The Impact of Capital Requirements on the Macroeconomy: Lessons from Four Macroeconomic Models of the Euro Area*

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This paper examines the impact of higher bank capital requirements on the real economy. We find, using a range of macroeconomic models used at the European Central Bank, that, in the long run, a 1 percent bank capital requirement increase has a small impact on real activity. In the short run, GDP declines by 0.15 to 0.35 percent. When banks are able to reduce their voluntary capital buffers and dividend payouts and when monetary policy reacts strongly to inflation deviations from target, the real impact of higher capital requirements is significantly reduced.

JEL Codes: G28, E54.

1. Introduction

Since the global financial crisis, regulatory authorities throughout the world have sought to enhance the resilience of the financial system with a multitude of new regulatory measures. Most prominent among those have been efforts to increase the quantity and quality of loss-absorbing equity buffers. In addition, macroprudential policy authorities now have the responsibility to lean against the financial

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cycle using the countercyclical capital buffer among other measures. It is clear, therefore, that bank capital requirements will be a more actively used and adjusted policy tool in the future than in the pre-crisis period. This makes it imperative that policymakers build up a good empirical and theoretical understanding of the way capital requirements affect the macroeconomy.

The impact of bank capital requirements on the real economy, however, remains highly uncertain, with much less empirical evidence compared with the impact of monetary policy changes. This is what makes structural macroeconomic models useful. They can be parameterized to fit various features of the aggregate banking, financial, and macro data and then used to provide a quantitative evaluation of the impact of capital requirement changes on the macroeconomy.

Gauging the real impact of policy using models is also subject to considerable uncertainties, and any quantitative predictions hinge on whether the model used is a reasonable approximation of reality. This is why most central banks rarely rely on a single model but on a "suite of models" which provides a range of estimates based on different quantitative tools. While such informal consideration of "model uncertainty" is certainly a feature of practical policymaking, there have been few studies which have examined its importance in a more rigorous manner. Ours is the first paper that offers a detailed comparison of the predictions of different models for the impact of capital requirements on the macroeconomy.

We use four medium-scale macro models used for policy analysis at the European Central Bank (ECB). These are the Darracq-Pariès, Kok-Sorensen, and Rodriguez-Palenzuela (2011) model (hereafter known as DKR); the Darracq-Pariès, Jacquinot, and Papadopoulou (2016) model (hereafter known as DJP); the Mendicino et al. (2018) model (hereafter known as 3D because it models the defaults of banks, firms, and households); and the Coenen et al. (2018) model (hereafter known as NAWM II).[1] These models share a number of features but also differ in some important respects, allowing us to

[1]The abreviation stands for New Area-Wide Model with a financial sector. The version extends and reestimates the original NAWM model (2008).

compare their implications for the way the macroeconomy responds to a surprise increase in capital requirements.[2]

We subject each of the four models to the same capital requirements shock—a 1 percentage point (pp) increase in the minimum capital ratio, implemented gradually over one year and then very slowly (with 0.99 persistence) unwound back to the starting value. This is a very persistent (but not permanent) shock to the capital ratio, and we compare the implications of the four models for the impact of the policy on the real economy.[3] The nature of the shock process is chosen to capture the nature of macroprudential policy interventions which change bank capital requirements in a highly persistent but not permanent fashion. The one-year implementation period reflects the usual time given to banks to satisfy the higher capital requirements when macroprudential policy is adjusted.[4]

We find considerable similarities across the implications of different models for the way the economy responds to an increase in bank capital requirements. All models incorporate a strong link between bank capital and credit supply (the bank capital channel) and all generate some decline in lending on impact as banks restrict credit supply. This reduces aggregate demand and leads to a modest but significant fall in GDP (peak decline of 0.15–0.35 percent) despite

[2]The models are chosen for two main reasons. First, their use in macroprudential policy simulations in the euro area makes a formal comparison of quantitative implications useful. Second, despite some similarities, the models feature several different mechanisms, which makes our comparison very didactic in highlighting the role of key model features in the transmission mechanism of capital requirement changes.

[3]We implement an exogenous shock to capital requirements rather than responding to a given "risk scenario" for a number of reasons. First, it is difficult to design a boom-bust scenario that affects different models in the same way. Second, we consider the marginal response of the economy to a capital requirements change and this is invariant to the initial condition (steady state or a "risk scenario") for the parameterization we have and for the relatively small shocks we consider. A full non-linear solution of the models that would permit the analysis of state-dependent effects of macroprudential measures throughout the entire state space is not possible for medium-scale dynamic stochastic general equilibrium (DSGE) models such as ours. For some recent examples of non-linear structural models incorporating macroprudential policy, see Adrian and Boyarchenko (2012), Darracq Pariès, Kok, and Rottner (2020), and Van der Ghote (2021).

[4]The implementation speed will be the subject of one of our sensitivity exercises.

the reaction of the monetary authority which lowers nominal interest rates.

There are, however, several interesting differences in both the short- and medium-term behavior of the different models.[5] In the medium term, the 3D model generates no decline in output, while the other models do. We show that this is due to the presence of bank failure risk in the 3D which is reduced by the higher capital requirements with a positive effect on economic activity in the medium term. In contrast, the other models either do not incorporate bank default or calibrate it to zero, thus eliminating this potential impact of the increase in bank capital requirements.[6]

In the short run, all models feature some degree of credit crunch as capital requirements increase. Each different framework, however, incorporates its own (mostly distinct) channels which allow the economy to adjust to higher capital requirements without a large decline in lending.

In the DJP and DKR models, banks reduce their voluntary buffers over the transition, thus smoothing bank loan supply. In the 3D model, bank capital ratios are always binding but banks reduce dividend payouts (or issue new stock), thus speeding up the accumulation of equity through retained earnings. And in the NAWM II and the 3D model, the corporate sector is able to replace some (though not all) of the lost bank funding with non-bank credit.

Sensitivity analysis shows that all of these built-in adjustment mechanisms are crucial in dampening the impact of higher capital requirements on the real economy. If banks are unwilling or unable to change capital buffers or dividend policy, this would result in a deeper contraction of lending and activity.

We also find that monetary policy choices are important in determining the real impact of an increase in capital requirements. The short-run negative impact is diminished by a stronger Taylor-rule response to inflation deviations from target because this counters

[5]For the purposes of this paper, we define the "short term" as the first 2–3 years after the policy change and "medium term" as 5–10 years after the policy change.

[6]The DJP framework models voluntary buffers by a cost of being undercapitalized. As banks build up large voluntary buffers, their probability of default goes to zero in equilibrium.

more effectively the decline in aggregate demand due to the macroprudential tightening. Equally, a weaker response (e.g., due to a binding zero lower bound (ZLB) on nominal interest rates) will increase the costs of higher bank capital requirements. While space and computational constraints preclude the analysis of the effects of the ZLB, this has been considered in detail in Mendicino et al. (2020) using a variant of the 3D model.[7]

Finally, phasing in the increase in capital requirements over a longer period also diminishes the negative short-run real impact of the policy change because it gives banks more time to react in ways other than cutting lending. This may be especially important when the costs of issuing equity are high.

The quantitative predictions of our models for the impact of bank capital requirements on lending and GDP fall easily within the wide range of estimates found in the empirical literature. The studies we surveyed found a 0–4 percent range for the peak lending reduction from a 1 pp increase in bank capital requirements and a 0.1–1.2 percent range for the peak impact on GDP. The wide range of estimates reflects both the difficulties in identifying exogenous variation in bank capital ratios as well as the different countries and time periods used for the different studies. Thus at least part of the wide range of empirical estimates comes from the fact that the real impact of capital requirements is likely to be state dependent. This motivates our extensive sensitivity analysis over key inputs which may vary in practice over different countries and over time.

There are also a number of papers that examine the implications of different models for the response of the macroeconomy to other shocks or economic policies. Coenen et al. (2012) compares the fiscal multipliers across a number of structural macro models. The paper finds that the different models have relatively uniform implications for fiscal multipliers which are large and positive.

Also related to our work is Guerrieri et al. (2019), which compares the impact of large banking-sector losses (12 percent of GDP) across several structural models. The models have very different

[7]We also abstract from issues related to the open economy and to cross-border spillovers from macroprudential measures. These issues have been analyzed by Darracq Pariès, Kok, and Rancoita (2019), who find significant effects of bank capital changes on economies with close trade and financial links.

predictions for the resulting recession, ranging from 1 percent in the Gertler, Kiyotaki, and Queralto (2012) model to 5 percent in the Iacoviello (2015) model. The paper identifies several important transmission channels which determine the size of the output costs of such a crisis event. The presence of a production sector which can obtain non-bank funding, the ability and cost of issuing equity for banks, and the labor supply elasticity are all shown to be important factors in the transmission of banking sector losses to the real economy.

Our results are consistent with theirs in that we find that having the flexibility to adjust financing sources for the corporate sector is an extremely important factor in determining the reaction of the economy to higher capital requirements. In addition, we stress the importance of banks' flexibility in adjusting capital buffers for the impact of capital requirements on bank credit.

The rest of the paper is organized as follows. Section 2 first outlines the main features of the four models we use for our exercise. Section 3 analyzes the range of equilibrium outcomes implied by the different macro models following an increase in bank capital requirements. Section 4 examines the sensitivity of the model implications to a number of alternative assumptions, and Section 5 concludes.

2. The Models Used

At the ECB, there are four medium-scale DSGE models used to analyze the impact of bank capital requirements: the DKR model, the DJP model, the NAWM II model, and the 3D model. A full account of their structure is impossible within the confines of this paper and the reader is referred to Appendix A, where we provide a brief description of each model, as well as to the papers describing the models in detail.[8]

In this section, we focus our discussion on the key features of the different models which determine their properties in response to a

[8] All the models we use are models of the aggregate euro area, and the capital requirement exercise we conduct assumes that all member countries are affected in the same way by the policies. For analysis of euro-area heterogeneities in the transmission of macroprudential policy, see Darracq Pariès, Jacquinot, and Papadopolou (2016) and Darracq Pariès, Kok, and Rancoita (2019).

Table 1. Key Model Characteristics

	NAWM II	DKR	DJP	3D
Bank Failures	No	No	Yes	Yes
Issue New Equity/Vary Dividends	No	No	No	Yes
Change Voluntary Capital Buffers	No	Yes	Yes	No
Non-bank Funding Sources for Firms	Yes	No	No	Yes

surprise increase in capital requirements. These key features are summarized in Table 1, and they concern mostly the long-term impact of capital requirements on the banking system as well as financial institutions' ability to adjust their balance sheets in response to an increase in capital requirements without reducing lending.

2.1 Costly Bank Failures

The first row of Table 1 shows which models explicitly feature bank failures. This is important because making banks safer is an important aim of macroprudential policy and a key benefit of tighter capital regulation. The table shows that bank failures are present in the 3D and DJP models, although they only play a prominent role in the former. The DJP model calibrates the probability of bank failure to zero.

This difference between the prominent role of bank default in the 3D model and its limited role in the other three models will prove to be important in explaining the differences in the various models' implications for the way the economy responds to higher capital requirements in the medium term.

All four models have the feature that equity is more expensive than debt in the sense that it has a higher risk-adjusted return. This is because equity in these models can only be held by a subset of households (called "Bankers"). Because the wealth of these households is scarce, this keeps the cost of equity above that of deposits because the latter can be held by all households. Consequently, increasing bank capital requirements raises the weighted average cost of bank funding since it forces financial institutions to move towards more expensive liabilities. A higher weighted average cost of capital then pushes up the cost of loans to firms and households, leading to lower output and lending volumes in the medium term.

The presence of positive bank default in the 3D model introduces another channel which is not present in the other frameworks—the bank debt funding cost channel. In the 3D model, a part of bank debt liabilities are uninsured and carry a default risk premium. Higher bank capital requirements reduce default risk and reduce the cost of uninsured bank debt, thus helping to bring down weighted average bank funding costs.

When the risk of bank failure is sufficiently high, the bank funding cost channel actually dominates the traditional liability composition channel. Hence better capitalized banks are able to provide credit at lower interest rates, helping to actually increase economic activity in the long run. As we will see in the next section, the presence of a positive bank default probability in the 3D model will be important in explaining why capital requirements do not lead to lasting reductions in real economic activity.

2.2 Flexible Bank Balance Sheets

The previous section outlined the channels through which capital requirements affected lending and economic activity in the medium term. The short-run impact can, however, be driven by very different factors. If bank equity is fixed (and equal to the wealth of "Banker" households) and bank capital requirements bind, an increase in the minimum capital ratio requires an almost exactly offsetting reduction in lending volumes in the short term. Over time, all models imply that banks will grow their net worth through retained earnings and recover some (or most) of the losses in lending. But in the short run, the credit crunch could be substantially more severe if banks have few options to adjust their balance sheets.

The second and third rows of Table 1 show two possible ways banks can react to the policy change without cutting lending. These are captured in some but not all of the models, and they will be very important in determining the short-term reaction of bank loans to changes in the minimum capital requirement.

The possibility to cut dividends, thus speeding up earnings retention (or issue equity),[9] is present in the version of the 3D model we

[9] In an aggregate model with ex ante identical banks, reducing dividends and issuing new equity are equivalent. In both cases, there is an additional transfer of wealth from households to banks.

have used for the exercise. It allows the banking sector to decrease the amount of funds it transfers back to the aggregate household by paying a convex cost. This ensures that net payouts to the household sector decrease in times when bank equity is particularly valuable, such as after a capital requirement increase which makes lending scarce and therefore more profitable. Banks pay fewer dividends despite the increased cost of doing so because the higher lending-deposit interest rate spread increases the value of internal funds. In general equilibrium, this ensures that lending volumes recover faster than they otherwise would have done under a constant dividend policy.

In practice, banks also maintain voluntary capital buffers over the minimum buffers required by regulation. This means that banks can absorb some of the increase in minimum capital requirements by temporarily reducing their voluntary capital buffers without cutting lending very much. This feature is present in the DJP and DKR models, while the other two models (3D and NAWM II) feature binding minimum capital requirements. In the DKR model, banks are able to vary their capital ratios subject to a quadratic cost. In the DJP model, banks have to meet their capital requirements also after shocks are realized. Hence, banks must ensure that they keep a voluntary buffer over and above the minimum to avoid paying a regulatory compliance cost when they are audited ex post by the supervisory authorities. Banks in the DJP model optimally choose leverage to trade off higher profits from additional lending against the greater probability of having to pay regulatory compliance costs if a shock pushes their ex post capital ratios below the regulatory minimum.

When bank capital requirements increase, the resulting reduction in credit supply leads to higher lending margins, encouraging banks to reduce their voluntary buffers in order to take advantage of the improved profitability of new loans. As we will see in the next section, the ability of banks in the DJP and DKR models to vary their voluntary capital buffers helps to smooth the impact of an increase in minimum bank capital buffers on loan supply. The 3D and NAWM II models do not model voluntary capital buffers and generate somewhat more abrupt changes in lending volumes.

2.3 Non-bank Funding Sources for the Corporate Sector

Finally, the fourth row of Table 1 shows that in the 3D and NAWM II models, non-bank funding sources can further help to shield the real economy from the tightening of bank loan supply. In contrast, the DJP and DKR models assume that investment is entirely conducted by firms which depend on bank credit for their operations.

Both NAWM II and 3D models introduce non-bank funding in a very simple way following the approach in Gertler and Karadi (2011). Productive capital can be held by specialized bank-credit-dependent entrepreneurial firms or directly by the aggregate household. However, when the capital is directly held by the aggregate household, it is subject to a management cost which is increasing in the total amount of directly held capital in the economy. This setup is justified by the fact that only certain firms can easily issue corporate bonds or stocks which can be directly held by the household. For smaller or more opaque firms, bank loans and privately held equity are more appropriate. Transferring the equity or debt of such firms into the hands of households would only come at some expense, which is what the management cost captures.

In the end, the presence of non-bank funding sources for the corporate sector will soften the impact of lending reductions on investment. This will tend to dampen the short-term impact of a capital requirements increase on the real economy.[10]

3. Bank Capital Requirements and Real Economic Activity

3.1 The Capital Requirement Increase Exercise

In the previous section, we discussed the key modeling features which matter for the transmission mechanism of a capital requirement increase. We are now ready to introduce the quantitative exercise of our paper.

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[10] An alternative less benign interpretation is that “macropru leaks” as discussed in Aiyar, Calomiris, and Wieladek (2014). Higher capital requirements may lead to lending being diverted towards foreign banks or “shadow banks.” This would soften the negative real impact of the policy but would also fail to effectively mitigate systemic risk.

We subject each of the four models to the same capital requirement shock—a 1 pp increase in the minimum capital ratio, implemented gradually over one year and then very slowly (with an autocorrelation coefficient of 0.99) unwound back to the starting value. So this is a very persistent (but still temporary) shock to the capital ratio. The scenario is designed to capture macroprudential policy interventions which are usually pre-announced (hence the one-year phase-in period) and highly persistent but not permanent (hence the 0.99 persistence).

Each of the four models feature the same simple Taylor-type monetary policy rule which has been estimated for the euro area by Coenen et al. (2018).

$$i_t = \phi_i i_{t-1} + (1 - \phi_i) [\phi_\pi (\pi_t - \pi^*) + \phi_{dy} (y_t - y_{t-1})],$$

where $\phi_i = 0.95$ is the degree of interest rate smoothing, $\phi_\pi = 2.5$ is the response to inflation deviations from target, and $\phi_{dy} = 0.1$ is the response to output growth deviations from trend.

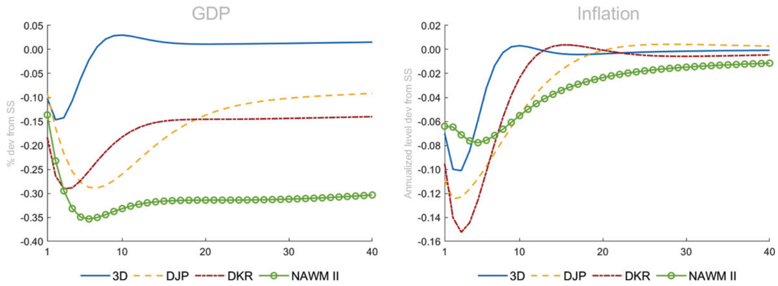
Throughout the section, we will compare the implications for the real economy impact of the policy in the four models. We will focus on a set of "executive summary" charts covering only the most important variables (output, inflation, total lending, consumption, and investment). In Appendix B, there is a full set of impulse response functions (IRFs) covering all variables.

3.2 Comparing the Four Models

We start with Figure 1, which documents the impact of the capital requirement change on GDP and inflation. There are several noteworthy features of the results. The negative macroeconomic impact of the increase in capital requirements is significant but not overly large in all the models. It is somewhat smaller and far less persistent in the 3D model than in the DJP, DKR, and NAWM II models. The impact on annualized inflation is modest and disappears within 8–10 quarters in all models due to a flat Phillips curve.

In what follows, we sketch out the transmission mechanism that aggregates up to the dynamic responses in Figure 1. We do this by comparing the reaction of several other key variables in the models which help us identify the way in which higher capital requirements propagate through the economy. We start first with the way that

Figure 1. GDP and Inflation



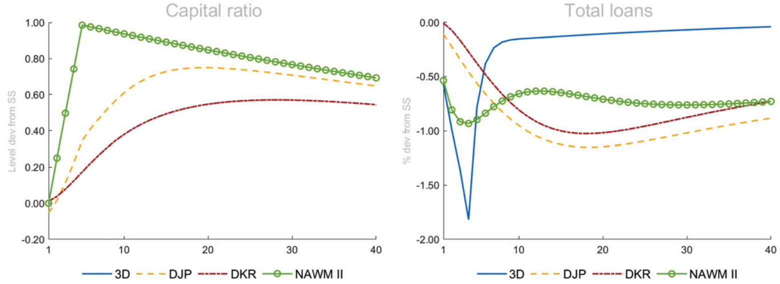
higher capital requirements affect bank loan supply before outlining the models' implications for the way bank lending transmits to the demand components and real GDP in the four models.

3.3 The Impact of the Capital Requirement Change on Bank Credit Supply

We start with the banking sector, which is affected directly by the increase in minimum capital requirements. Figure 2 shows the way banks adjust their actual capital ratios and what impact this has on lending. The path of the minimum capital ratio is shown by the green line. (For figures in color, see the online version of the paper at http://www.ijcb.org.) It is labeled NAWM II because the capital ratios in the NAWM II and 3D models exactly follow the regulatory minimum.

In the DKR and DJP models, there are endogenous voluntary buffers above the minimum capital requirement. At all times, banks in these two models face a trade-off between larger profits if they reduce their buffers and increase lending and a higher probability that their capitalization falls below the minimum with significant associated costs. The higher minimum capital requirements would lead to a large fall in lending and a big increase in lending spreads if banks maintained their previous buffers. The higher potential profits from a marginal unit of loans persuade banks to shrink their buffers while the financial system as a whole accumulates equity through retained earnings in reaction to the shock. This means that actual capital requirements increase gradually and reach the new minimum

Figure 2. Bank Capital Requirement and Total Loans



Note: The minimum regulatory capital requirement is binding in the 3D and NAWM II models.

only in the "medium term" (which, for the purposes of the current discussion, we define to be 40 quarters after the policy change).

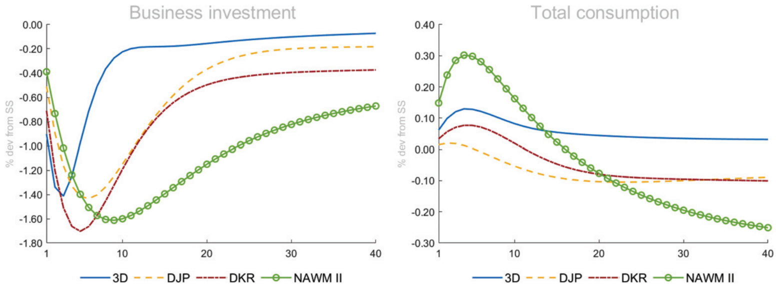
In addition, the DKR and DJP models feature sticky lending interest rates, which smooths the increase in lending spreads and hence the fall in bank lending in equilibrium.

In the 3D and the NAWM II models, the capital requirement always binds and the actual capital requirement follows the minimum. This leads to a sharper decline in lending, other things equal. However, these two models feature other mechanisms which dampen the impact of capital requirements on bank lending.

In the 3D, higher capital requirements make banks safer, leading to lower uninsured debt funding costs which are passed on to borrowers by competitive banks. This means that lending is broadly unchanged in the medium term, whereas it falls in the other models which either do not model bank defaults (NAWM II and DKR) or calibrate bank default to zero (DJP). In the 3D model, the risk of bank default is calibrated to approximately 0.8 percent (the average for euro-area banks since 2001), and this implies considerable benefits from increasing capital requirements to make banks safer.

In the short term, banks in the 3D model reduce dividend payouts, speeding up earnings retention. Dividend cuts are assumed to be costly for banks, reflecting the observed smoothness of dividends in reality. However the value of additional retained funds increases after a capital requirement increase because lending spreads are very high while credit is restricted. Banks accumulate funds rapidly both

Figure 3. Business Investment and Total Consumption



on the back of stronger profitability as well as due to lower dividend payouts. Lending supply recovers quickly and is back to its starting value within a year.

In the NAWM II model, debt is long term, so capital requirements reduce the debt stock only very gradually. There too loan interest rates are sticky, helping to avoid sharp movements in spreads.

Overall, the models produce relatively similar short-term declines in lending. In the estimated NAWM II, DKR, and DJP models, lending falls more gradually than in the calibrated 3D model, but the differences in peak responses are not overly large. Where the models do differ very strongly is in the medium-term impact of capital requirements on the real economy.

In the DJP, DKR, and NAWM II models, there is a very persistent decline. In the 3D model, lending and bank capital recover and are broadly unchanged in the medium term due to benefits for the economy as bank default declines. This is a channel which has been strongly stressed in Clerc et al. (2015) and Mendicino et al. (2018). We will be exploring further how the capital requirements impact is affected by this channel in subsequent sensitivity analysis.

3.4 The Impact of Bank Loan Supply on Aggregate Demand Components

As Figure 3 shows, reduced lending affects investment demand by firms and consumption demand by households through very standard transmission channels.

The corporate sector relies on bank credit for most of its funding, and the rise in the cost and reduction in the availability of bank lending cause a reduction in investment demand. However, the 3D and the NAWM II models also model non-bank funding which can be accessed but at an additional cost which grows with the size of non-bank funding. This cost is meant to reflect that, in practice, not all firms have access to the bond market on the same terms. For example, smaller and more opaque firms will find it more difficult or more costly to access public debt markets directly. Nevertheless, in an environment of reduced bank credit, some of these non-bank sources of funding expand to some extent, helping to moderate the fall in overall credit to the corporate sector.

Ultimately, business investment in the four models experiences a decline which reaches around 1.5 percent at its peak. Again, there is little difference between the models in the first few quarters. Further out, investment recovers most of its fall in the 3D model and continues to be depressed for four to five years in the DKR, NAWM II, and DJP models.

The fall in bank credit hits some parts of the household sector as well. In all models apart from the DJP and NAWM II, there is an impatient household which is a borrower in equilibrium and whose demand for non-durables and housing depends on bank credit. The higher cost and lower availability of bank lending leads to a fall in the expenditure of this "borrower" household.

However, as Figure 3 reveals, overall consumption increases over the adjustment path to the capital requirement policy change. This is due to the strong increase in the consumption and housing demands of saver (patient) households whose demand strengthens on the back of lower nominal and real interest rates.

Monetary policy is governed by the same Taylor rule in all the models, and nominal interest rates are driven by inflation deviations from target and by deviations of output growth from trend. The weakness of output and inflation therefore lead to a relaxation of monetary conditions, and savers who do not depend on bank lending increase their expenditure, helping to partially offset lower investment demand.

The endogenous response of monetary policy is an important determinant of the way lending restrictions affect final economic activity. We will return to this later in the paper when we examine how differences in the responses to inflation deviations from target affect the real impact of capital measures in the four models used in the paper.

3.5 Summary of Results and Comparison with Other Studies

The capital requirements increase exercise of this section showed that a macroprudential tightening can be expected to lead to a small decrease in lending and real activity in the short term. When banks are able to decrease their voluntary buffers or their dividend payouts, the fall in lending should be smaller and not very long-lived. Having deep and well-developed non-bank sources of debt funding will further reduce the impact of the lending contraction on investment and real activity.

It is also useful to put our results in the context of other studies. Table 2 reports the peak lending and GDP responses from the four ECB models (the top panel of the table) alongside alternative estimates. We surveyed a large number of studies, ranging from other DSGE models (the second panel of the table) to empirical studies based on either VAR models or bank panel regressions (the bottom panel of the table).

Overall, our four models produce comparable short-term effects on lending and GDP to those found in the literature. The four models generate a similar impact of capital requirements on the macroeconomy to those seen in other structural models, though with a slightly larger peak impact on GDP. The empirical studies we survey in Table 2 generate a much wider range of estimates of the impact on lending and GDP, and our models fall easily within this range.

When comparing structural models like the ones presented in this paper with more reduced-form empirical models (such as VARs or panel regressions), a number of important features distinguishing the different approaches should be kept in mind.

First of all, our models feature a representative euro-area banking system, while many of the empirical studies are based on individual countries in or outside the euro area. The wide range of empirical estimates may therefore arise due to differences between the countries on which the studies are based. Indeed, empirical studies document that the impact on lending to an increase in capital

Table 2. Macroeconomic Impact of Increasing the Capital Ratio by 1 pp

Model/Study	Lending Reduction	GDP Reduction	Country	Sample Period
DJP	1.15	0.29	Euro Area	2001–2016
DKR	1.03	0.29	Euro Area	2001–2016
NAWM II	1.26	0.36	Euro Area	1985–2014
3D	1.52	0.14	Euro Area	2001–2016
Other Structural Models:				
Angelini and Gerali (2012)		0.5 [0–0.36]	Euro Area	
Basel Committee on Banking Supervision (2010)		0.09	13 OECD Countries	
Macroeconomic Assessment Group (2010)	1.4	0.1–0.15	17 OECD Countries	
Roger and Vitek (2012)		0.11 [0.09–0.24]	15 Advanced and Emerging	
Slovik and Cournède (2011)		0.2	3 OECD Countries	
Empirical Studies:				
Bridges et al. (2014)	3.5		United Kingdom	1990–2011
De-Ramon et al. (2012)	1.6	0.3	United Kingdom	1992–2010
Fraisse, Lé, and Thesmar (2015)	1.8		France	2008–2011
Mesonnier and Monks (2015)	1.2		European Union	2012
Meeks (2017)	2.0–4.5	0.3	United Kingdom	1975–1989
Miles, Yang, and Marcheggiano (2013)		0.25*	United Kingdom	
Noss and Toffano (2014)	1.4		United Kingdom	1986–2008
Suturova and Teply (2013)	1.4–3.5		Europe	2006–2011
Mora and Logan (2012)	0.0–2.4		United Kingdom	1990–2004
Sivek and Volk (2017)	0.4–3.6		Slovenia	2009–2015
De Jonghe, Dewachter, and Ongena (2020)	0.4–2.1		Belgium	2013–2015
Carlson, Shan, and Warusawitharana (2013)	–0.36–1.25		United States	2001–2011
Gross, Kok, and Zochowski (2016)	0.2–4.5	0.1–0.6	EU Countries	1999–2014
Kanngiesser et al. (2020)	1.0–2.5	1.0–1.2	Euro Area	2005–2017
Imbierowicz, Loffler, and Vogel (2021)	0–1.7		Germany	2008–2018
D'Erasmo (2018)		0.15–0.6	United States	1996–2016

*Effect of a 1 percent increase in the cost of capital.
Note: Results are reported in percentage deviation from steady state. DKR and Roger and Vitek (2012) are also included in the suite of models used in Macroeconomic Assessment Group (2010).

requirements depends on factors such as the initial level of bank capitalization, the size of voluntary buffers, the risk profiles of banks, and their profitability.[11] As these factors vary at country level, this would add to the range of estimated macro impacts.

There are relatively fewer empirical studies that also provide a relevant GDP impact, and those that do tend to be based on VAR modeling approaches. D'Erasmo (2018) surveys a number of empirical estimates and finds a 0.15–0.6 percent range for the peak impact of a 1 pp increase in bank capital requirements on GDP. These quantitative magnitudes (as well as those from other studies) tend to be broadly in line with those of the four DSGE models presented in this paper, although some of the VAR-based approaches have somewhat larger quantitative effects.[12] This may indicate either that the models generate an impact which is somewhat smaller or it may indicate the difficulties and uncertainties in identifying pure capital requirement policy shocks on the basis of aggregate data.[13] In the end, the empirical estimates in the VAR literature remain subject to some uncertainty, and we consider our models' implications as broadly consistent with the available empirical evidence.

4. Sensitivity Analysis

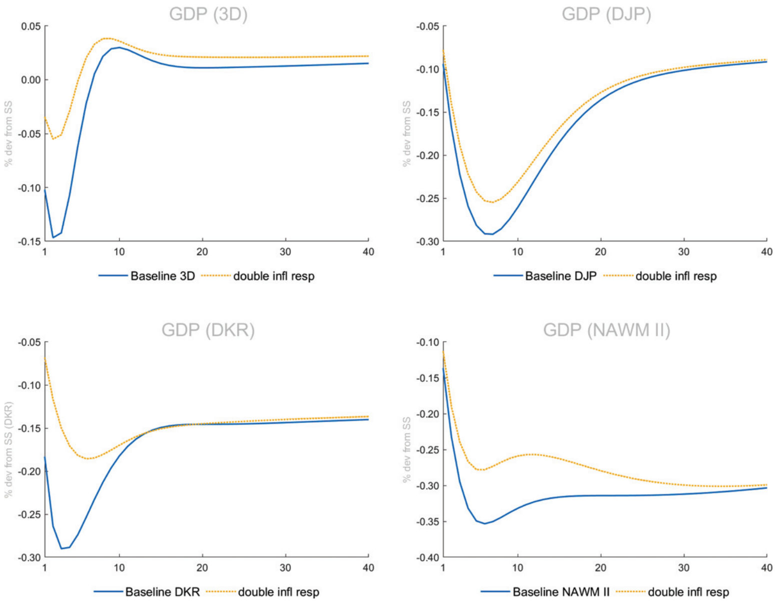
In the previous section we reported the implications of the four baseline models. This section performs some sensitivity analysis along several important dimensions. We first vary the monetary policy rule. We then examine the sensitivity of our results to the key factors we highlighted in the previous section—the cost of varying voluntary capital buffers (in the DKR and DJP models), dividend payouts (in

[11] This has been illustrated on both U.S. data (e.g., Berrospide and Edge 2010) and European data (e.g., Gambacorta and Mistrulli 2004). For an overview of more recent empirical estimates on European data, see Budnik et al. (2020).

[12] This finding is consistent with other model comparison studies, such as the Interim Report of the Bank for International Settlements' (BIS) Macroeconomic Assessment Group (2010).

[13] Empirical models often employ various identification schemes to uncover exogenous capital ratio shocks. This is indeed the approach traditionally followed to identify exogenous monetary policy shocks in the very well-established empirical literature on monetary policy transmission. However, following this approach in the case of macroprudential policy is hard because, unlike nominal interest rates, banks' capital ratios are endogenous variables and not a policy choice.

Figure 4. GDP in the Four Models



the 3D model), as well as the riskiness of the banking system (in the 3D and DJP models).

4.1 The Conduct of Monetary Policy

We start by examining the way changing the conduct of monetary policy alters the behavior of the real economy in response to a capital requirement increase. More specifically, we double the reaction coefficient to inflation deviations from target and examine how the change in the policy rule affects behavior both across models and across variables in each model.

Figure 4 focuses on the evolution of GDP. Each panel of the graph focuses on a particular model. The blue solid line within each panel is the baseline IRF while the yellow dotted line is the IRF in which the reaction coefficient to inflation has been doubled. The figure shows clearly that a stronger monetary policy response mitigates the costs of the capital requirements increase.

The responses of other variables (shown in Appendix B) show that the stronger monetary reaction results in a larger reduction in real interest rates in all models, helping to boost the consumption of leveraged households and the investment demand of bank-dependent firms. This moderates the fall in aggregate demand, helping economic activity to recover faster.[14] Of course the power of monetary policy to stabilize inflation does depend strongly on forward-looking behavior and may be considerably weaker if agents are myopic or backward looking in the way they form expectations.

4.2 The Fragility of the Banking System

The riskiness of the banking system is another important factor which changes the real impact of capital requirements. In this section, we use the 3D and DJP models in order to understand how the baseline responses change when we increase the default risk of banks to a 2 percent annual probability.[15] Figure 5 presents a summary of the results of this sensitivity exercise. Appendix B contains a full set of impulse responses covering other variables in the models.

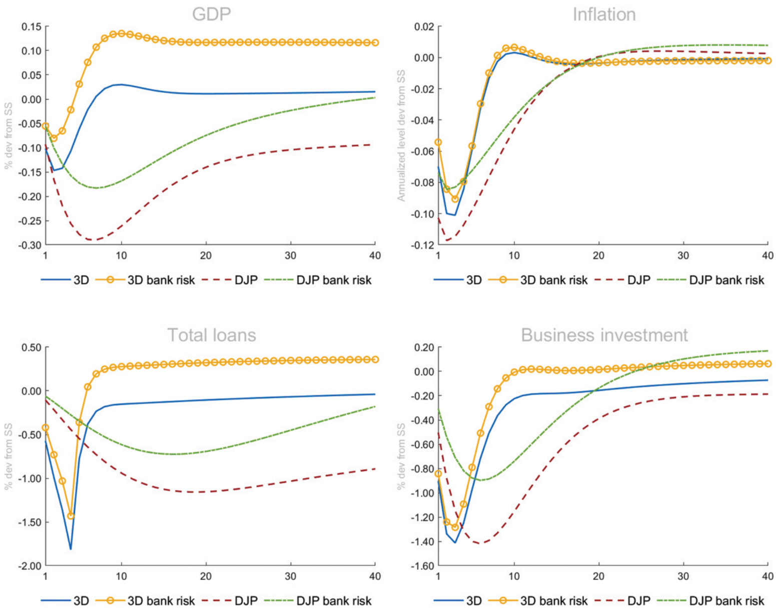
The main message of the sensitivity exercise is that both models deliver higher long-term lending and economic activity as well as smaller transitional costs in the case when bank risk is high. This is consistent with the findings in Mendicino et al. (2020), which shows that a capital requirements increase is less costly in the short term and more beneficial in the long term when the banking system faces higher default risk.

The intuition for this finding is that when bank capital requirements increase, banks become safer and the required interest rate on uninsured lending falls, which stimulates lending and economic activity, other things equal. This effect is stronger in the long term when banks have accumulated more capital through retained earnings. The lower funding cost is passed on to borrowers, expanding economic activity.

[14] This exercise also carries lessons for changing capital requirements when the effective lower bound (ELB) on nominal interest rates is binding. Due to a weaker reaction of monetary policy, the ELB increases the costs of increasing capital requirements. This is discussed in more detail in Mendicino et al. (2020).

[15] This is implemented by increasing the volatility of bank-idiosyncratic risk, which increases the proportion of banks that fail in each time period. As we model the aggregate euro area, the experiment implicitly assumes that all euro-area countries are affected by the increase in bank risk in the same way.

Figure 5. Sensitivity with Respect to Bank Risk by Increasing the Std. of the Idiosyncratic Bank Shock



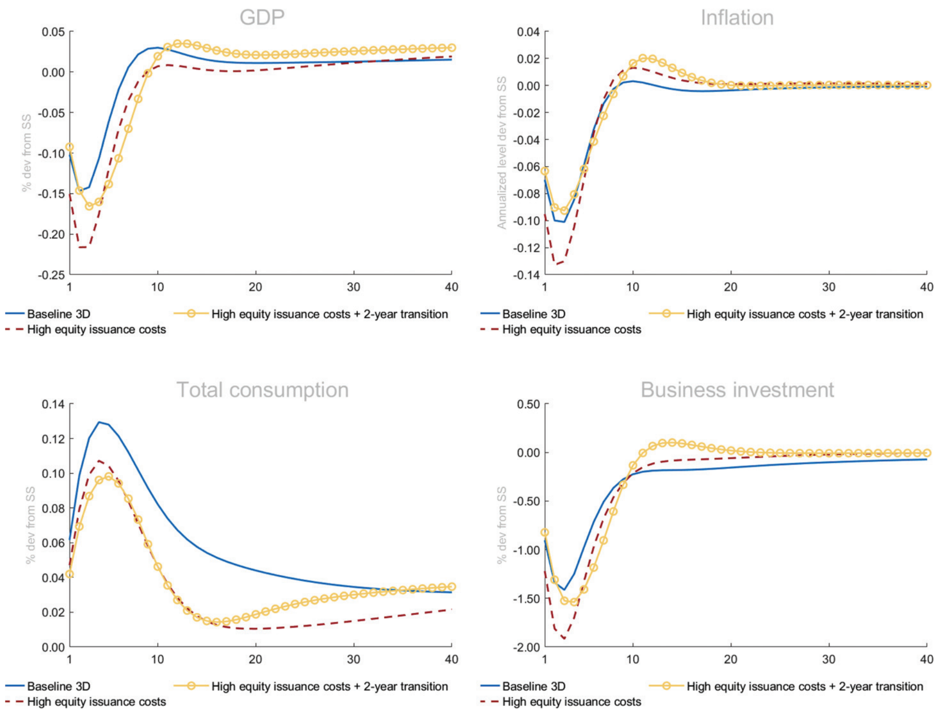
Perhaps more surprisingly, output falls by much less in the short term in the case of high bank risk. As discussed in Mendicino et al. (2020), this is due to the behavior of forward-looking firms and households who increase demand immediately in anticipation of the future benefits from a reduced risk of financial instability. Here again, we note the caveat that the strength of this channel depends strongly on forward-looking behavior.

In the end, both models are consistent with the view that warranted capital requirement increases (i.e., when bank risk is high) are likely to be less costly than unwarranted ones (i.e., when bank risk is low). This underlines the importance of modeling the costs of financial instability in models used for macroprudential policy analysis.

4.3 The Cost of Reducing Dividends and the Length of the Phase-in Period in the 3D Model

In the previous section, we found that it was less costly to increase capital requirements in riskier banking systems due to the positive

Figure 6. Sensitivity with Respect to Cost of Varying Dividends (issuing equity) and the Length of Phase-in Period in the 3D



reaction of consumers. One counter-argument against this benign view is that riskier banks may find it harder or costlier to raise equity or reduce their dividend payouts. In this section, we therefore examine the sensitivity of the transmission mechanism to the dividend adjustment cost paid by the household in the 3D. In what follows, we use the terms "dividend reductions" and "equity issuance" interchangeably because, in an aggregate model like ours, reducing dividend payouts and issuing new equity have an identical effect on the real economy and the banking system. We want to examine the extent to which making equity issuance more expensive for banks would also raise the short-term macroeconomic costs from tighter macroprudential policy.

Figure 6 compares the baseline simulation with the case where the cost of adjusting dividends (or issuing equity) is doubled relative to the baseline calibration so that the net payout ratio to the aggregate household is smoother and bank net worth accumulation has to rely primarily on retained profits. Motivated by the long phase-in period allowed when Basel III was implemented, we also include a simulation in which the cost of issuing equity is doubled relative to the baseline but the phase-in period of the capital requirement increase has been increased to two years instead of one in the baseline.

Doubling the cost of changing dividend payouts (or the cost of issuing fresh equity) boosts the short-term output cost of the capital requirement increase. Lending and business investment decline by a greater amount, feeding into lower output and inflation. Looser monetary policy (not shown) helps to stimulate consumption, but this is not sufficient to offset the negative impact of the lending reduction on aggregate demand and economic activity.

Doubling the phase-in period for the capital requirement increase to two years (shown in the yellow circles) broadly offsets the impact of higher equity issuance costs. The longer phase-in period dampens the lending impact of higher capital requirements and compensates for the reduced willingness of banks to lower dividends or issue equity. This simulation demonstrates that macroprudential authorities could mitigate some of the costs of higher capital requirements on the real economy if they choose a longer implementation period. This is particularly valuable when banks have difficulties in varying dividend payouts or issuing fresh equity.[16]

5. Conclusions

This paper compares the implications of four macroeconomic models for the impact of a 1 pp persistent increase in bank capital requirements. We find that in the short term output falls by between 0.15 and 0.35 pp while in the medium term the impact ranges from a small decline to a small increase in real activity, depending on whether bank default is modeled or not.[17]

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[16]Worries about banks' ability to raise fresh equity was also one reason why Basel III was implemented with a five-year phase-in horizon.

[17]We do not take a stand on which model has the most plausible implications. The DJP, DKR, and NAWM II models are estimated and probably give better short-term predictions. The 3D model implements bank default, which is a

From the comparison across models as well as from the sensitivity exercises, we learn that the precise impact of a change of bank capital requirements depends crucially on how banks, monetary policy authorities, and the wider economy react to it. In practice, there are many adjustment mechanisms, and those may function well in certain circumstances but not in others. For example, in normal times, banks may be able to raise equity, cut dividends, or reduce their voluntary capital buffers without problems. Corporate bond markets may be open to smaller and riskier firms and not just the safest and largest ones. Monetary policy may react aggressively, keeping aggregate demand and inflation stable. Then bank losses or changes to banks' capital ratios should not have a large real impact.

In contrast, in a recession or a financial crisis, all these adjustment mechanisms may break down. Equity issuance may be prohibitively expensive. Banks may be unwilling to reduce their dividend payouts or their capital buffers for fear of sending a bad signal to nervous financial markets. Monetary policy may be constrained by the ZLB of nominal interest rates. Then an attempt to strengthen banks' capital ratios could lead to significant short-term declines in lending, economic activity, and inflation. Longer phase-in periods could be valuable in such a scenario, as they mitigate these short-term costs of increasing bank capital requirements.

In practical use of models for macroprudential policy, it would be important to incorporate these adjustment mechanisms but to exercise judgment (or perform sensitivity checks) on the extent to which the banking system and the economy at large would be able to adjust to capital requirements without a reduction in credit supply. This is especially important at the zero lower bound of nominal interest rates when monetary policy cannot be relied on to offset a large fall in lending and aggregate demand.

The comparison between different models also highlights the importance of analyzing the impact of macroprudential measures in a framework that can capture the benefits of these measures whether those might relate to reducing bank default or dampening the financial cycle. Both the short- and long-term costs from imposing capital

strength in terms of its medium-term implications. Overall, we view the range of estimates which we can clearly connect to underlying model features as a strength of our "suite of models" approach.

requirements were shown to be much smaller when bank default risk is greater and higher bank capital is actually called for. Putting weak banks on a sound financial footing carries significant benefits in terms of cheaper debt funding, helping to maintain or even increase lending and output in the long run. Modeling bank default is crucial in capturing this transmission mechanism of higher bank capital to the real economy.

Appendix A. Brief Description of the Models

A.1 DKR Model

The DSGE model of Darracq Pariès, Kok, and Rodriguez Palenzuela (2011) is estimated on euro-area data and has the following set of financial frictions: bank capital channel (with capital accumulated out of retained earning and adjustment cost on bank capital structure which depends on the regulatory regime); imperfect interest rate pass-through on lending rates for households and non-financial corporations (NFCs); and financial accelerator mechanism for households' loans for house purchase (housing wealth as collateral) as well as for NFC loans (capital stock as collateral), which allows for endogenous default rates. The model can be used in particular to assess the effects of a bank capital shock and changes in the target capital ratio, also taking into account the risk sensitivity of capital requirements. A second version of the model could be used with binding collateral constraints à la Iacoviello (2005).

More precisely, the economy is modeled as a three-agent, two-sector economy, producing residential and non-residential goods. Residential goods are treated here as durable goods. A continuum of entrepreneurs, with unit mass, produce non-residential and residential intermediate goods under perfect competition and face financing constraints. Then retailers differentiate the intermediate goods under imperfect competition and staggered price setting, while competitive distribution sectors serve final non-residential consumption as well as residential and non-residential investments.

A continuum of infinitely lived households, with unit mass, is composed of two types, differing in their relative intertemporal discount factor. A fraction of households are relatively patient, the remaining fraction being impatient. Households receive utility from consuming both non-residential and residential goods, and disutility from labor. Impatient households are financially constrained.

The banking sector collects deposits from patient households and provides funds to entrepreneurs and impatient households. Three layers of frictions affect financial intermediaries. First, wholesale bank branches face capital requirements (which can be risk insensitive or risk sensitive) as well as adjustment costs related to their capital structure. Second, some degree of nominal stickiness generates some imperfect pass-through of market rates to bank deposit and lending rates. Finally, due to asymmetric information and monitoring cost in the presence of idiosyncratic shocks, the credit contracts proposed to entrepreneurs and impatient households factor in external financing premia which depend indirectly on the borrower's leverage.

The model is estimated on euro-area data using Bayesian likelihood methods. We consider 15 key macroeconomic quarterly time series from 1986:Q1 to 2014:Q2: output, consumption, non-residential fixed investment, hours worked, real wages, CPI inflation rate, three-month short-term interest rate, residential investment, real house prices, household loans, non-financial corporation loans, households deposits, and bank lending rates on household loans, on non-financial corporation loans, and on household deposits. All real variables and real house prices are linearly detrended prior to estimation. Inflation and nominal interest rates are mean-adjusted.

A.2 DJP Model

DJP is a multi-country DSGE model developed by Darracq Pariès et al. (2014) to examine the propagation of financial tensions to the broader economy that characterized the international financial crisis and the euro-area sovereign debt crisis.

Households are infinitely lived agents and are identified as Ricardian or non-Ricardian according to their access to financial markets. Ricardian households have access to financial markets, where a fraction of them are workers while the remaining is split into entrepreneurs and bankers. They gain utility from bank deposits over consumption due to the liquidity services. Both types of households supply differentiated labor services in monopolistically competitive markets where they act as setter of the nominal wage. It is assumed that wages are determined by staggered nominal contracts à la Calvo (1983).

The banking sector collects deposits from Ricardian households and provides funds to the retail deposit banks. Wholesale banking branches take these deposits and give loans to the retail lending branches. In doing so, they face capital requirements which can be risk insensitive or risk sensitive. Retail lending banks, through loan officers, provide loan contracts to entrepreneurs. The presence of nominal stickiness generates imperfect pass-through of market rates to both bank deposit and lending rates.

Credit contracts are proposed by loan officers to entrepreneurs with predetermined lending rates. Due to asymmetric information and costly state verification (monitoring costs), there are external financing premia which depend indirectly on the borrower's leverage.

There are also two types of firms, the intermediate and the final goods producing firms. The former consist of internationally tradable and non-tradable goods for consumption and investments, selling their differentiated output under monopolistic competition, under staggered price contracts à la Calvo. The latter use all intermediate goods to produce the final goods which are non-traded and used for consumption and investment.

Sovereign default may arise as a consequence of the government's inability to raise the funds necessary to honor its debt obligations. The monetary policy follows an interest rate rule of Taylor type. In the case of the euro area, the equation holds for the single monetary authority.

Overall, default can occur in the model in three ways. Firstly, sovereign default materializes whenever the government debt-to-GDP reaches the fiscal limit. Secondly, banks may default when their return on assets is not sufficient to cover the repayments. Lastly, entrepreneurs default when their income that can be seized by the lender falls short of the agreed repayment of the loan.

Real-sovereign-financial interactions and sources of impairments can arise in our model through the amplification of certain shocks which interplay between financial variables, sovereign default, and real variables. Furthermore, cross-country spillovers can arise in two ways: firstly, through cross-border lending from domestic bankers to foreign retail lending branches and, secondly, through trade of intermediate consumption and investment.

A.3 NAWM II Model

The extended version of the New Area-Wide Model (NAWM II) is a medium-scale open-economy DSGE model with a financial sector developed primarily to support forecasting and monetary policy analysis at the ECB. It includes a battery of nominal and real frictions that have been identified as empirically important, such as sticky prices and wages, habit persistence in consumption, and adjustment costs in investment. Moreover, it incorporates analogous frictions relevant in an open-economy setting, including local-currency pricing, and costs of adjusting trade flows. Its rich financial sector (i) assigns a genuine role both for financial frictions in the propagation of economic shocks and for shocks of a financial origin, (ii) captures the prominent role of bank lending rates and the gradual interest rate pass-through in the transmission of monetary policy, and (iii) provides a structural framework to assess the macroeconomic impact of large-scale asset purchases as well as macroprudential policies.

The model's financial sector is centered around two distinct types of financial intermediaries that are exposed to sector-specific shocks: (i) funding-constrained "wholesale banks" à la Gertler and Karadi (2011) which engage in maturity transformation and originate long-term loans, and (ii) "retail banks" à la Gertler and Kiyotaki (2010) which distribute these loans to the non-financial private sector and adjust the interest rates on loans only sluggishly. The long-term loans are required by the non-financial private sector to finance capital investments as in Carlstrom, Fuerst, and Paustian (2017). Furthermore, NAWM II includes a set of no-arbitrage and optimality conditions which govern the holdings of domestic and foreign long-term government bonds by the financial and the non-financial private sector, respectively, building on Gertler and Karadi (2013).

Employing Bayesian methods, the NAWM II model is estimated on 24 key macroeconomic variables, including per capita real GDP, private consumption, total investment, government consumption, exports and imports, a number of deflators, employment and wages, the short- and long-term nominal interest rates, and the long-term lending rate, as well as measures of private-sector expectations. In addition, data for the nominal effective exchange rate, euro-area foreign demand, euro-area competitors' export prices, and oil prices are used, which are deemed important variables in the projections capturing the influence of external developments. The model is estimated over a sample between 1985:Q1 and 2014:Q4.

Elevated capital requirements are modeled as a temporary tightening of the wholesale banks' market-based leverage constraint. As described in the text, this tightens credit conditions and generates an economic downturn. The ensuing decline in the value of the legacy loans worsens banks' balance sheet health in a negative feedback loop. A monetary policy easing can partially offset the negative impact of the tightening by easing credit costs and improving banks' balance sheets.

A.4 3D Model

The 3D model is a microfounded framework that introduces financial intermediation and positive equilibrium default rates into an otherwise standard DSGE model. In particular, 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 partially insured deposits, have their leverage limited by a regulatory capital requirement. Importantly, due to the fact that some deposits are uninsured, depositors suffer some losses if banks fail. This generates an ex ante default risk premium that acts as an important source of amplification when bank solvency is weak.

The model is suitable for a non-trivial welfare and policy analysis of requirements imposed on bank lending activity, which is at the core of macroprudential policy. The rationale for macroprudential policies in the model arises from two key distortions associated with banks' external debt financing. Both of these encourage banks to become overleveraged and to expose themselves to too much failure risk. The first distortion stems from banks' limited liability and the existence of deposit insurance. As in Kareken and Wallace (1978), deposit insurance pushes banks to take on risk at the expense of the deposit insurance agency (DIA), which may result in cheaper and more abundant bank lending than what a social planner would find optimal when internalizing the full costs of bank default (limited liability distortion).

The second distortion arises due to the assumption that depositors suffer some transaction costs in the event of a bank failure despite the presence of deposit insurance. In equilibrium, this leads to a deposit risk premium which raises banks' funding costs when failure risk is high. Moreover, we assume that, due to banks' opaqueness, this risk premium is related to economy-wide bank default risk rather than the individual risk of the issuing bank. This creates an incentive for banks to take excessive risk because their funding costs depend on system-wide choices rather than their own (bank funding cost externality).

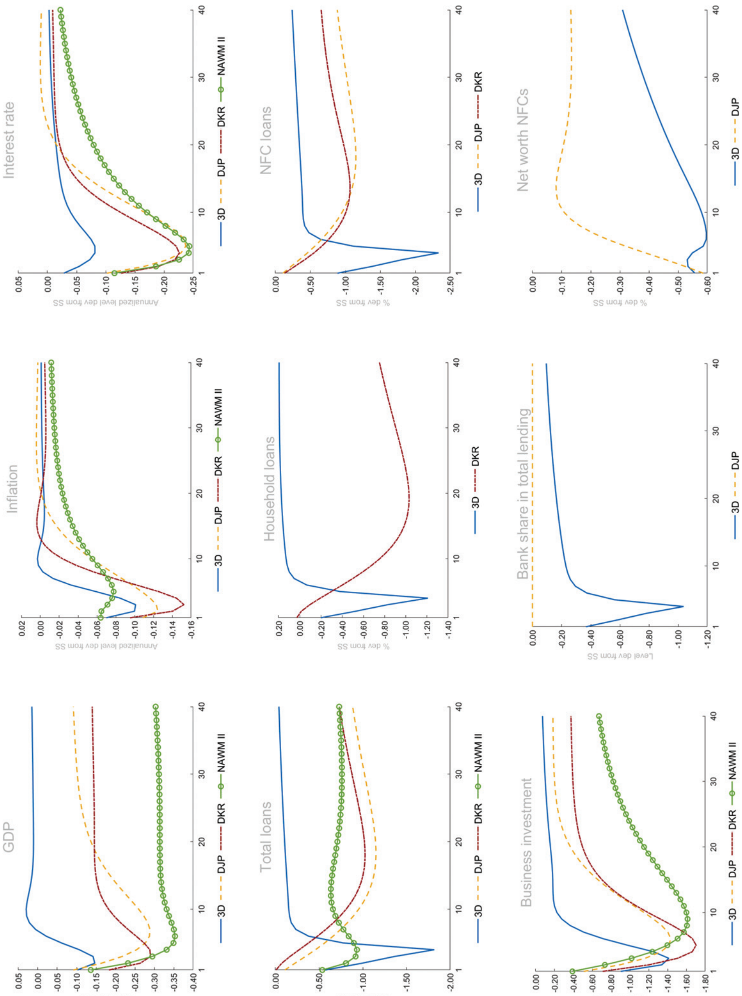
The model simulations provided in this note are based on the version of the 3D model in Mendicino et al. (2015) but with two key modifications. First, Calvo price stickiness has been introduced. Second, we have introduced the possibility of banks to vary their dividend payouts subject to a cost. The model parameters are set so as to match a number of important first and second moments referring to key euro-area macroeconomic and financial aggregates during the 2001–16 period.

Appendix B. Full Set of IRFs

B.1 Baseline Model Comparison Exercise

Below is a full set of IRFs for the main model comparison exercise in Section 3.

Figure B.1. Comparison of the Four Main Models



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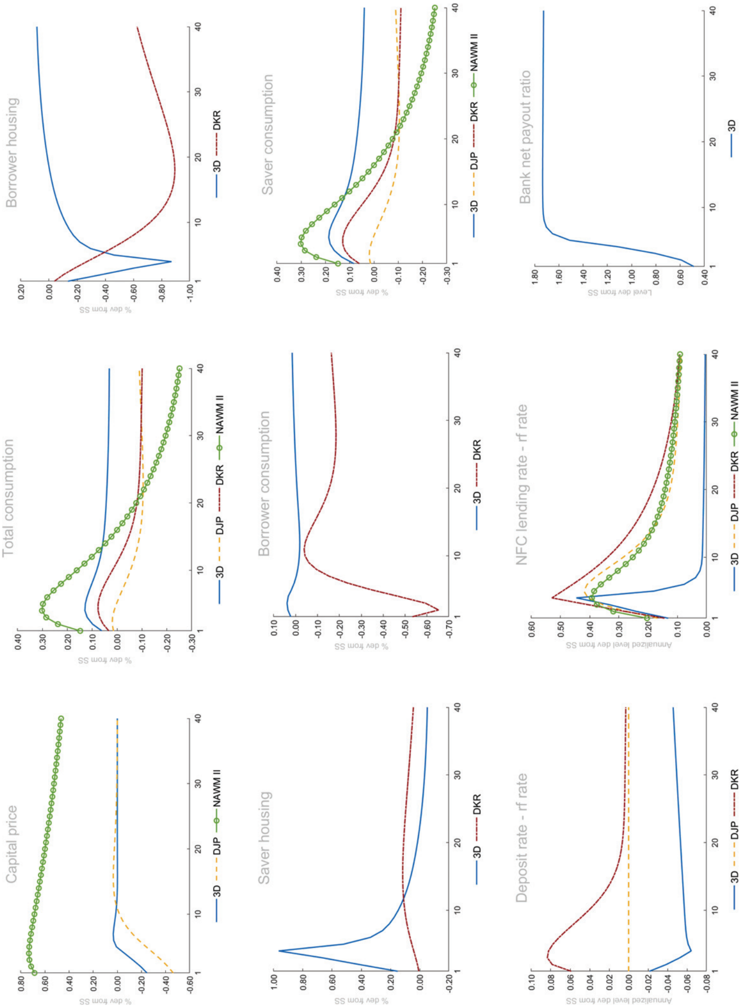
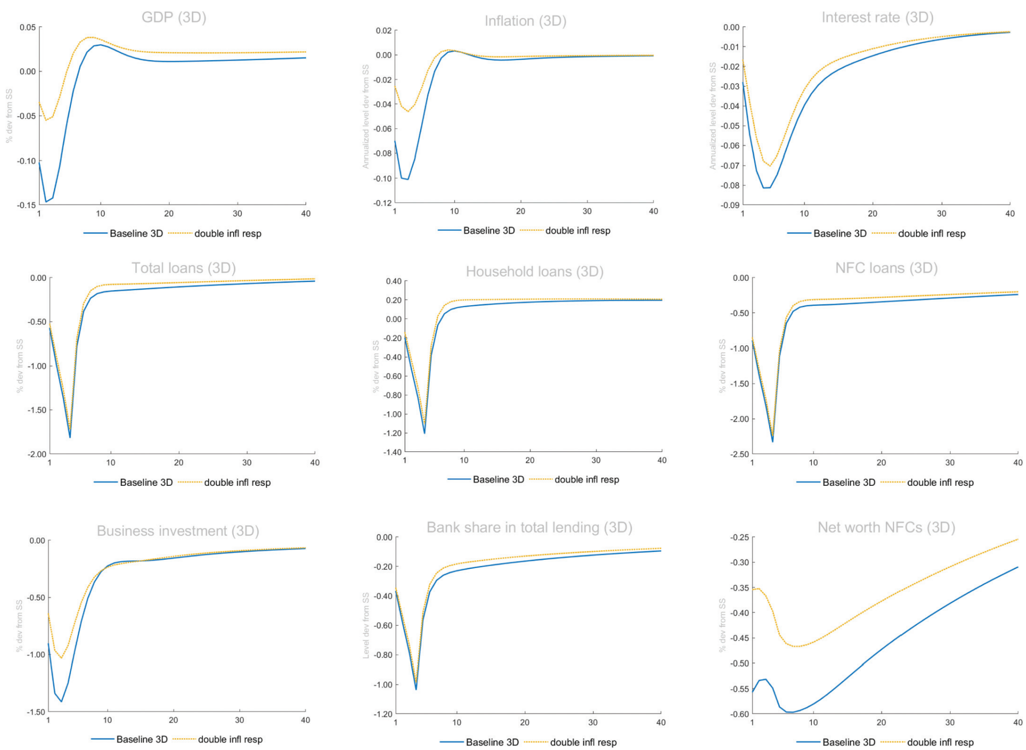


B.2 Sensitivity: Monetary Policy Rules

Below is a full set of IRFs for each model under different monetary policy rules as in Subsection 4.1. We show the baseline Taylor rule, a high inflation response Taylor rule, and a high GDP growth response Taylor rule in the 3D, DJP, DKR, and NAWM II models.

Figure B.2. Monetary Policy Rule Variations in the 3D Model



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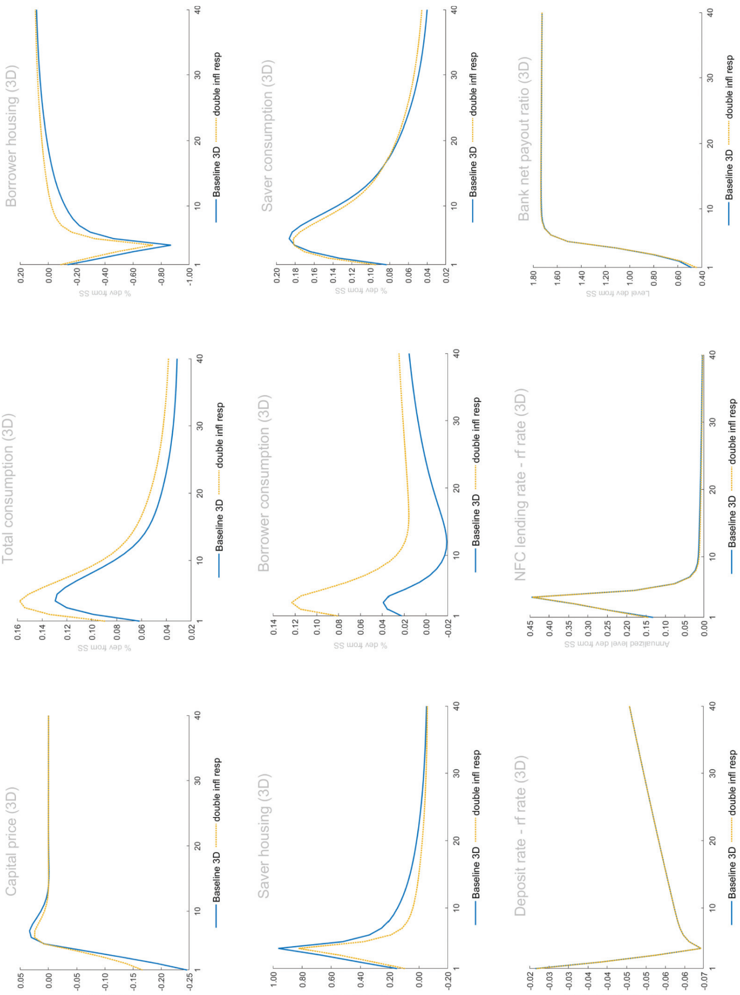
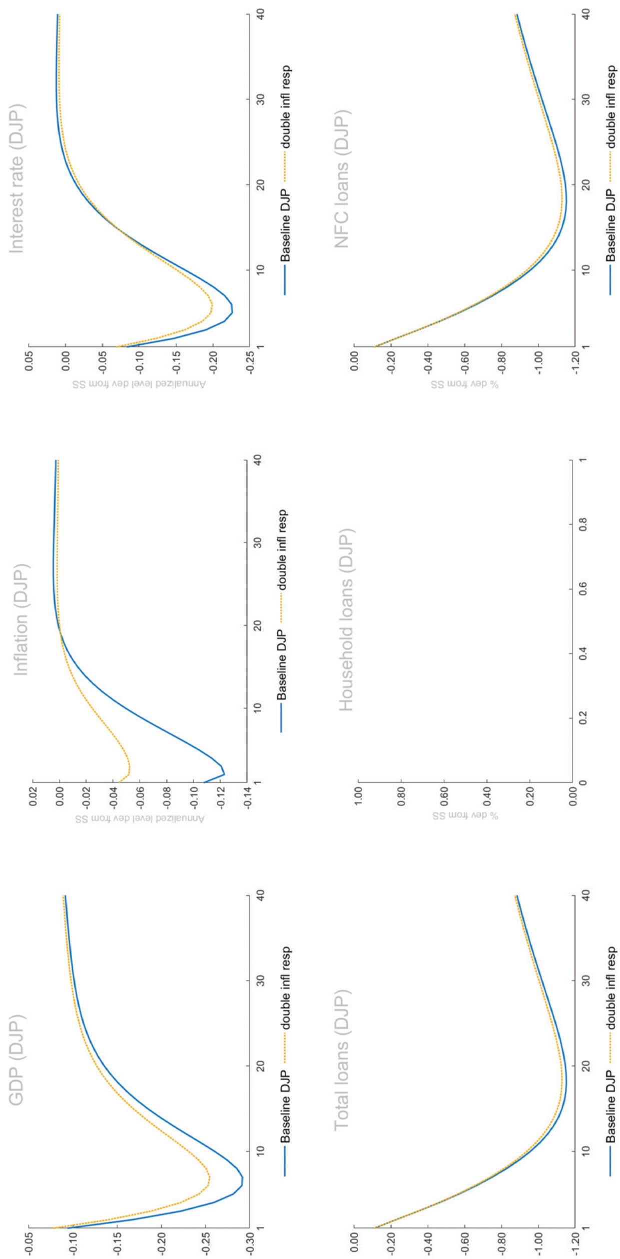


Figure B.3. Monetary Policy Rule Variations in the DJP Model



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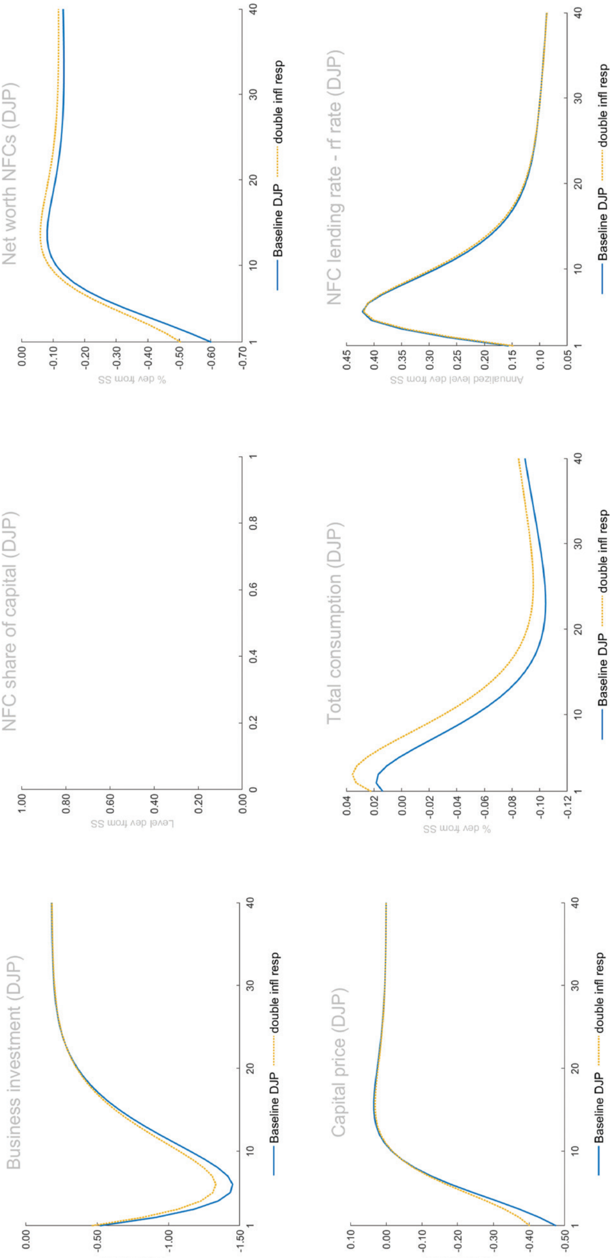
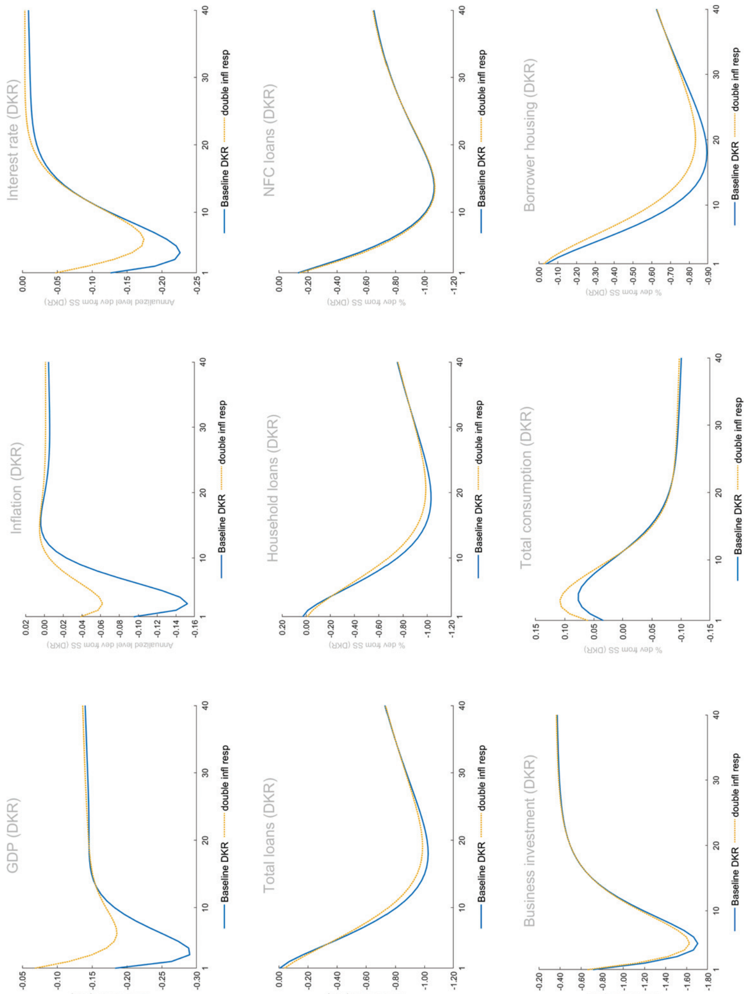


Figure B.4. Monetary Policy Rule Variations in the DKR Model



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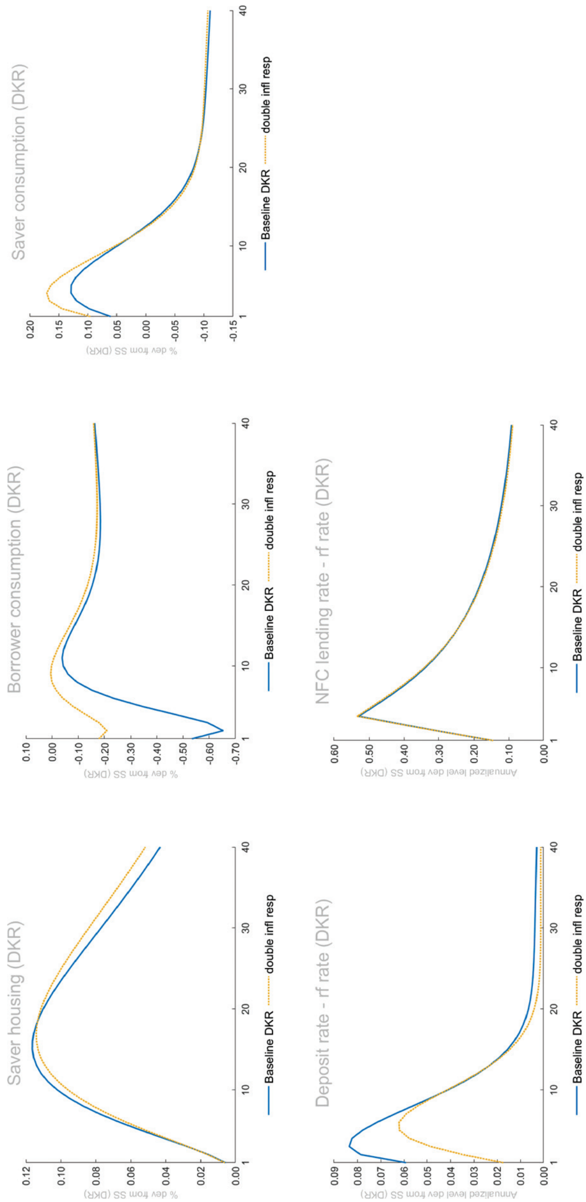
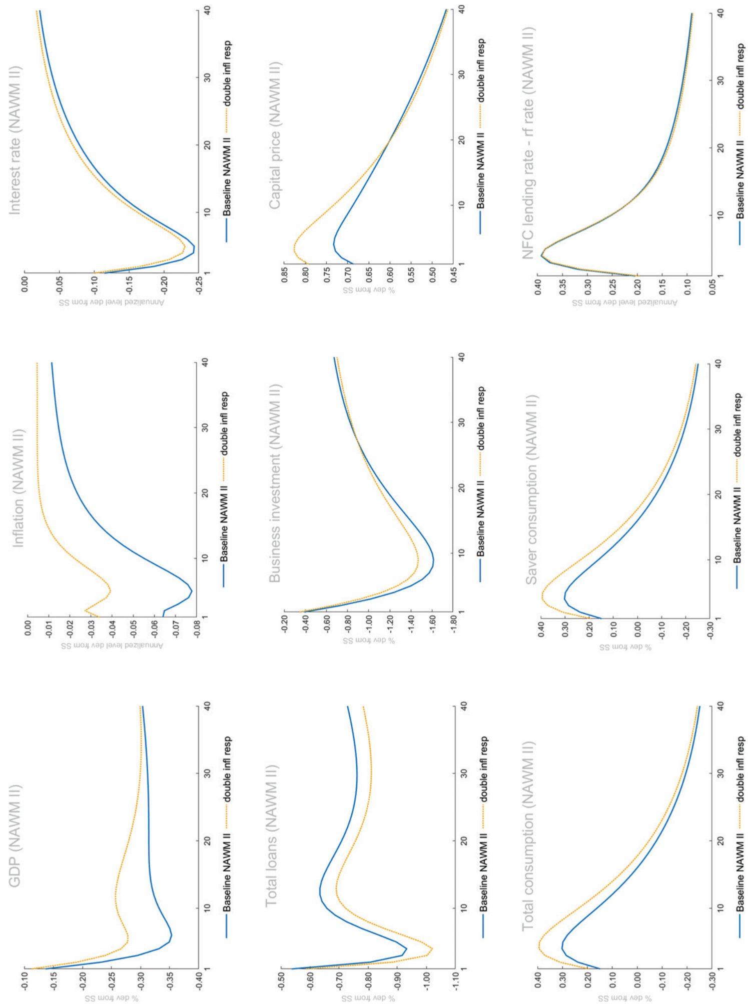


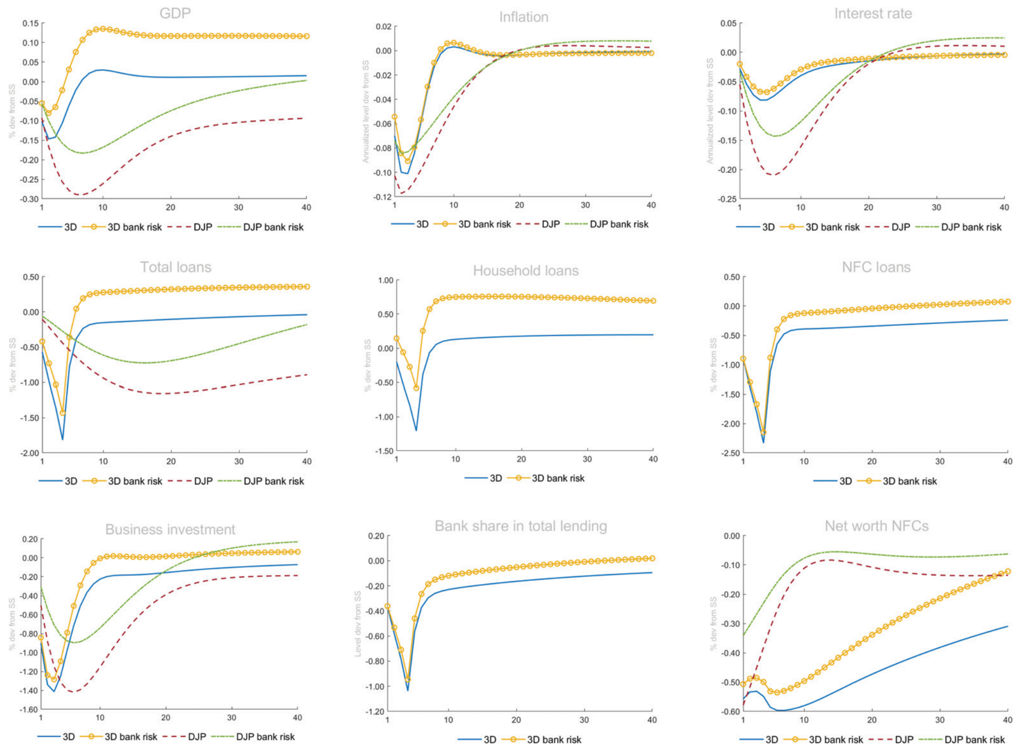
Figure B.5. Monetary Policy Rule Variations in the NAWM II Model



B.3 Sensitivity: Bank Risk

Below is a full set of IRFs for the bank risk sensitivity exercise in Subsection 4.2. We analyze high bank risk in both the 3D and the DJP models.

Figure B.6. Sensitivity with Respect to Bank Riskiness



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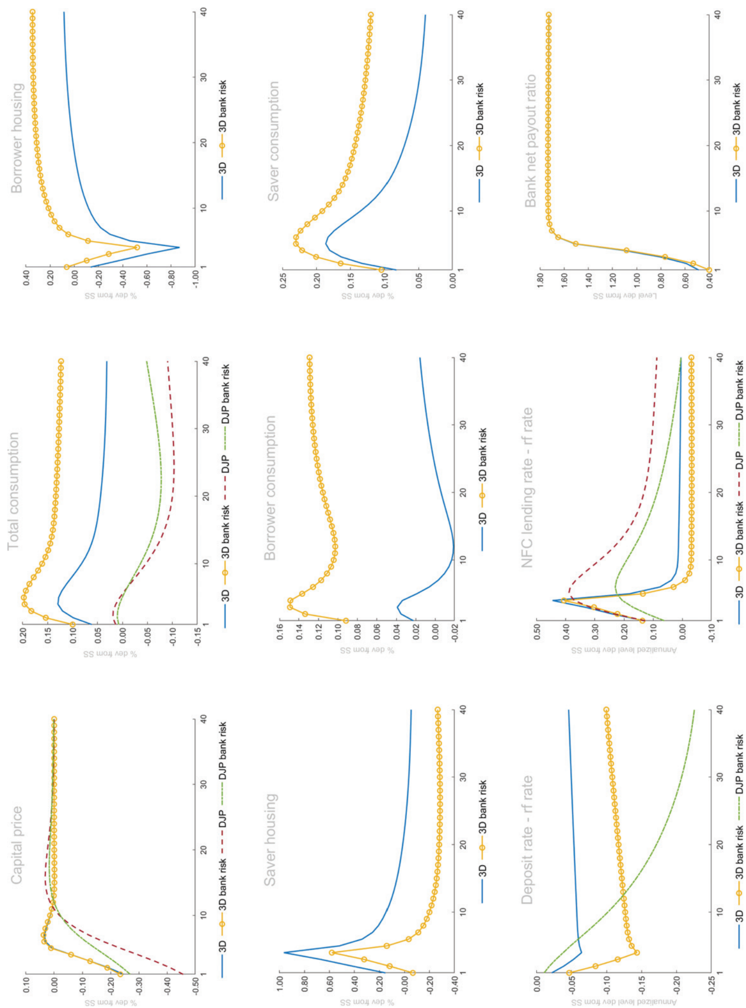
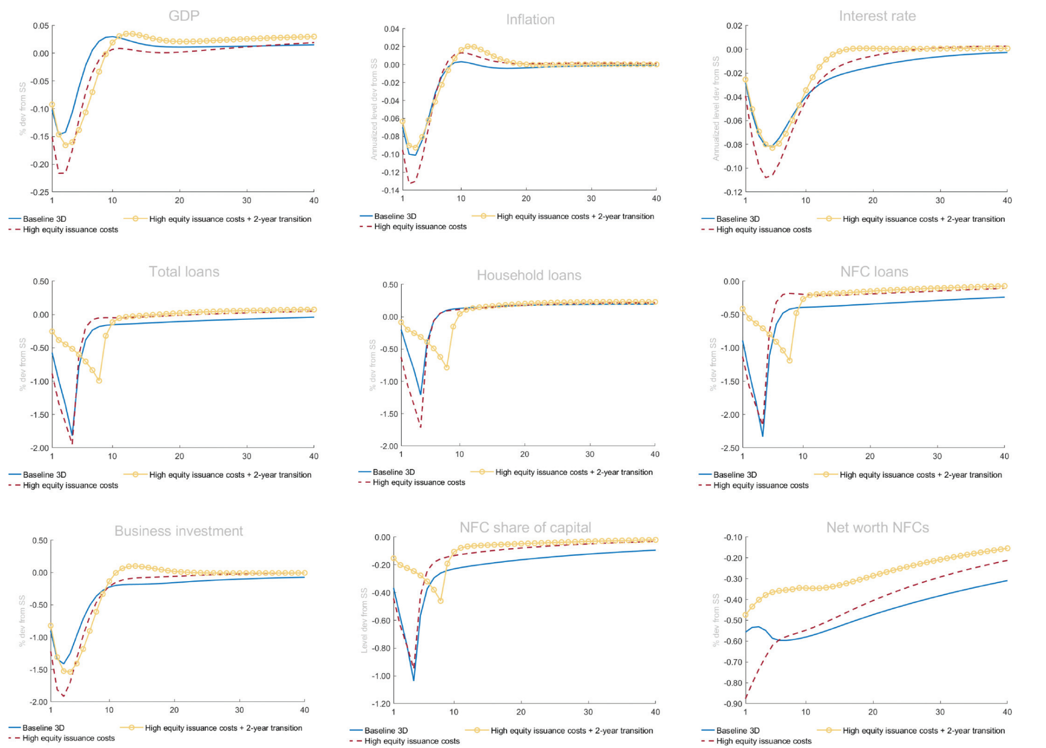


B.4. Sensitivity: Dividend Variation/Equity Issuance Costs

Below is a full set of IRFs for the dividend reduction/equity issuance cost sensitivity exercise in Subsection 4.3.

Figure B.7. Sensitivity with Respect to Equity Issuance Costs in the 3D Model



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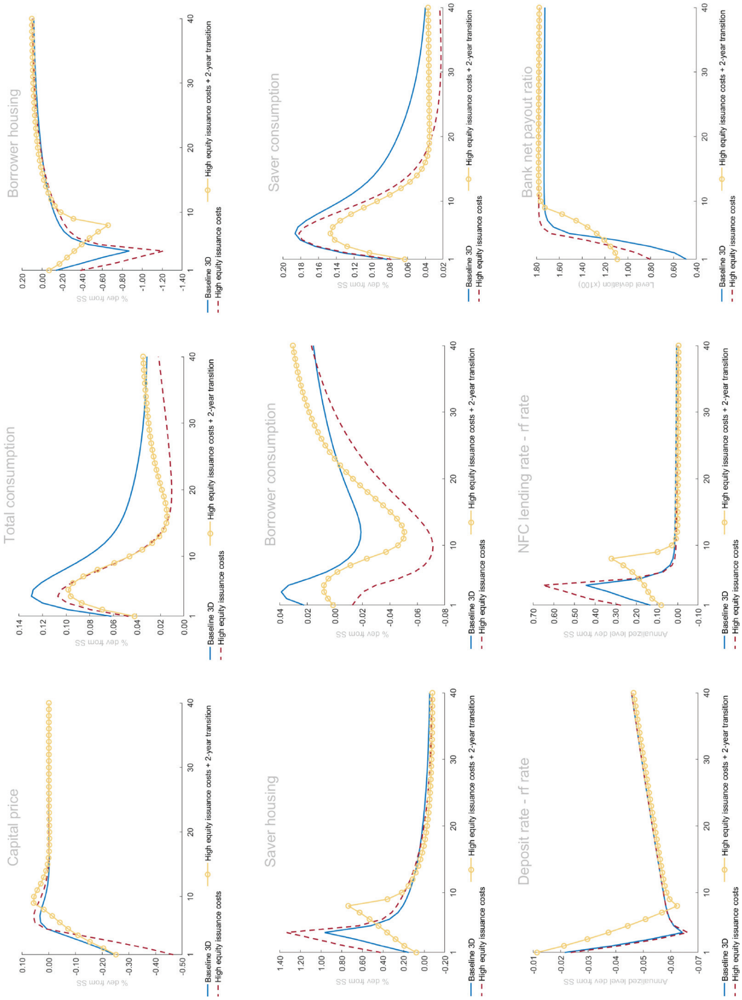
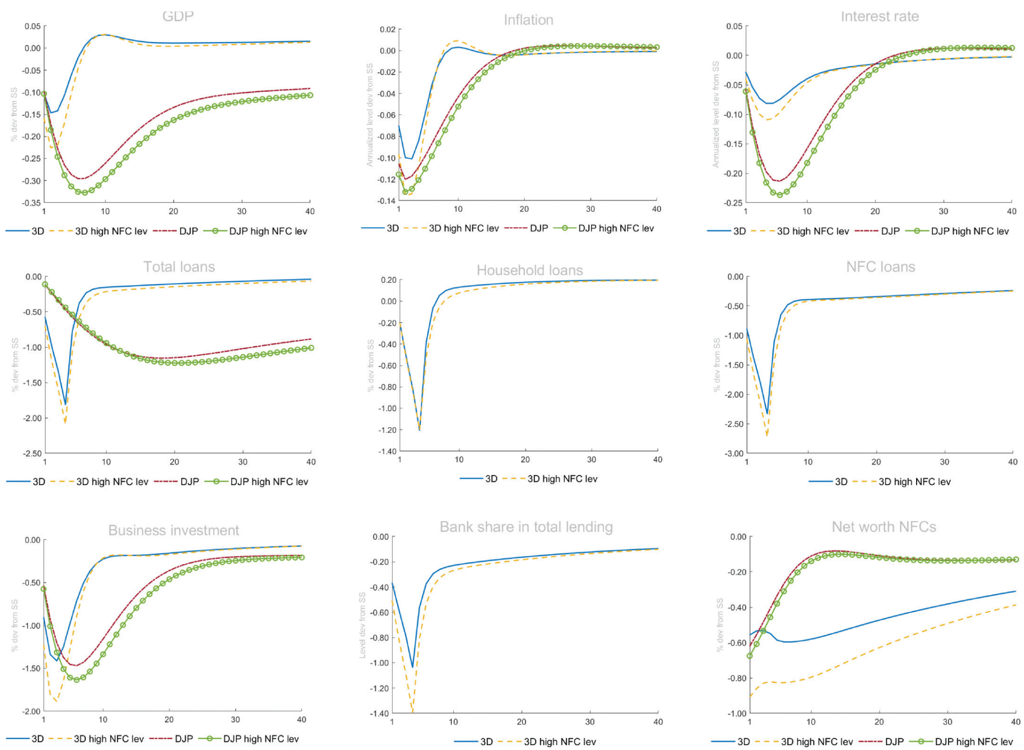


B.5. Sensitivity: NFC Risk

Below is a full set of IRFs for the NFC risk sensitivity exercise in the 3D and the DJP models. We examine the sensitivity of our results with respect to NFC leverage. In this exercise we reduce the deadweight default cost for firms until the NFC default rate reaches 2 percent.

Figure B.8. Sensitivity with Respect to NFC Riskiness



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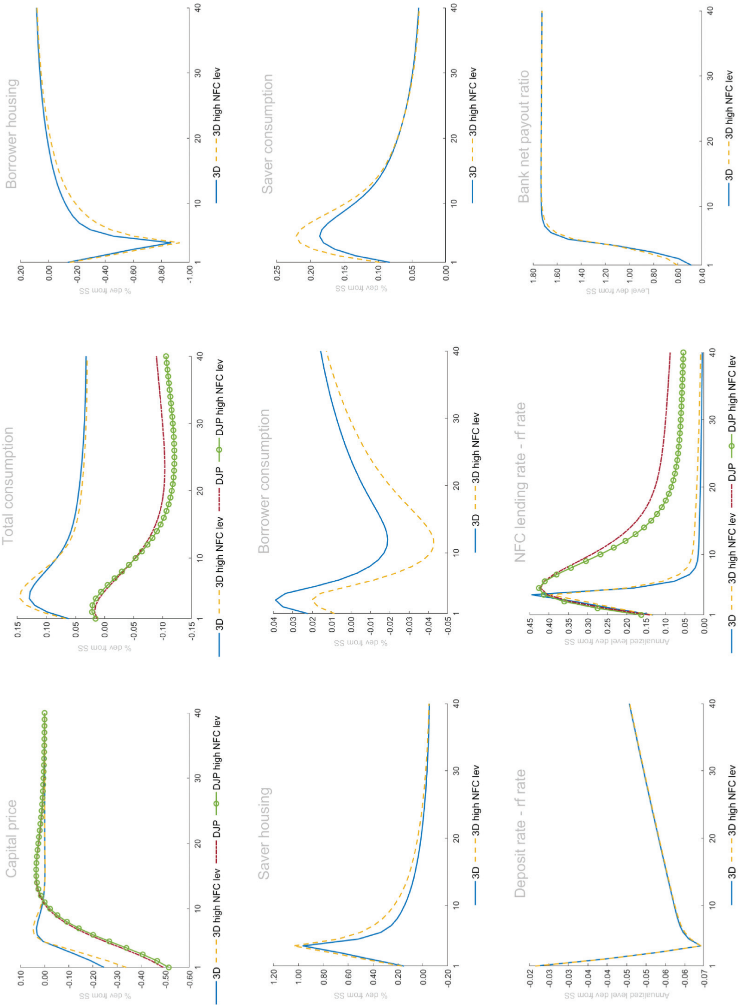

We can see in Figure B.8 that this change amplifies greatly the impact of higher capital requirements on investment, output, and inflation in both models used in the simulation (3D and DJP). Interest rates have to fall further in order to maintain aggregate demand. Consumption increases by more driven by looser monetary policy.

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