^{i,p} = (1 - \delta) q_t^K K_{t-1}^{i,p} + p_t^{i,e,p} Y_t^{i,e,p} + L_t^{i,p} \quad (5)$$

δ is the capital depreciation rate while $L_t^{i,p}$ represents the amounts of new loans that the whole banking sector is willing to lend to small entrepreneur i at a nominal interest rate $R_t^{L^p}$ assumed to be common to all small entrepreneurs.

The debt service charges the representative SME has to pay can thus be written recursively as :

$$J_t^{L^p,i} = \frac{\delta^{L^p}}{\pi_t} J_{t-1}^{L^p,i} + \left(1 - \delta^{L^p} + R_t^{L^p} \right) L_t^{i,p} \quad (6)$$

In addition, the entrepreneur faces a borrowing constraint in the sense that the expected value of its collateralizable (physical) capital stock at period t must be sufficient to guarantee lenders of debt repayment. We deviate to some extent from the standard Kiyotaki and Moore's (1997) framework in the sense that banks insure themselves from current moral hazard as well as future ones. Indeed, they insure themselves against a potential credit event in the current period as well as in the future as long as the borrower has to pay principal and interests. Indeed, banks require a part of borrowers' resalable capital as a collateral and they also require that this collateral has to be large enough to cover not only the amount of debt services of the current time t but also all of those of the next periods.

The collateral constraint is then written as :

$$F J_t^{L^p,i} \leq \theta_t^p \left(q_{t+1}^{K,p} \pi_{t+1} l^p K_t^{i,p} (1 - \delta) \right) \quad (7)$$

Upon default, bankers would take over all the resalable bankrupted firm's capital at a proportional cost, this coefficient of proportionality is here represented by $(1 - \theta_t^p)$. θ_t^p is also called the loan-to-value ratio (LTV).

The variations in the LTV can be interpreted as outright shocks to bank's loan standards and, all things being equal, loan supply. ι^p is the part of the SMEs' capital that can be considered as resalable. One can consider it as the value of bankrupted firm's building and heavy machinery that could find a buyer in the second hand market.

$FJ_t^{L^p,i}$ represents the residual value of interests and principal that the SME has to pay on the bank credit borrowed until time t . $FJ_t^{L^p,i}$ can be written recursively as :

$$FJ_t^{L^p,i} = \frac{\delta^{L^p}}{\pi_t} FJ_{t-1}^{L^p,i} + \left(1 + \frac{R_t^{L^p}}{1 - \delta^{L^p}}\right) L_t^{p,i} \quad (8)$$

Corporate Firms

Symmetrically with respect to small firms, large entrepreneurs (indexed by "g") form a continuum $i \in [0, 1]$ where each member has to optimize its specific utility function facing similar production and loan constraints than small entrepreneurs.

On top of differences in terms of parameter calibration, large firms differ also from the small ones in their ability to rely on a second type of debt contract. Indeed, large firms can enter the financial market and issue bonds which offer to them an alternative source of financing while small and medium sized firms are still bank dependant because of the relatively high fixed costs of issuance as well as the disclosure costs.

Indeed, to finance investment projects and their current expenditures, large firms use a combination of internal and external funds and we assume here that the latter refers exclusively to bank loans as well as direct debt security that they issue in the bond market. The latter is however costly to issue because of the agency costs associated with default. To derive the bond pricing program, we follow the Gilchrist et al. (2010)'s framework based on the presence of idiosyncratic shocks z_t hitting firms' production that are, if too low, able to make firm's manager decide to default.

From an investor point of view, the net-worth of a large firm is defined as :

$$\begin{aligned} \mathcal{W} = & z_t [p_t^{e,g} Y_t^{e,g}] + T_t^g + L_t^g + (1 - \delta) q_t^K K_{t-1}^G - q_t^K K_t^G - w_t N_t^g - \frac{J_{t-1}^{L^g}}{\pi_t} - \frac{J_{t-1}^{T^g}}{\pi_t} \\ & + \mathbb{E}_t [\iota^g (1 - \theta^g) q_{t+1}^K K_t^G (1 - \delta)] - FJ_t^{T^g} \end{aligned} \quad (9)$$

where $\iota^g (1 - \theta^g) q_t^K K_{t-1}^G (1 - \delta)$ is the resale value of installed capital. We note that the resale capital for a bond buyer represents the value of the defaulted firm's capital net of the collateralized part that would belong to the bank in case of a credit event, the bank loans being of a higher degree of seniority than bonds. This would also induce a potential substitution effect between banking loans and market financing, which is also consistent with the results found by Gertler and Gilchrist (1994) and Chari et al. (2007) among many others. Note also that since both current period and future bank loan repayments are entirely collateralized, banks are insured against any eventual default that could occur at the end of the period. They are thus not affected by the realizations of the shock z_t^i .

The firm purchases capital using this debt-financing coupled with other source of funds. In the next period, after observing the realization of shocks, the firm decides whether or not to fulfill its debt obligations. If the firm decides not to default, it pays the time t interests and principal parts on all the previous issued bonds (namely

$J_t^{T^g}$) as it has been contracted and optimizes its program for the next period and the process continues. If the firm does default, it enters a debt renegotiation process with the bond market investors that would ultimately try to get the residual value of the bankrupted firm's net worth. For the structure of the renegotiation process, we adopt Gilchrist et al. (2010) framework by assuming that there is a lower bound to the net-worth of the firm, $\overline{\mathcal{W}}$, below which the firm cannot guarantee the repayment of its debt obligation.

Thus, given the price of capital, the amounts of capital and debt, the firm defaults if and only if the realized production shock is lower than \overline{z}_t , which is defined as the level that makes the firm's net-worth equal to the default threshold:²

$$\begin{aligned} \overline{\mathcal{W}} = \overline{z}_t [p_t^{e,g} Y_t^{e,g}] + T_t^g + L_t^g + (1 - \delta) q_t^K K_{t-1}^G - q_t^K K_t^G - w_t^e N_t^g \\ - \frac{J_{t-1}^{L^g}}{\pi_t} - \frac{J_{t-1}^{T^g}}{\pi_t} + \mathbb{E}_t [l^g (1 - \theta^g) q_{t+1}^K K_t^G (1 - \delta)] - F J_t^{T^g} < \frac{J_{t-1}^{T^g}}{\pi_t} \end{aligned} \quad (10)$$

We assume a costly state verification framework a la Townsend (1979), where investors have to pay an irreversible disclosure cost in order to eliminate losses from the moral hazard of the bond issuer. We assume this cost to be proportional to the net worth value of the firm with μ being the factor of proportionality.

Thus, in the investor point of view, the average profit made on the credit allocation is given by :

$$\begin{aligned} \mathbb{P}_t = \int_{-\infty}^{\overline{\epsilon_z}} (1 - \mu) \left\{ z_t (p_t^{e,g} Y_t^{e,g}) + T_t^g + L_t^g + (1 - \delta) q_t^K K_{t-1}^G - q_t^K K_t^G - w_t^e N_t^g \right. \\ \left. - \frac{J_{t-1}^{L^g}}{\pi_t} - \frac{J_{t-1}^{T^g}}{\pi_t} + \mathbb{E}_t [l^g (1 - \theta^g) q_{t+1}^K K_t^G (1 - \delta)] \right\} dF(\epsilon_z) + \mathbb{E}_t \int_{\overline{\epsilon_z}}^{+\infty} \frac{J_t^{T^g}}{\pi_{t+1}} dF(\epsilon_z) \end{aligned} \quad (11)$$

\mathcal{F} representing the cumulative distribution function of a normal distribution.

The investor has also access to a riskless debt security that is characterized by a larger maturity and also lower interest rates payments than a corporate bond.

The trade-off equation for the investor can be written as :

$$\mathbb{P}_t = \mathbb{E}_t \left(\frac{J_t^{T^s} (1 - \Delta^s)}{\pi_{t+1}} \right) \quad (12)$$

$J_t^{T^s}$ represents the sum of all repayments the investor is expected to receive from sovereign debtors at time t and Δ^s is the default rate on sovereign bonds which is supposed to be different from zero. $J_t^{T^s}$ is written as :

$$J_t^{T^s} = \frac{\delta^{T^s}}{\pi_t} J_{t-1}^{T^s} + (1 - \delta^{T^s} + R_t) T_t^S$$

In order to be able to use a representative agent framework while maintaining the intuition of the default rule above, we adopt the Darracq Pariès et al. (2011) framework by assuming that borrowers belong to a large family that can pool their assets and diversify away the risk related to large firms after bond repayments are made. By pooling the large firms' resources, the representative family has the following aggregate repayments and

²Hereafter and for a matter of simplicity, we assume $\overline{\mathcal{W}} = 0$.

defaults, hence expected gain on its outstanding bonds:

$$\begin{aligned} \mathbb{H}_t = \int_{-\infty}^{\bar{\epsilon}_z} & \left[z_t (p_t^{e,g} Y_t^{e,g}) + T_t^g + L_t^g + (1 - \delta) q_t^K K_{t-1}^G - q_t^K K_t^G - w_t N_t^g \right. \\ & \left. - \frac{J_{t-1}^{L^g}}{\pi_t} - \frac{J_{t-1}^{T^g}}{\pi_t} + \mathbb{E}_t \left(\iota^g (1 - \theta^g) q_{t+1}^K K_t^G (1 - \delta) \right) \right] dF(\epsilon_z) + \mathbb{E}_t \int_{\bar{\epsilon}_z}^{+\infty} \frac{J_t^{T^g}}{\pi_{t+1}} dF(\epsilon_z) \end{aligned} \quad (13)$$

Overall, each large entrepreneur optimizes its utility function:

$$\max \mathbb{E}_t \left\{ \sum_{j=0}^{\infty} \beta_g^j \frac{1 - \eta^g}{1 - \sigma_c^g} \left[\frac{C_{t+j}^{i,g} - \eta^g \bar{C}_{t+j-1}^i}{1 - \eta^g} \right]^{1 - \sigma_c^g} \right\} \quad (14)$$

subject to an infinite sequence of real budget constraints:³

$$\begin{aligned} C_t^{i,g} + \frac{J_{t-1}^{L^g,i}}{\pi_t} + q_t K_t^{i,g} + w_t^e N_t^{g,i} + \left[1 - \mathcal{F} \left(\frac{\bar{\epsilon}_{z,t} + \sigma^2/2}{\sigma} \right) \right] \frac{J_{t-1}^{T^g,i}}{\pi_t} \\ + \mathcal{F} \left(\frac{\bar{\epsilon}_{z,t} + \sigma^2/2}{\sigma} \right) \mathbb{E}_t \left[\iota^g (1 - \theta_{t+1}^g) q_{t+1}^K \pi_{t+1} K_t^G (1 - \delta) - F J_t^{i,G} \right] = p_t^{e,g} Y_t^{e,g} + T_t^g + L_t^g + (1 - \delta) q_t^K K_{t-1}^G \end{aligned} \quad (15)$$

and the investor's trade-off equation discussed above as well as the production function and collateral constraint that are similar to those of their small counterpart (namely eq. (4) and (7)).

Capital Producers

At the beginning of each period, capital producers buy back the undepreciated capital stocks $(K_{t-1}^p + K_{t-1}^g)(1 - \delta) = K_{t-1}(1 - \delta)$ at real prices (in terms of consumption goods) q_t^K . Then they augment this stock using investment goods and facing adjustment costs. The augmented stock is sold back to entrepreneurs at the end of the period at the same price. The decision problem of capital stock producers is given by :

$$\max_{K_t, I_t} \mathbb{E}_t \left\{ \sum_{j=0}^{\infty} \beta_p^j \lambda_{1,t+j}^p [(K_t - K_{t-1}(1 - \delta)) q_t^K - I_t] \right\} \quad (16)$$

under the production function technology :

$$K_t = K_{t-1}(1 - \delta) + \left(1 - \frac{\phi^p}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right) I_t \quad (17)$$

³Using the probability density function of normal a normal distribution, one can easily show that,

$$\int_a^b z_t dF(\epsilon_z) = \left[\mathcal{F} \left(\frac{b - \sigma^2}{\sigma} \right) - \mathcal{F} \left(\frac{a - \sigma^2}{\sigma} \right) \right]$$

\mathcal{F} stands for the normal cumulative distribution, centered and standardized.

Retailer

There is a representative retailer who acts under perfect competition. First, the retailer aggregates intermediate goods from both small and large firms using a CES technology function.⁴ Afterwards, it sells its output to a monopolistic competitive distribution sector which is in charge of making the different goods accessible to final consumers.

The decision problem of the representative retailer is :

$$\max_{Y_t^e, Y_t^{e,p}, Y_t^{e,g}} [p^e Y_t^e - p^{e,p} Y_t^{e,p} - p^{e,g} Y_t^{e,g}] \quad (18)$$

subject to the aggregation technology function :

$$Y_t^e = \left(\nu^y \xi^y Y_t^{e,p}^{1-\xi^y} + (1-\nu^y) \xi^y Y_t^{e,g}^{1-\xi^y} \right)^{\frac{1}{1-\xi^y}} \quad (19)$$

Distribution Sector

The distribution market is assumed to be monopolistically competitive. Distributors' prices are sticky and are indexed to a combination of past and steady-state inflation, with relative weights parameterized by γ^p . In addition, if retailers want to change their price beyond what indexation allows, they face a quadratic adjustment cost parameterized by κ^p .

Each firm f choose its selling price p_t^f (in terms of consumption goods) so as to maximize its market value :

$$\max_{p_{f,t}} \mathbb{E}_t \sum_{i=0}^{\infty} \beta_w^i \lambda_{w,t+i} \left\{ \left(p_{t+i}^f - p_{t+i}^e \right) Y_{t+i}^f - \frac{\kappa^f}{2} \left(\frac{p_t^f}{p_{t-1}^f} \frac{1}{\pi_t} - \pi_{t-1}^{\gamma^p} \bar{\pi}^{1-\gamma^p} \right)^2 Y_{t+i} \right\} \quad (20)$$

subject to the demand derived from consumers' maximization :

$$Y_t^f = (p^f)^{-\nu^f} Y_t \quad (21)$$

ν^f is the demand price elasticity which is supposed to be constant.

Banking Sector

The banking sector is represented by a continuum $n \in [0, 1]$ of universal banks evolving in a monopolistic competition framework. We enrich our banking sector modeling by assuming different types of assets and liabilities. Indeed, each bank n has three types of liabilities : its own capital ($K_t^{b,n}$), savers-deposits (D_t^n) and interbank funds (IB_t^n). On the assets side, it can invest on four types of assets : loans to SMEs ($L_t^{p,n}$), loans to corporate firms ($L_t^{g,n}$), corporate bonds ($T_t^{Bg,n}$) and sovereign bonds ($T_t^{Bs,n}$).

⁴The fact that intermediate goods are not perfect substitutes allows for defining different levels of intermediate goods' prices according to whether they are produced by small or large firms.

Assets	Liabilities
Loans to Small Firms ($SL_t^{p,n}$)	Bank Equity (K_t^n)
Loans to Large Firms ($SL_t^{g,n}$)	Households deposits (SD_t^n)
Large Corporate Bonds ($ST_t^{Bg,n}$)	Interbank Funds (IB_t^n)
Sovereign Bonds ($ST_t^{Bs,n}$)	

Like the universal bank model, each bank n is composed of two main branches, namely retail branch and investment branch. The retail branch of bank n optimizes the discounted value of its contemporaneous and future flow of funds. For this purpose, it sets the optimal amount of the different types of liabilities and assets (except for its capital) as well as their correspondent interest rates (except for bond market rates and for the interbank interest rate which is supposed to be equal to the policy rate R_t).

The investment branch of the bank is in charge of dealing with assets in the bond market and chooses the optimal amount of corporate and sovereign bond holdings according to the relative yield of such assets as well as the regulatory constraints.

Indeed, each bank faces two kinds of costs descending from the Basel III's prudential requirements. The first cost is related to the bank's capital position whenever its solvency - measured by its capital-to-weighted assets ratio - moves away from a target value ν^K ; the second one has more to do with its balance-sheet liquidity standard and more specifically its short term liquidity coverage ratio (LCR) while the net stable funding ratio (NSFR) will be added further for comparison with the LCR.⁵

Since we use multi-period assets, we are able to model the liquidity ratios in a more suitable way than what it is usually done in the literature. For example, in the paper, we enrich the LCR modeling through different perspectives. First, contrary to a one-period asset maturity, we distinguish between short term and long term incoming and outgoing cash flows and, second, using different kind of assets, we take into account different liquidity weights for each type of assets following the Basel III implementation.

The optimization program for the universal bank n , which maximizes its cash flow, is then of the form :

$$\begin{aligned}
\max \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_w^i \lambda_{w,t} \{ & \frac{J_{t-1}^{L^p,n}}{\pi_t} + \frac{J_{t-1}^{L^g,n}}{\pi_t} + \frac{J_{t-1}^{T^g,n}}{\pi_t} + \frac{J_{t-1}^{T^{bs},n}}{\pi_t} - L_t^P - L_t^G - T_t^{Bg,n} - T_t^{Bs,n} \\
& - \frac{J_{t-1}^{D,n}}{\pi_t} - \frac{1 + R_{t-1}}{\pi_t} IB_{t-1}^n + D_t^n + IB_t^n - INTCOST_t^{T^{Bg},n} - INTCOST_t^{T^{Bs},n} \\
& - \frac{\kappa^p}{2} \left(\frac{R_t^{L^p,n}}{R_{t-1}^{L^p,n}} - 1 \right)^2 R_t^{L^p} L_t^P - \frac{\kappa^g}{2} \left(\frac{R_t^{L^g,n}}{R_{t-1}^{L^g,n}} - 1 \right)^2 R_t^{L^g} L_t^G - \frac{\kappa^d}{2} \left(\frac{R_t^{D,n}}{R_{t-1}^{D,n}} - 1 \right)^2 R_t^D L_t^D \\
& - \frac{\kappa^K}{2} (BCAP_t^n - RCAP_t^n)^2 K_t^B - \frac{\kappa^L}{2} (BLCR_t^n - RLCR_t^n)^2 K_t^B \\
& \left. - \frac{\kappa^N}{2} (BNSFR_t^n - RNSFR_t^n)^2 K_t^B \right\}
\end{aligned} \tag{22}$$

Where $INTCOST_t^{T^{Bg}}$ and $INTCOST_t^{T^{Bs}}$ represent the cost of intermediation in the bond market that are composed of transaction and adjustment costs on corporate and sovereign bonds respectively. For $x \in (g, s)$ we

⁵The Figure 6 in the appendix sums up the main financial interactions between the different agents.

set :

$$INTCOST_t^{T^{Bx},n} = \mu^{B,x} T_t^{Bx,n} + \frac{\kappa^{Bx}}{2} \left(\frac{ST_t^{Bx,n}}{ST_{t-1}^{Bx,n}} - 1 \right)^2 ST_t^{Bx} \quad (23)$$

Bank capital accumulates from reinvesting profits in the banks as in Gerai et al. (2010):

$$K_t^{B,n} = (1 - \nu^b) \frac{K_{t-1}^{B,n}}{\pi_t} + \Pi_t^{B,n} \quad (24)$$

where $\Pi_t^{B,n}$ represents the overall profits made by bank 'n', and ν^b represents the share of capital used up in managing bank capital.

$BCAP_t^n$ and $RCAP_t$ stand for the capital to risk weighted assets ratio for bank n as well as its regulatory level. $BLCR_t^n$ and $RLCR_t$ (resp. $BNSFR_t^n$ and $RNSFR_t$) are the equivalent for the liquidity to assets ratio (resp. the net stable funding ratio).

$$BCAP_t^n = \frac{SK_t^{B,n}}{\gamma^{LP} SL_t^{P,n} + \gamma^{LG} SL_t^{G,n} + \gamma^{Tg} ST_t^{G,n} + \gamma^{TS} ST_t^{S,n}}, \quad (25)$$

where the capital ratio is defined as capital divided by risk weighted assets.

$$BLCR_t^n = \frac{\mu^{NT^G} ST_t^{T^G,n} + \mu^{NT^S} ST_t^{T^S,n}}{\underbrace{\mu^D SD_t^n + \mu^{JD} J_t^D + \mu^{IB} (1 + R_t) IB_t^n - (\mu^{LP} J^{LP,n} + \mu^{Lg} J^{Lg,n} + \mu^{Tg} J^{Tg,n} + \mu^{Ts} J^{Ts,n})}_{BLCRD}} \quad (26)$$

where the LCR is defined as the ratio of liquid assets to net outflows, with weights defined in the numerator and denominator by the regulation.

$$BNSFR_t^n = \frac{\zeta^{NK} K_t^{B,n} + \zeta^{D1} SD_t^n (1 - \delta_{1-4}^D) + \zeta^{D2} SD_t^n \delta_{1-4}^D \zeta^{NIB} IB_t^n}{\underbrace{\zeta^{TS} ST_t^s + \zeta^{TG} ST_t^g + \zeta^{LP} SL_t^p \delta_{1-4}^{LP} + \zeta^{LG} SL_t^g \delta_{1-4}^{LG} + \zeta^{OtherA} OtherAssets}_{BNSFRD}} \quad (27)$$

where the NSFR is defined as the ratio of Available Stable Funding (a weighted sum of liabilities) to Required Stable Funding (a weighted sum of assets). $\delta_{1-4}^x = \prod_1^4 (1 - \delta^x)^j$ represents the share of assets with a residual maturity of less than one year. *OtherAssets* contains all remaining assets that are not included in the first part of the NSFR denominator.

The above functions represent respectively the capital and the liquidity regulatory costs. γ_t^x , μ_t^x and ζ_t^x are the weights used when defining the Basel regulatory ratios.

Evolving in a monopolistic competitive framework, each bank n faces the following new borrowing (deposit) demand (supply) equations, namely for deposits and the banking loans :

$$D_t^n = \left(\frac{R_t^{D,n}}{R_t^D} \right)^{-\nu^D} D_t \quad (28)$$

$$L_t^{P,n} = \left(\frac{R_t^{L^p,n}}{R_t^{L^p}} \right)^{-\nu^{L^p}} L_t^P \quad (29)$$

$$L_t^{G,n} = \left(\frac{R_t^{L^g,n}}{R_t^{L^g}} \right)^{-\nu^{L^g}} L_t^G \quad (30)$$

In our setting, the elasticities of loan demand (ν^{L^p} from SMEs and ν^{L^g} from large firms) are of finite values. However, in order to interpret the FOC's and for a matter of simplicity, it is useful to consider the special case where $\nu^{L,P} = \infty$ (perfect competitive framework) and $\kappa^p = 0$ (flexible rates). In this case, the maximization of banks profits function with respect to the default threshold $J_t^{L^p}$, L_t^P , SL_t^P and IB_t results in the following first order conditions:⁶

$$\lambda_{1,t} + \kappa^L (BLCR_t - RLCR_t) BLCR_t \frac{SK_t^B}{BLCRD_t} \mu^{L^p} = \frac{\lambda_{w,t+1}}{\lambda_{w,t}} \frac{\beta_w}{\pi_{t+1}} \left(1 + \lambda_{1,t+1} \delta^{L^p} \right) \quad (31)$$

$$-1 + \lambda_{1,t} \left(1 - \delta^{L^p} + R_t^{L^p} \right) + \lambda_{2,t} = 0 \quad (32)$$

$$\kappa^K (BCAP_t - RCAP_t) BCAP_t^2 \gamma^{L^p} - \lambda_{3,t} - \lambda_{2,t} + \frac{\lambda_{w,t+1}}{\lambda_{w,t}} \frac{\beta_w}{\pi_{t+1}} \lambda_{2,t+1} \delta^{L^p} = 0 \quad (33)$$

$$-\lambda_{3,t} = 1 - (1 + R_t) \left[\frac{\lambda_{w,t+1}}{\lambda_{w,t}} \frac{\beta_w}{\pi_{t+1}} - \kappa^L (BLCR_t - RLCR_t) BLCR_t \frac{SK_t^B}{BLCRD_t} \mu^{IB} \right] \quad (34)$$

By putting $\delta^{L^p} = 0$ and $\kappa^L = \kappa^N = 0$, one finds the standard FOC in a one period maturity framework, namely:

$$R_t^{L^p} = R_t + \frac{\lambda_{w,t}}{\lambda_{w,t+1}} \frac{\pi_{t+1}}{\beta_w} \kappa^K (BCAP_t - RCAP_t) BCAP_t^2 \gamma^{L^p} \quad (35)$$

We can thus identify $-\lambda_{2,t}$ as the marginal cost for a bank that considers lending to SMEs. Indeed, our banking sector modelling differs slightly from Gerali et al. (2010) in that we allow for different marginal costs for the bank depending on the identity of borrower since the regulatory constraints take into account the heterogeneity of borrowers. However, with $\delta^{L^p} = 0$, we find similar result to Gerali et al. (2010) with regulatory constraints increasing the marginal cost $-\lambda_{2,t}$ when the Banks ratios are below the regulatory ones and decreasing it when they are above the thresholds. Moreover, eq. (32) refers to the standard equilibrium equation linking the marginal cost $-\lambda_{2,t}$ to the "selling price" $R_t^{L^p}$.

Still, the introduction of long term maturities modifies the values of the marginal costs and prices as considered at time t . Since, the lending decision matters for all the future periods, the marginal costs have to take into account next period values of the interbank rate R_t when the future marginal profits induced by the lending decision in the current period have to be discounted by a specific discount factor $\lambda_{1,t}$ which would be equal to the households discount factor in the absence of the liquidity constraint. However, the LCR as it has been defined depends among others on the bank lending rates, this liquidity constraint enters thus the banks's optimal decision by affecting their discount factor. This is a key feature that a standard representation of the LCR constraints lacks. To assess the impact of the liquidity constraints, the MAG examined the impact of a 25%

⁶ $\lambda_{i=1..4}$ are lagrangian coefficients related to the accounting equation for the banks as well as for the definitions of $J_t^{L^p}$ and SL_t^P .

increase in the ratio of liquid assets to total assets considering for example the liquidity constraint as the sum of cash and government bonds, a very crude assumption as argued by Angelini et al. (2011). We can then legitimately wonder whether these studies on the impact of the LCR on bank lending spreads may create biased results as the liquidity constraint has an ambiguous impact on bank lending rates as they reinforce the banks' marginal cost and at the same time may lessen the banks' lending rate if banks collect more funding, (see section 4.2).

Government

The Government is able to fund its public spending by levying lump sum taxes \mathcal{T}_t or by issuing sovereign bonds T_t^S at an interest rate $R_t^{T^S}$. The budget constraint for the government can thus be addressed as follows :

$$G_t + \frac{J_{t-1}^{T^S}}{\pi_t} = \mathcal{T}_t + T_t^S \quad (36)$$

In order to avoid any multiplier effect from public spending, we suppose the latter exogenous and we set the ratio of public spending to GDP at 25% at the steady-state.

Levying taxes is used to reach the public debt to GDP target level, the latter being its steady-state value. Thus, the law of motion of taxes is as follow :

$$\frac{\mathcal{T}_t}{Y_t} = \frac{\mathcal{T}_{t-1}}{Y_{t-1}} + \gamma^{\mathcal{T}} \left(\frac{ST_t^S}{Y_t} - \overline{ST}_y \right) \quad (37)$$

Where ST_t^S is the outstanding amount of public debt.

Monetary Policy

Monetary policy is specified in terms of an interest rate rule targeting inflation, its first difference as well as the first difference in output. The Taylor interest rate rule used has the following form :

$$R_t = R_{t-1}^{\rho_R} \left[R^* \left(\frac{\pi_t}{\bar{\pi}} \right)^{r_\pi} \right]^{1-\rho_R} \varepsilon_{R,t} \quad (38)$$

where r_π is the weight assigned to inflation. R^* is the steady-state policy rate, and $\varepsilon_{R,t}$ is the white noise monetary policy shock.

Market clearing conditions

Aggregating all agents budget constraints and using the financial market equilibrium (aggregate accounting equality of the banking system⁷), we can set the following market clearing condition in goods market :

$$\begin{aligned} C_t^w + C_t^g + C_t^p + I_t^p + I_t^g + G_t + \mathcal{F} \left(\frac{\overline{\varepsilon_{z,t}} + \sigma^2/2}{\sigma} \right) & \left\{ \mathbb{E}_t [l^g (1 - \theta_{t+1}^g) q_{t+1}^K \pi_{t+1} K_t^G (1 - \delta)] - F J_t^G - \frac{J_{t-1}^{T^g}}{\pi_t} \right\} \\ & + CapRegCost(t) + LiqRegCost(t) + Adj_t = Y_t \end{aligned} \quad (39)$$

⁷Note that the aggregate level of interbank funds is equal to zero, $\int_0^1 IB^n dn = 0$.

Where Adj_t includes all adjustment costs (in both good and banking sectors) when $CapRegCost(t)$ and $LiqRegCost(t)$ stand for the costs related to the capitalization and liquidity constraints.

3 Calibration

We set several parameters to values in the range suggested mainly by the euro area data⁸ from 1999 (creation of the euro zone) to the mid of 2007 (the beginning of the subprime crisis) and if it is not available, we refer to the literature. Thus, relatively to the interest rates, we set the steady-state nominal interest rate (R^*) value at 0.75% (in quarterly terms) according to Euro Area data. The interest elasticity of households' deposits at -2.5 induces an annual deposit rate about 1.8% which corresponds to a households' discount factor of 0.9995. Relatively to bank lending rates, we calibrate the demand elasticities at 2.5 and 4.2 for respectively small and large firms which corresponds to a spread SME's loan rate - Corporate Loan rate about 100 bp.

With regard to volumes, we calibrate the LTV parameters θ^p and θ^g to 0.47 and 0.7 when we calibrate the resalable part of capital ι at 0.8 in order to match a steady-state value of loans to non financial corporates to (annual) GDP about 41%. The steady-state values of SMEs (resp. corporate firms) banks loans to GDP being about 10% (resp. 30%).

Furthermore, we calibrate the parameters δ^X in a way to get Macaulay's maturities about 4, 5, 7, 10 and 15 years for respectively SMEs bank loans, large firms bank loans, large firms bonds, risk-less (sovereign) bond and households deposits.

Moreover, we calibrate the steady-state value of the corporate firms default rate about 0.18% which with the risk-less bond maturity and yield induces a corporate bond yield about 3.3%.

We set the public debt to GDP ratio at 64% in line with the observed value in 2007. We also set the parameter ν^b at 11.3% to ensure a share of sovereign debt held by banks at 45% which is close to the ratio observed for French data.

We set the steady state SME's part in the global production volume ν^y equal to 0.33 in line with official studies on the French economy⁹ with SMEs referring particularly to independent SMEs.

Turning to the Basel constraints parameters, we first set the coefficient κ^K at 11 in line with the range of values estimated by Gerali et al.(2010). The calibration of parameter κ^L is more problematic since there is no benchmark model to use. We however choose to set κ^L in a way that, in a partial equilibrium model, a 10% increase in the liquidity constraint induces a similar impact on the bank lending rate to SMEs than a 10% increase in the capital ratio. This implies to set κ^L at a value about 0.2.

Second, and in order to set the Basel III weighting coefficients, we mainly use French data to calibrate most of the parameters.

In this order, we set the capital/RWA ratio parameters as follows : γ^{L^P} at 0.81, when γ^{L^G} is set at 0.46 and γ^{T^G} 0.33 and finally γ^{T^S} is set 0.04.

⁸In the case when euro area data are not available when French data are, we make the choice to use the French data as a benchmark for calibration.

⁹"Les chiffres-cles des TPE-PME", Ministère de l'économie, de l'industrie et de l'emploi - DGCIS - October 2009.

Regarding the weights of the LCR, we set the parameters at:

$$\begin{array}{lll}
\mu^{NT^G} & = & 0.11 & \mu^{NT^S} & = & 0.8 & \mu^{TG} & = & 1/3(1 - \mu^{NT^G}) \\
\mu^{TS} & = & 1/3(1 - \mu^{NT^G}) & \mu^D & = & 0.2 & \mu^{JD} & = & 1/3 \\
\mu^{LG} & = & 0.5/3 & \mu^{LP} & = & 0.5/3 & \mu^{IB} & = & 1/3
\end{array}$$

We divide most of the outflows parameters by 3 since the regulation is based on a monthly stress scenario while we use a quarterly framework. Note that the corporate bonds weight μ^{NT^G} may be seen as too low. This is mainly due to the low share of corporate bonds that can be considered as high quality liquid assets which is close to 20% according to French banks data.

Regarding the weights of the NSFR, we set the parameters using mainly the Basel calibration :

$$\begin{array}{lll}
\zeta^{NK} & = & 1 & \zeta^{D1} & = & 0.52 & \zeta^{D2} & = & 0 \\
\zeta^{TS} & = & 1+(0.05 - 1)\mu^{NT^S} & \zeta^{TG} & = & 0.45 & \zeta^{LP} & = & 0.5 \\
\zeta^{LG} & = & 0.5 & \zeta^{OthA} & = & 1 & & &
\end{array}$$

μ^{NT^S} enters the calibration of ζ^{TS} as they represent the HQLA share of sovereign bonds.

The rest of parameters were calibrated at estimated values found in Gerai et al. (2010) paper. Table 2 in the appendix reports the values of the calibrated parameters.

4 The implementation of Basel III Regulation

We consider several types of experiments in the following subsections. First, we investigate the separate implementation of solvency and liquidity (more specifically the LCR) requirements and their impact in the long run (sub-section 4.1) and in the short-medium run (sub-section 4.2). Then we discuss the question of the interaction between both constraints (sub-section 4.3). Finally, we investigate the effects of the introduction of the NSFR and its potential externalities with the other liquidity requirement (sub-section 4.4).

4.1 The long term effects of Basel III Constraints

In this sub-section, we model the scenario of a steady increase in banking capital and liquidity constraints separately. To disentangle the effects of the liquidity constraint from the capital ratio, we set the parameter related to the capital constraint κ^K close to 0 in the model when the liquidity is still active, and inversely for the capital shock.

With regard to the capital ratio, we implement a scenario similar to the MAG (2010b) by assuming a linear increase in the capital ratio of 1 pp through 16 quarters. For the liquidity constraints, we choose to implement a scenario of a linear increase in the LCR by +25 pp in 4 years (i.e. from 60% to 85%), also in line with MAG (2010b) hypothesis.

In this part, we mainly focus on the LT effects and compare our results with some of those in the literature. The results are shown in Table 1 below. The table reveals that while solvency regulation has persistent effects, this is not the case for liquidity according to our model.

Table 1: Long-term Impact of capital and liquidity requirements

Paper	Capital requirement			LCR requirement		
	Bank Loans	GDP	Spread BLR	Bank Loans	GDP	Spread BLR
de Bandt and Chahad - EA	-1.75% (SMEs) -1.98% (large corporates)	-0.31%	+5.8bp (SMEs) +2.6bp (large corporates)	-0.0% (SMEs) -0.0% (large corporates)	-0.00%	0.0bp (SMEs) 0.0bp (large corporates)
Angelini & Gerali (2012) - EA	-1.96%	-0.36%	+31bp	-	-	-
Covas & Driscoll** (2014) - USA	-0.8%	-0.1%	+4bp	-3.1%	-0.3%	+11bp
Sutorova & Teply (2013) - UE	-0.03%	-	+18.8bp	-	-	-
MAG (2010) - 17 OECD	-	-0.09%	12.2bp	-	-0.15%	+25bp

*1pp increase in the capital ratio and 25pp increase in the LCR

**6pp increase in the capital ratio

Capital Requirements

According to our evaluation, GDP decreases by about 0.31% as a result of the 1 pp increase in the capital constraint. This result is somewhat higher than the MAG (2010b) one (0.09%), but is in line with Angelini and Gerali (2012) (0.036%) under their "increasing profits" scenario which is also the one used in our model.

Regarding the credit channel, we estimate the impact of the increase in the capital requirement on the bank loans to be about -2% which is in line with the literature¹⁰ (see also table 1 in BCBS (2016)). The effect on bank lending spreads appears comparatively lower than the effect on volumes.

This result has to be linked to our model specificities. Indeed, an increase in the regulatory capital ratio comes with a general drop in all banks assets components. However, since we have in our model a distinction between flows and stocks of loans and since the risk weighted assets (RWA) variable is based on stocks of assets, a drop in the outstanding amount of banks loans can be reached by momentarily cutting in the flows of new loans by increasing the loans rate. According to our simulations, the increase in BLR spreads reaches a peak after 2.5 years at +7.5 bp for SMEs and +4.0 bp for corporate firms. This would help the stock of loans to decrease sharply and in a short time. But, after this (relatively long) transitory period, the BLR spreads would then steadily decrease to reach their long term values reported in table 1. The cumulative process of loans will make the stock of loans decreasing for a longer period without a significant increase in the BLR.

Moreover, the adjustment of banks capital to the RWA would also be reached through other assets components (namely sovereign and corporate bonds in our model), which will partly alleviate the constraint on banking loans.

Liquidity Coverage Ratio

According to our modeling and calibration, the LCR should have no long term effect on the GDP, neither on the lending volumes and rates. This result is also related to Basel calibration of the LCR which gives considerable weight to the high quality assets (known as the HQLA) that are mainly composed of sovereign bonds of advanced economies. Since the weight of this kind of assets is much higher than for other types of assets, the LCR requirements could be achieved only by a sharp increase in the share of sovereign debts held by

¹⁰the evaluation of Sutorova and Teply (2013) seems to be low as compared to ours but it is based only on the estimated value of the loans demand elasticity to the interest rates.

banks, the latter being financed by a rise in households deposits (see section 4.4). Moreover, since we assume a neutral role of the government in our model, the increase in banks' holding of sovereign bonds would, in the long run, have no impact on aggregate demand for bank loans. The latter result is rather different from those of other DSGE models (MAG (2010b), Covas and Driscoll (2014)) which generally conclude to a negative impact of the LCR on bank lending. Our results are nevertheless consistent with the finding of Banerjee and Mio (2015) who, on UK data, find no evidence of an impact of the Individual Liquidity Guidance (ILG¹¹) on output or lending volumes to non financial counterparts. These results that are also in line with EBA (2014) finding based on QIS data.

4.2 Discussion of the transitory effects of Basel III constraints

In this sub-section, we now discuss more fully the transmission channels of higher regulatory constraints in the short and medium run. We simulate the scenario of a linear increase through 16 quarters of the capital ratio of 2.5 pp and of the liquidity coverage ratio by 40 pp. Such scenarios are consistent with the Basel III implementation deadlines. The results are shown in Figure 1.

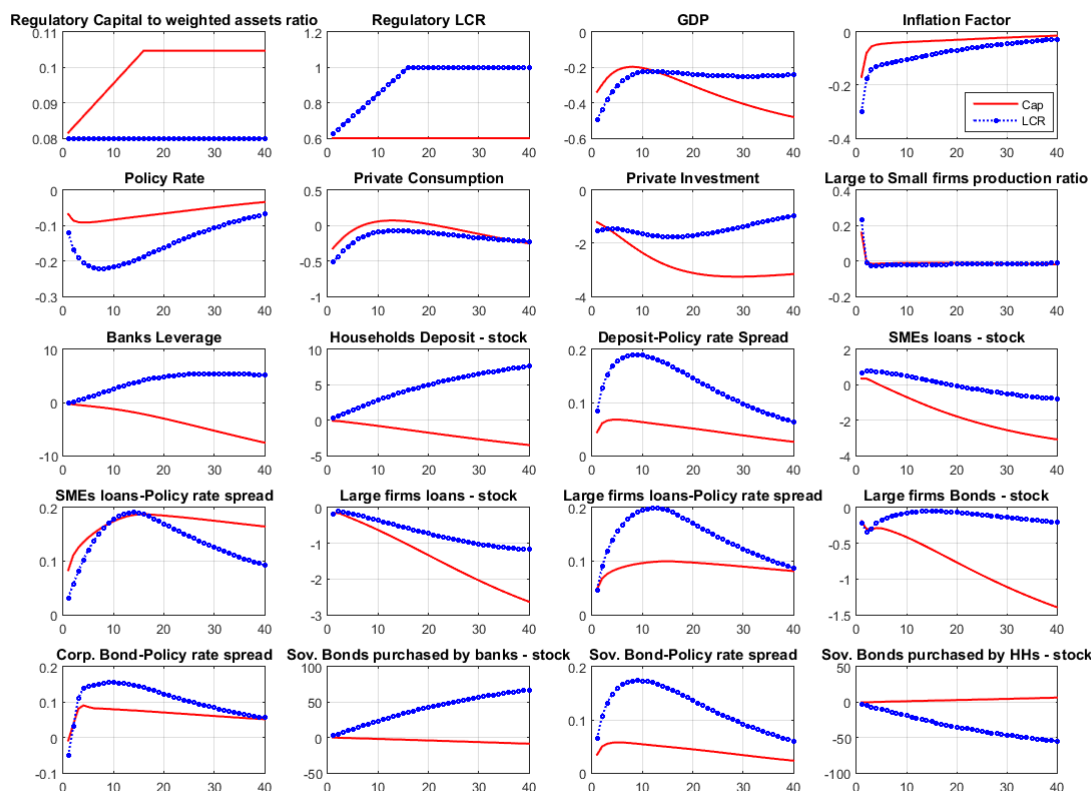


Figure 1: The impact of the Basel III new Capitalization (red curve) and Liquidity (blue curve) thresholds. The regulatory ratios are in level. All rates are shown as absolute deviations from steady state, expressed in percentage points. All other variables are percentage deviations from steady state.

¹¹The ILG requires banks to hold a minimum quantity of HQLA to meet a scenario of stressed net outflows which is conceptually similar to the Basel III LCR.

Capital Requirement

The capital ratio aims among others at limiting any increase in leverage from credit institutions. It is then not surprising to expect a deleveraging process in the banking sector in the absence of any additional incentives to raise their asset level. Thus, in a scenario with no additional shock, the rise in the regulatory capital ratio induces a deleveraging process from the banking sector as well as a simultaneous rise in banks' lending rates, especially for SMEs. An increase in the interest rate on new bank loans would probably not be sufficient to match the regulatory constraint especially in the case of a large share of long maturity fixed rate loans. Banks resort to a cut in their bank loans, and more particularly the riskier ones (namely SMEs loans here). After 10 years, loans to SMEs drops by about 3.1% when loans to corporate firms falls by 2.6% (see cells (3,4) and (4,2)).

The lower credit supply combined with the decrease in the demand for corporate bonds (see cell (4,4)) induces a sharp reduction in the demand for investment goods, magnified by the presence of financial frictions and more precisely the collateral constraint as emphasized in Gertler and Kiyotaki (2009). This also explains differences in the impact of regulatory constraints between large and small companies.

Liquidity Coverage Ratio

Turning to the other Basel III constraint, a first striking result is the mainly short run recessive effect of the LCR as compared to the more persistent capitalization constraint effect.

With respect to the liquidity constraint, an increase in the regulatory ratio has a direct impact on the bank lending rate as suggested by equations (31) to (34) in section 2. However, the impact of an increase in the regulatory liquidity ratio has two opposite effects on the bank lending rates. On the one hand, any increase in interbank borrowing represents additional future cash outflows which reinforces the burden of the liquidity constraint while, on the other hand, any lending opportunity will loosen it, as it will create future inflows. Figure 1 shows that the increase in the lending rate spreads (to SMEs and corporate firms) offsets the policy rate decrease. By increasing their lending rates, banks also generate future cash inflows with larger yields and higher revenues in the short run, comparatively to corporate or sovereign bonds which are characterized by longer maturity and lower yields.

Indeed, the increase in the LCR requirements has initially recessionary effects which are largely the consequence of the sharp decrease in private consumption in anticipation of future adverse economic developments. However the drop in consumption is also due to a second order effect of the LCR, namely the increase in deposits. Indeed, on the one hand, deposits create more outflows, while more deposits is a way to increase future liquid assets, i.e. to purchase bonds in our model. The increase in deposits has a negative impact on the LCR, although less than an increase in interbank borrowing. Accordingly, in its scenario of development of the LCR, the Basel committee considers the scenario of partial retail deposit run-off which implies that the outstanding amount of households deposits increase outflows in the denominator of the LCR. Moreover, the LCR denominator should also contain deposit repayments as they are considered as agreed future cash outflows. For these two reasons, we expect that banks would restrain their willingness of holding deposits by decreasing their demand for deposits as well as their remuneration rate. Nevertheless, we note that according to our simulation exercise, both deposits volumes and interest rates spreads increase. This simultaneous increase indicates that

it comes from the demand side, namely the banking sector.¹² This effect originates in the definition of the LCR. The LCR implementation stresses the necessary accumulation of Highly Quality Liquid Assets (HQLA) - containing notably sovereign bonds - that materializes with a high weighting factor in the LCR expression (from 50% to 100%). As compared to the weight of retail deposits volume (between 3% for the most stable funds to 10% for the less stable ones according to Basel 3 standard calibration), it can happen that the marginal benefit of holding liquid securities outpaces the marginal cost of holding deposits. Banks will then rather prefer to loosen their accounting constraint by increasing their liabilities (their demand of retail deposits) in order to purchase more liquid assets than limiting their leverage ratio. The LCR can, if it is implemented alone, not necessarily trigger a deleveraging process. This increase in deposit rate combined with the rise in sovereign bonds spread leads to an increase in the saving rates of households, who then cut in their consumption expenses.

Note also that, after an initial decrease, private investment tends to recover 15 quarters after the rise in the LCR regulatory constraint. The increase in investment suffers, however, from a crowding out effect from public debt. Indeed, one of the expected effects of the new LCR is the search for highly rated sovereign debt as it can be shown in Figure 2, cell (5,2).

This is the result of the relatively higher weight given to HQLA in the numerator of the LCR ratio, and more particularly the so called "level 1 assets" (with weight equal to 100%) which are mainly composed of deposits at the central banks and (higher yield) sovereign bonds. Corporate bonds might receive a 85% or 50% weight depending on whether they are considered as "level 2A" or "level 2B" assets. However, the share of corporate bonds that could reach the required rates to be considered as HQLA is generally low. This makes the effective weight corresponding to corporate bonds in the LCR to be very low too. In this case, banks would not have an incentive to hold corporate bonds in order to meet the LCR constraint and more particularly when the supply of HQLA level 1 assets is not constrained. Neglecting the sovereign bonds channel may therefore underestimate the transitory negative effect of the LCR on real variables that can not be adjusted using different calibration of the LCR parameters.

4.3 The interaction between the capital ratio and the LCR

Figure 2 shows the overall impact of the simultaneous implementation of capital and the LCR constraints. The main results that can be assessed is that, surprisingly, the global impact of both shocks is close to the sum of the impacts of each shock.¹³ In other words, it seems there is no strong positive externalities between liquidity and capitalization constraints which makes them complementary.

When we consider the full implementation of Basel III, with the LCR ratio moving to 100%, GDP decreases by 0.68% at the 10 year horizon, with private consumption reduced by 0.46% (hence exhibiting consumption smoothing) and private investment by 3.8%. SME loans are reduced by 3.6% (cell (3,4) and corporate loans by 3.7% (cell (4,2)). In our modeling framework, banks are not able to decrease their leverage and simultaneously increase their spreads in order to meet the LCR target since the latter is positively correlated with future assets repayments. As seen before, the liquidity shock induces a significant rise in the bank leverage, in contrast

¹²If we allow for an increase in sovereign bond supply from the government, we see that both the spread and the level of deposit rates increase eliminating the possibility that the increase in households deposits comes from an increase in their treasuries.

¹³Note that the results related to the capitalization and the liquidity constraints differ for some variables from what has been shown in the previous section since in this exercise, we do not shut down the other constraint when we implement one.

with the effects of the capital-to-weighted assets ratio shock. As a consequence and in order to reach the new regulatory threshold, banks have to make larger effort, in comparison to what they would do in the absence of the LCR shock. As a result, the simultaneous regulatory shocks trigger a transitory dampening in the aggregate demand components. Such results contrast with De Nicolo et al. (2014) who conclude to the substitutability of the requirements, focusing on the effect of retained earnings, while the main transmission channel comes from banks' balance sheet structure in our model.

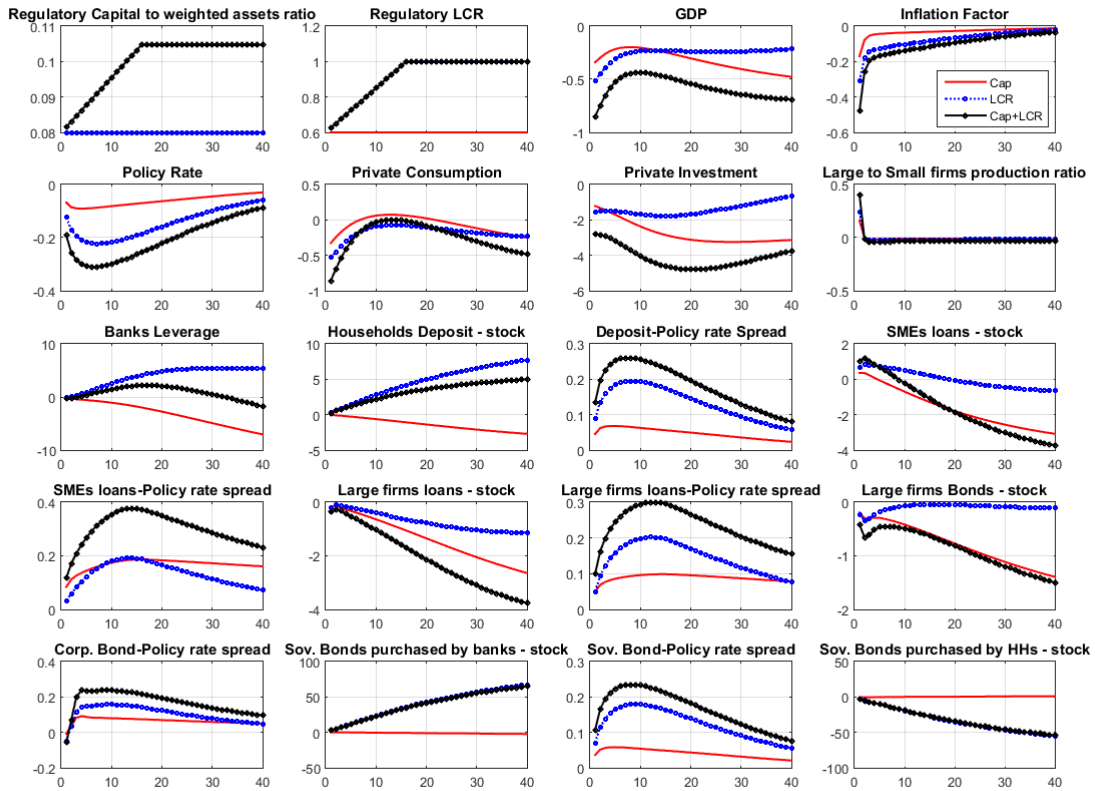


Figure 2: The overall impact of Basel III capitalization and liquidity constraints.

As mentioned before, the most relevant way for banks to reach quite easily the LCR requirement is to increase their holding of sovereign bonds. This strategy would be financed by a rise in households' deposits which represent also a simple and cheap way to raise funds as suggested by our simulation output. These results are also consistent with some stylized facts that post crisis banking systems exhibit. Birn et al. (2016) describe for example the outcome of the Basel III Quantitative Impact Studies for a sample of 156 global banks over the 2010-2014 period, which, broadly speaking, was characterized by the implementation of capital regulation as well as the LCR ratio. They show that the median increase in total assets is about 10% over the period, but deposits from non banks, which increase by 12.5%, contribute the most with a 5.3 pp contribution. Adenot et al. (2014) describe changes in the balance sheet structure of French banks at the consolidated level from 2009 to 2013. They show that total assets hardly changed (-13 bn euros), while non bank deposits increase by 229 bn, which amounts to about 10% of French annual GDP. Figure 4 in the Appendix shows how the loan-to-deposit ratio of EU banks as available from the ECB Consolidated Banking database (CBD), is cyclical but also exhibits a downward trend over the Basel III implementation period. During that period banks accumulated a larger share of non bank deposits in their balance sheet (see for EU banks).

Similarly, according to Birn et al. (2016), for High Quality Liquid Assets (HQLA), which include notably sovereign bonds, the median increase is 21.5% over the 4 years, with a 2.3 p.p. contribution to total asset growth. In the euro area, it corresponds to the accumulation of sovereign bonds from "core" euro area countries as one source of High Quality Liquid assets (HQLA) (see Fig 5 in the Appendix). For banks in the euro area, the other source of HQLA were banks' deposits and reserves at the European Central Bank.

4.4 The Net Stable Funding Ratio and its interaction with the LCR

In this part, we discuss the effects of the implementation of the Net Stable Funding Ratio keeping the effects of the LCR as a benchmark.

Figure 3 compares the implementation of the LCR and the NSFR. Such an experiment leverages on one key feature of the model, namely the fine description of multi period claims as described in section 2. It appears that the two liquidity requirements, although different in nature (LCR targets short run liquidity, while NSFR targets long term liquidity mismatch), have qualitatively the same impact. The coefficient given to the HQLA in the scenario of required stable funding is much lower, as compared to those of other assets. It is therefore not surprising to expect a strong appetite for sovereign bonds as witnessed for the LCR at the expense of other assets such as loans and corporate bonds. Bank capital being generally sluggish, the easiest way for banks to fund this rise in sovereign bonds would be to increase households' deposit which, with own capital, benefit from a relatively high weight for the available stable funding term in the numerator of the NSFR.

However, our simulation output underlines a small impact of the implementation of NSFR, as compared to the implementation of the LCR or the increase in capital ratio. This result has to do with the structure of the balance sheet of our representative bank. The current calibration of the NSFR gives large ASF weights (close to 100%) to banks' capital and households' deposits. It also gives such weights to the long term (more than one year) assets such as bank loans to non financial counterparts. Thus, if we omit the RSF coefficients of sovereign

bonds and those of corporate bonds (from 15% for level 2A ones to 50% to level 2B bonds and 100% for non HQLA bonds), the NSFR ratio is more or less close to the ratio of total liabilities to total assets which is equal to 1. Thus meeting the 100% objective of the NSFR is not too costly according to our modelling. In other words, as long as the share of short-term assets (and liabilities) is limited, reaching a 100% of the NSFR wouldn't be so much costly in terms of impact on the real activity and to some extent on the retail banking sector. This highlights the need to investigate further the role of interbank net liabilities in the assessment of the impact of regulatory changes.

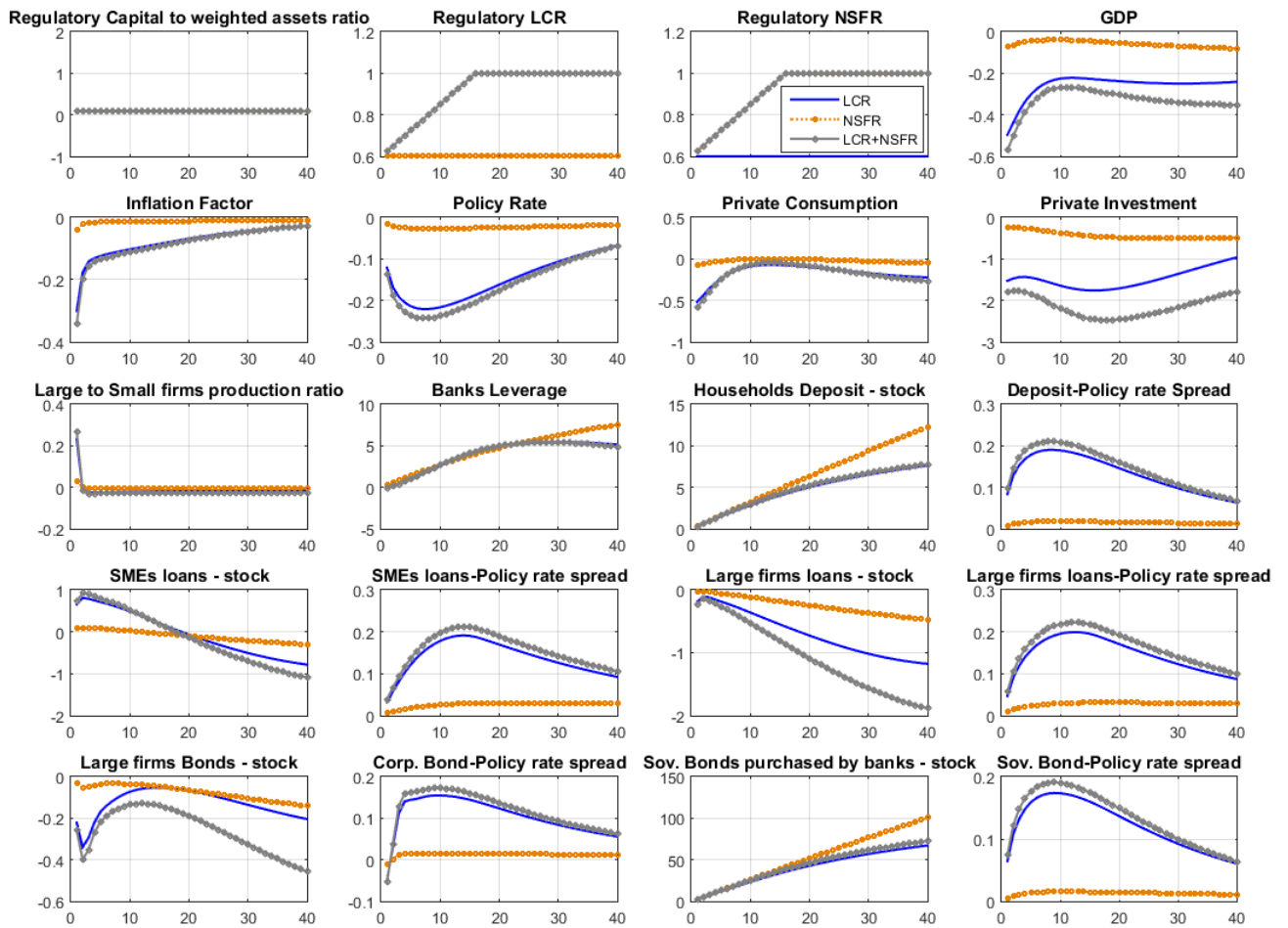


Figure 3: The impact of the NSFR and the LCR. All rates are shown as absolute deviations from steady state, expressed in percentage points. All other variables are percentage deviations from steady state.

Figure 3 shows also that the effects of the implementation of the NSFR would not be costly in case the LCR is already or being increased. Indeed, the figure above shows strong externalities between the impact of the LCR and of the NSFR when they are implemented simultaneously. This fact is especially true for banking sector variables for which the impact of the simultaneous shocks is lower than the sum of the impact of each implemented separately. Therefore, we can conclude that banks would not have to make much stronger effort to meet the NSFR when they are already implementing the LCR ratio.

5 Conclusion

In this paper, we extend the results of the numerous studies on the Basel III new requirements implementation and notably those of the (MAG (2010b) and MAG (2010a)). Focusing on the impact of the new banking regulation in presence of firms' heterogeneity, we find that both capital and liquidity requirements widen the discrepancy between small and large companies in favor of the latter. This result is moreover amplified when we implement both constraints simultaneously. Indeed, we find that there is no potential positive spill-over effects between the implementation of the new capitalization ratio and the liquidity coverage ratio as their effects are compounded when the two regulations are implemented jointly. The model sheds some light on the channel of accumulation of sovereign bonds, and partial substitution away from loans to non financial companies. This puts forward the role of sovereign debt when dealing with capital and more particularly liquidity regulations.

Regarding the interaction between liquidity and capital requirements, the paper uncovers large complementarity between both requirements. Indeed, we show that liquidity implementation would not necessarily trigger a deleveraging process, while the implementation of the solvency ratio would probably have such an effect. Moreover, the liquidity constraint would have strong incentives for banks to hold sovereign bonds when it would have no effect on the loans volumes. This change in the structure of banks balance sheet would not help improving their capital to RWA ratio. An additional strategy to improve this capital to RWA ratio is also to increase banks net interest income which is not necessarily achieved through an increase in the liquidity constraint (see BCBS (2016)) since the latter comes with a sharp increase in deposit rates. As a consequence, apart from the unpopular strategy for banks to issue new equity, we found no evidence of potential externalities between the two requirements.

Regarding the two liquidity requirements, it seems that the current calibration of the NSFR would not be significantly more costly for banks to reach and more particularly when they are already implementing the LCR ratio, since we find a high degree of substitutability between the two liquidity constraints.

Future research would include considering the interaction with macroprudential instruments, like the counter-cyclical capital buffer, as well as investigating further the impact on interbank liabilities.

References

- Adenot, C., J. Guilmo, and E. Point (2014). French banks' performance in 2013. *Banque de France, Autorite de Controle Prudentiel et de Resolution, Analyses et Syntheses*.
- Angelini, P., L. Clerc, V. Curia, L. Gambacorta, A. Gerali, A. Locarno, R. Motto, W. Roeger, S. Van en Heuvel, and J. Vlcek (2011). Basel iii: Long term impact on economic performance an fluctuations. Technical Report 338.
- Angelini, P. and A. Gerali (2012). Banks' reactions to basel-iii. *Bank of Italy Working Paper, no 876*.
- Banerjee, R. N. and H. Mio (2015). The impact of liquidity regulation on banks. *Staff Working Paper No. 536, Bank of England*.
- BCBS (2016). Literature review on integration of regulatory capital and liquidity instruments. *BCBS Working Paper No 30*.
- Benes, J. and K. Lees (2010). Multi-period fixed-rate loans, housing and monetary policy in small open economies. Discussion paper series, Reserve Bank of New Zeland.
- Birn, M., M. Dietsch, and D. Durant (2016). How to reach all basel requirements at the same time? debats economiques et financiers. *Banque de France, Autorite de Controle Prudentiel et de Resolution*.
- Bonner, C. (2015). Preferential regulatory treatment and banks' demand for government bonds. *CentER Discussion Paper no 2015-056, Tilburg University*.
- Bridges, J., D. Gregory, M. Nielsen, S. Pezzini, A. Radia, and M. Spaltro (2015). The impact of capital requirements on bank lending. *Bank of England Working Paper No. 486*.
- Cecchetti, S. (2014). The jury is in. *CEPR Policy Insight No. 76*.
- Chari, V., L. Christiano, and P. Kehoe (2007). The gertler-gilchrist evience on small an large firm sales.
- Covas, F. and J. Driscoll (2014). Bank liquidity and capital regulation in general equilibrium. *Finance and Economics Discussion Series*.
- Darracq Pariès, M., C. Kok Sørensen, and D. Rodriguez-Palenzuela (2011). Macroeconomic propagation under different regulatory regimes: Evidence from an estimated dsge model for the euro area. *International Journal of Central Banking* 7(4), 49–113.
- De Nicolo, G., A. Gamba, and M. Lucchetta (2014). Microprudential regulation in a dynamic model of banking. *Review of financial studies*, 27, 7, 2097-2138.
- EBA (2014). Second report on impact assessment for liquidity measures under article 509(1) of the crr. *EBA Report*.
- Gambacorta, L. (2010). Do bank capital and liquidity affect real economic activity in the long run? a vecm analysis for the us.
- Gerali, A., S. Neri, L. Sessa, and F. M. Signoretti (2010). Credit and banking in a dsge model of the euro area. *Journal of Money, Credit and Banking* 42, 107–141.

- Gertler, M. and S. Gilchrist (1994). Monetary policy, business cycles, and the behavior of small manufacturing firms. Technical report.
- Gertler, M. and N. Kiyotaki (2009). Financial intermediation and credit policy in business cycle analysis. Technical report.
- Giesecke, K., F. Longstaff, S. Schaefer, and I. Strebulaev (2012). Macroeconomic effects of corporate default crises: a long term perspective. *NBER Working Paper* (17854).
- Gilchrist, S., J. Sim, and E. Zakrajsek (2010). Uncertainty, financial frictions, and investment dynamics. Meeting Papers 1285, Society of Economic Dynamics.
- Iacoviello, M. (2005). House prices, borrowing constraints, and monetary policy in the business cycle. *American Economic Review* 95(3), 739–764.
- MAG (2010a). Assessing the macroeconomic impact of the transition to stronger capital and liquidity requirements. Technical report.
- MAG (2010b). An assessment of the long-term economic impact of stronger capital and liquidity requirements. Technical report.
- Rogoff, S. and J. Vlcek (2000). Macroeconomic costs of high bank capital and liquidity requirements. IMF Working Paper 11/103, International Monetary Fund.
- Rotemberg, J. (1982). Monopolistic price adjustment and aggregate output. *The Review of Economic Studies* (49), 517–531.
- Sutorova, B. and P. Teplý (2013). The impact of Basel III on lending rates of EU banks. *Czech Journal of Economics and Finance*.
- Townsend, R. (1979). Optimal contracts and competitive markets with costly state verification. *Journal of Economic Theory* (21), 265–293.
- Vinas, F. (2015). Credit supply by universal vs retail banks during the great recession. *Banque de France, Autorité de Contrôle Prudentiel et de Résolution, mimeo*.

Appendix

Table 2: Calibration

Parameter	Description	Value
Households		
σ_c^w	Inter-temporal elasticity of substitution of workers' consumption	1
η^w	Habit in workers' consumption coefficient	0.87
σ_n	Inverse of the Frisch elasticity	1
ν_w	$\frac{\nu_w}{\nu_w-1}$ is the mark-up in the labor market	5
γ_w	Wage indexation	0.28
κ_w	Wage adjustment cost	100
Production		
σ_c^p	Inter-temporal elasticity of substitution of small entrepreneurs' consumption	1
η^p	Habit in small entrepreneurs' consumption coefficient	η^w
α	Capital share in the production function	0.25
δ	Capital depreciation rate	0.025
σ_c^g	Inter-temporal elasticity of substitution of large entrepreneurs' consumption	1
η^g	Habit in large entrepreneurs' consumption coefficient	η^w
ϕ	Capital producers' investment adjustment cost	10
ξ^y	Inverse of Elasticity of substitution between SMEs and large corporate	0.1
ν^y	SME's share in the production	1/3
ν^f	$\frac{\nu^f}{\nu^f-1}$ is the mark-up in the good market	3.86
γ_f	Price indexation	0.16
κ_f	Price adjustment cost	30
μ	Monitoring cost coefficient	0.25
Banking Sector		
κ^{LP}	SMEs' loans interest rate adjustment cost	13
κ^{LG}	Large firms' loans interest rate adjustment cost	7
κ^D	Savers' deposits interest rate adjustment cost	20
ν^{LP}	$\frac{\nu^{LP}}{\nu^{LP}-1}$ is the mark-up on rate on loans to SMEs	2.5
ν^{LG}	$\frac{\nu^{LG}}{\nu^{LG}-1}$ is the mark-up on rate on loans to large corporate	4.2
ν^D	$\frac{\nu^D}{\nu^D-1}$ is the mark-down on rate on deposits	-2.5
κ^K	"Leverage" deviations cost	11
κ^L	"Liquidity" deviations cost	0.20
δ^{LP}	$(1 - \delta^{LP})$ The principal repayment part of the loans to SMEs residual outstanding amount	0.9446
δ^{LG}	$(1 - \delta^{LG})$ The principal repayment part of the loans to large firms residual outstanding amount	0.9571
δ^{TG}	$(1 - \delta^{TG})$ The principal repayment part of the large firms bonds residual outstanding amount	0.9715
δ^{TS}	$(1 - \delta^{TS})$ The principal repayment part of the risk-less bonds residual outstanding amount	0.9823
δ^D	$(1 - \delta^D)$ The principal repayment part of the households deposits	0.9907
Monetary Policy		
r_π	Taylor rule coefficient on inflation	2
\bar{R}	Nominal policy rate in %(ssv)	0.75
$\bar{\pi}$	The long term Inflation rate in %(ssv)	0.49
Shocks		
$\sigma_{\nu\kappa}$	The SD coefficient of the solvency ratio	0.0170
$\sigma_{\nu L}$	The SD coefficient of the LCR	0.0319

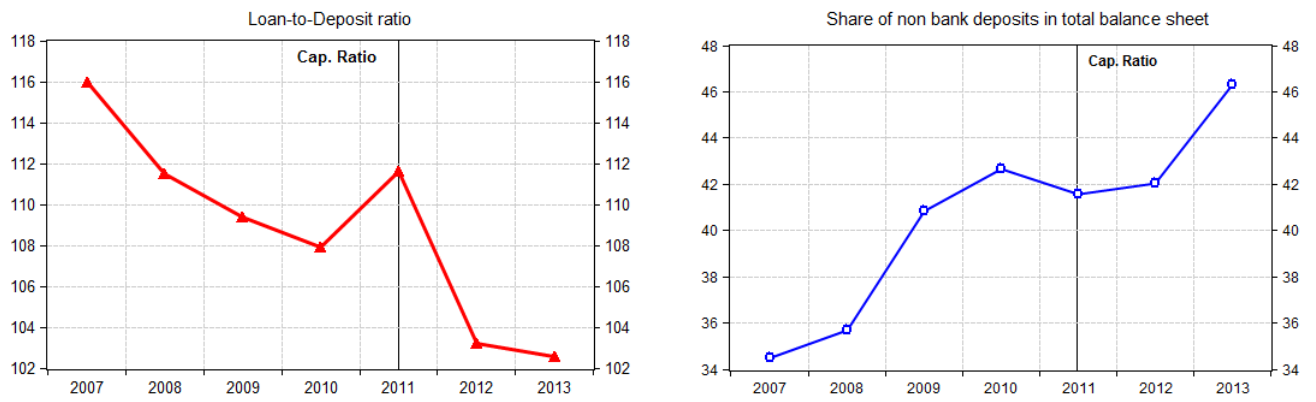


Figure 4: Loan-to-Deposit ratio and Share of non bank deposits in total balance sheet, EU banks.

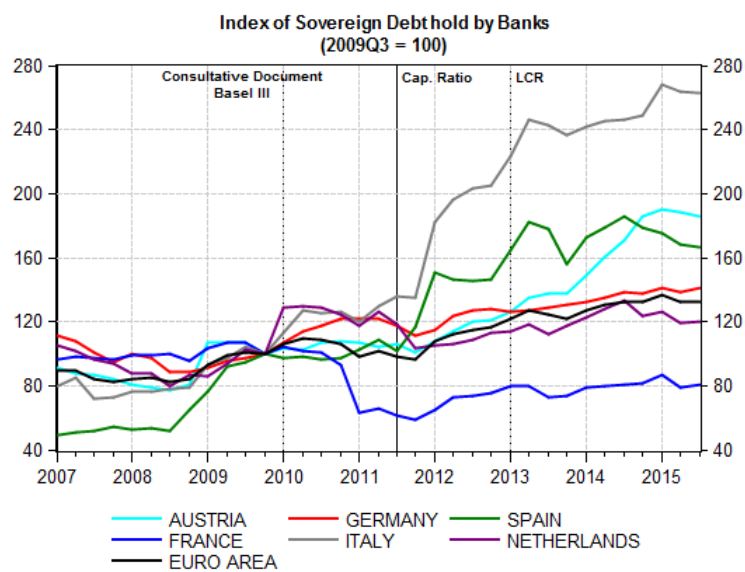


Figure 5: Dynamics of Sovereign Debts hold by banks in the main euro area countries.
Source : Consolidated Banking Data, ECB.

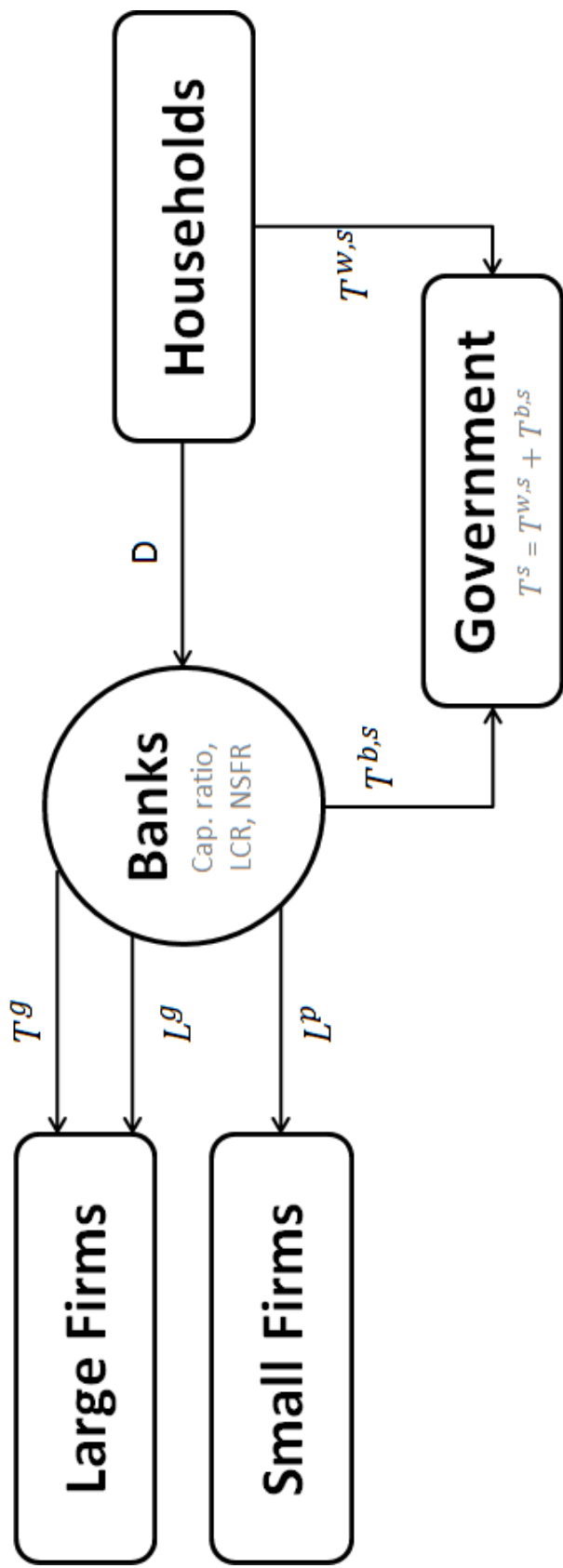


Figure 6: Financial Flows in the model

Documents de Travail

590. M. Girotti, “How Monetary Policy Changes Bank Liability Structure and Funding Cost” April 2016
591. E. Monnet and C. Wolf, “Demographic Cycle, Migration and Housing Investment : a Causal Examination” April 2016
592. E. Monnet and D. Puy , “Has Globalization Really Increased Business Cycle Synchronization?” April 2016
593. N. Cassola and F. Koulischer, “The Collateral Channel of Open Market Operations” May 2016
594. G. Gaballo and A. Zetlin-Jones, “Bailouts, Moral Hazard and Banks' Home Bias for Sovereign Debt” May 2016
595. M. Lemoine and J. Lindé, “ Fiscal Consolidation Under Imperfect Credibility” May 2016
596. C. Thubin, T.s Ferrière, É. Monnet, M. Marx and V. Oung, “The PRISME model: can disaggregation on the production side help to forecast GDP?” June 2016
597. A. M. Mayda, G. Peri and W. Steingress, “Immigration to the U.S.: A problem for the Republicans or the Democrats?” June 2016
598. A. Bernales and M. di Filippo, “The Information Contained in Money Market Interactions: Unsecured vs. Collateralized Lending” July 2016
599. M. Bussière, J. Schmidt, F. Vinas, “International Banking and Cross-Border Effects of Regulation: Lessons from France” August 2016
600. M. Mogliani and T. Ferrière, “Rationality of announcements, business cycle asymmetry, and predictability of revisions. The case of French GDP” September 2016
601. R. S.J. Koijen; F. Koulischer; B. Nguyen and M. Yogo, “Quantitative Easing in the Euro Area: The Dynamics of Risk Exposures and the Impact on Asset Prices” September 2016
602. O. de Bandt and M. Chahad, “A DGSE Model to Assess the Post-Crisis Regulation of Universal Banks” September 2016

Pour accéder à la liste complète des Documents de Travail publiés par la Banque de France veuillez consulter le site : www.banque-france.fr

For a complete list of Working Papers published by the Banque de France, please visit the website: www.banque-france.fr

Pour tous commentaires ou demandes sur les Documents de Travail, contacter la bibliothèque de la Direction Générale des Études et des Relations Internationales à l'adresse suivante :

For any comment or enquiries on the Working Papers, contact the library of the Directorate General Economics and International Relations at the following address :

BANQUE DE FRANCE
49- 1404 Labolog
75049 Paris Cedex 01
tél : 0033 (0)1 42 97 77 24 ou 01 42 92 63 40 ou 48 90 ou 69 81
email : 1404-ut@banque-france.fr