

The 3D Model: a Framework to Assess Capital Regulation¹

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ABSTRACT

This article discusses the contribution of the MaRS WS1 cross-country project, which aims at providing a framework for the positive and normative analysis of macroprudential policies. The analysis relies on a micro-founded model that introduces financial intermediation and

three layers of default (3D) into an otherwise standard dynamic stochastic general equilibrium (DSGE) model. A distinctive feature of the model is a clear rationale for capital regulation, which arises as a welfare improving response to excessive risk taking by banks.

1. Introduction

The recent financial crisis questioned the traditional (micro) focus of financial supervision and regulation, and suggested the need to strengthen the preventive (macro-prudential) aspects of financial stability policies. In the spring of 2010, the European System of Central Banks launched a macroprudential research network (MaRS) with the goal of “developing core conceptual frameworks, models and/or tools that would provide research support in order to improve macro-prudential supervision in the European Union (EU).”¹⁰

This article summarizes the findings of a cross-country project developed in the context of MaRS’s primary research topic, that is, macro-financial models linking financial instability and the performance of the economy (WS1).¹¹ The aim of this project is to build a decision-support tool that provides analytical feedback to policymakers regarding the positive and normative analysis of macroprudential policy, with a specific focus on capital requirements (CRs).

We develop a micro-founded model that introduces financial intermediation and positive equilibrium default rates into an otherwise standard DSGE model. The model economy is populated by households, entrepreneurs and bankers. Borrowing households borrow from banks to buy houses, whereas savers supply deposits to banks. Bankers allocate both their scarce wealth (inside equity) and the funds raised from savings households across two lending activities: mortgage lending to borrowing households and corporate lending to entrepreneurs. Borrowing by households, corporations, and banks features default risk due to the combination of idiosyncratic and aggregate factors. As in the costly state verification setup of Gale and Hellwig (1985), defaults cause deadweight losses.

Households and firms leverage is an endogenous multiple of their net worth. In contrast, banks, which are assumed to obtain their outside funding in the form of government-guaranteed deposits, have their leverage limited by a regulatory capital requirement. Importantly, in spite of the presence of deposit insurance, we assume that depositors suffer some transaction costs if banks fail. This generates a risk premium that acts as an important source of amplification when bank solvency is weak.

The normative results of the project rely on an explicit welfare analysis. Our results document that:

- Large gains from rising CRs when bank risk of failure is significant. Deposits are formally insured, providing an implicit subsidy to lending made by risky banks. Thus, there is a clear rationale for capital regulation, which arises as an optimal response to excessive risk taking by banks;
- Bank-related amplification channels are strong and CRs are effective in shutting them down. In particular under the optimal CRs the economy mimics the behavior of a no bank default economy;
- Countercyclical adjustments mitigate the impact of shocks with high CRs (or low bank risk), but are otherwise counterproductive.

A number of recent papers has focused on introducing bank frictions into otherwise standard dynamic stochastic general equilibrium models (e.g. Gerali, *et al.*, 2010; Gertler and Kiyotaki, 2010; Gertler and Karadi, 2011; Meh and Moran, 2010).¹² Most studies overlooks the (harmful) macroeconomic consequences of borrowers' default, including that of banks. Some papers rule out the possibility of default through appropriately chosen financial contracts, as in Kiyotaki and Moore (1997), others allow for default in equilibrium but assume that the losses from default can be completely hedged, as in Bernanke, Gertler and Gilchrist (1999). Therefore, default exists but does not harm at least ex post. Our framework differs from previous models, in that it incorporates a central role for default. Default risk arises from both aggregate and idiosyncratic risk. Contracts are incomplete in that they cannot be made fully contingent on aggregate variables. Thus, default impinges on the balance sheet of the lenders, influencing their optimal behavior and thereby macroeconomic outcomes. This allow us to explore the consequences of default on financial stability and, subsequently, on the real economy.¹³ This project focuses on bank capital regulation, the key microprudential policy, that it is arguably also one of the main tools for macroprudential policy.

This article is organized as follows. Section 2 describes the key ingredients and the sources of financial instability embedded into the model. Section 3 comments on the results of three policy experiments and Section 4 concludes.

2. Overview of the 3D Model

We develop a theoretical model which aims to provide a framework for the positive and normative analysis of macroprudential policies. The main features of the model are: financial intermediation takes center stage; there is a clear channel through which financial instability imposes costs on the real economy; positive equilibrium default rates exist for all classes of borrowers (households, firms and banks); there is an explicit welfare analysis of regulatory tools. In what follows, we provide in-depth descriptions of these features.

2.1 Model Details

Chart 2.1.1 presents the structure of the economy.¹⁴ The economy is populated with two dynasties of households which provide risk sharing to their members: patient and impatient. All households consume non-durable goods, invest in housing, and supply labor to the production sector. The members of the two dynasties differ in their discount factor. This type of ex-ante heterogeneity generates credit flows into the economy.¹⁵ Impatient households (borrowers) have

a lower subjective discount factor, which, in equilibrium, generates an incentive to anticipate future consumption to the current period through borrowing. These households borrow from banks to buy houses and optimally decide to default if their house is worth less than their mortgage repayment. Patient households (savers) supply deposits to the banks.

Entrepreneurs are risk neutral agents that own the stock of physical capital. They borrow from corporate banks in order to finance part of their investment in capital. Default occurs if their assets are worth less than their loan repayments.

Bankers are also risk neutral agents that provide inside equity to banks. They allocate inside equity and funds raised from saving households across two lending activities: mortgage lending to borrowing households and corporate lending to entrepreneurs. Banks operate in a perfectly competitive market. All banks enjoy deposit insurance and are subject to regulatory capital requirements. A bank defaults if its loan portfolio is worth less than deposit repayments.

The model features three sectors of production: non-durable goods, physical capital and housing. All sectors of production are standard. Consumption goods are produced by firms that combine capital rented from entrepreneurs and households labor. The production of new capital involves investment adjustment costs, as in Christiano *et al.* (2005). The production of housing is assumed to be similar to the production of physical capital. All firms operate in a perfectly competitive market and are owned by the patient households.

The policy tools present in the model are steady-state capital requirements, counter-cyclical capital buffers and risk weights.

2.2 Sources of Systemic Risk

Default plays a key role in the model. The external financing from all borrowers, including banks, takes the form of non-contingent (non-recourse) loans which are subject to default risk due to borrowers' exposure to both idiosyncratic and aggregate risk factors. For instance, bank default risk arises from imperfect diversification of the loans portfolio (idiosyncratic risk), and also from aggregate real and financial shocks that affect asset prices and the default risk of borrowers (aggregate risk). Defaults are costly in terms of aggregate economic resources.

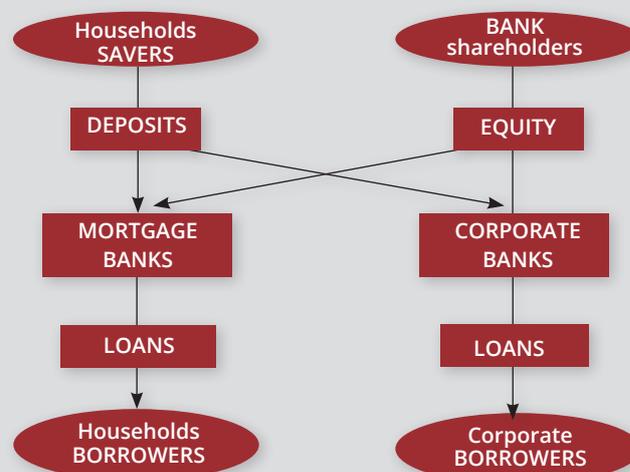


Chart 2.1.1•
Structure of the
Economy

Source: Authors' calculations.

Aggregate (exogenous) shocks that hit the model economy are amplified through two main channels: a bank capital amplification channel and a bank funding costs amplification channel. Equity funding required to satisfy the capital requirements is exclusively provided by bankers whose wealth comes from retained earnings (bank capital channel). Thus, the aggregate shocks that increase the likelihood that borrowing households and entrepreneurs default reduce bank capital. This limits the supply of bank credit, contributing to a further deterioration of the real economy and creating more defaults which further reduce bank capital. Aggregate shocks that destroy bankers' net worth cause the amplification and propagation of shocks.

Despite the presence of deposit insurance, depositors suffer transaction costs when banks fail. Depositors therefore charge banks for the perceived risk of bank failure (funding cost channel). Shocks that lead to a reduction of bank capital also increase banks' default probability. The fear of bank defaults raises bank funding costs, leading to a further deterioration in the real economy and thus, to an increase in banks' defaults.

The model demonstrates the operation of three interconnected net worth channels, all of which create the potential for amplification and propagation noted in various strands of the existing literature (including the channel operating through the price of housing, *i.e.*, the collateral used by the borrowing households), as well as distortions due to deposit insurance. While limited net worth typically leads to under-investment, the subsidization linked to deposit insurance creates the potential for an excessive supply of bank credit. Indeed, deposits are formally insured, providing an implicit subsidy to lending made by risky banks. Lending and defaults in the economy turn out to be excessive because bailout expectations increase the willingness of banks to lend cheaply. This implies excessive bank leverage and greater amplification in response to shocks.

3. Policy Exercises

The model presented above is suitable for a non-trivial welfare analysis of requirements imposed on bank lending activity, which is likely to be the core of macroprudential policy. In the following, we summarize the findings of three policy exercises.

For an illustration purpose, we parameterize the model such that it features a leverage of entrepreneurs and households of 70% and 75%, respectively. The annualized default rates by banks, entrepreneurs and households are about 2%, 3% and 0.35%, respectively. Capital requirements on corporate loans are 8% and a risk weight on mortgage loans is 50%. Note that the mechanism of the model is not affected by a particular parameterization, whereas the exact quantitative details strongly depend on the model calibration.

3.1 Higher Steady-State Capital Requirements

What are the macroeconomic and welfare effects of a permanent increase in the capital ratios? We address this question by relying on the model's long-run implications (deterministic steady state) of an increase in the CRs, beginning with the baseline CR of 8% on corporate loans and 4% on mortgage loans.

Chart 3.1.1 reports the social welfare gains as a function of the level of CRs. Social welfare gains are the weighted average of the steady state welfare gains experienced by each group of agents (saving and borrowing households, entrepreneurs and bankers). The weights are equal to the steady-state consumption share of each group of agents. The individual welfare gains are expressed in terms of consumption-equivalent measures, *i.e.*, the percentage increase in steady-state

consumption that would make welfare under the baseline policy (capital requirements on corporate loans of 8% and on mortgage loans of 4%) equal to the welfare level under the alternative CRs.

Chart 3.1.1 documents the sizable social benefits from increasing bank capital from low levels as well as the limited social costs of relatively high bank capital levels. CRs higher than the baseline levels correct the risk-taking incentives of banks and, thus, reduce both bank leverage and the risk of bank failure. A lower risk of bank failure increases the households' perception of safer banks, mitigating the intensity of the bank funding cost channel. The reduction in the cost of deposit together with a reduced social cost of default (bankruptcy cost) have a positive effect on the economy, which initially dominates. However, when bank default is close to zero, the negative effects stemming from the reduction in the supply of credit to the economy weakly dominate.

3.2 Shock Amplification under Different Capital Ratios

How are shocks transmitted under alternative capital ratios? To address this question, we hit the economy with a large depreciation shock, *i.e.*, a shock to the stock of housing and physical capital that implies a persistent collapse in both asset prices. We then explore the economy's response under different capital ratios (high vs low). For the transmission mechanism of other shocks, see Clerc et al (2014).

Chart 3.1 (left panel) reports the response of GDP under the optimal CRs (dashed line) as well as under the baseline CRs (starred line). It also displays the behavior of the model economy in the case of no bank default (solid line). This latter case assumes that banks are not subject to idiosyncratic default risk. Higher capital requirements (dashed line) mitigate the effects of the large decline in asset prices. Further, the economy mimics the dynamics of a no bank default economy.

The right panel of Chart 3.1 reports the response of the economy under low and high CRs in a high financial distress scenario, *i.e.*, 20% larger volatility in the idiosyncratic default risk of banks w.r.t. baseline. Banks that are subject to high financial distress exacerbate the negative effects of the shock. As a result, under the baseline CRs (starred line) the model displays substantial amplification. It is important to highlight that even in the case of high financial distress, higher CRs make the economy behave similarly to a no bank default economy.

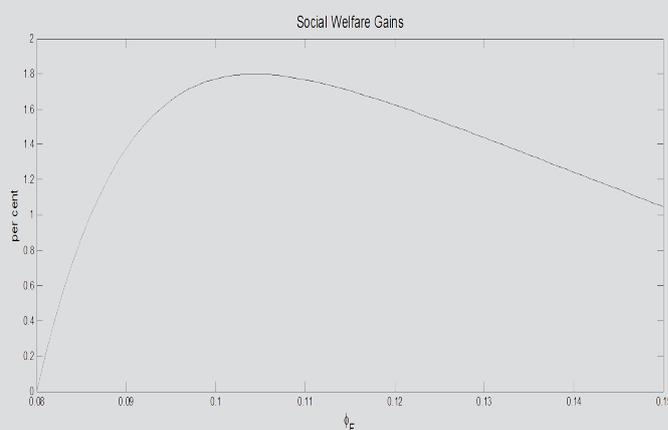


Chart 3.1.1 • Social Welfare Gains w.r.t. capital requirements on corporate loans (Φ_F), where capital requirements on mortgage loans are $\Phi_H = 0.5 \Phi_F$
In percentage points

Source: Authors' calculations.

3.3 CCB Release at Different Steady-State Capital Ratios

Can a capital ratio reduction help in a crisis? Chart 3.3.1 reports the response of GDP to a depreciation shock under constant CRs (dashed line) like in the previous analysis, and under CRs that are cyclically adjusted (solid line). In this latter case, the capital requirements vary according to the percentage deviation of total credit from its steady state level, in a symmetric fashion, with a coefficient of 0.3. We consider the behavior of the economy under low CRs (left panel) and high CRs (right panel).

Allowing for adjusting CRs in response to adverse shocks mitigates the reduction in credit supply but at the same time increases the risk of a bank default and the cost of funds for banks. Overall, we find that under high CRs, CRs that are cyclically adjusted result in a policy improvement. By contrast, a reduction in the capital ratio after a bad shock does not help to maintain economic activity under low CRs. When large negative shocks hit an economy with poorly capitalized banks, the positive effects of a more limited tightening in credit supply are somewhat beneficial in the short run, but the negative effects of greater risk of banks default dominate in the medium/long run.

4 . Summary

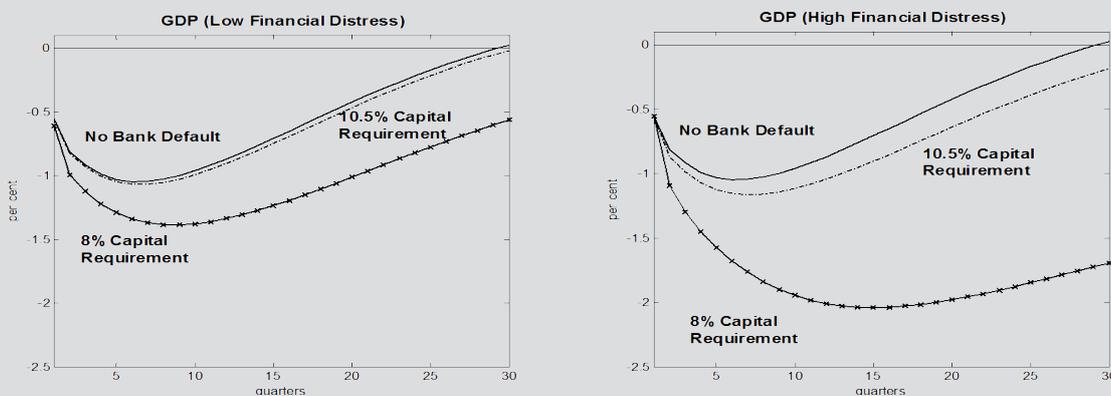
The model developed by Clerc *et al.* (2014) analyzes the effects of capital requirements on the steady state and on the transmission of shocks. A distinctive feature of the model is default risk for different types of borrowers and a clear rationale for capital regulation, which arises as a welfare improving response to excessive risk taking by banks.

Shock propagation and amplification is very large when bank risk is high and/or bank capital is low. High capital requirements eliminate the extra shock propagation coming from bank defaults.

Countercyclical response is only beneficial when high capital requirements are in place.

The model can be extended to allow for the possibility of securitization and liquidity risk (*e.g.* in the form of interim funding shocks suffered by banks). These extensions may allow for the

Chart 3.1 • GDP response to depreciation shock under alternative CRs and low (left panel) and high (right panel) financial distress | In percentage points



Source: Authors' calculations.

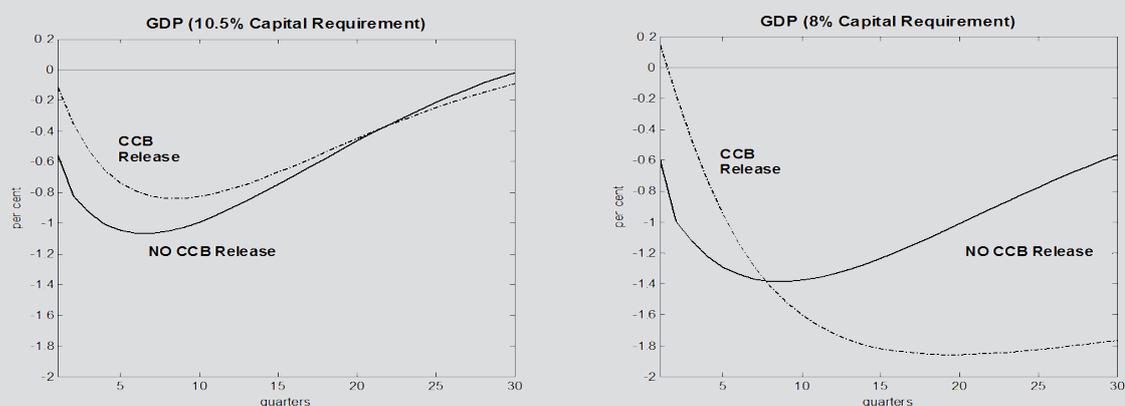
Source: Authors' calculations.

expansion of the analysis to the regulatory treatment of securitization, liquidity regulation, and the assessment of lending of last resort policies. While the basic model belongs to the class of non-monetary models, introducing nominal rigidities and a meaningful role for monetary policy constitutes a natural third possible extension that would allow us to assess the interactions between macroprudential policy and monetary policy.

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Chart 3.3.1 • GDP response to depreciation shock under constant CRs (starred line) or countercyclical adjustments of the CRs (dashed line) for low (left panel) and high (right panel) CRs



Source: Authors' calculations.

Source: Authors' calculations.

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Notes

1. This article builds upon the joint paper entitled "Capital Regulation in a Macroeconomic Model with Three Layers of Defaults". It also relates to the Banque de France, joint article "Macroprudential Capital Tools: Assessing their Rational and Effectiveness" (Financial Stability Review, 18, April 2014). The analyses, opinions and findings of this article represent the views of the authors, which are not necessarily those of the European Central Bank, the Eurosystem of Central Banks, the Banco de Portugal or any of the institutions with which we are affiliated. We thank Dominik Supera for his excellent research assistance.

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8. CEMFI.

9. Federal Reserve Board of Governors, Office of Financial Stability..

10. See http://www.ecb.europa.eu/home/html/researcher_mars_en.html.

11. The MaRS network conducted research in the following three areas: macro-financial models linking financial stability and the performance of the economy (WS1); early warning systems and systemic risk indicators (WS2); assessing contagion risks (WS3).

12. For a survey, see also the report of the Mars research network. See http://www.ecb.europa.eu/home/html/researcher_mars_en.html

13. For a discussion on the importance to introduce default in macro-models, see Geanakoplos (2011) and Goodhart, Tsomocos and Shubik (2013).

14. For the mathematical formulation of the model see Clerc *et al.* (2014).

15. This modeling feature has been introduced in macro models by Kiyotaki and Moore (1997) and extended by Iacoviello (2005) to a business-cycle framework with housing investment.