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Risk shocks, due loans, and policy options: When less is more!

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Abstract
We use a dynamic stochastic general equilibrium model endowed with a complex banking system—in which due loans, occasionally binding credit restrictions, a cost of borrowing channel, and regulatory (capital and impairment) requirements coexist—to analyze the performance of various policy options impacting impairment recognition by banks. We discuss how looser or tighter policy designs affect output and welfare—both in the steady state and alongside dynamics—and the main driving forces that lie beneath the effects. The holding cost of due loans, restrictions to credit, dividend strategy, and the cure rate are key components of the driveshaft propelling policies to outcomes. We find that looser policies outperform tighter ones only if reflected into higher capital buffers (extra income is retained and not distributed as dividends) and for sufficiently low values of the holding cost. Higher cure rates increase the effectiveness of looser policies—they dominate for a wider range of holding costs—by raising the benefits of delaying impairment recognition. A policy targeting impairment recognition seems to take the upper edge due to its combined steady-state and business-cycle effects, but a policy that allows the regulatory impairment recognition to respond to the cycle is more effective from a business-cycle stabilization standpoint. Occasionally binding credit restrictions boost the effectiveness of looser policies during recessions due to its asymmetric effects over the cycle, pushing the mean output upwards.

JEL: E32, E44, H62

Keywords: DSGE models, euro area, small-open economy, financial accelerator, banks, credit supply restrictions, due loans.

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1. Introduction

The large Non-Performing Loans (NPL) stock in banks' balance sheets has been a persistent legacy of a number of euro area economies in the aftermath of the financial crisis, and addressing asset quality issues has been a priority in the European Union (EU).[1] It is nowadays a common view that high levels of NPLs may affect banks' financial soundness and, eventually, markets perceptions. In addition, the concomitant negative impact on balance sheet, profitability, liquidity and capital may constraint bank lending to the economy.

The DSGE modeling literature often deals with credit default flows by assuming that they are fully covered by state contingent interest rates (Bernanke *et al.* 1999), immediately recognized as impairment losses and written-off (Benes and Kumhof 2015; Clerc *et al.* 2015), or somehow embodied in an exogenous shock to the value of bank capital (Gerali *et al.* 2010; Pariès *et al.* 2011). In practice, there is a delay between the identification of a credit risk and their coverage by impairments, as strategies and mechanisms in place depend upon a number of factors, namely economic cycle, clients' situation, and banks' own funds and liquidity. As an alternative to immediate impairment recognition, banks may recover, renegotiate or sell part of their claims, which still may involve the recognition of a loss.[2] Against this background, there has been a number of EU initiates to cope with the excessive accumulation of non-performing exposures in banks' balance sheet that are not covered by impairments.[3]

This article uses the Dynamic Stochastic General Equilibrium (DSGE) model developed in Júlio and Maria (2020) to study output and welfare implications of various policy options regarding the regulatory impairment framework.[4] The model is empowered with regulatory requirements, due loans, a cost of borrowing channel, and occasionally binding endogenous credit restrictions, important mechanisms to propel issues rooted in the banking system to the rest of the economy.[5] Due loans emerge endogenously within the model since some solvent entrepreneurs are unable

1. The EU has implemented several guiding rules to tackle the issue of non-performing loans in Europe. One of the action plans introduces the concept of prudential backstop, which is minimum provisioning levels for new exposures when they become non-performing.

2. This has prompted numerous supervisory and regulatory actions over the years, aimed at assessing whether bank assets have been correctly valued. One example is the 2014's Asset Quality Review.

3. According to the Single Supervisory Mechanism guidance rules in place, banks should identify short, medium and long-term strategy options for NPL reductions and their respective financial impact. Possibilities encompass a forbearance strategy, an active portfolio reduction (sales and/or write-offs), a change of exposure type (foreclosure, debt to equity swap, debt to asset swap or collateral substitution) or legal options (insolvency or out-of-court solutions). In addition, banks are expected to fully recognize as a loss the uncollateralized portion of any loan which has been classified as non-performing for more than 2 years.

4. Model details are available in our companion technical appendix.

5. We use the term due loans instead of NPL in the context of the model to stress that it generates a concept that does not exactly match the definition of NPL as defined at the EU level.

to reimburse borrowed amounts. Bankers optimally delay the loss recognition, in an attempt to recover (cure) some amount of the claim at a future date and postpone the corresponding equity erosion (which raises the chances of violating regulatory capital requirements) to more favorable times. These mechanisms are balanced against holding and penalty costs. The former reflects for instance recovery efforts and management costs. The intuition is that due loans are often associated with auditing expenses, judicial proceedings aimed at recovering some of the claim's value, and costly proof providence to investors respecting their correct valuation.[6] The latter is associated with regulatory impairment requirements, which banks are bound to comply.

Under "bad" financial-based shocks—such as entrepreneurial risk shocks—due loans play an important role in macroeconomic dynamics, and policy options significantly affect that equilibria.[7] We aim at better understanding whether an increase in the size of due loans triggered by a riskier environment should be fought against with tighter or looser policy designs or if there exists any specific policy which welfare-dominates the alternatives. Tighter designs keep the size of the due loans stock under control, bounding the crowding-out effect on performing loans, at the expense of large impairment losses which erode banks' equity and boost the chances of a given bank being unable to comply with regulatory capital requirements. Looser designs let the stock of due loans increase, alleviating expenses related with capital regulatory requirement as write-offs are pushed back—particularly important during financial crisis—but pressing up the holding cost and the crowding-out effect. The latter consists in due loans being financed with either deposits/foreign funds or equity, resources which will be unavailable to lend to productive entrepreneurs.

We find that the tight *versus* loose dichotomy largely depends on the cure rate and on whether bankers react to the policy by adjusting dividend distribution or by letting the capital buffer adapt. Looser policies are only able to welfare-dominate tighter alternatives if the concomitant equity cushion is reflected into wider capital buffers and therefore in more resilient banks, instead of breeding larger dividends. In addition, the holding cost of due loans needs to be sufficiently small so that the society benefits from the looser framework. Specifically, the equity buildup promoted through fewer write-offs must offset the equity erosion triggered by the balance sheet accumulation of due loans—holding cost, crowding-out effect, and possibly larger write-offs in the future during more favorable times. Higher cure rates increase the effectiveness of looser policies—they dominate for a wider range of holding costs—by raising the benefits of delaying impairment recognition. Against this background, looser policy options may effectively promote regulatory capital compliance and concomitantly a more advantageous path for the wholesale interest

6. For details on the NPL life-cycle and the due diligence required by the Single Supervisory Mechanism, see ECB (2017).

7. The role played by policy options under non-financial shocks is to a large extent unimportant, since due loans remain relatively stable along the dynamics in that case.

rate spread, as compared with a *laissez-faire* (no policy change) approach. The entrepreneurial sector accesses cheaper credit and becomes able to finance more capital as interest expenses are pushed back. More output and greater income levels generated by firms flow to households, ultimately raising welfare standards.

The existence of credit restrictions increases the welfare-gains of looser designs relative to the *laissez-faire* equilibria for sufficiently low values of the holding cost and/or sufficiently high values of the cure rate, and *vice-versa*. As the equity erosion is pushed back by the policy in these cases, creditors become willing to channel more funds to the bank, boosting their external financing capability. Greater levels of credit are then available to flow to the entrepreneurial sector without pressing up the wholesale interest rate, resulting into higher capital accumulation.

Policies are not all alike in which respects their effectiveness. We analyze three distinct policy options within the risk shock context, without foregoing their steady-state implications. The "impairment policy" consists in a permanent decline in regulatory impairment requirements. The "penalty policy" considers a permanent fall in the penalty rate that banks pay when unable to comply with regulatory impairment requirements. Finally, the "sensibility policy" consists in a temporary descent in impairment requirements throughout the cycle, depending on the level of the due loans ratio. The "penalty policy" is the least effective one and enhances welfare relative to the *laissez-faire* equilibria only for a narrow range of holding costs. The reason is that this option lights up perverse incentives by boosting regulatory impairment non-compliance, which dampens the improvement in banks' equity position. The "sensibility policy" is the most effective from a business-cycle stabilization standpoint, since it only frees up bank capital temporarily as needed, thus avoiding the costs brought about by an increase in the steady-state stock of due loans. The option to smooth loss recognition across time provides a cushion against spread hikes, dampening the effect of bank capital losses on credit supply. The "impairment policy," however, presents a non-negligible steady-state impact for sufficiently low values of the holding cost and/or sufficiently high values of the cure rate, and against this background it may outperform the "sensibility policy" when combining steady-state and business-cycle considerations. Banks take advantage of the lower regulatory target and low holding costs to let the capital buffer increase alongside the stock of due loans in the steady state, becoming at the same time more resilient to perturbations. They are therefore able to charge lower wholesale interest rate spreads as their equity position improves, laying ground for the entrepreneurial sector to permanently accumulate larger capital levels and better resist adverse perturbations. The boost in productive capacity raises output and results in higher income, which flows to households, allowing them to increase consumption and ultimately pushing up welfare.

Occasionally binding credit restrictions create asymmetric cycles with a negative mean, since recessions are empowered by tightening credit conditions. In this case, for sufficiently low values of the holding cost, looser policies have also a positive mean impact on output, in addition to a stabilization effect. By weakening the size of credit restrictions due to the extra cushion provided to banks, the policy depicts greater impacts during slumps than in expansions, wherein only the stabilization effect prevails.

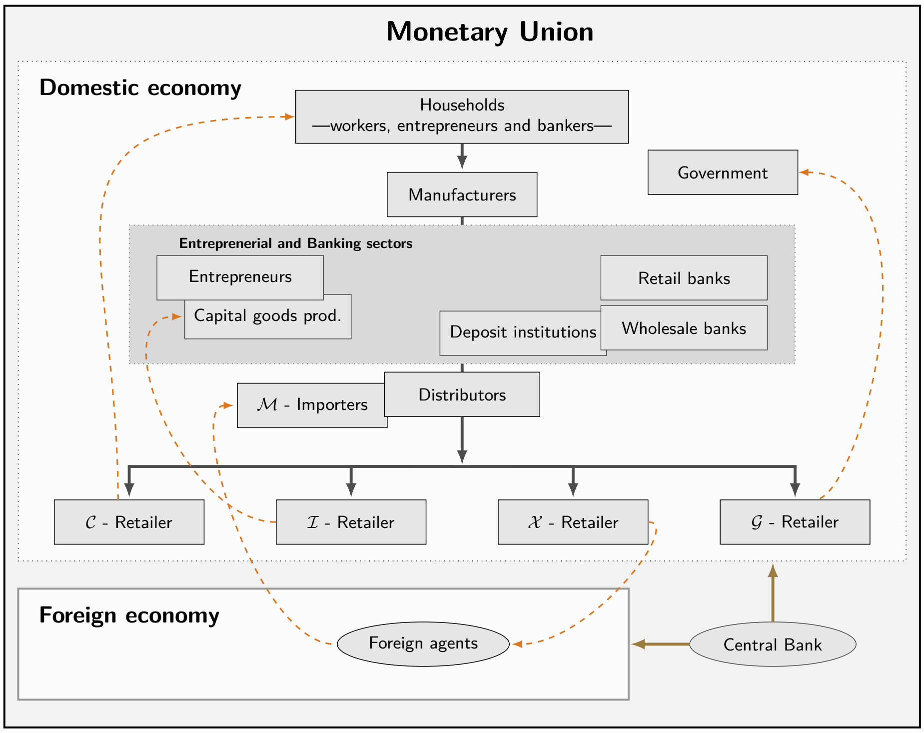
Both institutional work (Aiyar *et al.* 2015; Constâncio 2017) and academic studies (Gerali *et al.* 2010; Pariès *et al.* 2011; Benes and Kumhof 2015) have emphasized the link between credit defaults and credit supply restrictions in amplifying output fluctuations.[8] For instance, Gourinchas *et al.* (2016) shows that credit losses amplified negative shocks by impairing bank capital and loans supply during the Greek crisis, resulting in a reinforced recession due to hampered consumption and investment. Balgova *et al.* (2016) use aggregate panel data to compare NPL reduction episodes with periods where the NPL ratio is persistently at high levels, concluding that foregone GDP growth due to NPL forbearance is 2 percentage points per annum on average. Marques *et al.* (2020) and Accornero *et al.* (2017) through the estimation of a credit supply function conclude that NPL ratios *per se* have no impact on banks' lending behavior. Nevertheless, although NPL may not be a concern to the credit market, their variation can temporarily lead to a contraction in the credit market. In this vein, by exploring the Asset Quality Review data, Accornero *et al.* (2017) conclude that credit granted to the same firm by banks which were forced to increase their NPL ratios and provisions was on average 1 to 2 percent lower *vis-à-vis* that granted by banks which did not had to adjust. The authors attribute this result to the crowding-out effect of non-performing exposures on performing loans and to the deleveraging process imposed by market pressure, both reflected into higher funding costs (see also Bofondi *et al.* 2017).

The article is organized as follows. Sections 2 and 3 present the non-financial and financial blocks of the model, respectively. Section 4 explains in detail the simulation exercises. Section 5 addresses the transitional dynamics and long run effects of policy change. Section 6 analyzes the role played by different policy options and rules governing impairment recognition on risk-driven slumps. Section 7 collects and joins the most important results into a general overview. Section 8 concludes.

2. A DSGE model for a small euro area economy

The domestic economy is composed of nine types of agents: households, intermediate goods producers (manufacturers), final goods producers (distributors), retailers, capital goods producers, entrepreneurs, banks, the government, and importers. The model is closed with the foreign economy—the remaining euro area composed of foreign agents and the central bank—with whom domestic agents interact in the

8. Most articles use some type of dynamic VAR or panel VAR to establish that adverse economic conditions—such as rising unemployment and high interest rates—are positively associated with a larger NPL stock. These studies also conclude in general that exogenous increases in the NPL stock negatively impact GDP and credit growth (Espinoza and Prasad 2010, Nkusu 2011, Klein 2013).



Notes: Identifier C stands for consumption goods, I for investment goods, G for government consumption goods, X for export goods, and M for import goods. The financial accelerator mechanism comprises capital goods producers, entrepreneurs, and banks.

Figure 1: Interactions between agents.

goods and financial markets. This section presents a canonical model for all agents except entrepreneurs and banks, which are analyzed separately in the next section. The exposition omits most details, which can be found in our companion technical appendix. Figure 1 presents the main interactions between non-financial agents in the model.

2.1. Households

Households are composed of workers, entrepreneurs and bankers, and there is perfect consumption insurance within the family. For simplicity, we assume that the percentage of entrepreneurs and bankers is infinitesimally small to avoid keeping track of their mass. A representative household derives utility from consumption $C_t(h)$ and real money holdings $DEP_t(h)/P_t$, and disutility from working $U_t(h)$. The term U_t stands for hours worked as a fraction of total time endowment, $DEP_t(h)$ for nominal deposits, and P_t for the price paid to retailers for the consumption good, taken as *numéraire*. Expected lifetime utility is $\mathrm{E}_t \sum_{s=0}^{\infty} \beta^s \mathrm{UTIL}_{t+s}(h)$, where E_t is the expectation operator and $0 \leq \beta \leq 1$ stands for the discount factor. Flow utility is separable in all arguments

$$\mathrm{UTIL}_t(h) = (1-\nu)\log(C_t(h) - Hab_t) - \frac{\eta_L}{1+\sigma_L}(U_t(h))^{1+\sigma_L} + \eta_D \log\Big(\frac{DEP_t(h)}{P_t}\Big)$$

where $\eta_L, \eta_D > 0$ are utility weights and σ_L is the inverse Frisch elasticity of labor supply. The element $Hab_t = \nu C_{t-1}$ stands for external habits, where ν is a scale parameter. Deposits pay a gross nominal interest rate of i_t^D if held between period t and $t+1$.[9]

The household supplies labor services totaling $U_t(h)$ to manufacturers and banks (through workers), receiving a wage rate $V_t(h)$, pays a lumpsum tax LT_t to the government, and receives dividends D_t^x, $x \in \{\mathcal{M}, \mathcal{D}, \mathcal{KP}, \mathcal{IM}, \mathcal{E}, \mathcal{BK}\}$. These can originate from manufacturers ($\mathcal{M}$), distributors ($\mathcal{D}$), capital goods producers ($\mathcal{KP}$), importers ($\mathcal{IM}$), entrepreneurs ($\mathcal{E}$) and banks ($\mathcal{BK}$). Over time, an entrepreneur in period t stays an entrepreneur in the next period with probability $\iota^{\mathcal{E}}$, and a banker with probability $\iota^{\mathcal{BK}}$, independent of history. The remaining fractions become workers and transfer accumulated earnings to their respective household, and are replaced by a similar measure of entrepreneurs and bankers. The household provides these elements with small amount of startup funds. We let $D_t^{\mathcal{E}}$ and $D_t^{\mathcal{BK}}$ denote transferred earnings net of startup funds. Households are not allowed to hold foreign financial assets.

The nominal budget constraint embodying that expenditures cannot exceed revenues is

$$P_t C_t(h) + DEP_t(h) \leq i_{t-1}^D DEP_{t-1}(h) + V_t(h)U_t(h) - LT_t + DIV_t$$

where $DIV_t = \sum_x \int_0^1 D_t^x(i)\mathrm{d}i$.

Manufacturer j combines specialized labor supply from households into a homogeneous labor service according to a Constant Elasticity of Substitution (CES) aggregator, yielding the usual demand for labor variety h, $U_t(h) = (V_t(h)/V_t)^{-\sigma^{\mathcal{U}}} U_t$. The element $\sigma^{\mathcal{U}} \geq 0$ is the elasticity of substitution between labor varieties, $V_t(h)$ and V_t denote the wage charged by household h and aggregate wage, and U_t is aggregate labor demand. We consider Calvo-type frictions and assume that households are unable to reoptimize the wage in each period with probability $\iota^{\mathcal{U}}$. The wage rate is $V_t = \big(\iota^{\mathcal{U}} V_{t-1}^{1-\sigma^{\mathcal{U}}} + (1-\iota^{\mathcal{U}})(V_t^*)^{1-\sigma^{\mathcal{U}}}\big)^{\frac{1}{(1-\sigma^{\mathcal{U}})}}$, where V_t^* is the optimal wage.

9. Adopting a more general Constant Relative Risk Aversion specification for deposits does not bring any important change in results. When recalibrating the model for a given deposits-to-GDP ratio, the parameter η_D adjusts to the intertemporal elasticity of substitution in deposits to deliver similar dynamics.

2.2. The non-financial block

2.2.1. Capital goods producers. There exists a continuum of capital goods producers indexed by $i \in [0,1]$. In each period, capital goods producers combine the undepreciated installed productive capital stock $(1-\delta^{\mathcal{K}})\bar{K}_t(i)$, bought from entrepreneurs, with investment goods $I_t^{\mathcal{K}}(i)$, bought from retailers, to produce new installed productive capital $\bar{K}_{t+1}(i)$, according to the law of motion $\bar{K}_{t+1}(i) = (1-\delta^{\mathcal{K}})\bar{K}_t(i) + I_t^{\mathcal{K}}(i)$, where $\delta^{\mathcal{K}}$ is the depreciation rate and $\bar{K}_t(i)$ represents the available physical capital stock (which may differ from the capital stock that is actually used in production at t since entrepreneurs adjust capital utilization). We impose a sluggish pattern for investment by assuming quadratic adjustment cost function $\Gamma_t^{\mathcal{IK}}(i)$. Capital goods producers select the intertemporal profile $\{I_{t+s}^{\mathcal{K}}(i)\}_{s=0}^{\infty}$ that maximize the present discounted value of the dividends stream.

2.2.2. Manufacturers. Manufacturers combine capital with labor services to produce intermediate goods, which distributors use as inputs. There is a continuum of manufacturing firms $j \in [0,1]$. Each firm produces a specific variety of the intermediate good, which is bought by a continuum of distributor firms $f \in [0,1]$. Let $Z_t(j,f)$ stand for the time t quantity of variety j produced by manufacturer j and purchased by distributor f. Distributors buy intermediate goods from many manufacturers, bundling them together in a homogeneous intermediate good, $Z_t(f)$, to be used in the final goods production. The bundling technology is given by the CES aggregator yielding the usual demand for intermediate goods $Z_t(j) = \left(P_t^{\mathcal{Z}}(j)/P_t^{\mathcal{Z}}\right)^{-\sigma^{\mathcal{Z}}} Z_t$, where $\sigma^{\mathcal{Z}} \geq 0$ is the elasticity of substitution between varieties of the intermediate good, $P_t^{\mathcal{Z}}(j)$ denotes the price charged by manufacturer j, and Z_t is the aggregate demand for the intermediate good. Each manufacturing firm j combines labor services $U_t^{\mathcal{Z}}(j)$ with capital $K_t(j)$ according to the following production function

$$Z_t(j) = \left((1-\alpha_{\mathcal{U}})^{\frac{1}{\xi_{\mathcal{Z}}}} \left(K_t(j)\right)^{\frac{\xi_{\mathcal{Z}}-1}{\xi_{\mathcal{Z}}}} + (\alpha_{\mathcal{U}})^{\frac{1}{\xi_{\mathcal{Z}}}} \left(U_t^{\mathcal{Z}}(j)\right)^{\frac{\xi_{\mathcal{Z}}-1}{\xi_{\mathcal{Z}}}} \right)^{\frac{\xi_{\mathcal{Z}}}{\xi_{\mathcal{Z}}-1}}$$

where $\xi_{\mathcal{Z}} \geq 0$ is the elasticity of substitution between capital an labor and $0 \leq \alpha_{\mathcal{U}} \leq 1$ is a distribution parameter. We impose a sluggish adjustment of hours worked through a quadratic adjustment cost function. Manufacturer j sets labor demand $U_t^{\mathcal{Z}}(j)$ and capital demand $K_{t+1}(j)$ in each period in order to maximize the present discounted value of the dividends stream. Each firm is unable to reoptimize the price in each period with probability $\iota^{\mathcal{Z}}$, facing a Calvo-type problem. The intermediate goods price is $P_t^{\mathcal{Z}} = \left(\iota^{\mathcal{Z}} \left(P_{t-1}^{\mathcal{Z}}\right)^{1-\sigma^{\mathcal{Z}}} + (1-\iota^{\mathcal{Z}})(P_t^{\mathcal{Z}*})^{1-\sigma^{\mathcal{Z}}}\right)^{\frac{1}{(1-\sigma^{\mathcal{Z}})}}$, where $P^{\mathcal{Z}*}$ is the optimal intermediate goods price.

2.2.3. Distributors and retailers. Distributors combine intermediate goods with imported goods to produce the final good. There is a continuum of distributors

$f \in [0,1]$, each producing a specific variety of the good, which are bundled together by retailers to form the final good, Y_t. Let $Y_t(f)$ stand for the time t quantity of variety f from the final good, purchased by a continuum $r \in [0,1]$ of retailers. The bundling technology is given by the CES aggregator yielding the usual demand for variety f, $Y_t(f) = \left(P_t^{\mathcal{Y}}(f)/P_t^{\mathcal{Y}}\right)^{-\sigma^{\mathcal{Y}}} Y_t$, where $\sigma^{\mathcal{Y}} \geq 0$ is the elasticity of substitution between varieties of the final good, and $P_t^{\mathcal{Y}}(f)$ denotes the price charged by distributor f. Each distributor f combines domestic manufactured goods $Z_t^{\mathcal{Y}}(f)$ with imported goods $M_t(f)$ to obtain the final good $Y_t(f)$, according to the technology

$$Y_t(f) = \left((\alpha_{\mathcal{Z}})^{\frac{1}{\xi_{\mathcal{Y}}}} \left(Z_t^{\mathcal{Y}}(f)\right)^{\frac{\xi_{\mathcal{Y}}-1}{\xi_{\mathcal{Y}}}} + (1-\alpha_{\mathcal{Z}})^{\frac{1}{\xi_{\mathcal{Y}}}} \left[M_t(f)\left(1-\Gamma_t^{IM}(f)\right)\right]^{\frac{\xi_{\mathcal{Y}}-1}{\xi_{\mathcal{Y}}}} \right)^{\frac{\xi_{\mathcal{Y}}}{\xi_{\mathcal{Y}}-1}}$$

where $\xi_{\mathcal{Y}} \geq 0$ is the elasticity of substitution between domestic manufactured goods and imported good and $0 \leq \alpha_{\mathcal{Z}} \leq 1$ is the home bias parameter. We impose a quadratic adjustment cost function on changes in the import content. Each distributor f selects $\{Z_{t+s}^{\mathcal{Y}}(f), M_{t+s}(f)\}_{s=0}^{\infty}$ to maximize the discounted value of the dividend stream. With Calvo-type frictions, the firm is unable to reoptimize its price in each period with probability $\iota^{\mathcal{Y}}$. The final goods price is $P_t^{\mathcal{Y}} = \left(\iota^{\mathcal{Y}}(P_{t-1}^{\mathcal{Y}})^{1-\sigma^{\mathcal{Y}}} + (1-\iota^{\mathcal{Y}})(P_t^{\mathcal{Y}*})^{1-\sigma^{\mathcal{Y}}}\right)^{\frac{1}{(1-\sigma^{\mathcal{Y}})}}$, where $P^{\mathcal{Y}*}$ is the optimal final goods price.

The sole function of retailers is to bundle together the different varieties f produced by distributors to form an homogeneous final good Y_t that can be reallocated to different costumers—households, capital goods producers, government, and foreign distributors. They are perfectly competitive in input and output markets, charging to final costumers the same price paid to distributors, *i.e.* $P_t = P_t^{\mathcal{Y}}$.

2.2.4. Importers. There is a continuum of importers $g \in [0,1]$, each producing a specific variety of imported good $M_t(g)$, which are bundled together by distributors to form the imported good M_t. The bundling technology is given by the CES aggregator, yielding the usual demand for variety g, $M_t(g) = \left(P_t^{\mathcal{IM}}(g)/P_t^{\mathcal{IM}}\right)^{-\sigma^{\mathcal{IM}}} M_t$, where $\sigma^{\mathcal{IM}} \geq 0$ is the elasticity of substitution between varieties of the imported good and $P_t^{\mathcal{IM}}(g)$ denotes the price charged by importer g. Dividends are simply $d_t^{\mathcal{IM}}(g) = \left(P_t^{\mathcal{IM}}(g) - P_t^*\right) M_{t+s}(g)$, *i.e.* importers buy imported goods from abroad at price P_t^* (the nominal exchange rate is assumed to be irrevocably set to unity), and sell it domestically at price $P_t^{\mathcal{IM}}(g)$. With Calvo-type frictions, the imported goods price is $P_t^{\mathcal{IM}} = \left(\iota^{\mathcal{IM}}(P_{t-1}^{\mathcal{IM}})^{1-\sigma^{\mathcal{IM}}} + (1-\iota^{\mathcal{IM}})(P_t^{\mathcal{IM}*})^{1-\sigma^{\mathcal{IM}}}\right)^{\frac{1}{(1-\sigma^{\mathcal{IM}})}}$, where $P^{\mathcal{IM}*}$ is the optimal price, and $\iota^{\mathcal{IM}}$ is the complement of the probability of optimizing the price level in each period.

2.3. Fiscal authorities

The government keeps the budget balanced at all times, financing nominal public consumption $P_t G_t$ with lump-sum taxes LT_t levied on households. The government budget constraint is simply $P_t G_t = LT_t$.

2.4. Rest of the world

In a monetary union the real exchange rate is $\varepsilon_t = P_t^*/P_t$, implying $\varepsilon_t/\varepsilon_{t-1} = \pi_t^*/\pi_t$, where $\pi_t^* = P_t^*/P_{t-1}^*$ is the imported goods inflation rate (the nominal exchange rate is assumed to be irrevocably set to unity). For tractability, trade and financial flows are restricted to euro area countries. We follow Adolfson *et al.* (2007) and assume that in the rest of the world there exists a continuum of distributors $m \in [0,1]$, who demand $Y_t^{\mathcal{X}}(m)$ units of the final good from domestic retailers. This good is thereafter combined with foreign intermediate goods $Z_t^*(m)$ according to the following production function

$$Y_t^*(m) = \left(\left(\alpha_Y^*\right)^{\frac{1}{\xi^*}} \left(Y_t^{\mathcal{X}}(m)\left(1 - \Gamma_t^{IX}(m)\right)\right)^{\frac{\xi^*-1}{\xi^*}} + \left(1-\alpha_Y^*\right)^{\frac{1}{\xi^*}} \left(Z_t^*(m)\right)^{\frac{\xi^*-1}{\xi^*}} \right)^{\frac{\xi^*}{\xi^*-1}}$$

where ξ^* is the elasticity of substitution between intermediate goods and domestic exports, and α_Y^* is the bias towards domestic exports. As in the case of home distributors, we impose a quadratic adjustment cost function on changes in the demand for domestic exports. Each foreign distributor selects the quantities $\{Y_t^{\mathcal{X}}(m), Z_t^*(m)\}_{s=0}^{\infty}$ to maximize the present discounted value of the dividends stream.

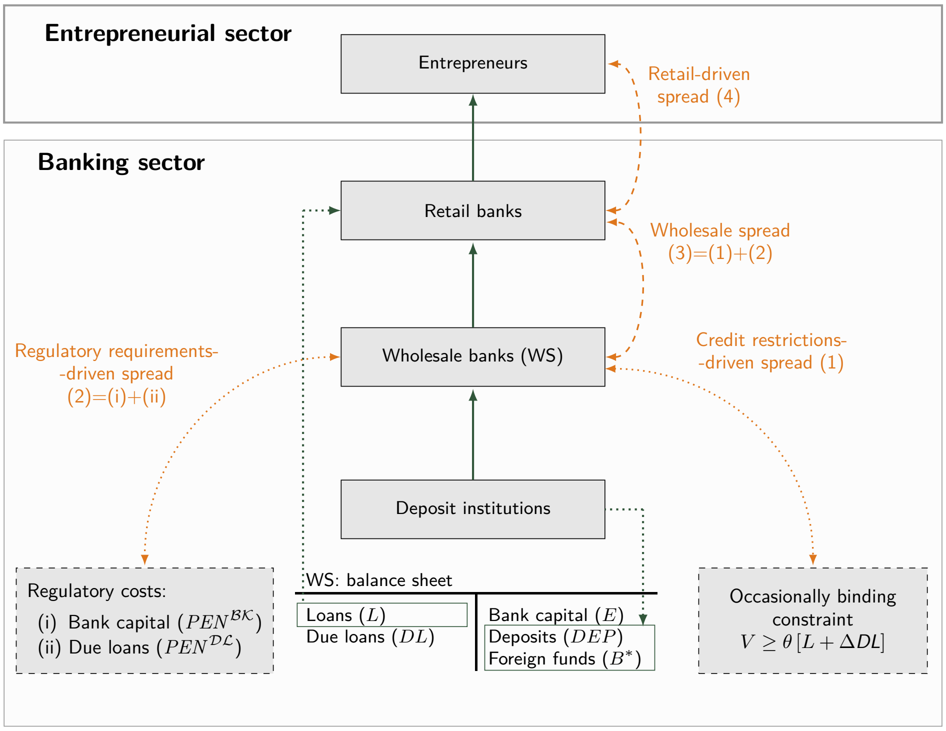
Banks are allowed to borrow from abroad whenever internal funds do not suffice to meet credit requirements, paying a country-specific risk premium $\Psi_t = 1 - \varphi_{BF} \cdot \exp\left[B_t^*/(4 \cdot P_t \cdot GDP_t) - \left(B_{GDP}^*\right)^{target}\right]$ over the foreign interest rate i_t^*, with φ_{BF} representing a scale parameter, and $B_t^*/(4 \cdot P_t \cdot GDP_t) - \left(B_{GDP}^*\right)^{target}$ the deviation of annualized foreign assets-to-GDP ratio from target.

3. The financial sector: entrepreneurs and banks

Figure 2 provides a simple diagram representing the financial sector of the model.

3.1. Retail branches and the entrepreneurial sector

Macro-financial linkages builds on Bernanke *et al.* (1999) and Christiano *et al.* (2014), in which financial frictions affect the return on capital and therefore capital demand. There is a continuum of infinitely lived entrepreneurial firms $l \in [0,1]$.



Notes: Green arrows identify the flow of funds from creditors to debtors, *e.g.* from retail banks to entrepreneurs. Green dotted lines clarify that loans are assets of wholesale banks, and that deposits and foreign funds (external finance) are collected through deposit institutions. Deposits are collected from households and foreign funds from euro area agents. Orange arrows identify operating restrictions from which interest rate spreads emerge. The credit restrictions-driven spread is conditional on the occasionally binding constraint pending on wholesale banks, while the regulatory requirements-driven spread is due to non compliance with capital and due loans requirements. Wholesale banks also finance the asset side of their balance sheet (loans and due loans) with their bank capital. The occasionally binding constraint, which stems from a moral hazard/costly enforcement problem, is not binding if the bank's value $V \geq \theta\,[L + \Delta DL]$, where $\theta\Delta$ is the fraction of due loans that can be diverted, and $0 \leq \Delta \leq 1$. The external finance premium of the economy is the sum of spreads (3) and (4). For simplicity we removed time scripts from all variables.

Figure 2: The entrepreneurial and banking sectors.

At the end of each period, entrepreneurs buy the new capital stock from capital goods producers and rent it, partially or entirely, to manufacturers, for usage in the production process.

The entrepreneurial firm l selects the capital utilization rate, $u_t(l)$ in each period to maximize the net return per unit of capital, $\left[R_t^{\mathcal{K}} u_t(l) - P_t a\big(u_t(l)\big)\right]$, where $a\big(u_t(l)\big)$ is the cost of capital utilization and $R_t^{\mathcal{K}}$ is the nominal rental rate of capital charged to intermediate goods producers, taken as given. Capital effectively rented to manufacturers and used in production is $K_t = u_t \bar{K}_t$, and the resource cost associated with variable capital utilization is $RCU_t = P_t a(u_t)\bar{K}_t$.[10]

Entrepreneurs do not have access to sufficient internal funds, $N_t(l)$, to finance desired capital purchases, but can cover the funding gap by borrowing $L_t(l)$ from retail branches at the gross nominal interest rate $i_t^R(l)$.[11] Entrepreneurs face the balance sheet constraint $P_t^{\mathcal{K}} \bar{K}_{t+1}(l) = L_t(l) + N_t(l)$. After acquiring the capital stock from capital goods producers (but before selecting the utilization rate), entrepreneurs experience an idiosyncratic shock $\omega_{t+1}^{\mathcal{K},l}$, $\log \omega_{t+1}^{\mathcal{K},l} \sim \mathcal{N}\big(-0.5(\sigma_{t+1}^{\mathcal{K}})^2, (\sigma_{t+1}^{\mathcal{K}})^2\big)$, distributed independently over time and across entrepreneurs, affecting the value of capital. Specifically, there exists an endogenous threshold level for the idiosyncratic shock, $\bar{\omega}_{t+1}^{\mathcal{K},l}$, below which the entrepreneur cannot meet her debt obligations and is forced to declare bankruptcy.

Entrepreneurs celebrate a standard debt contract with retail branches, specifying a nominal loan amount $L_t(l)$ and a non-state contingent gross nominal retail interest rate, $i_t^R(l)$, to be paid if $\omega_{t+1}^{\mathcal{K},l} \geq \bar{\omega}_{t+1}^{\mathcal{K},l}$. The value for the threshold $\bar{\omega}_{t+1}^{\mathcal{K},l}$ satisfies the condition $\bar{\omega}_{t+1}^{\mathcal{K},l} Ret_t^{\mathcal{K}} P_t^{\mathcal{K}} \bar{K}_{t+1}(l) = i_t^R(l) L_t(l)$, where $Ret_t^{\mathcal{K}}$ is the entrepreneurs' *ex-ante* return on capital. Retail branches must incur in a unitary repossession cost $\mu^{\mathcal{K}}$ over the firm value to repossess the capital value of bankrupted and insolvent firms. This cost, detailed below, is a payment for labor services hired from households. Let $\mathfrak{F}^{\mathcal{K}}(x) = \Pr[\omega_{t+1}^{\mathcal{K},l} < x]$ denote the cumulative distribution function and $\mathfrak{f}^{\mathcal{K}}(x)$ the corresponding probability density function of $\omega_{t+1}^{\mathcal{K},l}$. Since retail branches are perfectly competitive, their participation constraint corresponds to zero-expected profits

$$\underbrace{[1 - \mathfrak{F}^{\mathcal{K}}(\bar{\omega}_{t+1}^{\mathcal{K},l})]}_{\substack{\text{No bankruptcy}\\ \text{probability}}} \underbrace{i_t^R(l) L_t(l)}_{\substack{\text{Bank revenues}\\ \text{(no bankruptcy)}}} + \underbrace{(1 - \mu^{\mathcal{K}})}_{\substack{\text{Repossession}\\ \text{rate}}} \underbrace{\int_0^{\bar{\omega}_{t+1}^{\mathcal{K},l}} \omega_{t+1}^{\mathcal{E},l} Ret_t^{\mathcal{K}} P_t^{\mathcal{K}} \bar{K}_{t+1}(l) \mathfrak{f}^{\mathcal{K}}(\omega_{t+1}^{\mathcal{K},l}) \mathrm{d}\omega_{t+1}^{\mathcal{K},l}}_{\substack{\text{Average value of capital}\\ \text{in case of bankruptcy } (\omega_{t+1}^{\mathcal{K},l} < \bar{\omega}_{t+1}^{\mathcal{K},l})}} = \underbrace{i_t^W L_t(l)}_{\substack{\text{Cost of}\\ \text{funds}}} \tag{1}$$

10. The cost of capital utilization $a(u_t(l))$ takes the following functional form

$$a(u_t(l)) = \frac{1}{2}\varphi_a \sigma_a \big(u_t(l)\big)^2 + \varphi_a(1 - \sigma_a)u_t(l) + \varphi_a\left(\frac{\sigma_a}{2} - 1\right)$$

where $\varphi_a > 0$ is calibrated to ensure a unitary capital utilization in the steady state and $\sigma_a > 0$ is a parameter that controls the curvature.

11. At this stage it is unimportant to distinguish between performing and due loans, or between stocks and flows. This will only become important for wholesale banks.

Entrepreneurs maximize the expected value of terminal wealth, and the solution steps are identical to those in Bernanke *et al.* (1999). Let $P_t \Lambda_t^{\mathcal{K}}$ represent, as in Benes and Kumhof (2015), *ex-post* period t loan losses from retail branches on all contracts celebrated with all entrepreneurs in the previous period

$$P_t \Lambda_t^{\mathcal{K}} = i_{t-1}^{W} L_{t-1} - \left[\left[1 - \mathfrak{F}^{\mathcal{K}}(\bar{\omega}_t^{\mathcal{K}}) \right] i_{t-1}^{R} L_{t-1} + (1 - \mu_t^{\mathcal{K}}) \int_0^{\bar{\omega}_t^{\mathcal{K}}} \omega_t^{\mathcal{K}} Ret_{t-1}^{\mathcal{K}} P_{t-1}^{\mathcal{K}} \bar{K}_t \mathfrak{f}^{\mathcal{K}}(\omega_t^{\mathcal{K}}) \mathrm{d}\omega_t^{\mathcal{K}} \right]$$

This amount—to be transferred to wholesale banks— corresponds to a gain for entrepreneurs, resulting from unexpected events (*i.e.* unforeseen aggregate shocks) that, due to the non-state contingent nature of the interest rate, could not be taken into account in the loan contract. Obviously, $\Lambda_t^{\mathcal{K}}$ can be negative, a case in which entrepreneurs' loan losses correspond to branches gains.

A fraction $1 - \iota^{\mathcal{E}}$ of entrepreneurs goes out of business in every period, transferring the residual value of the firm to the household. In addition, we assume that some surviving entrepreneurs may still be unable to reimburse the loan, for instance due to liquidity problems, an issue which retail branches pass on to wholesale banks to be managed.[12] Specifically, there exists a second threshold shock $\bar{\bar{\omega}}_{t+1}^{\mathcal{K},l} > \bar{\omega}_{t+1}^{\mathcal{K},l}$ below which a surviving entrepreneur does not immediately reimburse the loan, which is classified as due by the wholesale bank. This amount DL^{new} must be added to net worth since entrepreneurs owe it to the bank but do not pay. Over time, wholesale banks are able to cure some amount DL_t^{cured} of the total stock of due loans, to be subtracted to net worth since it represents a reimbursement.[13] Aggregate net worth N_t evolves over time according to

$$N_t = \iota^{\mathcal{E}} \left[i_{t-1}^{W} N_{t-1} + P_{t-1}^{\mathcal{K}} \bar{K}_t \left(Ret_{t-1}^{\mathcal{K}} \left(1 - \mu_t^{\mathcal{K}} \int_0^{\bar{\omega}_t^{\mathcal{K}}} \omega_t^{\mathcal{K}} \mathfrak{f}^{\mathcal{K}}(\omega_t^{\mathcal{K}}) \mathrm{d}\omega_t^{\mathcal{K}} \right) - i_{t-1}^{W} \right) + P_t \Lambda_t^{\mathcal{K}} + DL_t^{\text{new}} - DL_t^{\text{cured}} \right] + \mathit{WT}^{\mathcal{E}}$$

where $\mathit{WT}^{\mathcal{E}}$ are initial wealth transfers from households to new businessmen.[14]

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12. The profit condition of retail branches remains therefore unaffected by this event.

13. Whenever a firm owing due loans exists the market, either because the entrepreneur quits activity or goes bankrupt, those are transferred to the remaining entrepreneurs. Due loans only exit the system when they are cured or written off.

14. Since the solution does not depend on $\iota^{\mathcal{E}}$, we only require that the pair $(\iota_t^{\mathcal{E}}, \mathit{WT}^{\mathcal{E}})$ does not allow net worth to grow indefinitely over time, a situation in which entrepreneurs would no longer need external funding.

3.2. Wholesale banks

There exists a continuum of infinitely lived wholesale banks $k \in [0,1]$. Each bank k issues deposits $DEP_t(k)$ to households, combining them with equity $E_t(k)$ and foreign funds $B_t^*(k)$, to lend $L_t(k)$ to entrepreneurs, and finance due loans $DL_t(k)$.[15] Lending is processed through retail branches. Bank k's balance sheet is

$$L_t(k) + DL_t(k) = DEP_t(k) + B_t^*(k) + E_t(k) \tag{2}$$

The expected bank value at $t+1$ given that the banker remains in the job, $\mathrm{E}_t\left[EV_{t+1}(k)\right]$, is

$$\begin{aligned}\mathrm{E}_t\left[EV_{t+1}(k)\right] =& i_t^W L_t(k) + DL_t(k) - i_t^D DEP_t(k) - i_t^* \Psi_t B_t^*(k) \\ & - \mathrm{E}_t \text{Operational costs}_{t+1}(k) - \mathrm{E}_t \text{Regulatory costs}_{t+1}(k) \\ & - \mathrm{E}_t \text{Banking frictions}_{t+1}\end{aligned} \tag{3}$$

where the costs and frictions will be presented below (and detailed in Appendix A).

3.2.1. Risky bank lending. Each bank is exposed to an idiosyncratic shock $\omega_{t+1}^{\mathcal{BK},k}$ that changes the return on total loans from $i_t^W L_t(k) + DL_t(k)$ to $\omega_{t+1}^{\mathcal{BK},k}\left(i_t^W L_t(k) + DL_t(k)\right)$, creating a risky environment. This shock may reflect differing loan recovery rates and differing success at raising non-interest income and minimizing non-interest expenses, and is therefore interpreted as a loan return shock (as in Benes and Kumhof 2015). The random variable $\omega_{t+1}^{\mathcal{BK},k}$ follows a log-normal distribution with a mean of unity, $\log \omega_{t+1}^{\mathcal{BK},k} \sim \mathcal{N}(-0.5(\sigma_t^{\mathcal{BK}})^2, (\sigma_t^{\mathcal{BK}})^2)$, distributed independently over time and across banks. Let $\mathfrak{F}^{\mathcal{BK}}(x) = \Pr[\omega_{t+1}^{\mathcal{BK},k} < x]$ denote the cumulative distribution function and $\mathfrak{f}^{\mathcal{BK}}(x)$ the corresponding probability density function of $\omega_{t+1}^{\mathcal{BK},k}$. A given bank faces a penalty/reputation loss $\bar{\chi}^{\mathcal{BK}}$ for each unit of total assets if she does not comply with capital regulatory requirements $\bar{\gamma}_t^{\mathcal{BK}}$. Let $\bar{\omega}_{t+1}^{\mathcal{BK},k}$ denote the threshold loan return shock below which bank k is unable to comply with capital regulatory requirements

$$\begin{aligned}\bar{\omega}_{t+1}^{\mathcal{BK},k}\left(i_t^W L_t(k) + DL_t(k)\right) - i_t^D DEP_t(k) - i_t^* \Psi_t B_t^*(k) - \text{Operational costs}_{t+1}(k) \\ - \text{Banking frictions}_{t+1} = \bar{\gamma}_t^{\mathcal{BK}} \bar{\omega}_{t+1}^{\mathcal{BK},k}\left(i_t^W L_t(k) + DL_t(k)\right)\end{aligned} \tag{4}$$

Notice that expected loan gains/losses from retail banks are zero, $\mathrm{E}_t\left[P_{t+1}\Lambda_{t+1}^{\mathcal{K}}(k)\right] = 0$. The expected cost associated with non-compliance is $\mathrm{E}_t PEN_{t+1}^{\mathcal{BK}} = \bar{\chi}^{\mathcal{BK}}[L_t(k) + DL_t(k)]\mathfrak{F}^{\mathcal{BK}}(\bar{\omega}_{t+1}^{\mathcal{BK},k})$.

15. We use the terms banks' capital and equity interchangeably throughout the article.

3.2.2. Due loans. In each period, a given fraction $\varphi_{t-1}^{DL} = \left[\mathfrak{F}^{\mathcal{K}}(\bar{\bar{\omega}}_t^{\mathcal{K}}) - \mathfrak{F}^{\mathcal{K}}(\bar{\omega}_t^{\mathcal{K}})\right] > 0$ of the total loans stock is reclassified as non-productive and gives raise to an amount of due loans totaling $DL_t^{\text{new}}(k) = \varphi_{t-1}^{DL} L_{t-1}(k)$, where for tractability we assume $\bar{\bar{\omega}}_t^{\mathcal{K}} = \tilde{\varphi}^{DL}\bar{\omega}_t^{\mathcal{K}}, \tilde{\varphi}^{DL} > 1$.[16] On the opposite direction, banks convert an exogenous fraction $\tau^{\mathcal{BK}}$—henceforth termed cure rate—of the initial due loans stock, $DL_t^{\text{init}}(k) = DL_{t-1}(k) + DL_t^{\text{new}}(k)$, into funds which can be used to either lower external finance or increase lending. Banks also decide to write-off from the balance sheet an endogenous fraction $\upsilon_t(k)$—hereinafter termed impairment rate—which deduct to banks equity (and add to entrepreneurial net worth). A cure therefore consists in that amount being deducted to the asset side of the balance sheet at no cost, and hence either in a potential reduction in external finance or extra funds available to lend to the entrepreneurial sector, while a write-off consists in the same reduction, but at the expense of banks' capital. Impairment losses are $DL_{t+1}^{\text{imp}}(k) = \upsilon_t(k) DL_t^{\text{init}}(k)$, which we consider an operational cost to be paid at $t+1$, whilst total cures are defined as $DL_{t+1}^{\text{cured}}(k) = \tau^{\mathcal{BK}} DL_t^{\text{init}}(k)$. Due loans at t correspond to the amount that is carried over from the previous period deducted from recoveries and impairment losses, to which one must add new inflows of due loans,

$$DL_t(k) = (1 - \upsilon(k) - \tau^{\mathcal{BK}}) DL_t^{\text{init}}(k) \tag{5}$$

Managing the due loans portfolio is not without costs. In particular, we assume that banks incur in a unitary holding cost κ^{DL} over the total amount of due loans—an expense that we also place under the umbrella of operational costs. The intuition is that due loans are often associated with additional recovery efforts, auditing expenses, judicial proceedings aimed at recovering some of the claim's value, and costly proof providence to investors respecting their correct valuation. The holding cost, totaling $DL_{t+1}^{\text{hold}}(k) = \kappa^{DL} DL_t(k)$ at $t+1$, is a payment for labor services hired from households, further detailed below.

The regulator requires each bank to recognize impairment losses totaling no less than a fraction $\bar{\gamma}_t^{DL}$ of a risk-corrected stock measure of due loans, otherwise she imposes a fixed penalty $\bar{\chi}^{DL}$. This amount can be interpreted as the cost of additional measures or an action plan imposed by the regulator to trespassing banks, corresponding to the adoption of measures aimed at decreasing the stock of due loans.[17] Let $\bar{\omega}_{t+1}^{DL,k}$ denote the threshold shock above which bank k is unable

16. Notice that the threshold shocks $\bar{\omega}_t^{\mathcal{K}}$ and $\bar{\bar{\omega}}_t^{\mathcal{K}}$ respect the entrepreneur and not the bank.

17. We assume a fixed penalty for tractability purposes, since the interaction between regulatory capital and regulatory impairments would be too complex otherwise. Nevertheless, notice that expected penalties increase with the probability of non-compliance, which in turn increases with the size of the due loans stock. Competent authorities are allowed to require credit institutions to apply specific adjustments (deductions, filters or similar measures) to own funds calculations when the accounting treatment is considered not prudent from a supervisory perspective, and this can be understood as part of a penalty.

to comply with due loans regulatory standards, resulting from a distribution $\mathfrak{f}^{DL}(\cdot)$. The threshold rule is[18]

$$DL_{t+1}^{\mathrm{imp}}(k) = \bar{\gamma}_t^{DL} \frac{DL_t(k)}{\bar{\omega}_{t+1}^{DL,k}} \tag{6}$$

Whenever $\omega_{t+1}^{DL,k} \geq \bar{\omega}_{t+1}^{DL,k}$, the ratio of due loans to impairment losses is considered adequate and the regulator requires no additional effort from the bank. On the opposite direction, if $\omega_{t+1}^{DL,k} < \bar{\omega}_{t+1}^{DL,k}$, the ratio of due loans to impairment losses is considered excessively high and the regulator forces the bank to adopt an action plan and pay the penalty. Intuitively, banks with higher returns due to more favorable idiosyncratic shocks are able to support larger amounts of due loans without violating regulatory requirements as compared with those hit by less favorable shocks. We consider in addition that the regulator may tighten regulatory standards as the risk-corrected ratio of due-to-total loans increase, by postulating the following process for the regulatory target

$$\bar{\gamma}_t^{DL} = \bar{\gamma}^{DL} + \rho^{dlr} \left[\frac{DL_t/\bar{\omega}_{t+1}^{DL}}{L_t + DL_t/\bar{\omega}_{t+1}^{DL}} - dlr \right]$$

where $\bar{\gamma}^{DL} \in [0,1]$ is a steady-state value and ρ^{dlr} is a sensibility parameter. This specification postulates that regulatory standards $\bar{\gamma}^{DL}$ may respond to deviations of the due-to-total loans ratio of non-complying banks from a pre-specified target value *dlr* at the macro level. Larger values for the sensibility parameter ρ^{dlr} imply a greater regulatory weight on the due-to-total loans ratio *vis-à-vis* the impairment-to-due loans ratio. To put differently, the regulatory rule postulates that, at an individual level, impairments must cover a fraction of the due loans stock, but banks may be required to hasten impairments if the macro level stock of due loans becomes excessively high. The expected cost of trespassing the regulatory standards is $\mathrm{E}_t PEN_{t+1}^{DL}(k) = \bar{\chi}^{DL} \mathfrak{F}^{DL}(\bar{\omega}_{t+1}^{DL,k})$, where $\bar{\omega}_{t+1}^{DL,k} = (\bar{\gamma}_t^{DL}/\upsilon_t(k)) \cdot (1 - \upsilon_t(k) - \tau^{\mathcal{BK}})$ results from simplifying Equation (6) and $\mathfrak{F}^{DL}(\cdot)$ is the cumulative distribution function of $\mathfrak{f}^{DL}(\cdot)$. For simplicity, we assume that $\mathfrak{f}^{DL}(\cdot)$ is a mean preserving spread of $\mathfrak{f}^{\mathcal{BK}}(\cdot)$.[19]

3.2.3. Deposit institutions. There exists a continuum of zero-profit deposit institutions bridging the connection gap between wholesale banks and

18. This rule is in line with ECB guidelines to banks on nonperforming loans and with EU regulations.

19. Our specification has the purpose of allowing banks with larger (idiosyncratic) returns to be able to have higher due loans ratios and still comply with the rule. We use a mean preserving spread of $\mathfrak{f}^{\mathcal{BK}}(\cdot)$ for this purpose to introduce a larger variability in the distribution of due loans amounts across banks without the cumbersomeness of having another distribution in the model. For further details, see our companion technical appendix.

households/foreign agents. At the beginning of the period deposit institutions borrow funds from households and foreign funds at the rate i_t^D or $\Phi_t i_t^*$ and lend those funds to wholesale banks by celebrating a debt contract. The contract specifies that, at the end of the period, wholesale banks must pay the principal plus a state contingent interest—$i_t^{RD}(k)DEP_t(k)$ in the case of deposits and $i_t^{R*}(k)\Phi_t B_t^*(k)$ in the case of foreign funds—if they comply with regulatory capital requirements, *i.e.* $\omega_{t+1}^{\mathcal{BK},k} \geq \bar{\omega}_{t+1}^{\mathcal{BK},k}$. Deposit institutions are still able to fully recover the principal in the case of non-compliant banks, but must pay in the process a unitary repossession cost μ^D for labor services hired from households. Since deposit branches are perfectly competitive, their participation constraint corresponds to zero-expected profits

$$\underbrace{[1-\mathfrak{F}^{\mathcal{BK}}(\bar{\omega}_{t+1}^{\mathcal{BK},k})]}_{\substack{\text{Compliance}\\ \text{with reg.}\\ \text{CAR}}}\underbrace{\left[i_t^{RD}(k)DEP_t(k)+i_t^{R*}(k)\Phi_t B_t^*(k)\right]}_{\substack{\text{Bank revenues}\\ \text{(compliance}\\ \text{with CAR)}}}+\underbrace{(1-\mu^D)}_{\substack{\text{Repossession}\\ \text{rate}}}$$
$$\underbrace{\mathfrak{F}^{\mathcal{BK}}(\bar{\omega}_{t+1}^{\mathcal{BK},k})\left[DEP_t(k)+B_t^*(k)\right]}_{\substack{\text{Repossessed liabilities}\\ \text{in case of non-compliance}}}=\underbrace{i_t^D DEP_t(k)+i_t^*\Phi_t B_t^*(k)}_{\substack{\text{Payments to}\\ \text{creditors}}} \quad (7)$$

3.2.4. Moral hazard/costly enforcement problem. We consider that the banker will always retain earnings until exiting the industry. The banker's objective is therefore to maximize expected terminal wealth $V_t(k) = \mathrm{E}_t\sum_{s=1}^{\infty}(1-\iota^{\mathcal{BK}})(\iota^{\mathcal{BK}})^{s-1}\Lambda_{t,t+s}^N EV_{t+s}(k)$, which iterating forward can be restated as

$$V_t(k)=\mathrm{E}_t(1-\iota^{\mathcal{BK}})\Lambda_{t,t+1}^N EV_{t+1}(k)+\iota^{\mathcal{BK}}\Lambda_{t,t+1}^N V_{t+1}(k) \quad (8)$$

The moral hazard/costly enforcement problem has the following structure. At the beginning of each period the banker has the option to divert a fraction θ_t of assets. The decision to divert assets at $t+1$ is made at the end of period t, before both individual and aggregate uncertainty at $t+1$ are revealed. The intuition is that it takes some time to reallocate assets. If the banker decides to divert funds, the bank defaults on deposits (and foreign reimbursements) and is shut down. Depositors and foreign creditors will be willing to supply funds to bank k if and only if the following incentive compatibility constraint is satisfied

$$V_t(k) \geq \theta_t\left[L_t(k)+\Delta DL_t(k)\right] \quad (9)$$

where $\theta_t\Delta$ is the fraction of due loans that can be diverted, with $0 \leq \Delta \leq 1$. That is, due loans are assumed to be (weakly) more difficult to divert than performing ones. The left-hand side is the bank's value for the banker whereas the right-hand side is the gain from diverting assets.

In practice, the non-linearity of the model may impose some convergence issues when credit restrictions become binding. We go around this issue by postulating that bankers are more effectively monitored and thus face lower diversion gains as the spread (hence incentives to divert) increase. In particular, we assume $\theta_t = \overline{\theta}\left(1 - \theta_a\left(\exp(1 + (i_t^W - \tilde{i}_t^W)/\mathrm{E}_t\pi_{t+1}) - \exp(1)\right)\right)$, where $\overline{\theta}$ and θ_a are parameters. This functional form smooths the spread dynamics and allows non-linear convergence without affecting the nature of the mechanism.

Wholesale banks must hire monitoring services from households worth $\mu^{AG}(i_{t-1}^W - \tilde{i}_{t-1}^W)L_{t-1}$ in the event of moral hazard issues and hence of restrictive credit conditions. Otherwise bankers may misreport the value of assets *ex-post* and still divert some fraction for personal benefit, and no depositor would therefore ever supply funds to banks *ex-ante*.

3.2.5. The banker's problem. The banker will select the vector

$$\{L_{t+s}(k), DEP_{t+s}(k), B_{t+s}^{*}(k), DL_{t+s}(k)\}$$

in each period to maximize expected terminal wealth in (8), subject to (2), (3), (4), (5), (6), (7), and (9). Deciding on $DL_{t+s}(k)$ is the same as deciding the impairment rate $\upsilon_{t+s}(k)$, implications of the corresponding law of motion (5).

We break down the overall spread $i_t^W - i_t^D$ into the contribution of two elements, risky bank lending, $\tilde{i}_t^W - i_t^D$, and moral hazard, $i_t^W - \tilde{i}_t^W$. The spread triggered by risky bank lending, *i.e.* that prevail in the absence of moral hazard issues, states that the return on loans will be at a premium over the cost of funds, given by the interest rate on deposits, to cover for the expected costs triggered by the possible non-compliance of regulatory requirements in case of an adverse shock. Due loans affect the wholesale rate insofar they influence the threshold $\bar{\omega}_{t+1}^{\mathcal{BK}}$. That is, an increase in due loans necessarily trigger larger impairment losses, pushing bank's capital downwards and increasing the probability of non-compliance with capital regulatory requirements.

The spread triggered by moral hazard states that the premium over the shadow rate depends on the tightness of the incentive constraint and the fraction of funds that can be diverted. It is zero when the constraint does not bind, but is positive whenever the incentive compatibility constraint binds. Intuitively, households and foreign agents restrict the amount of deposits and foreign finance up to the point where the banker's incentives to divert funds are fully canceled out. This creates a wedge between the rate wholesale banks are willing to supply funds and the rate that creditors are willing to pay for funds.

The occasionally binding nature of credit restrictions is able to generate powerful asymmetric responses to financial or banking shocks—those whose nature is endowed with important effects on the banking system. Under "good" shocks that expand terminal wealth credit restrictions remain slack and play no role whatsoever. In contrast, under "bad" shocks negatively impacting terminal wealth credit restrictions may become binding for some time and greatly affect the model dynamics, amplifying and increasing business cycle persistence.

The first-order condition on foreign bonds implies a nil premium *vis-à-vis* deposits. The first-order condition with respect to due loans balances, on the one hand, the cost of recognizing one unit of due loans as impairment loss net of the incentives to divert funds, and on the other, the expected cost of carrying-over that unit to the next period. The latter is composed of the opportunity, holding and penalty costs—both direct and indirect, through their effect on the compliance of capital requirements. Larger impairment losses push down the gain from diverting assets, and thus the incentive compatibility condition becomes "less binding."

Finally, aggregate equity therefore evolves according to

$$E_t = \iota^{\mathcal{BK}} \Big[(i^W_{t-1} - i^D_{t-1}) L^p_{t-1} + (1 - i^D_{t-1}) DL_{t-1} + i^D_{t-1} E_{t-1} - (i^*_{t-1} \Psi_{t-1} - i^D_{t-1}) B^*_{t-1}$$
$$- \text{Regulatory costs}_t - \text{Operational costs}_t - \text{Banking frictions}_t \Big] + WT^{\mathcal{BK}}_t$$

where $1 - \iota^{\mathcal{BK}}$ is the fraction of bankers that goes out of business in every period, transferring the residual value to the household, and $WT^{\mathcal{BK}}_t$ are startup funds provided by households to new bankers. Banks are required to pay regulatory penalties to the government if the target $\bar{\gamma}^{DL}_t$ is violated, and therefore they hold a capital conservation buffer to cushion adverse shocks.

3.3. Repossession costs and monitoring activities

Repossession costs paid by retail banks for services hired from households total $RC_t = \mu^{\mathcal{K}}_t Ret^{\mathcal{K}}_{t-1} P^{\mathcal{K}}_{t-1} \bar{K}_t G^{\mathcal{K}}_t$. This amount compounds with the expenses associated with banking frictions and due loans holding costs, all services provided by households according to the technology

$$RC_t + \text{Banking frictions}_t + DL^{\text{hold}}_t = P_t \cdot A^{\text{mon}} \left(U^{\text{mon}}_t\right)^{\alpha^{\text{mon}}}$$

where A^{mon} and α^{mon} are technology parameters calibrated so that the labor required by these services is devoid of any important role in the model dynamics and U^{mon}_t is the labor effort applied in those activities.

3.4. Market clearing conditions and GDP definition

We close the model through a set of market clearing conditions. Labor market clearing implies $U_t = U^{\mathcal{Z}}_t + U^{\text{mon}}_t + \Gamma^{\mathcal{U}}_t$. In the intermediate goods market, we have $P^{\mathcal{Z}}_t Z_t - RCU_t - \text{Regulatory costs}_t - P^{\mathcal{Z}}_t \varpi^{\mathcal{Z}} = P^{\mathcal{Z}}_t Z^{\mathcal{Y}}_t$. In the final goods market, $P^{\mathcal{Y}}_t Y_t - \Gamma^{\mathcal{IK}}_t - P^{\mathcal{Y}}_t \varpi^{\mathcal{Y}} = P^{\mathcal{Y}}_t (C_t + I_t + G_t + X_t)$. Finally, GDP is $GDP_t = C_t + G_t + I_t + X_t - p^{\mathcal{IM}}_t M_t$.

3.5. Calibration

We calibrate the model to match long-run data or studies for small euro area economies, using Portugal as reference. Some parameters are exogenously set by taking into consideration common options in the literature, available historical data, or empirical evidence, whilst others are endogenously determined to match great ratios or other measures. See Appendix B for details.

4. Policy design

Our simulation exercise considers three policy dimensions endowed with important impacts on the accumulation of due loans. The first dimension that we consider is the penalty rate $\bar{\chi}^{DL}$ that banks pay when unable to comply with regulatory impairment requirements. We name this "penalty policy." The second dimension is related with the parameter $\bar{\gamma}_t^{DL}$ that directly governs regulatory impairment requirements. This is termed "impairment policy" henceforth. The final dimension relates with the sensibility parameter ρ^{dlr}, which governs how impairment requirements change with the due loans ratio throughout the cycle. We label this "sensibility policy."

We analyze the relative performance of each of these policies as a function of holding costs κ^{DL}, and use lifetime utility as a comparison criterion. Alongside, we perform also a comparative statics for the cure rate $\tau^{\mathcal{BK}}$. For a numerical solution to exist, it cannot generate excessively high or low levels of bank capital, towards regions where no bank or all banks comply with regulatory capital requirements. To avoid that outcome, we adjust banks' startup funds $WT_t^{\mathcal{BK}}$ to changes in the parameter κ^{DL} such that the equity-to-loans ratio (*aka* banks' capital-to-loans ratio) remains unchanged at the initial level of 14 percent for the baseline policy vector.[20] We study the effects of policies under two dividend strategies. A stiff strategy, in which startup funds remain unchanged and dividends adjust only thought transferred earnings from exiting bankers (which depend on the state of the economy), letting the capital buffer move towards a new steady-state value. And a soft strategy, wherein startup funds adjust to keep the buffer constant at initial levels.

The DSGE model is too complex to provide closed form solutions, and hence we organize our exposition in claims, deducted through vast numerical simulations and grid search exercises. Our figures and discussion in the text are merely illustrative of the main mechanisms that lie behind those claims and do not intend to be a proof of those. In the figures, we consider only the effects of looser designs, associated with

20. Put differently, banks adjust dividend redistribution to changes in holding costs so as to keep the capital buffer unchanged in the steady state. Although there is no explicit dividend distribution in the banking setup, we understand dividends as transferred earning to households net of startup funds through the remaining of the article.

larger accumulation of due loans.[21] Specifically, we consider 25 percent declines in the penalty rate and regulatory impairment requirements, respectively. As for the sensibility policy, we set $\rho^{dlr} = -1$. These figures are compared with the benchmark case of no policy change.[22]

We organize our exposition into steady-state and business cycle considerations. The former consists in a set of exercises aimed at the long-run effects of looser designs. That is, we implement permanent shocks to the policy options, and analyze the corresponding steady-state implications. The latter addresses the role of policies in business cycle stabilization and welfare. Some steady-state effects of policy options are of key importance to understand business cycle dynamics. For illustrative purposes, we consider $\kappa^{DL} = 0$ for the low management cost case, and $\kappa^{DL} = 0.1$ for the high management cost case.

Due loans only play an important role in macroeconomic dynamics under shocks that strongly impel them upwards, and therefore we ground our simulation exercises on the well-known entrepreneurial risk shock $\sigma_t^{\mathcal{K}}$, perturbing our economy with the following autoregressive process of order 1

$$\sigma_t^{\mathcal{K}} = (1-\rho)\sigma_{ss}^{\mathcal{K}} + \rho\sigma_{t-1}^{\mathcal{K}} + \varepsilon_t^{\mathcal{K}} \tag{10}$$

where ss stands for steady state and $\{\varepsilon_t^{\mathcal{K}}\}$ is and *i.i.d.* innovation. The autoregressive parameter is calibrated at 0.9, and $\varepsilon_0^{\mathcal{K}} = 0.1$.[23]

Finally, we bring together the steady state and business cycle results into a single analysis, and generate complete business cycles driven by risk fluctuations. Specifically we simulate non-anticipated increases in risk at quarters 0, 80 and 160 (10 percent innovation), followed by non-anticipated declines in risk at quarters 40 and 120 (-10 percent innovation), with an autoregressive of 0.9.

5. Policy designs in the long run

This section focuses solely on steady-state considerations originating from policies, leaving aside business cycle dynamics to be considered in the next section. Specifically, we study a permanent decline in the penalty rate and in impairment requirements. Since the "sensibility policy" does not affect the steady state, we

21. Tighter designs result in opposite effects.

22. Without loss of generality, we impose a negative sensibility parameter to analyze the effects of a looser policy design implemented upon a benchmark case which is invariant to the "sensibility policy."

23. See Christiano *et al.* (2013) for the key role played by these type of shocks in business cycle fluctuations. Results for other type of disturbances are available from the authors upon request. The banks' and nationwide risk shocks, and a balance sheet shock impacting expected bank returns are also of particular interest, but the conclusions do not differ substantially from those herein and are omitted for brevity.

omit it from the remainder of this section. Credit restrictions are absent here, since they play no role in the steady state (they are only activated for sufficiently large shocks).

Claim 1 *In the long run, under a stiff dividend strategy, there exists a threshold level for holding costs $\overline{\kappa}_1^{DL}$ such that:*

i *Looser designs welfare dominate tighter ones if and only if $\kappa^{DL} < \overline{\kappa}_1^{DL}$;*
ii *The range of κ^{DL} for which looser designs welfare dominate tighter ones is wider for the impairment policy;*
iii *A higher cure rate increases the range of κ^{DL} for which looser designs welfare dominate tighter ones.*

Under a soft dividend strategy, tighter designs in general welfare dominate looser ones in the long run.

From the banker's point of view, holding costs are an expense which wears out equity, but which they are able to pass on to entrepreneurs through larger interest rate spreads, and to partly cushion *via* more cures. What happens in the banking system therefore affects the cost of credit and hence capital accumulation. We illustrate Claim 1 and mechanisms that lie beneath in Figures 3 to 5. These plots depict the transition path triggered by loosening the policy design, for two different holding cost values, $\kappa^{DL} = 0$ and $\kappa^{DL} = 0.10$, alongside with a comparative static for the cure rate.

Banks take advantage of the decline in regulatory costs triggered by the new policy design to decrease impairment recognition and let total cures increase (the cure rate is fixed), while the total stock of due loans in the balance sheet rides up (Figure 3). When holding costs are low the equity position of banks improves and they are able to charge lower wholesale interest rate spreads. Specifically, banks take advantage of a more relaxed policy to switch from a more costly option—impairments—to a less expensive one—management of due loans, increasing cures in the process. The boost in equity generates a larger capital buffer and concomitantly a lesser probability of violating regulatory capital requirements, pushing down the wholesale spreads. Facing a lower cost of funds, entrepreneurs increase the quantity of credit demanded alongside their leverage position, accumulating more capital. The concomitant increase in the retail interest rate spread is insufficient to offset the advantageous impact triggered by the lower wholesale spread, which translates into a lower external finance premium. The boost in productive capacity raises output and results in higher income, which flows to households, allowing them to increase consumption and ultimately pushing up welfare.

On the opposite direction, when holding costs are high, banks' equity position deteriorates. In this case, each bank takes advantage of the decline in regulatory costs to let the due loans stock increase, and pass on an eventual upraise in costs—either related with holding costs or increased violation of regulatory standards—to the entrepreneurial sector *via* larger wholesale spreads. The upward pressure in

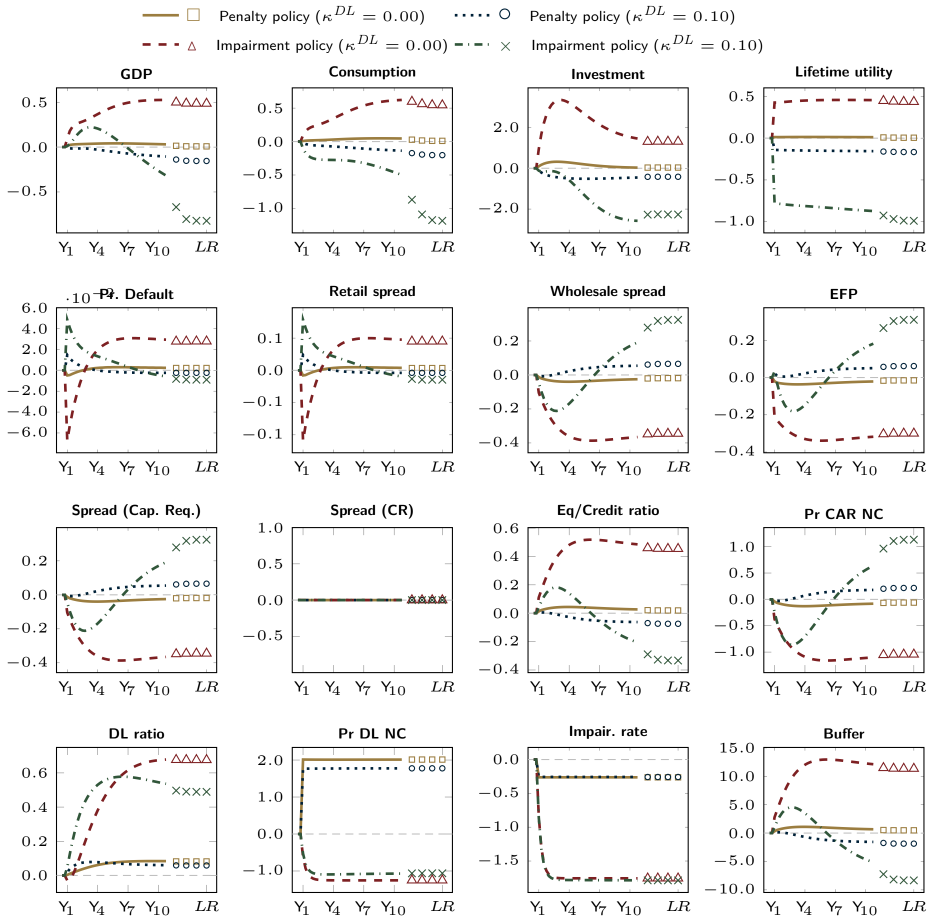

Figure 3: Transition path to looser policies (25 percent decline) under stiff dividend strategy (fixed startup funds); baseline cure rate ($\tau^{\mathcal{BK}} = 0.06$).

Notes: All variables are in percentage deviations from steady-state values except ratios, probabilities, and spreads/premiums, which are in percentage points deviations. "NC" stands for non-compliance,"Pr." for probabiliy, "CR" for credit restrictions, "Cap. Req" by capital requirments, "DL ratio" for the ratio of due to total loans, and "impair ratio" for the impairment-to-loans ratio. Notation Y_x refers to the first quarter of year x. The "Eq/credit ratio" is defined as post-return equity over post-return loans. The external finance premium (EFP) is measured by $i_t^R - i_t^D = (i_t^R - i_t^W) + (i_t^W - i_t^D)$, where the retail spread is given by $i_t^R - i_t^W$, and the wholesale spread by $i_t^W - i_t^D$. In the graphs, the wholesale spread corresponds to the sum of the contribution of the spread driven by capital requirements and the spread driven by credit restrictions.

interest costs wears out entrepreneurial net worth, boosting leverage along the process. In order to keep total interest costs under control, entrepreneurs are

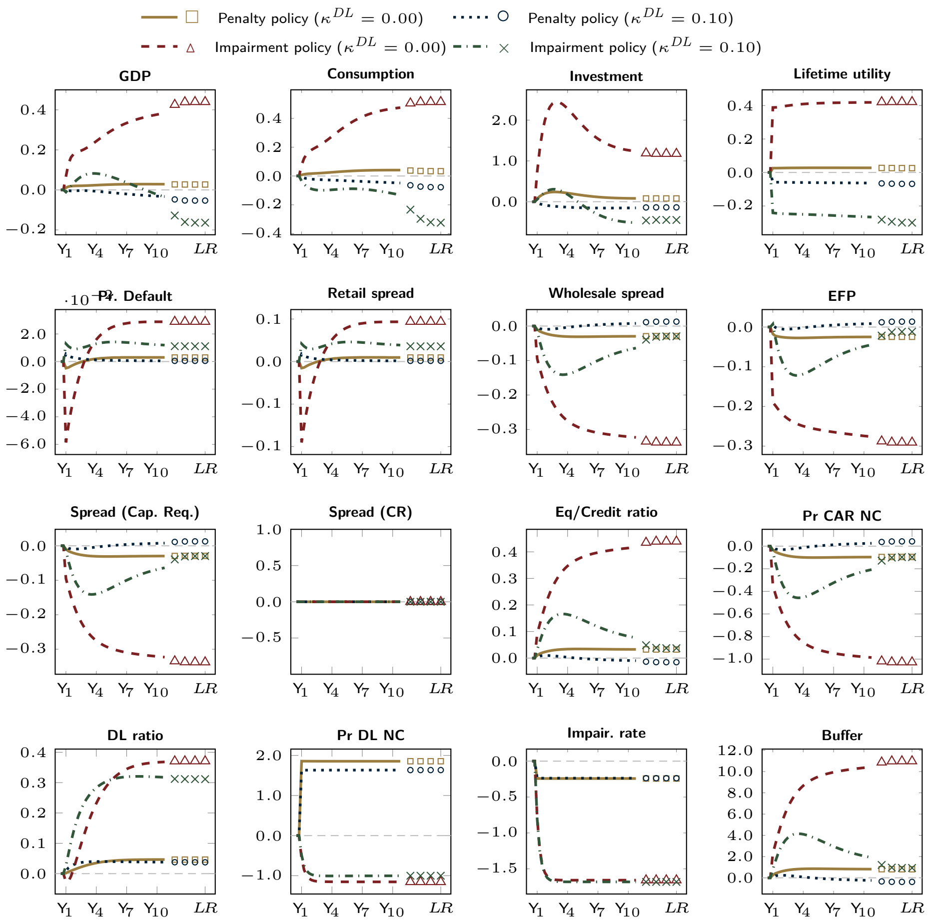

Figure 4: Transition path to looser policies (25 percent decline) under stiff dividend strategy (fixed startup funds); higher cure rate ($\tau^{\mathcal{BK}} = 0.12$).

Notes: See Figure 3.

forced to push down the quantity of credit demanded.[24] Balance sheet shrinks and hinders capital accumulation, resulting in lower output, consumption, and ultimately welfare.

It follows that there exists a threshold level for holding cost $\overline{\kappa}^{DL}$ for which the macro benefits from looser or tighter regulatory policy designs leave output and welfare nearly unchanged in the long run. This threshold is lower for the penalty

24. The impact on leverage and the retail spread can go either way, depending on how high holding costs are. The effect is always of second order. It may cushion but never offsets the impacts triggered by the increase in the wholesale spread, which ends up pushing the external finance premium upwards.

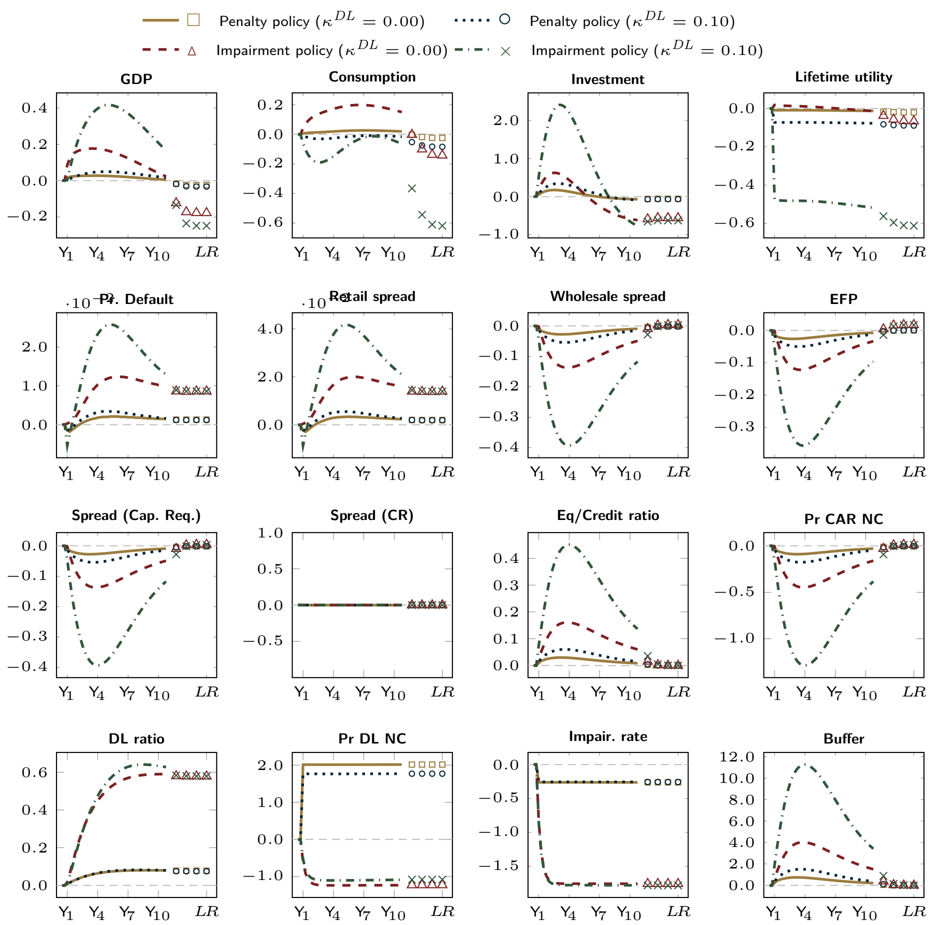

Figure 5: Transition path to looser policies (25 percent decline) under soft dividend strategy (fixed buffer); baseline cure rate ($\tau^{\mathcal{BK}} = 0.06$).

Notes: See Figure 3.

policy (in our simulations the long-run welfare impact is positive but close to zero for $\overline{\kappa}^{DL} = 0$), due to the boost in regulatory impairment non-compliance, which lightens up perverse incentives that cushion the improvement in banks' equity position. A higher cure rate boosts the advantage depicted by looser policies (Figure 4). As managing due loans gets even less expensive *vis-à-vis* impairments due to greater chances of repayment, banks become able to charge lower wholesale interest rates, triggering a more powerful chain of events. As a result, the welfare indifference between looser and tighter policy designs is only attained for higher values of the holding cost, *i.e.* $\overline{\kappa}_1^{DL}$ is increasing in the cure rate .

A looser policy design is only able to improve output and welfare if banks take advantage of the regulatory scheme to push up their equity position, increasing the size of the buffer and regulatory compliance. If bank managers decide to distribute those additional amounts as dividends, leaving the buffer constant, there is no improvement in banks' equity position and no reduction in the wholesale interest spread—the key variables driving capital accumulation (Figure 5). In this case, the downside of looser policy designs emerges as the main driving force of the welfare decline—the increase in due loans crowds out good credit and triggers an increase in banks' borrowing costs, which leads to a reduction in the size of entrepreneurs' balance sheet. The crowding-out effect here consists in due loans being financed with either deposits/foreign funds or equity, resources which will be unavailable to lend to productive entrepreneurs. This forces capital accumulation downwards, pushing down income and welfare, for any positive level of holding costs κ^{DL}. Tighter policy designs, by keeping due loans under control, limit this crowding-out effect and are therefore more efficient from the welfare standpoint. The cure rate has little impact on these forces.

We end this section by summarizing in a corollary some mechanism addressed above that will be important later on to explain the short-run macroeconomic dynamics.

Corollary 1 *In the long run looser policy designs:*

i *Trigger lower impairment rates and push up the size of the due loans stock;*
ii *Generate an increase (a decline) in the size of the capital buffer under a stiff dividend strategy if holding costs are sufficiently low (high);*
iii *Leave the size of the capital buffer broadly unchanged under a soft dividend strategy, for any value of holding costs.*

6. Policy designs and the business cycle

We now address the business cycle properties of the various policy options. Though we focus on the specific case of a risk shock, our claims remain valid in a wider set of scenarios, particularly under financially driven slumps. Nonetheless, perturbations that trigger more contained reactions in due loans are also associated with fewer gains derived from policy changes alongside the business cycle. Furthermore, it is important to recall that different policies may generate distinct steady states, and issue that we forego here to solely focus on the stabilization properties over the business cycle, and corresponding welfare consequences. We analyze separately the case where credit restrictions are fully ignored (never activated), and the situation where they are occasionally binding, *i.e.*, they are slack in the steady state but become binding for some period of time as the shock implies a severe collapse in banks' value. We begin our analysis by putting forward the following claim.

Claim 2 *Absent of restrictions to credit and under a stiff dividend strategy, there exists a threshold level for holding costs $\overline{\kappa}_2^{DL}$ such that:*

i *Looser designs welfare dominate tighter ones if and only if $\kappa^{DL} < \overline{\kappa}_2^{DL}$;*

ii *The range of κ^{DL} for which looser designs welfare dominate tighter ones is in general wider for the sensibility policy and narrower for the penalty policy.*
iii *A higher cure rate increases the range of κ^{DL} for which looser designs welfare dominate tighter ones.*

The key essence of Claim 2 is illustrated in Figures 6 and 7 (see Appendix C.1 for an intermediate case). These plots represent the dynamics of the risk shock specified in Section 4, if looser policy designs *vis-à-vis* the benchmark case of no policy change are to be adopted. Notice that the stock of due loans remains relatively unchanged throughout the cycle under the penalty and impairment policies *vis-à-vis* the no policy change case, as the impacts occur mostly at the initial steady state level (a consequence of Corollary 1). The sensibility policy, on the other hand, presents no steady-state effect. Instead, regulatory impairments become looser throughout the cycle, triggering a decline in the impairment rate and pushing the stock of due loans upwards *vis-à-vis* the no policy change case.

If holding costs are sufficiently low, then looser policy designs always welfare dominate tighter ones and *vice-versa*. Regulatory costs are pressed downwards by the looser policy design. For the penalty and impairment policies, this implies a wider buffer at the initial steady state for sufficiently low values of κ^{DL}, and hence a greater resiliency of the banking system in dealing with financial perturbations (Corollary 1). For the sensibility policy, regulatory impairment requirements are alleviated throughout the cycle, and thus a wider buffer becomes available alongside the dynamics as compared with the no policy case. All policies therefore generate less severe equity losses along the model dynamics due to the greater resiliency of the banking system, a mechanism which positively impacts the compliance with regulatory capital requirements (Figure 6). Bankers are then able to charge a lower wholesale interest rate spread and to grant more credit relative to the baseline case of no policy change. This mechanism allows entrepreneurs to expand their balance sheet—lower interest expenses boost up net worth and the quantity of credit demanded—and finance more capital. Ultimately, production increases, alongside with consumption and welfare, *vis-à-vis* the no policy change equilibria.

When holding costs are high, the opposite mechanism is at action. For the penalty and impairment policies, the size of the buffer is smaller at the initial steady state (Corollary 1). As a result, non-compliance is larger throughout the cycle, triggering a loss that bankers cover by charging a larger wholesale interest rate spread as compared with the benchmark case. The higher price of credit negatively impacts net worth and diminishes the borrowing capacity of entrepreneurs, resulting in a tinier capital accumulation, fewer output, and ultimately lower welfare (Figure 7). The sensibility policy creates incentives for banks to alleviate impairment recognition and let the "very costly" stock of due loans increase. These costs eventually offset the benefits of the policy for sufficiently high levels of holding costs, generating also welfare losses *vis-à-vis* the no policy case.

It follows that, for each policy, there exists a threshold level $\overline{\kappa}^{DL}$ under which these forces balance each other and changing the policy design becomes welfare

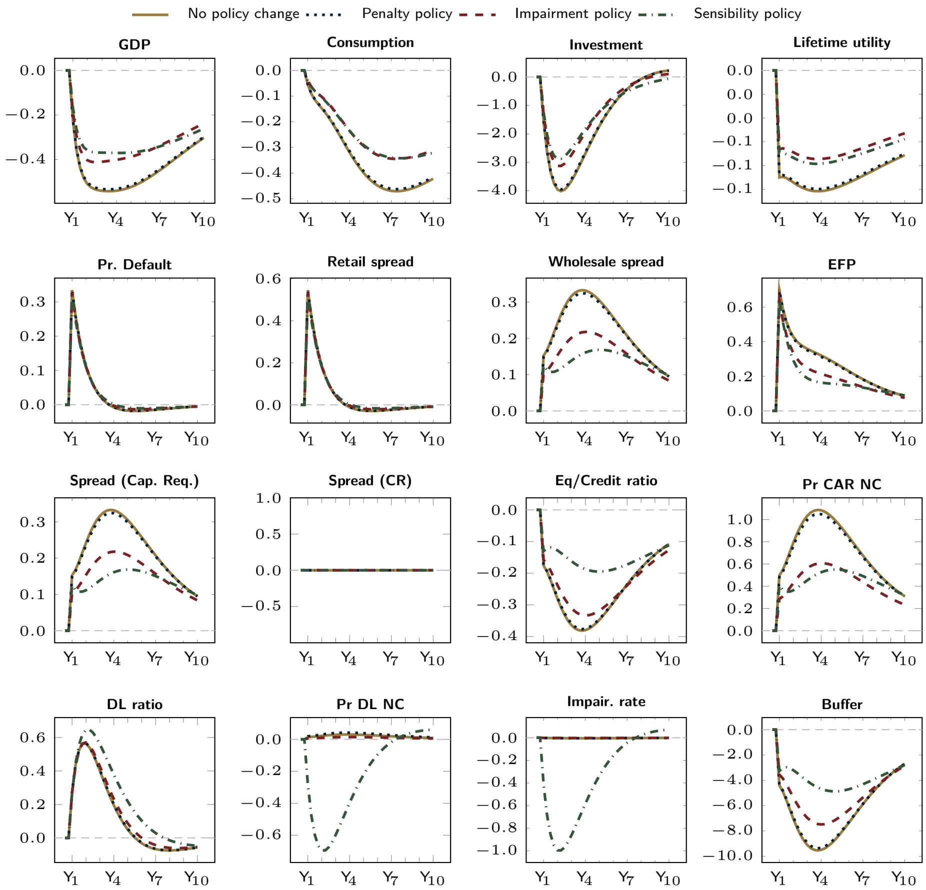

Figure 6: Loosening the policy design under a stiff dividend strategy, with $\kappa^{DL} = 0$ and absent credit restrictions; baseline cure rate ($\tau^{\mathcal{BK}} = 0.06$).

Notes: See Figure 3.

neutral. The threshold is lower for the penalty policy due to its perverse incentives, namely by encouraging banks to increase the violation of regulatory impairment requirements, at a cost. The threshold is higher for the sensibility policy, because it frees up bank capital temporarily and only as needed, thus avoiding the costs brought about by an increase in the stock of due loans at the initial steady state. Recall that due loans crowds out “good credit,” and therefore looser policy designs are only worthwhile if they are able to bring about other benefits, namely a higher resiliency of the banking system through an increase in the size of the capital buffer.

A higher cure rate increases the relative costs of impairment recognition, since a greater amount might be recovered at a future date. This shifts the game toward looser policies, which become comparatively more attractive and dominate for a wider range of holding costs. Appendix C.2 plots the figures for this case. Despite

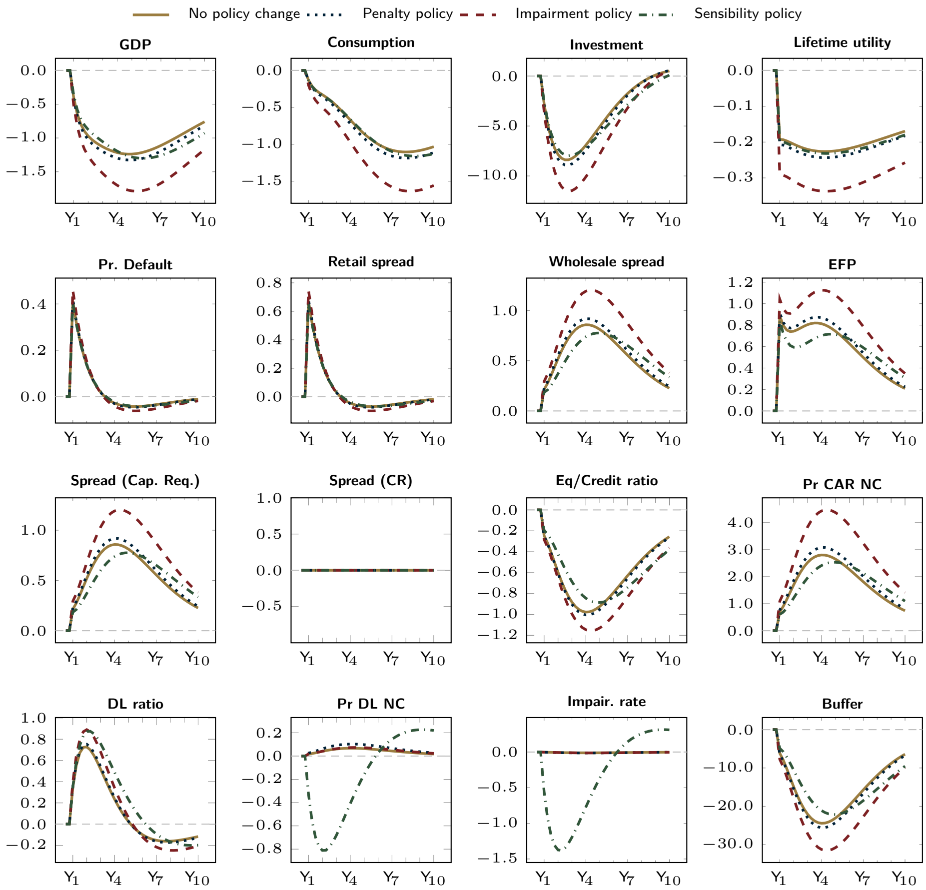

Figure 7: Loosening the policy design under a stiff dividend strategy, with $\kappa^{DL} = 0.10$ and absent credit restrictions; baseline cure rate ($\tau^{\mathcal{BK}} = 0.06$).

Notes: See Figure 3.

the wider range of dominance, the relative gain of looser policies is lower even for low κ^{DL}, because a higher cure rate decreases the relative costs of due loans due to the decline in their average life.

We next address how results change when the occasionally binding credit restrictions mechanism is active in the model. We focus on the most interesting case of stiff dividend strategy.[25]

Claim 3 *With occasionally binding credit restrictions and under a stiff dividend strategy, the threshold* $\overline{\kappa}_2^{DL}$ *does not change in an important manner for the*

25. The amplification effects triggered by credit restrictions are analyzed in detail in Júlio and Maria (2020) and are not covered herein.

penalty and impairment policies, $\overline{\kappa}_3^{DL} \approx \overline{\kappa}_2^{DL}$*, but increases for the sensibility policy,* $\overline{\kappa}_3^{DL} > \overline{\kappa}_2^{DL}$*. Furthermore, welfare gains (losses) from looser designs are strengthened for* $\kappa^{DL} < \overline{\kappa}_3^{DL}$ *(*$\kappa^{DL} > \overline{\kappa}_3^{DL}$*).*

The claim is illustrated in Appendix C.3 (see also Appendix C.4 for comparative statics on the cure rate). In all cases the risk shock triggers a reduction in bank's terminal wealth that is sufficiently large to create a credit restrictions-driven spread, amplifying the increase in the overall external finance premium and a larger output fall against previous results, when credit restrictions were absent. The threshold $\overline{\kappa}^{DL}$ is barely affected for the penalty and impairment policies, an idea which can be grasped by comparing lifetime utility in Figure C.1 with that of Figure C.6. Here, the selected value of $\overline{\kappa}^{DL}$ is close to the threshold level, and lifetime utility for the penalty and impairment policies is similar to that of the no policy change in both Figures, with and without occasionally binding credit restrictions. This occurs because credit restrictions are to a great extent homothetic, in a sense that they deliver similar amplification impacts for identical initial outcomes. That is, if for an initial level of $\overline{\kappa}^{DL}$ both policies have similar macroeconomic impacts, then credit restrictions trigger identical amplification effects on both and leave the value of $\overline{\kappa}^{DL}$ nearly unchanged. This can be observed in the spread driven by credit restrictions in Figure C.6, whose increase is nearly identical for the penalty and impairment policies, and for the no policy case.

Notice that the amplification effects brought about by credit restrictions are larger the more severe is the initial drop in banks' value. The banker has the option to divert a fraction of assets, and depositors and foreign creditors restrict the amount of funds they make available to the bank until those incentives vanish. Hence, policies that lead to a more severe initial decline in banks' capital trigger tighter restrictions, and concomitantly lay ground for fewer and more expensive credit. Entrepreneurs' ability to accumulate capital becomes severely affected as they see their balance sheet shrink and are unable do to nothing about it.

When κ^{DL} is initially low with absent credit restrictions (observe for instance Figure 6), the collapse in banks' capital is smaller for the impairment policy and larger for the case of unchanged policy (a consequence of Claim 2). Introducing credit restrictions impacts less severely the former and more severely the latter, with the penalty policy lying in between (compare with Figure C.5). To put differently, since the impairment policy alleviates equity costs for low values of κ^{DL}, restriction to credit become simultaneously less severe—and welfare gains more important—as compared with the alternatives.

When κ^{DL} is high (observe for instance Figure 7), the reverse occurs. Initially, prior to credit restrictions, the impairment policy is the least effective, implying a larger output downfall and concomitantly a more severe decline in banks' equity. The role of credit restrictions is therefore amplified in this case, as compared with the no policy case and the penalty policy (compare with Figure C.7).

This reasoning does not hold for the sensibility policy, since the mechanism embedded therein contributes to alleviate credit restrictions throughout the cycle. Specifically, by lowering impairment requirements, the policy provides simultaneously a buffer that hinders the equity downfall and concomitantly the drop in banks' value. As compared with the no policy case, bankers have additional funds to lend to the entrepreneurial sector. This effect explains why the threshold $\overline{\kappa}^{DL}$ increases for the sensibility policy when credit restrictions are introduced, and why welfare gains *vis-à-vis* the no policy case are also higher.

The following claim addresses the case of a soft dividend strategy.

Claim 4 *Under a soft dividend strategy, the benefits (losses) of looser (tighter) designs are substantially reduced for the penalty and impairment policies, but remain broadly unchanged for the sensibility policy.*

We support Claim 4 with figures only for the case with occasionally binding credit restrictions (plotted in Appendix C.5), since the alternative case does not bring a substantial addition to the discussion (the benefits/losses of looser/tighter designs are even further reduced).[26] The main idea underlying Claim 4 is that the major advantage of looser regulatory policies—the increase in the resiliency of the banking system due to a wider buffer—vanishes if bankers use the extra funds to increase dividend distribution in the initial steady state. Banks are thus left with a simple trade-off as the policy design becomes looser (or tighter), which consists in the balance between regulatory *versus* holding *versus* crowding out costs, which takes place alongside the dynamics. The equity savings involved here are substantially lower than under the stiff dividend strategy, reducing the gains depicted by the penalty and impairment policies. As the sensibility policy does not impact the steady state, its effects remain broadly unchanged in this case, making it more robust as compared with the alternatives.

7. Bringing together short and long run considerations

Several policy conclusions emerge from bringing together the results in Sections 5 and 6. The sensibility policy seems to be advantageous from a business cycle perspective. This policy—which consists in alleviating regulatory impairment requirements during slumps—has no impact in the steady state and allows banks to reduce impairments during 'holding cost times,' when they need capital the most. The policy generates an equity cushion that banks use to better cope with regulatory capital requirements, resulting in fewer violations and concomitantly in smaller wholesale interest rate spreads *vis-à-vis* the benchmark case of "no policy change," softening the slump. The effects hold unless due loans holding costs are excessively high, case in which letting them increase becomes actually more harmful than registering the impairment loss and facing the consequences for non-compliance with regulatory requirements (as it is the case in Figure 7). A higher

26. Additional figures are available from the authors upon request.

cure rate increases the value of holding costs above which a looser policy is actually harmful, since it raises the benefits of delaying the impairment recognition.

Since the policy behaves symmetrically during recessions and expansions, it would stabilize output and welfare fluctuations throughout a business cycle up to a first-order approximation of the model, *i.e.* ignoring restrictions to credit. That is, the rule would contribute to push down equity during an expansion phase, hindering credit along the way. However, this is not the case in an environment with fully non-linear credit restrictions. To illustrate this point, we simulate a risk-driven business cycle exercise as described in Section 4. Results are depicted in Figure 8, for the benchmark value $\kappa^{DL} = 0.025$ (The case of a higher cure rate is plotted in Appendix C.6). In this scenario, the policy is able to cushion the effects of credit restrictions during slumps. Creditors are more willing to supply funds to the bank and avoid sudden stops in banks' financing as they observe the capital buffer building up. This obviously generates a larger bank value as regulatory costs are pushed back, as compared with the no policy change equilibria. As a result, the increase in the credit restrictions-driven interest rate spread is smaller, directing larger flows of credit to the entrepreneurial sector. The economy therefore benefits from more capital *vis-à-vis* the "no policy change" scenario, which results in lower output downfalls and greater utility levels. During upturns, when credit restrictions are always slack, the policy effect is essentially absent in which respects output, an outcome resulting from two opposing forces. On the one hand, there is a stabilization effect associated with the policy, which consists in the same mechanism described in the previous section, but reverted and applied to an expansion phase. On the other, by diminishing the role played by credit restrictions, the policy essentially generates fewer frictions along business cycles. Higher levels of income therefore flow from firms and banks to households, allowing them to attain greater consumption patterns and higher welfare standards even during 'good times,' due to their ability to smooth consumption through time. To put differently, although the "sensibility policy" is unable to affect the steady state, it pushes up the mean output of the economy, conditional on the fact that cycles are asymmetric due to occasionally binding credit restrictions. The asymmetric nature of the cycle is therefore reduced under this policy option.

A higher cure rate diminishes the benefits of the sensibility policy (compare Figure 8 with Figure C.14 in Appendix C.6), because it decreases the average lifetime of due loans. That is, due loans become a lesser problem as they can be recovered at a higher rate and their average stock in the banks' balance sheet declines.

The impairment policy—which consists in a permanently looser criteria regarding impairment recognition—presents also important effects in an environment with fully non-linear credit restrictions, if due loans holding costs are sufficiently low and the banker does not take advantage of the looser criteria to increase dividend distribution. Though benefiting welfare for a narrower range of κ^{DL} along the model dynamics as compared with the "sensibility policy," it has the potential to positively impact the steady state. Figure 9 illustrates this feature

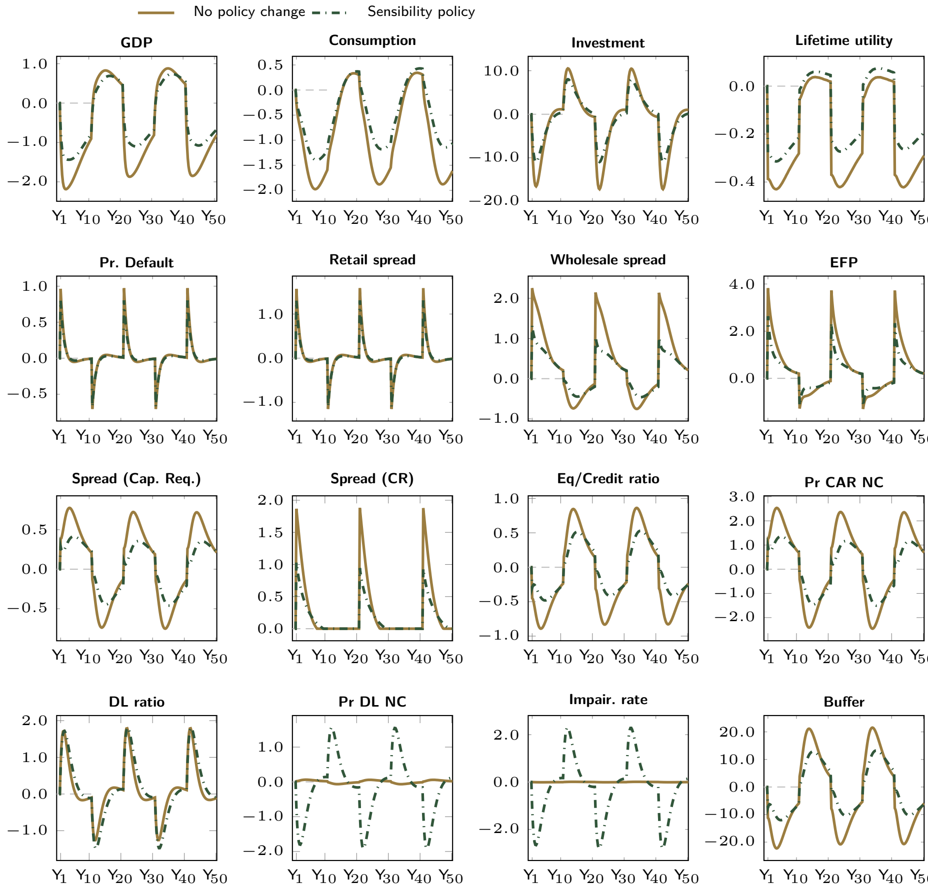

Figure 8: Financially-driven business cycle and the sensibility policy rule under a stiff dividend strategy and occasionally binding credit restrictions ($\kappa^{DL} = 0.025$); baseline cure rate ($\tau^{\mathcal{BK}} = 0.06$).

Notes: The figure represents a business cycle driven by an increase in risk at quarters 0, 80 and 160 (10 percent innovation), followed by a non-anticipated decline in risk at quarters 40,120 (-10 percent innovation), with the same autoregressive as before. See Figure 3 for additional notes.

for the same risk-driven business cycle exercise, with and without the steady-state effects of the policy. When comparing solely the model dynamics, we observe that the "sensibility policy" depicted in Figure 8 seems more advantageous both from output and welfare stances. However, the extra element brought about by the steady-state impact—materialized in a larger steady state buffer and therefore more resilient banks—changes the game towards the "impairment policy," which is able to permanently deliver higher output and welfare standards while contributing to cushion the effects of credit restrictions during 'bad times.' If the moral hazard mechanism which lays ground for credit restrictions is switched off, we are left with

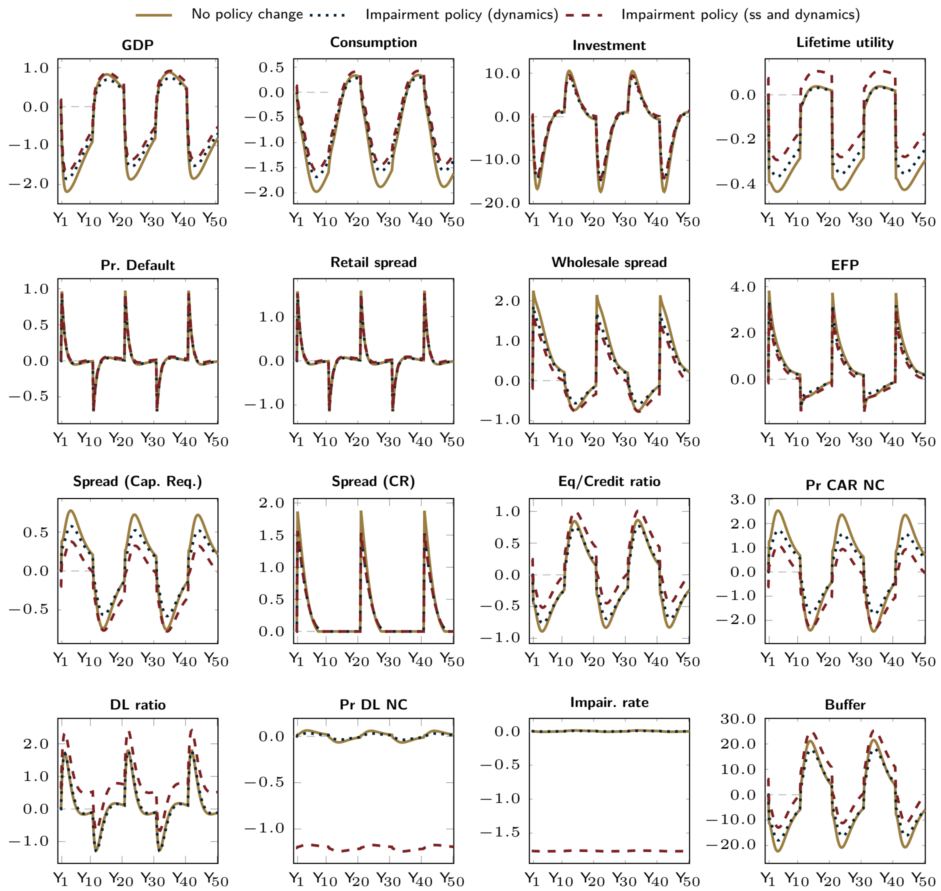

Figure 9: Financially-driven business cycle and the impairment policy under occasionally binding credit restrictions ($\kappa^{DL} = 0.025$); baseline cure rate ($\tau^{\mathcal{BK}} = 0.06$).

Notes: See Figures 3 and 8.

a simple symmetric stabilization effect along the model dynamics, and the most important impact arises through the steady-state effect.

As in the sensibility policy, the benefits of the impairment policy also diminish with the cure rate alongside the model dynamics, due to the lower average lifetime of due loans (compare Figure 9 with Figure C.15 in Appendix C). However, a higher cure rate boosts the benefits of delaying impairment recognition, *i.e.* of a policy that promotes the delay, an effect which dominates in the steady state. Even though a smaller amount of due loans is held by banks, each unit that is delayed entails a larger benefit due to the greater probability of cure. This results in a higher level of equity, translated into a wider buffer and hence a greater resiliency of the banking system in the steady state.

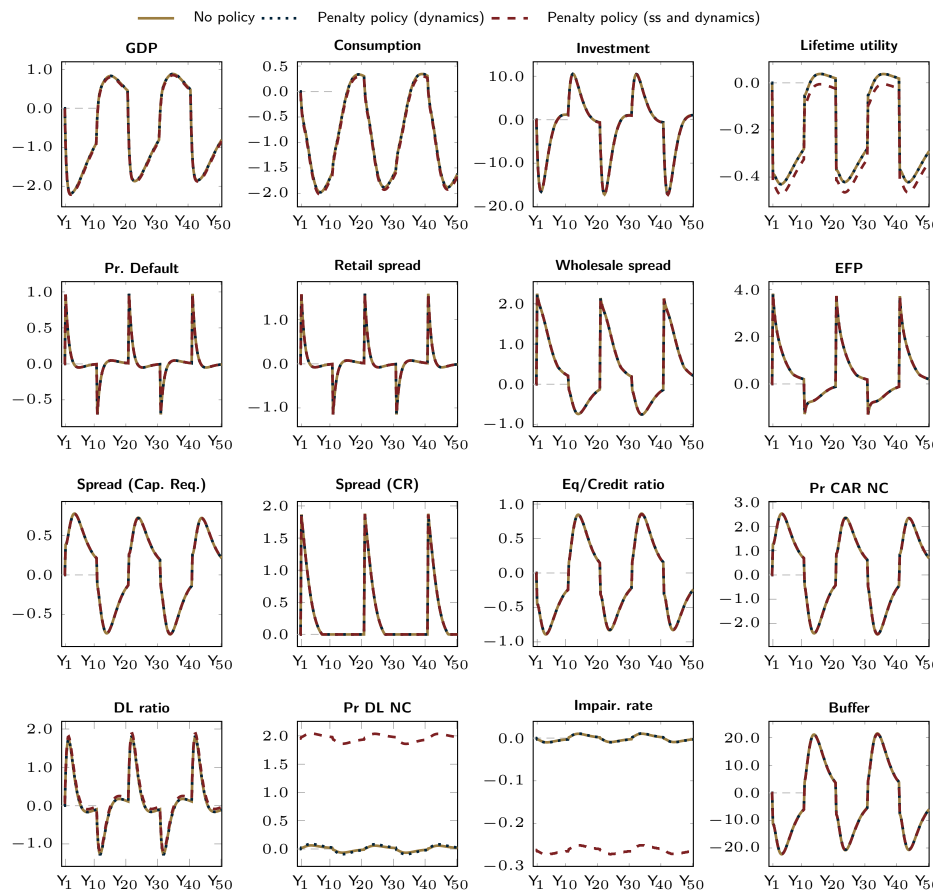

Figure 10: Financially-driven business cycle and the penalty policy under occasionally binding credit restrictions ($\kappa^{DL} = 0.025$); baseline cure rate ($\tau^{\mathcal{BK}} = 0.06$).

Notes: See Figures 3 and 8.

Finally, the penalty policy—consisting in a permanently decline in fines due to regulatory impairment violation—is the least effective of the three policies discussed herein. The outcome is illustrated in Figure C.16, for the risk-driven business cycle exercise and the same due loans holding cost, with and without the steady-state effects of the policy. The stabilization effect along the dynamics is the least efficient both from the output and welfare stances, and the steady-state welfare impact of the policy for the drawn holding cost is actually negligible. These results are mostly explained by the perverse incentives brought about by the policy—namely the substantially larger regulatory non-compliance as regards impairment requirements—which offsets the benefits of the lower penalty rate. The cure rate plays no important role in this case as it does change the interplay between opposing effects.

8. Concluding remarks

Our article addresses the relative performance of various due loans policy options and the tight *versus* loose dichotomy in a rich dynamic stochastic general equilibrium environment. The model is endowed in a complex banking system in which due loans, occasionally binding credit constraints, a cost of borrowing channel, and regulatory capital and impairment requirements coexist and interact. The framework constitutes an ideal setup to analyze the role played by various policy options since the endogenous mechanisms of the model convey the key driving forces behind the driveshaft propelling policies to outcomes. We focuses both on steady-state effects and business cycle dynamics, restricting specifically to risk-induced fluctuations since these are the amidst most important trigger of large increases in due loans.

Our findings suggest that looser designs only have a welfare improving effect if bankers are not allowed to take advantage of any equity cushion to increase dividend distribution. Instead, policies must be used to push up the size of the capital buffer, raising the resiliency of the banking system. In addition, the holding costs associated with due loans must be sufficiently small and/or the cure rate sufficiently high, so that the gains of fewer write-offs propelled by looser designs outweigh the balance sheet costs and the crowding-out effect over performing loans. Under these two conditions, looser designs may effectively increase welfare, not only during slumps, but also in expansion phases.

However, policies are not all alike. While our "sensibility policy" (penalizing/depenalizing higher due loans in expansion/depression periods) seems to be more effective in terms of business cycle stabilization, the "impairment policy" (lowering institutional requirements) adds an extra dimension with a steady-state impact that dominates for sufficiently low values of the holding cost. On the steady state, banks use the extra equity cushion to become more protected against idiosyncratic shocks, and effect which increases with the cure rate. Throughout the business cycle, banks use the larger equity buffer to better absorb incoming aggregate shocks. In both cases, there is a downfall in regulatory capital violation, which concomitantly leads to a lower wholesale interest rate spread, *vis-à-vis* a "no policy change" equilibria. Capital accumulation increases as entrepreneurs enlarge their balance sheet size, benefiting from cheaper credit. The extra input quantity is thereafter translated into more production and consumption, and ultimately greater welfare standards. Nonetheless, if the holding cost is not sufficiently small, the steady-state effect dissipates and eventually becomes harmful, and the "sensibility policy" outperforms all the alternatives. These policy options are also capable of raising the mean output of business cycle fluctuations if holding costs are sufficiently low, by weakening the size of credit restrictions during slumps due to the extra equity cushion provided to banks. The "penalty policy" (lowering costs in case of non-compliance) is the least effective one as it triggers preserve incentives that ultimately boost the violation of regulatory impairment requirements.

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Appendix A: Costs and Frictions

This appendix clarifies what we classify as regulatory costs, operational costs, and banking frictions.

There are two regulatory schemes in the model, *viz.* capital requirements and impairment loss recognition. The non-compliance with each one results in penalties for the bank ($PEN_t^{\mathcal{BK}}(k)$ and $PEN_t^{DL}(k)$, respectively), which, after aggregation, take the form

$$\begin{aligned}\text{Regulatory costs}_t &= PEN_t^{DL} + PEN_t^{\mathcal{BK}} \\ &= \bar{\chi}^{DL}\mathfrak{F}^{DL}(\bar{\omega}_t^{DL}) + \bar{\chi}^{\mathcal{BK}}[L_{t-1} + DL_{t-1}]\mathfrak{F}^{\mathcal{BK}}(\bar{\omega}_t^{\mathcal{BK}})\end{aligned}$$

where $\bar{\chi}^{DL}$ and $\bar{\chi}^{\mathcal{BK}}$ are penalty rates, $\mathfrak{F}^{DL}(\cdot)$ and $\mathfrak{F}^{BK}(\cdot)$ cumulative distribution functions, and $\bar{\omega}_t^{DL}$ and $\bar{\omega}_t^{BK}$ threshold levels of the idiosyncratic shocks.

There exist three operational costs, one resulting from impairment losses (DL_t^{imp}), other triggered by due loans holding costs (DL_t^{hold}), and the last one entailing *ex-post* loan losses from retail branches ($P_t\Lambda_t^{\mathcal{K}}$),

$$\begin{aligned}\text{Operational costs}_t &= DL_t^{\text{imp}} + DL_t^{\text{hold}} + P_t\Lambda_t^{\mathcal{K}} \\ &= \upsilon_{t-1}DL_{t-1}^{\text{init}} + \kappa^{DL}DL_{t-1} + P_t\Lambda_t^{\mathcal{K}}\end{aligned}$$

Finally, there are two different frictions affecting banks' balance sheet, one related with repossession costs of deposit institutions—which reflect an increase in financing costs as the asset base expands—and other related with agency costs,

$$\text{Banking frictions}_t = \mu^D\mathfrak{F}^{\mathcal{BK}}(\bar{\omega}_t^{\mathcal{BK}})\left[DEP_{t-1} + B_{t-1}^*\right] + \mu^{AG}(i_{t-1}^W - \tilde{i}_{t-1}^W)L_{t-1}$$

A larger μ_t^D triggers greater externality costs of non-compliant banks upon complying ones, working through the cost of credit channel. The element μ^{AG} represents the degree of "agency revenues" that are paid to households as labor services. We require this parameter to be high, avoiding a rapid recovery in equity levels once credit restrictions become binding.

Appendix B: Calibration

Tables B.1 and B.2 present the model's calibrated parameters, whereas Table B.3 exhibits the implied key steady-state relationships.

	Parameter	Value
Households		
Inverse Frisch elasticity	σ_L	2.5
Habit persistence	ν	0.80
Weight in utility, labor supply	η_L	1.00
Weight in utility, deposits	η_D	0.0025
Discount factor	β	0.996
Wage and price markups		
Wage markup	$\sigma^{\mathcal{U}}/(\sigma^{\mathcal{U}}-1)-1$	0.40
Intermediate goods price markup	$\sigma^{\mathcal{Z}}/(\sigma^{\mathcal{Z}}-1)-1$	0.20
Final goods price markup	$\sigma^{\mathcal{F}}/(\sigma^{\mathcal{F}}-1)-1$	0.10
Imported goods price markup	$\sigma^{\mathcal{IM}}/(\sigma^{\mathcal{IM}}-1)-1$	0.05
EoS and technology		
EoS, intermediate goods	$\varepsilon_{\mathcal{Z}}$	0.99
EoS, final goods	$\varepsilon_{\mathcal{Y}}$	1.50
EoS, exports	ε_{*}	1.50
Quasi-labor income share	$\alpha^{\mathcal{U}}$	0.62
Home bias in domestic distributors	$\alpha^{\mathcal{Z}}$	0.65
Export market share	α^{*}	0.03
Rigidities		
Labor	φ_U	5.0
Investment, productive capital	$\varphi_{I\mathcal{K}}$	5.0
Utilization rate	σ_a	25.0
Import content	φ_{IM}	2.0
Import content from rest of EA	φ_{IX}	2.0
Calvo parameters		
Wage	$\iota^{\mathcal{U}}$	0.75
Intermediate goods	$\iota^{\mathcal{Z}}$	0.75
Final goods	$\iota^{\mathcal{Y}}$	0.50
Imported goods	$\iota^{\mathcal{IM}}$	0.50
Miscellaneous		
Depreciation rate, productive capital	$\delta^{\mathcal{K}}$	0.025
ECB interest rate target	i^*	1.008
ECB Inflation target	π^*	1.005
Target NFA-to-GDP ratio	$(B^*_{GDP})^{\text{target}}$	-0.30
NFA risk premium scale parameter	φ_{BF}	0.0001

Table B.1. Main parameters (non-financial).

Sources: *Banco de Portugal* data, National accounts data, several studies on the Portuguese and euro area economies, and authors' own calculations.
Notes: EoS—Elasticity of Substitution; NFA—Net Foreign Assets; ECB—European Central Bank; EA—Euro Area. The model is quarterly and parameters are not annualized.

We set the interest rate target at 3.2 percent per year, matching the 1999–2007 average for the 3-month EURIBOR. Steady-state inflation is set at 2 percent per year, in line with the ECB's price stability target. The inverse Frish elasticity σ_L is set to 2.5, and the parameter k indexing habit persistence to 0.8. The discount factor is 0.996, resulting in a net foreign asset position of around -50 percent of GDP for a target ratio of -30 percent and a risk premium scale parameter φ_{BF} of

	Parameter	Value
Households		
Technology parameter—HH services	A^{mon}	20
Technology parameter—HH services	α^{mon}	10
Entrepreneurs		
Repossession cost fraction of retail branches	$\mu^{\mathcal{K}}$	0.35
Idiosyncratic shock volatility	$\sigma^{\mathcal{K}}$	0.24
Probability of transition to worker	$1-\iota^{\mathcal{E}}$	0.04
Startup funds (net worth ratio)	$WT^{\mathcal{E}}/N$	0.00
Banks		
Repossession cost of deposit institutions	μ^{D}	0.05
Probability of transition to worker	$1-\iota^{\mathcal{BK}}$	0.05
Startup funds (Equity ratio)	$WT^{\mathcal{BK}}/E$	0.07
Banks—Capital requirements		
Idiosyncratic shock volatility	$\sigma^{\mathcal{BK}}$	0.02
Penalty rate if non-compliance with regulatory requirements	$\overline{\chi}^{\mathcal{BK}}$	0.006
Capital ratio requirement	$\overline{\gamma}^{\mathcal{BK}}$	0.10
Banks—Due loans		
Management cost	κ^{DL}	0.025
Mean preserving spread parameter	n.a.	9.2
Cure rate	$\tau^{\mathcal{BK}}$	0.06
Penalty rate if non-compliance with regulatory standards	$\overline{\chi}^{DL}$	0.16
Impairment ratio requirement	γ^{DL}	0.07
Banks—Policy rule for due loans		
Pre-specified target value for the due-to-total loans ratio	dlr	0.05
Sensibility parameter	ρ^{dlr}	0
Banks—Credit restrictions		
Degree of "agency revenues"paid as monitoring services	μ^{AG}	0.75
Fraction of corporate loans that can be diverted	$\overline{\theta}$	0.13
Smoothness parameter	θ_a	4.0
Relative weight, diversion of due loans	Δ	0.5

Table B.2. Main parameters (financial).

Sources: *Banco de Portugal* data, National accounts data, several studies on the Portuguese and euro area economies, and authors' own calculations.
Notes: The model is quarterly and parameters are not annualized.

1×10^{-4}. Utility weights are $\eta_L = 1$ and $\eta_D = 0.0025$, which yields a deposits-to-GDP ratio close to 40 percent.

Steady-state price markups are set at 40 percent for wage setting, 20 percent for the intermediate goods sector, 10 percent for the final goods sector, and 5 percent for the import goods sector. The elasticity of substitution between capital and labor is set to 0.99, whereas for domestic and foreign goods distributors the elasticity of substitution between inputs is 1.5. The depreciation rate of capital is calibrated at 10 percent per year. The cost of capital utilization takes the functional form $a(u_t(l)) = \frac{1}{2}\varphi_a\sigma_a(u_t(l))^2 + \varphi_a(1-\sigma_a)u_t(l) + \varphi_a(\frac{\sigma_a}{2} - 1)$, where φ_a is calibrated to ensure a unitary capital utilization in the steady state and σ_a is a parameter that controls the curvature.

The labor quasi-share and the home bias parameters are endogenously calibrated to take into account the actual labor income share and the import share,

	Model	Data	Period
Expenditure (GDP ratio)			
Private consumption	0.63	0.64	1999-2018
Private investment	0.19	0.17	1999-2018
Public consumption & investment	0.23	0.21	1999-2018
Exports	0.35	0.31	1999-2018
Imports	0.40	0.33	1999-2017
Shares (output ratio)			
Import share	0.28	0.30	1999-2018
Labor income share	0.60	0.66	1999-2017
External account (GDP ratio, in %)			
Net foreign assets (annualized)	-53.0	-82.2	1999-2018
Current and capital accounts	-1.1	-3.5	1999-2018
Trade balance	-4.6	-4.7	1999-2018
Entrepreneurs			
Leverage ratio	1.2	1.3	1999-2018
Probability of bankruptcy (in %)	2.5	1.8	1999-2018
Probability that loan becomes due (in %)	2.5	2.0	1999-2018
Banks			
Deposits-to-GDP ratio	0.39	0.46	1999-2018
Loss given bankruptcy (in %)	39.9	n.a.	(1)
Wholesale-deposits interest rate spread (in p.p.)	1.0	n.a.	(1)
Retail-wholesale interest rate spread (in p.p.)	1.0	n.a.	(1)
Banks—Capital requirements			
Probability of not fulfilling capital requirements (in %)	2.5	n.a.	(2)
Capital-to-loans ratio (in %)	14.0	n.a.	(2)
Endogenous capital buffer (in %)	4.0	n.a.	(2)
Banks—Due loans			
Due loans-to-credit ratio (in %)	3.5	n.a.	(3)
Due loans-to-credit ratio threshold (in %)	5.0	n.a.	(3)
Probability of not fulfilling regulatory standards (in %)	5.0	n.a.	(3)
Impairment rate (in %)	8.3	n.a.	(3)
New due loans (credit ratio, in %)	0.60	n.a.	(3)
Due loans cured (credit ratio, in %)	0.24	n.a.	(3)
Impairment losses (credit ratio, in %)	0.34	n.a.	(3)

Table B.3. Key steady-state relationships.

Sources: *Banco de Portugal* data, National accounts data, and authors' own calculations.
Notes: (1) We endogenously recalibrate the model such that the LGB is close to 40 percent. The sum of the retail and wholesale spreads is close to the 1999-2007 period average interest rate spread paid by non-financial corporations *viz.* the 3-month Euribor rate. (2) These figures are in accordance with Basel III rules (see *https://www.bportugal.pt/en/page/macro-prudential-measures*). (3) We impose an average due-loans-to-credit ratio of 3.5 and let 5 percent of the banks have insufficient impairment losses to comply with regulatory requirements. This outcome occurs for banks with a due loans-to-credit ratio above 5 percent (see *https://eba.europa.eu/regulation-and-policy/credit-risk/guidelines-on-management-of-non-performing-and-forborne-exposures*).

whereas the export market share is adjusted according to the exports-to-GDP ratio. The investment and labor adjustment costs are parameterized to ensure plausible dynamics. Likewise for the parameter assessing the cost of under- or over-utilization of capital. The import content adjustment costs ensures plausible real exchange rate fluctuations. Calvo parameters imply an average contract duration and intermediate goods average price duration of 1 year, and a final and imported goods average price duration of half a year. We assume no indexing.

On the entrepreneurial side, we calibrate the idiosyncratic shock volatility and transferred earnings to households net of startup funds to match a target leverage (net worth-to-debt ratio) of 1.2 and a yearly bankruptcy probability of 2.5 percent. In practice, we set startup funds to zero and adjust the fraction of entrepreneurs going out of business. The repossession cost parameter $\mu^{\mathcal{K}}$ is set to 35 percent, in order to generate a retail-wholesale spread of 100 basis points and a loss given bankruptcy (LGB) close to 40 percent, proxied by $LGB = 1 - (1-\mu^{\mathcal{K}}) \int_0^{\bar{\omega}^{\mathcal{K}}} \omega^{\mathcal{E}} Ret^{\mathcal{K}} P^{\mathcal{K}} \bar{K} \mathfrak{f}^{\mathcal{K}}(\omega^{\mathcal{K}}) \mathrm{d}\omega^{\mathcal{K}} / [\mathfrak{F}^{\mathcal{K}}(\bar{\omega}_t^{\mathcal{K}}) L]$.

For the banking sector, we set regulatory capital requirements to 10 percent and let banks build an endogenous capital buffer of 4 percentage points, yielding a steady-state capital-to-loans ratio of 14 percent. The probability of non-complying with regulatory capital requirements is set at 2.5 percent per year, and the spread between the wholesale interest rate and the deposits rate is 1 percentage points. This recalibration determines the idiosyncratic shock volatility $\sigma^{\mathcal{BK}}$ and the penalty rate $\overline{\chi}^{\mathcal{BK}}$. The sum of the retail and wholesale spreads corresponds approximately to the 1999–2007 period average interest rate spread paid by non-financial corporations *vis-à-vis* the 3-month Euribor rate. The fraction of bankers going out of business is 5 percent—the banker stays on the job on average around 5 years—and startup funds amount to 7 percent of banks capital. The repossession cost parameter of deposit institutions μ^{D}, capturing the link between banks' financing costs and the mass of non-compliant banks, is set to 5 percent.

For due loans, our benchmark calibration considers a management cost κ^{DL} of 2.5 percent and a cure rate $\tau^{\mathcal{BK}}$ of 6 percent. The mean preserving spread parameter close to 9 allows to have 5 percent of banks surpassing the threshold level for the due loans to credit ratio of 5 percent. This value, together with the imposed 1.5 percentage points buffer (and hence a due-loans-to-credit ratio of 3.5 percent), result in the endogenous recalibration of the the regulatory requirement parameter γ^{DL} and the penalty rate $\bar{\chi}^{DL}$. New due loans correspond to the value of loans from those firms that were unable to repay to the bank (corresponding to 2.5 percent of firms), and in the steady state this value matches the amount that is withdrawn from the balance sheet—0.24 percent is cured and 0.34 percent is recognized as impairment loss and written off. The resulting steady-state impairment rate is 8.3 percent. The policy rule is imposed later on and is deactivated in the baseline calibration.

Finally, technology parameters for the services provided by households are calibrated so that the required labor for the task plays a minor role in the model dynamics. Parameter $\overline{\theta}$, defining the functional form of θ_t, is endogenously calibrated so that agency problems do not arise in the steady state, but are triggered in the presence of shocks with large negative impacts on banks' terminal wealth. We achieve this by imposing a slack sl in the incentive compatibility constraint

$$\overline{\theta}\left[1 + \Delta \frac{DL_t}{L_t}\right] - \frac{V_t}{L_t} = -sl$$

calibrated at an annualized rate of 0.40 percentage points, and finding the fixed point for $\bar{\theta}$ that solves the model. We assume that $\Delta = 0.5$ and set the smoothing parameter θ_a to 4. The share of "agency revenues"paid as monitoring services to households is 0.75, to avoid a swift recovery in banks capital under binding credit restrictions.

Appendix C: Additional figures

C.1. Intermediate case with stiff dividend strategy and absent credit restrictions

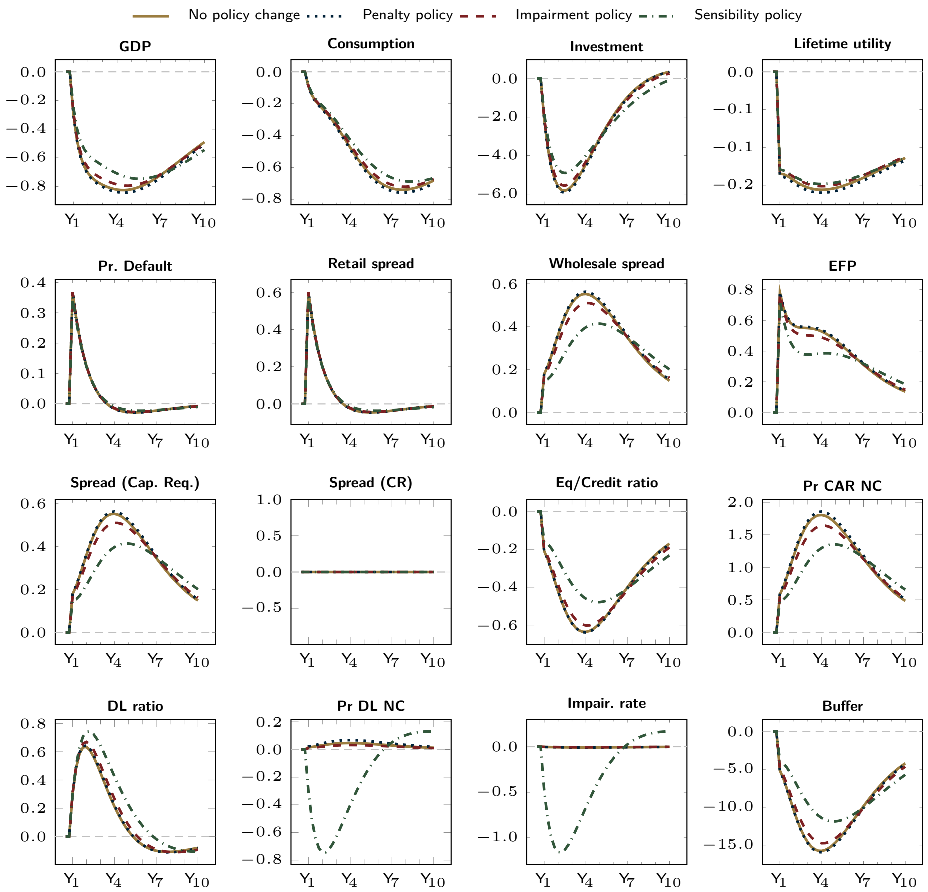

Figure C.1: Loosening the policy design under a stiff dividend strategy, with $\kappa^{DL} = 0.05$ and absent credit restrictions; baseline cure rate ($\tau^{\mathcal{BK}} = 0.06$).

Notes: See Figure 3.

C.2. Cure rate effects with stiff dividend strategy and absent credit restrictions

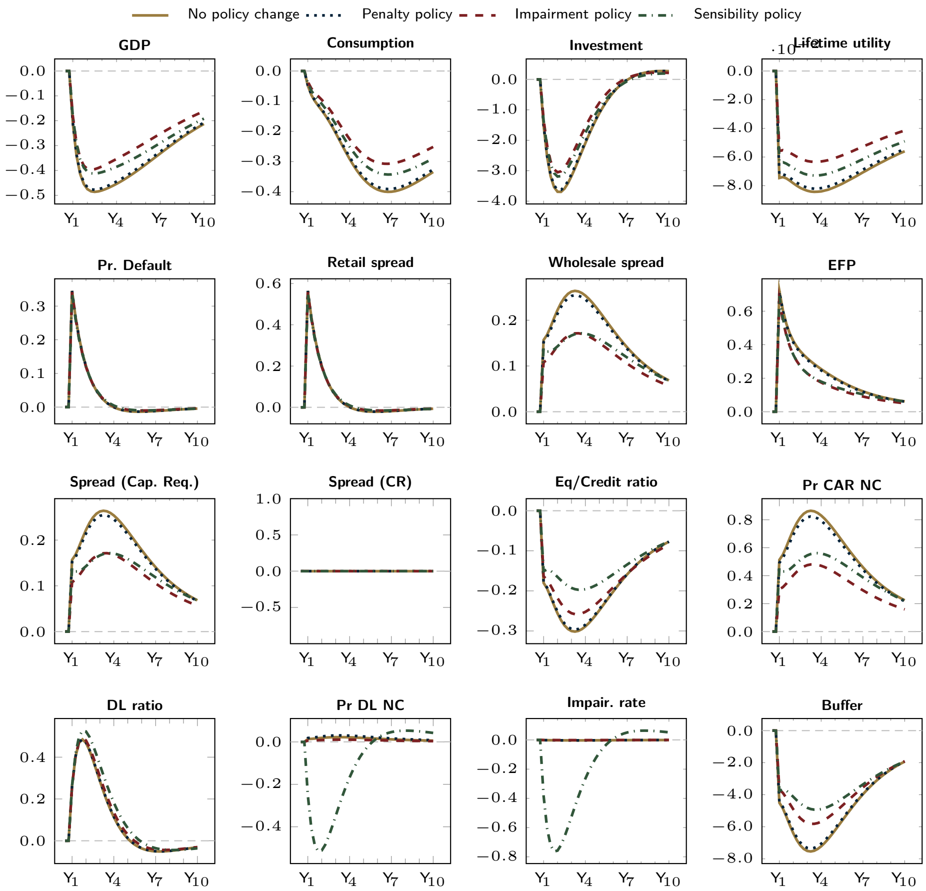

Figure C.2: Loosening the policy design under a stiff dividend strategy, with $\kappa^{DL} = 0$ and absent credit restrictions, higher cure rate ($\tau^{\mathcal{BK}} = 0.12$).

Notes: See Figure 3.

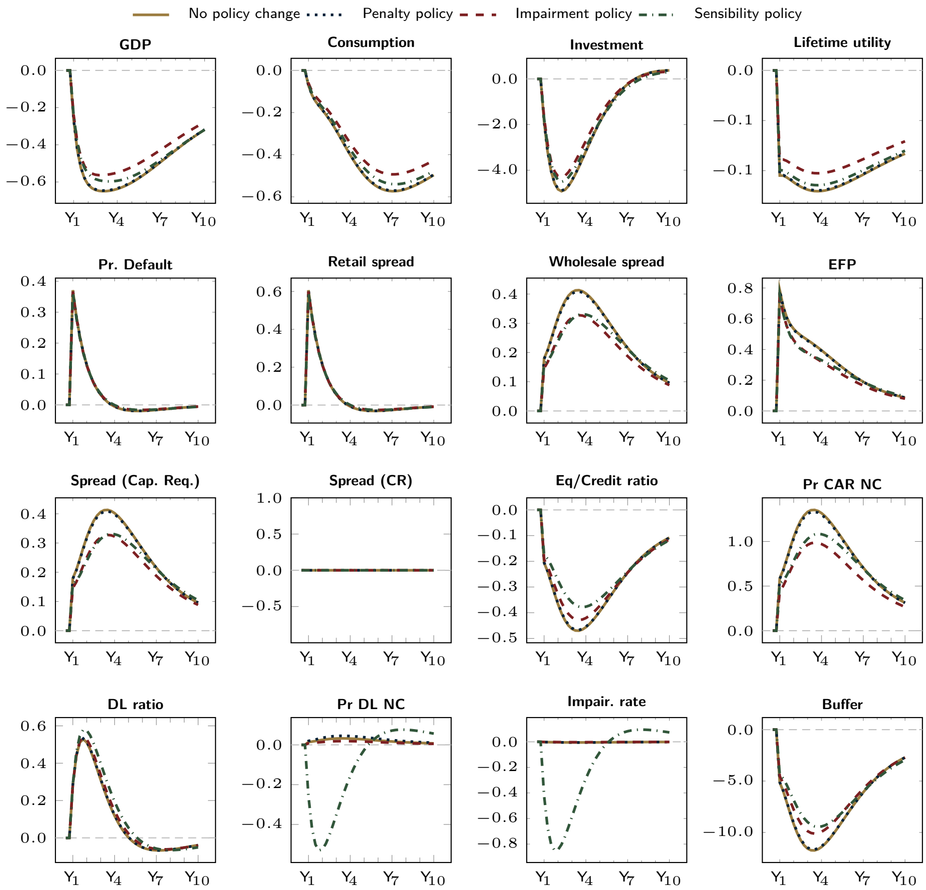

Figure C.3: Loosening the policy design under a stiff dividend strategy, with $\kappa^{DL} = 0.05$ and absent credit restrictions; high cure rate ($\tau^{\mathcal{BK}} = 0.12$).

Notes: See Figure 3.

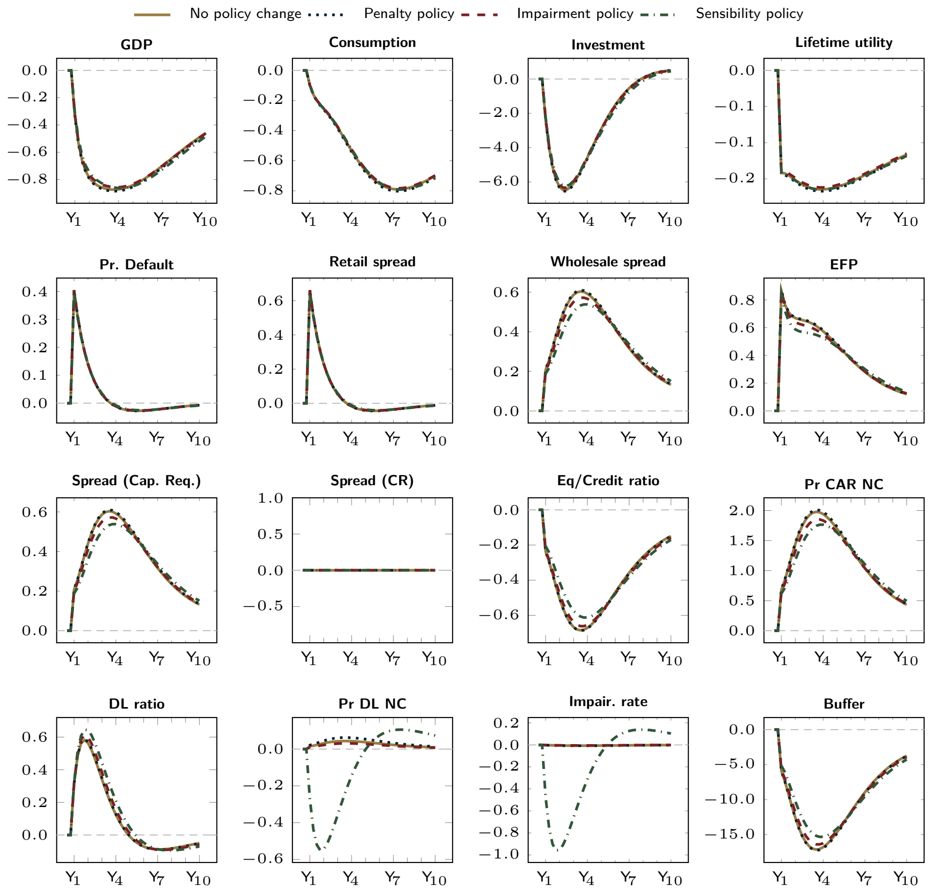

Figure C.4: Loosening the policy design under a stiff dividend strategy, with $\kappa^{DL} = 0.10$ and absent credit restrictions, higher cure rate ($\tau^{\mathcal{BK}} = 0.12$).

Notes: See Figure 3.

C.3. Stiff dividend strategy and occasionally binding credit restrictions

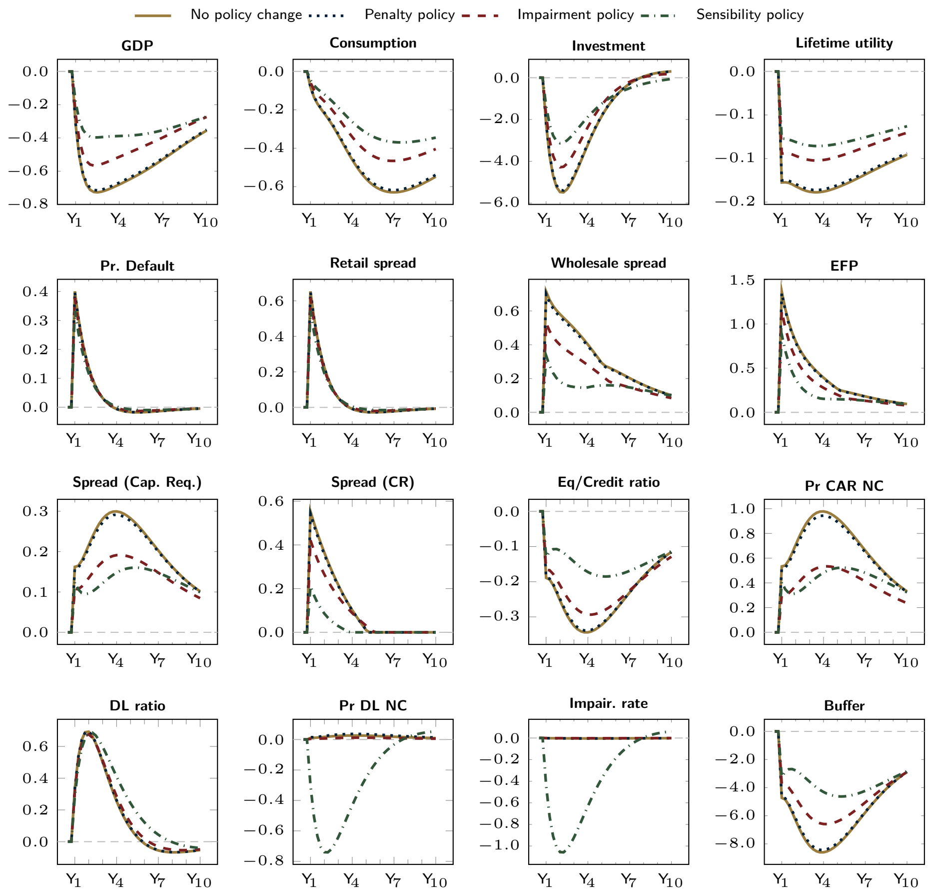

Figure C.5: Loosening the policy design under a stiff dividend strategy, with $\kappa^{DL} = 0$ and occasionally binding credit restrictions; baseline cure rate ($\tau^{\mathcal{BK}} = 0.06$).

Notes: See Figure 3.

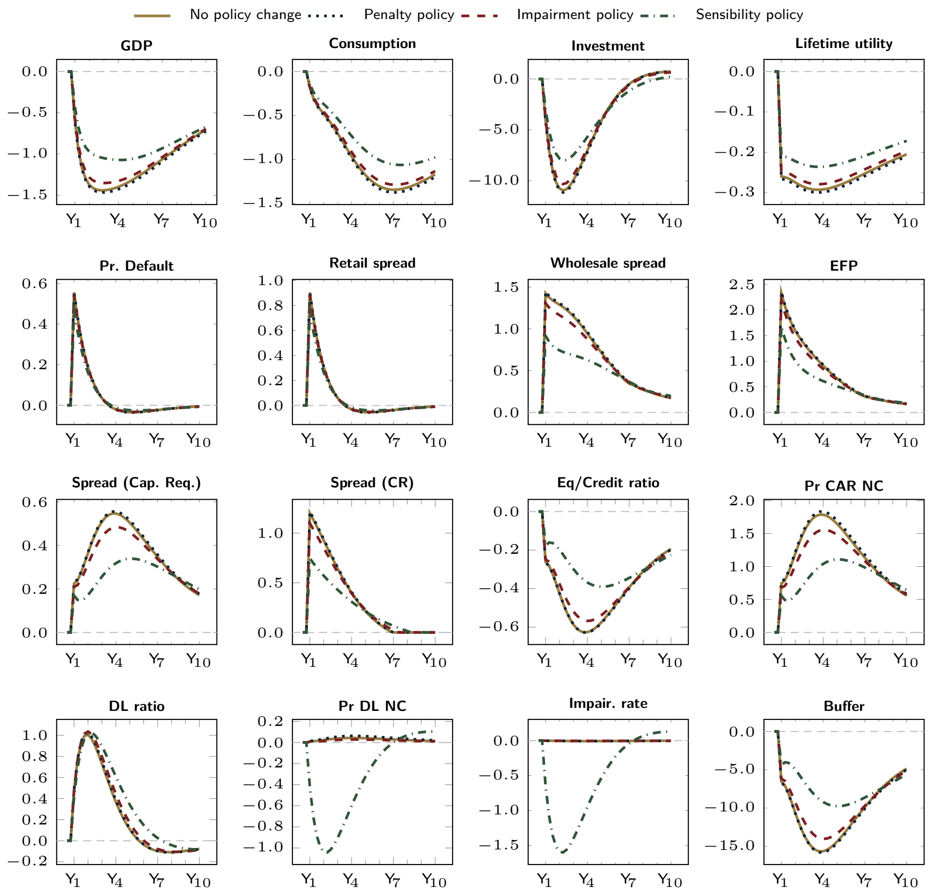

Figure C.6: Loosening the policy design under a stiff dividend strategy, with $\kappa^{DL} = 0.05$ and occasionally binding credit restrictions; baseline cure rate ($\tau^{\mathcal{BK}} = 0.06$).

Notes: See Figure 3.

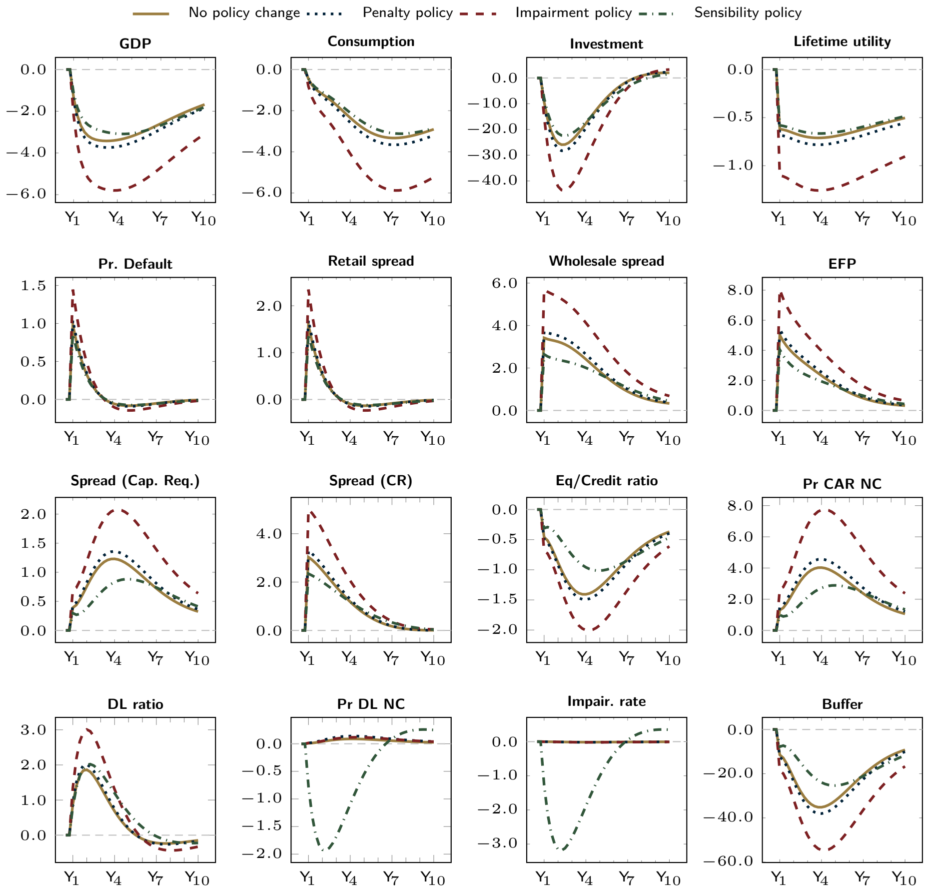

Figure C.7: Loosening the policy design under a stiff dividend strategy, with $\kappa^{DL} = 0.10$ and occasionally binding credit restrictions; baseline cure rate ($\tau^{\mathcal{BK}} = 0.06$).

Notes: See Figure 3.

C.4. *Cure rate effects with stiff dividend strategy and occasionally binding credit restrictions*

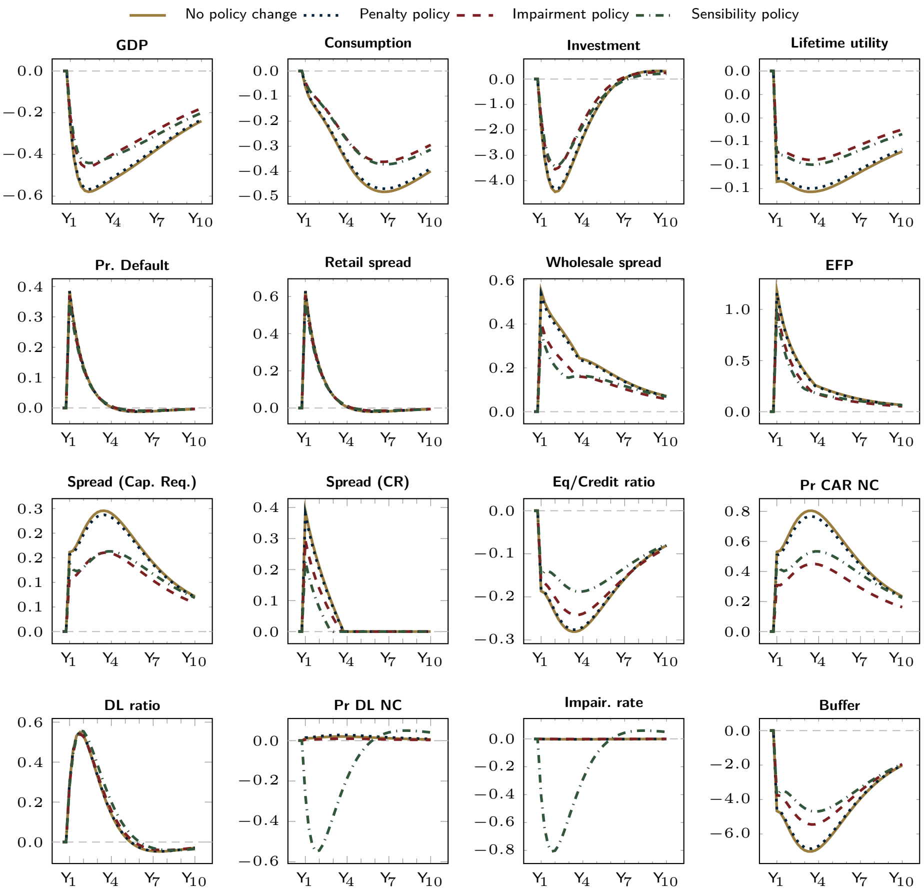

Figure C.8: Loosening the policy design under a stiff dividend strategy, with $\kappa^{DL} = 0$ and occasionally binding credit restrictions; high cure rate ($\tau^{\mathcal{BK}} = 0.12$).

Notes: See Figure 3.

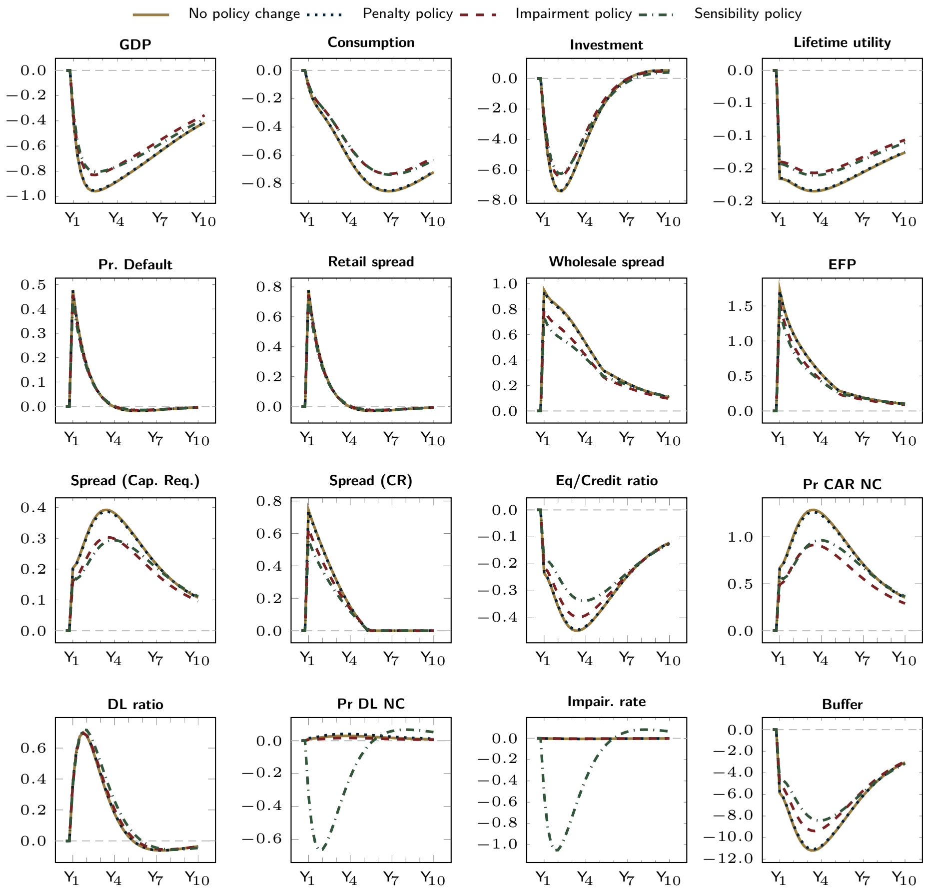

Figure C.9: Loosening the policy design under a stiff dividend strategy, with $\kappa^{DL} = 0.05$ and occasionally binding credit restrictions; high cure rate ($\tau^{\mathcal{BK}} = 0.12$).

Notes: See Figure 3.

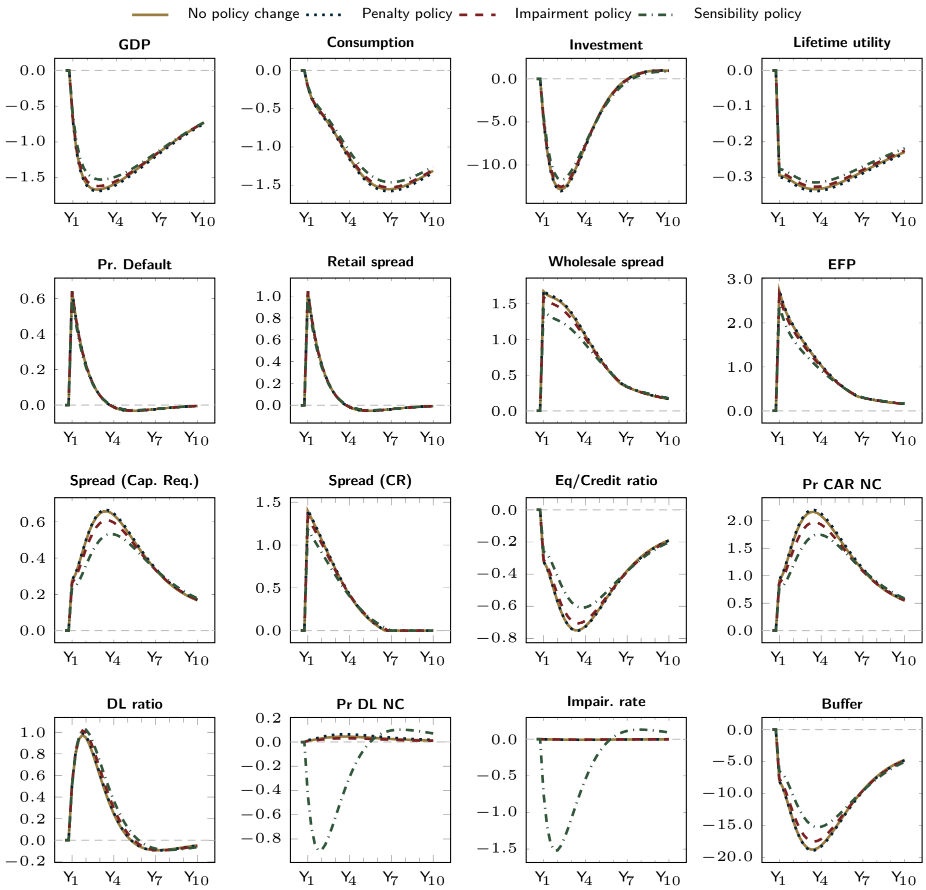

Figure C.10: Loosening the policy design under a stiff dividend strategy, with $\kappa^{DL} = 0.10$ and occasionally binding credit restrictions; high cure rate ($\tau^{\mathcal{BK}} = 0.12$).

Notes: See Figure 3.

C.5. The case of a soft dividend strategy

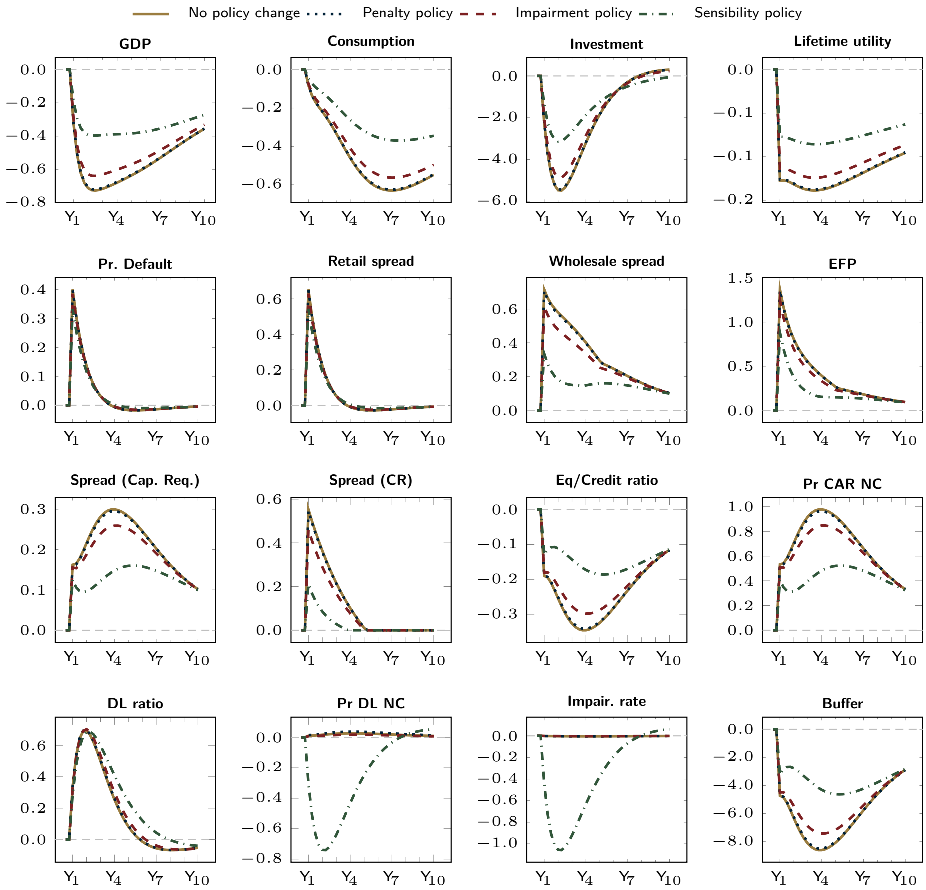

Figure C.11: Loosening the policy design under a soft dividend strategy, with $\kappa^{DL} = 0$ and occasionally binding credit restrictions; baseline cure rate ($\tau^{\mathcal{BK}} = 0.06$).

Notes: See Figure 3.

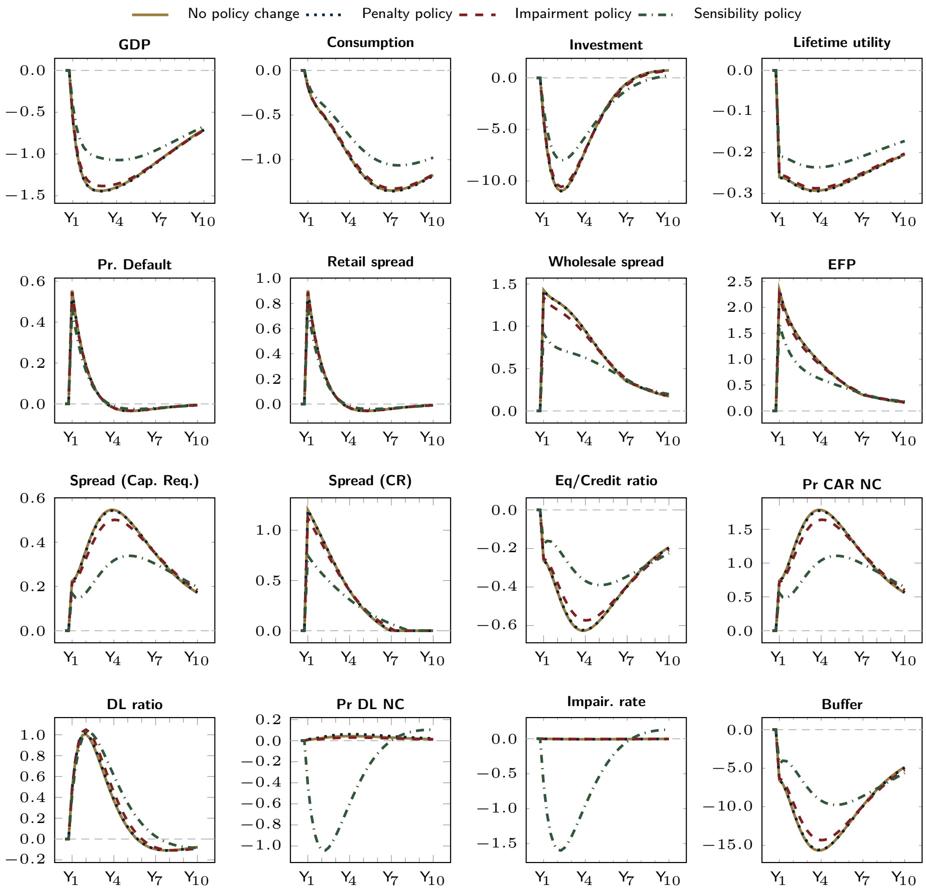

Figure C.12: Loosening the policy design under a soft dividend strategy, with $\kappa^{DL} = 0.05$ and occasionally binding credit restrictions; baseline cure rate ($\tau^{\mathcal{BK}} = 0.06$).

Notes: See Figure 3.

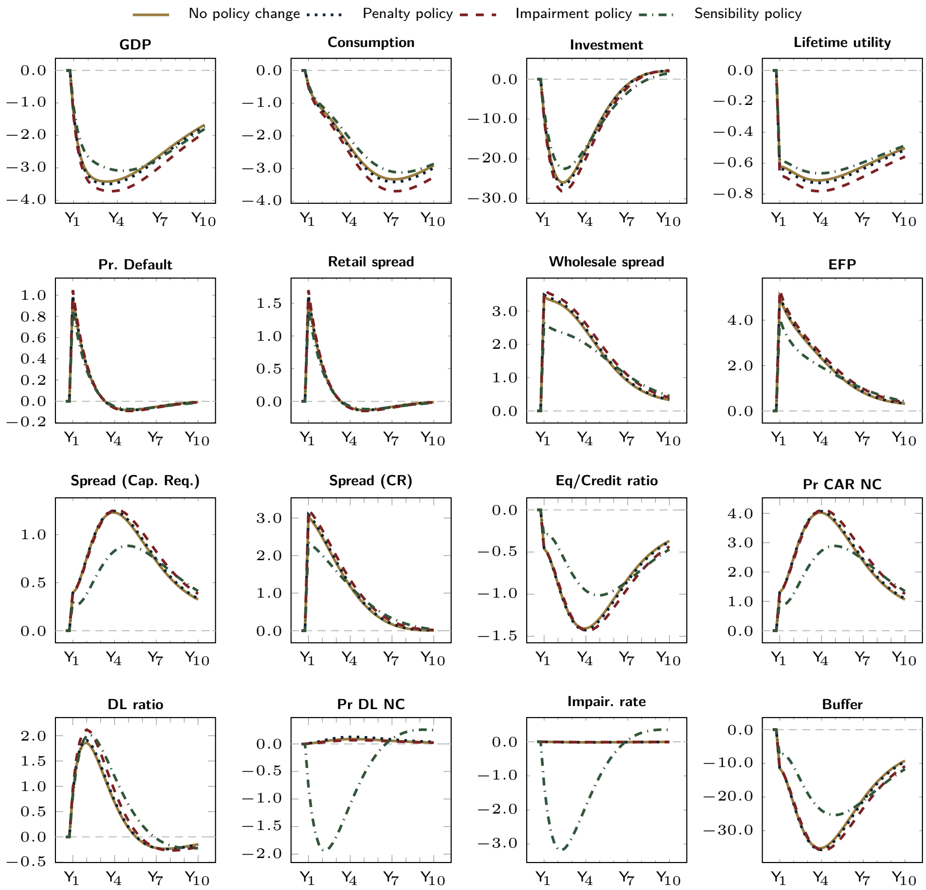

Figure C.13: Loosening the policy design under a soft dividend strategy, with $\kappa^{DL} = 0.10$ and occasionally binding credit restrictions; baseline cure rate ($\tau^{\mathcal{BK}} = 0.06$).

Notes: See Figure 3.

C.6. Cure rate and financially-driven business cycle

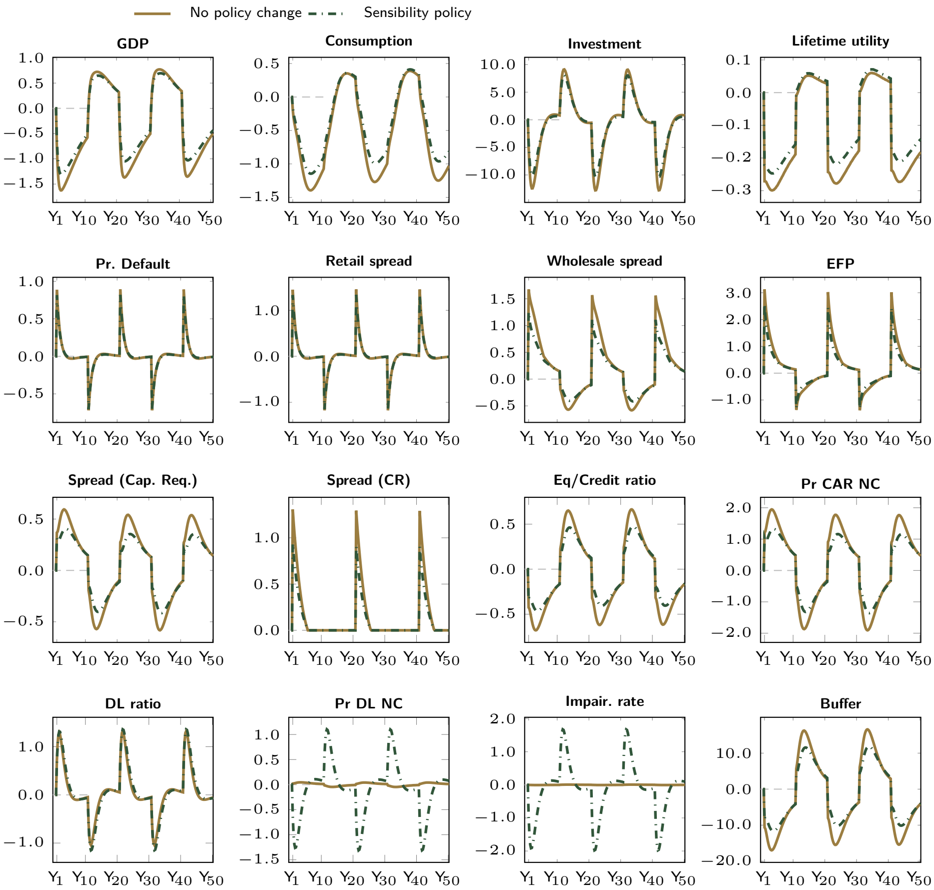

Figure C.14: Financially-driven business cycle and the sensibility policy rule under a stiff dividend strategy and occasionally binding credit restrictions ($\kappa^{DL} = 0.025$); high cure rate ($\tau^{\mathcal{BK}} = 0.12$).

Notes: See Figures and 3 and 8.

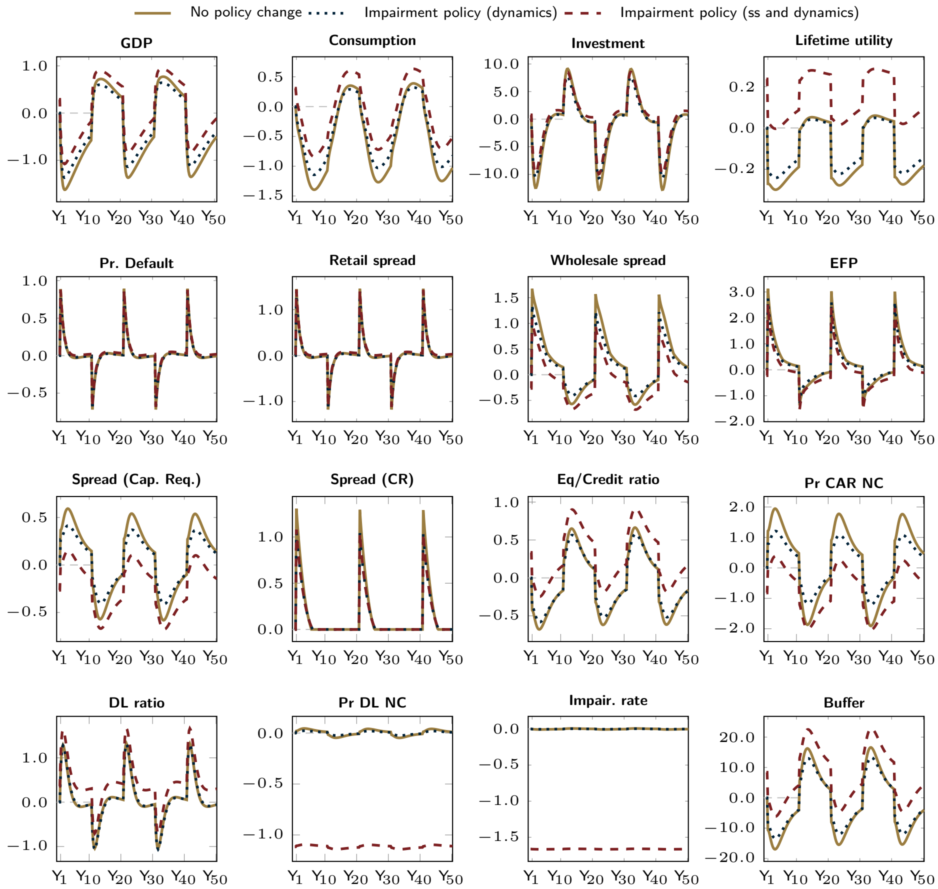

Figure C.15: Financially-driven business cycle and the impairment policy under occasionally binding credit restrictions ($\kappa^{DL} = 0.025$); high cure rate ($\tau^{\mathcal{BK}} = 0.12$).

Notes: See Figures and 3 and 8.

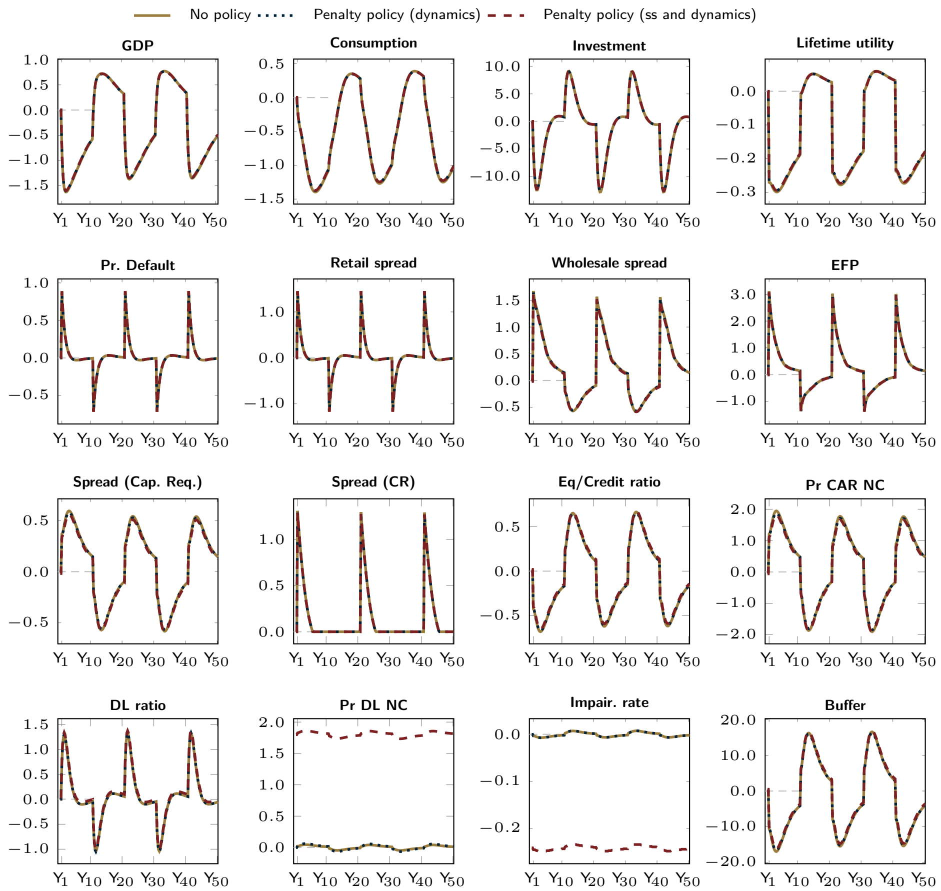

Figure C.16: Financially-driven business cycle and the penalty policy under occasionally binding credit restrictions ($\kappa^{DL} = 0.025$); high cure rate ($\tau^{\mathcal{BK}} = 0.12$).

Notes: See Figures and 3 and 8.

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2018

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Nikolay Iskrev

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