13
WORKING
PAPERS 2023

THE COVID-19 PANDEMIC, SOVEREIGN LOAN GUARANTEES, AND FINANCIAL STABILITY

Ivan De Lorenzo Buratta | Tiago Pinheiro

BANCO DE PORTUGAL
EUROSYSTEM

13
WORKING PAPERS 2023

THE COVID-19 PANDEMIC, SOVEREIGN LOAN GUARANTEES, AND FINANCIAL STABILITY

Ivan De Lorenzo Buratta | Tiago Pinheiro

AUGUST 2023
The analyses, opinions and findings of these papers represent the views of the authors, they are not necessarily those of the Banco de Portugal or the Eurosystem.

Please address correspondence to
Banco de Portugal
Rua do Comércio 148, 1100-150 Lisboa, Portugal
Tel.: +351 213 130 000, email: info@bportugal.pt

BANCO DE PORTUGAL
EUROSYSTEM

Lisboa, 2023 • www.bportugal.pt

Working Papers | Lisboa 2023 • Banco de Portugal Rua do Comércio 148 | 1100-150 Lisboa • www.bportugal.pt •
Edition Banco de Portugal • ISBN (online) 978-989-678-872-8 • ISSN (online) 2182-0422

The COVID-19 Pandemic, Sovereign Loan Guarantees, and Financial Stability

Ivan De Lorenzo Buratta
Banco de Portugal

Tiago Pinheiro
Banco de Portugal

August 2023

Abstract
We analyze the effects of the Portuguese COVID-19 sovereign loan guarantee scheme on financial stability using a DSGE model. Sovereign loan guarantees decrease the default rate of banks, increase credit, and speed up economic recovery. On the other hand, guarantees increase the leverage and default rate of firms. These effects are larger the lower the sensitivity of the capital of banks to capital requirements. Behind these results are the reduction in regulatory risk-weights and the transfer of loan losses from banks to the sovereign brought by sovereign loan guarantees.

JEL: E3, E44, G01, G21, O52

Keywords: COVID-19 pandemic, sovereign loan guarantees, financial stability.

Acknowledgements: We thank Dina Batista, Diana Bonfim, Inês Drumond, Pedro Gete, Nobuhiro Kiyotaki, Ana Cristina Leal, Diana Lima, José R. Maria, Ana Pereira, José-Luis Peydró, Fátima Silva, Andra Smadu and the participants in the CEMLA's XXVII Meeting of the Central Bank Researchers Network, in the 42nd EBES Conference, in the Banco de Portugal and University of Surrey Workshop, and in the 16th IRMC for the helpful comments and suggestions. The views expressed in this article are those of the authors and do not necessarily reflect the views of Banco de Portugal or the Eurosystem. Any errors and mistakes are ours.

E-mail: ilorenzo@bportugal.pt; tmpinheiro@bportugal.pt

1. Introduction

Sovereign guarantees on firm loans are among the policy measures adopted to mitigate the effects of the COVID-19 pandemic outbreak. In this paper we measure the impact of these guarantees on Portugal's financial stability. We focus specifically on how the guarantees affect the probability of default of banks and credit to the economy.

To measure the effect of sovereign guarantees we use and extend the DSGE model in Clerc *et al.* (2015). We hit the model's steady-state with a series of shocks that mimic the forecasts of the evolution of the economy after the onset of the COVID-19 pandemic, and we compare the response of variables of interest in two scenarios: one with and another without sovereign guarantees.

We find that sovereign guarantees reduce the aggregate default rate of banks, and increase credit and output. On average, guaranteeing one percent of the banks' credit to firms over a year decreases the default rate of banks by 0.48 percent, increases credit and output by 0.32 and 0.01 percent, and has a fiscal cost of 0.02 percent of output.

The sensitivity of the banks' capital to capital requirements is an important determinant of the policy's impact on the default rate of banks. If the elasticity of banks' capital to capital requirements decreases from 0.81 to 0.3, then one percent of sovereign guarantees decreases the default rate of banks by 1.76 percent. Similarly, the loan guarantee fee is a key driver of the policy's fiscal cost. When the fee drops from 0.66 percent to 0, then one percent of guarantees has a yearly fiscal cost of 0.035 percent of output.

Our results are explained by two key effects of sovereign guarantees. Guarantees transfer loan losses from banks to the sovereign and reduce the regulatory risk-weights on firm loans. Banks, operating in a competitive environment, respond to lower losses and lower risk-weights with more credit to firms and less bank capital. Firms use the additional credit to invest more than they would in a setting without sovereign guarantees, and output recovers faster. Firms' additional credit also implies higher leverage and higher firms' default rate. In contrast, the default rate of banks, on the other hand, decreases. The capital of banks reduces by less than the expected credit losses transferred to the sovereign, thus increasing the banks' capacity to withstand losses on the loans without sovereign guarantees.

We explore alternative designs of the scheme to assess the impact of its size, duration and timeliness. Increasing the scheme's size enhances its effect on bank default, on credit, and on economic recovery but entails higher expected fiscal costs. Extending the maturity of sovereign guarantees has a negligible effect on bank default and credit. But it increases the benefits to the economy and postpones the drop in output associated with the phasing out of the scheme. Finally, delaying the implementation of the scheme past the quarter of the COVID-19 shock would lengthen the economic recovery and increase the banks' default probability at the time of the shock.

To our knowledge, this work is one of the first attempts to assess the impact on financial stability of the COVID-19 sovereign guarantees on firm loans in a general equilibrium model with firms' and banks' default. We can quantify how the scheme impacts credit to firms, the default probability of banks, output and the expected fiscal costs. Moreover, the framework allows for the comparison of different schemes, and hence for a more comprehensive evaluation of the scheme in place.

The literature on the effects of sovereign loan guarantees during the COVID-19 pandemic crisis includes Falagiarda *et al.* (2020), Budnik *et al.* (2021), Demmou and Franco (2021), Mateus and Neugebauer (2022), Rancoita *et al.* (2020), Laeven *et al.* (2022) and Cascarino *et al.* (2022). Falagiarda *et al.* (2020) and Budnik *et al.* (2021) show that sovereign guarantees increased corporate lending. Falagiarda *et al.* (2020) also show that sovereign guarantees helped in maintaining favorable lending conditions. The results in Demmou and Franco (2021) suggest that increased lending on favorable terms and conditions did not come at the expense of credit misallocation: loan guarantees protected high productivity firms while barely sustaining zombie firms. Mateus and Neugebauer (2022) find that the Portuguese loan guarantee scheme mainly supported lower credit-risk firms, with riskier firms paying higher interest rates and obtaining smaller guaranteed loans. The literature on sovereign loan guarantees in Portugal also includes Bonfim *et al.* (2023), where it is shown that the loan guarantees increased Portuguese firms' borrowing and investment, while decreasing their probability of default. Cascarino *et al.* (2022) document high levels of sovereign guarantees' credit additionality for Italy. Laeven *et al.* (2022) find that Spanish firms with higher pre-COVID credit exposure to banks were more likely to obtain guaranteed loans, particularly the riskier ones, in heavily affected sectors and exposed to weaker banks. Their results also point to a substitution of non-guaranteed credit, to a reduction of loan impairment recognition and an increase in market share for banks granting guarantees. On an aggregate level, Rancoita *et al.* (2020) estimate a positive impact on GDP for the euro area arising from sovereign guarantees.

The paper is organized as follows. Section 2 summarizes the main features of the baseline model and how the guarantees are included in it. Section 3 defines the shocks, the calibration and the numerical approximation we implement. Main results, sensitivity analysis and alternative policies are discussed in section 4. Finally, section 5 concludes.

2. Modeling sovereign loan guarantees

2.1. The sovereign loan guarantee scheme in Portugal

In March 2020, Portugal authorized a loan guarantee scheme to support the economy after the COVID-19 shock. The scheme complies with the rules in OJ C 91I, 20.3.2020 set by the European Commission (EC). It consists of 13 billion euros of guaranteed loans, notably for firms in the sectors most affected by the pandemic – for example, restaurants, hotels, and travel agencies. Firms in difficulty, as defined in Article 2 (18) of the Commission Regulation (EU) No 651/2014, cannot access the scheme. This restriction puts an upper bound on the credit risk of the borrowers of guaranteed loans. The guarantee's coverage varies between 80 and 90 percent depending on firm size but cannot exceed 90 percent. The maximum maturity of the guarantee is six years. The borrowers pays a guarantee fee that depends on the maturity of the loan and on the borrower's size. In October 2021, the amount of guaranteed loans reached 8.87 billion euros, eighty-five percent of which issued in 2020. Most guarantees were granted with the maximum maturity, and in October 2021 the average residual maturity was about 4.5 years.[1]

2.2. The original 3D model

We start with the model in Clerc *et al.* (2015) – henceforth the 3D model – and extend it to include loans with sovereign guarantees. The model is particularly suited to assess the effect of loan guarantees on financial stability. It has an economy where banks are subject to capital requirements, experience loan losses arising from the default of firms, and may default themselves. Thus, the model can capture the role of sovereign guarantees in reducing regulatory risk-weights on loans and in safeguarding banks against loan losses.

Figure 1 summarizes the key relationships between economic agents in the 3D model. The model synthesizes an economy composed of households, entrepreneurs, and banks. Patient households save and finance banks with deposits, while impatient households borrow. Both types of households consume, invest in housing, and work in the production sector. Entrepreneurs run firms and invest in capital with inherited equity and with credit granted by the banking sector. Mortgage banks lend to impatient households for investment in housing and corporate banks lend to entrepreneurs. Banks operate with limited liability, and are subject to minimum capital requirements.

In the model, all agents can default, including banks. A bank defaults when the losses in its loan portfolio are higher than its capital. Losses in a bank's loan portfolio can arise from bank's idiosyncratic shocks and from the default of entrepreneurs and impatient households.

When banks default, depositors' losses are covered with lump-sum taxes levied on patient households. These taxes are charged by the deposit insurance agency in the same period of bank default.

The default of any agent leads to deadweight losses. These losses are the source of frictions in the model.

1. Data from Banco de Portugal Financial Stability Report, December 2021.

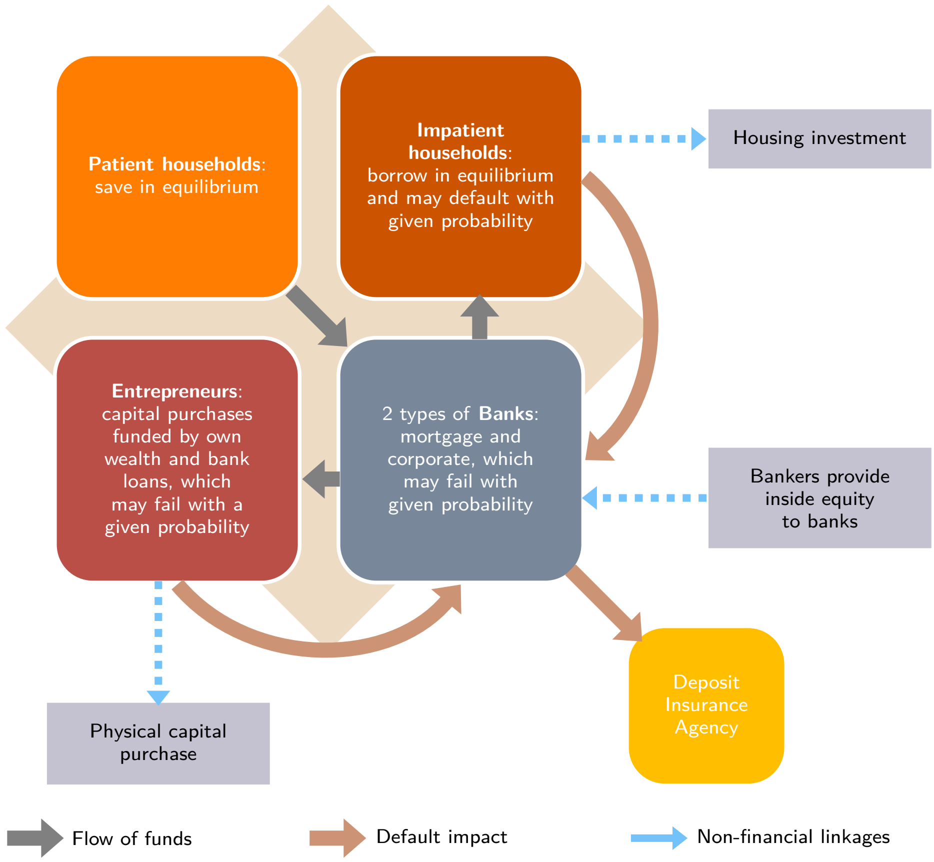


Figure 1: Main features of the 3D model

2.3. *Adding sovereign loan guarantees to the 3D model*

In the 3D model there is no sovereign. That role is played implicitly by the deposit insurance agency which has the power to tax households. We follow a similar approach.

We assume that a sovereign guarantee fund guarantees a fraction g_t of every firm loan. The fund charges corporate banks a fee f_t per unit of guaranteed credit. In return, it compensates corporate banks for loan losses by transferring the difference between the contractual and the realized gross interest rates of loans, R_t^F and $\tilde{R}_{t+1}^F$. The fund raises the necessary revenue to compensate corporate banks by levying lump-sum taxes, T_{t+1}^G, on patient households:

$$T_{t+1}^G = \left(R_t^F - \tilde{R}_{t+1}^F - f_t \right) g_t b_t^e \tag{1}$$

with b_t^e being corporate loans.

We also reduce the banks' minimum capital requirements in proportion to the share of guaranteed credit. This reduction reflects the zero percent risk-weight assigned to loans guaranteed by the sovereign.[2] The capital of corporate banks e_t^F must then satisfy the following constraint:

$$e_t^F \geq \left(\bar{\kappa}^F + \bar{\phi}^F \left(1 - g_t\right)\right) b_t^e \tag{2}$$

where $\bar{\phi}^F$ is the fraction of risk-weighted assets that banks must hold as capital to comply with regulatory requirements. Risk-weighted assets, $(1 - g_t)b_t^e$, result from a zero percent risk-weight on the share g_t of guaranteed credit and a hundred percent risk-weight on the remaining credit. Parameter $\bar{\kappa}^F$ in equation 2 controls the sensitivity of the banks' capital to capital requirements. It generalizes the banks' capital constraint in the 3D model. We will return to it in Subsection 2.5.

Given our modelling choices, the corporate banks' profits are described by:

$$\max\left[\left(R_t^F - f_t\right) b_t^e g_t + \omega_{t+1}^F \tilde{R}_{t+1}^F b_t^e (1 - g_t) - R_t^D d_t^F, 0\right] \tag{3}$$

where ω_{t+1}^F captures idiosyncratic shocks to the loan returns of corporate banks, R_t^D is the deposit interest rate, and d_t^F are the corporate banks' deposits.

Corporate banks will default if the shock ω_{t+1}^F is lower than a threshold $\bar{\omega}_{t+1}^F$, with the threshold being defined as:

$$\bar{\omega}_{t+1}^F = \frac{R_t^D d_t^F - g_t \left(R_t^F - f_t\right) b_t^e}{\left(1 - g_t\right) \tilde{R}_{t+1}^F b_t^e} \tag{4}$$

$$= \frac{1}{\tilde{R}_{t+1}^F} \frac{R_t^D \left[1 - \left(\bar{\kappa}^F + \bar{\phi}^F \left(1 - g_t\right)\right)\right] - \left(R_t^F - f_t\right) g_t}{1 - g_t}. \tag{5}$$

The last equality in the previous equation follows from the accounting identity between the banks' assets and liabilities, $b_t^e = e_t^F + d_t^F$, and from a binding capital requirement constraint in equation 2. Equation 5 highlights the fraction of guaranteed loans, the fee and the minimum capital ratio as key drivers of the default of corporate banks.

The sovereign loan guarantee scheme has direct and indirect fiscal costs. Transfers T_{t+1}^G in equation 1 represent the direct costs. The indirect costs of the scheme include the additional costs borne by the deposit insurance agency after the implementation of the guarantees. These additional costs can be negative – if the banks' default rate decreases – or positive – if the banks' default rate increases.

We now move to comments about our modeling of sovereign loan guarantees. Assuming that a fraction g_t of every firm loan is guaranteed is without loss of generality. In the context of the 3D model, firms are identical. It is irrelevant whether only a share g_t of firms have guaranteed credit or whether each firm has a

2. Articles 116, 150, 213, 214 and 235 of OJ L 176, 27.6.2013.

fraction g_t of its loans that is guaranteed. Outside the model, our assumption fails to capture the fact that sovereign loan guarantees are mainly targeted to small and medium enterprises operating in sectors most affected by the COVID-19 pandemic crisis. To the extent that these firms are more likely to generate losses for banks, our results are underestimating the positive effect of loan guarantees on financial stability and the cost of the scheme.

We assume that loan guarantees protect banks against losses that arise from the banks' *idiosyncratic* shocks. While the assumption may seem odd, we interpret the banks' idiosyncratic shocks in the 3D model as shocks arising from undiversified credit risk.[3] Sovereign loan guarantees insure banks against all credit risk, diversified or not.

Finally, we deviate from the terms and conditions of the Portuguese sovereign loan guarantee scheme and assume that banks, rather than borrowers, pay the guarantee fee. This assumption is for expediency and it is without loss of generality. The credit market equilibrium would be unchanged if we assumed otherwise. Note further that our assumption is in line with the typical terms and conditions of loan guarantees.

2.4. The effects of loan guarantees on the credit market equilibrium

The sovereign loan guarantee scheme impacts the credit market equilibrium and has three different first-order effects on bankers' returns. The guarantees (i) reduce loan returns' risk, (ii) increase the expected loan return when the fee is lower than the fee that makes expected net transfers equal to 0, and (iii) decrease the required banks' capital. The last two effects increase bankers' returns, while lower loan risk decreases them – risk-neutral bankers are ultimately risk-loving due to limited liability.

Changes in bankers' returns are passed on to borrowers, since banks operate in a competitive environment. This result implies that entrepreneurs would not demand sovereign guarantees if their effect was to only reduce loan returns' risk. It also implies that when bankers' returns do increase, entrepreneurs are granted loans with lower interest rates or higher credit amounts, or a combination of both.

The reduction in the risk of loan returns and the increase in expected loan returns improve financial stability, as both effects reduce the probability of the banks' default. On the other hand, lower loan's risk-weights raises bank leverage, which increases bank default probability. The model parameterization is decisive in determining which effect dominates.

3. In Clerc *et al.* (2015), the authors of the original 3D model offer a similar interpretation.

2.5. Generalization of the capital requirements' constraint

Departing from the original 3D model, we generalize the capital requirements constraint to include a parameter that determines the sensitivity of the banks' capital, e_t^F, to required capital, $\bar{\phi}^F b_t^e$. We want the model to be more realistic and include the possibility that the elasticity of the banks' capital to required capital is less than one. Generalizing the banks' capital constraint as we did in equation 2 is a reduced-form approach of capturing this possibility. Since equation 2 is always binding in equilibrium, the elasticity of bank capital to required capital is given by $\varepsilon^F = \bar{\phi}^F/(\bar{\kappa}^F+\bar{\phi}^F)$, which is less than one if parameter $\bar{\kappa}^F$ is positive.

As we shall see in Section 4, the generalization of the capital requirements constraint has relevant implications for the effects of the loan guarantee scheme.

3. Shocks, parameters and numerical approximation

We calibrate a COVID-19 shock, the path of guaranteed credit, the loan guarantee fee f_t, the different components of capital ratio $\bar{\phi}^F$ and $\bar{\kappa}^F$, and the remaining parameters of the 3D model.

3.1. The COVID-19 shock

We model the COVID-19 shock as a series of productivity shocks to approximate the forecasted drop in Portugal's GDP during the pandemic crisis. This strategy follows De Lorenzo Buratta *et al.* (2023) and Banco de Portugal (2020a), in which authors argue that supply-side factors, and especially the decline in global productivity, mainly determined the GDP contraction. A similar approach was followed in Fornaro and Wolf (2021). Alternatively, Guerrieri *et al.* (2020) and Bodenstein *et al.* (2021) model the COVID-19 shock as a negative labour supply shock.

Productivity shocks mimic the partial or total closure of firms, the lockdown effects on specific economic activities at the global level, and the efficiency disruptions impacting both labor and capital. As in De Lorenzo Buratta *et al.* (2023), we consider a series of productivity shocks decreasing output that simulate the two lockdown periods of March 2020 and January 2021. We set the magnitude of the productivity shocks to reproduce the fall in Portugal's GDP predicted in Banco de Portugal (2020b). In addition, we calibrate the persistence of the productivity shocks to mimic the recovery in GDP predicted before the second lockdown. Panel A of Figure 2 shows the productivity shocks and dynamics from 2019Q4 to 2021Q4.

We use forecasted instead of observed GDP growth so that we assess the effect of loan guarantees with no more information than the one available at the time of their implementation. In addition, we want to avoid double counting the effect of loan guarantees on output. This effect is not captured in the forecasts in Banco de Portugal (2020b). Despite the conceptual differences between forecasted and observed GDP growth, results don't change much if we use observed GDP growth. The two series are similar.

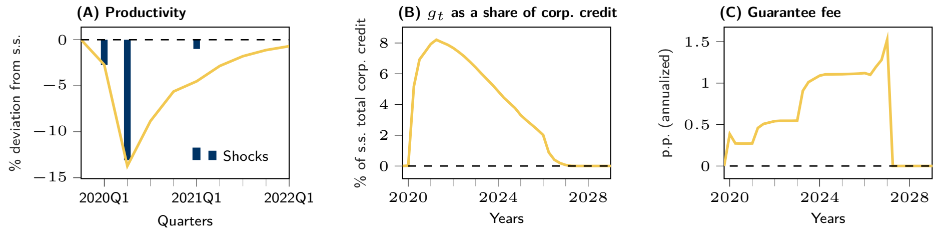


Figure 2: Paths of productivity, guaranteed loans and guarantee fee

3.2. Guaranteed credit

The share g_t of guaranteed loans is endogenous and equal to G_t/b_t^e, where G_t is the amount of credit guaranteed in quarter t.

We use granular data from Banco de Portugal's Credit Register to compute guaranteed credit, G_t. Granular data is necessary because the amount of guaranteed credit depends on which loans receive a COVID-19 sovereign guarantee, on the fraction of each loan that is guaranteed, and on the loans' maturity and amortization schedules. Our identification of loans with a COVID-19 sovereign guarantee runs from March 2020 to July 2021. To put guaranteed credit on the same scale of the model's variables, we multiply it by the ratio of Portugal's GDP in 2019Q4 and the model's steady-state output level.

Panel B of Figure 2 shows that the share of guaranteed credit rises rapidly to 8.21 percent between 2020Q1 and 2021Q2, decreases steadily until 2026, and then abruptly converges to 0 in 2027. The abrupt fall in guaranteed credit towards the end of the scheme raises the possibility of cliff-effects. We will discuss them in Section 4. The average share of guaranteed credit throughout the life of the scheme is 4.7 percent.

3.3. The loan guarantee fee

To compute the aggregate time series for the fee, we rely on the guidelines of the multiple programs implementing the Portuguese COVID-19 public guarantees. The guidelines regulate the amount of the guarantees' premia.[4] The fee' value varies with the maturity of the guarantee, the size of the firm (micro, small, medium, small cap, mid cap, large), and the loan guarantee program. After merging this information with data on guarantee maturity, we compute a fee term structure for

4. For details, see https://financiamento.iapmei.pt/inicio/home The fee term structures follow the EC rules for the minimum amounts as in OJ C 91I, 20.3.2020.

each loan contract. To obtain the aggregate time series, we average fees across loans weighting each fee by the loan's guaranteed amount at each point in time. The time series of fees is depicted in Panel C of Figure 2. The average loan guarantee fee throughout the life of the scheme is 0.66 percentage points.

3.4. *Required capital ratio and* $\bar{\kappa}^F$

We calibrate the required capital ratio $\bar{\phi}^F$ and the parameter $\bar{\kappa}^F$ so that their sum equals the asset-weighted average of the observed capital ratio of the largest Portuguese banks in the period between 2017 and 2019 – 13.87 percent.[5] In the absence of an estimate of the elasticity of the banks' capital to required capital, we set the required capital ratio $\bar{\phi}^F$ equal to 11.25 percent. It corresponds to the sum of the required total capital ratio (8 percent), the asset-weighted average of the OSII capital buffer (0.75 percent), and the capital conservation buffer (2.5 percent). Parameter $\bar{\kappa}^F$ is then 2.62 percent. With this calibration the elasticity of the banks' capital, ε^F, to required capital, $\bar{\phi}^F b_t^e$, is 0.81. In section 4 we show results with different calibrations of parameters $\bar{\phi}^F$ and $\bar{\kappa}^F$, corresponding to different elasticities of bank's capital to required capital.

3.5. *The remaining parameters and numerical approximation*

The rest of the parameters results from the calibration of the 3D model for the Portuguese economy using quarterly data from 2017Q1 to 2019Q4. The calibration strategy follows Lima *et al.* (2023). The data targets and the obtained parameter values are reported in Appendix.

We use Dynare to numerically compute the model's steady-state and the impulse response functions resulting from the COVID-19 shock and loan guarantee scheme. We use a second order approximation around the steady state, as non-linear effects are relevant for our analysis.

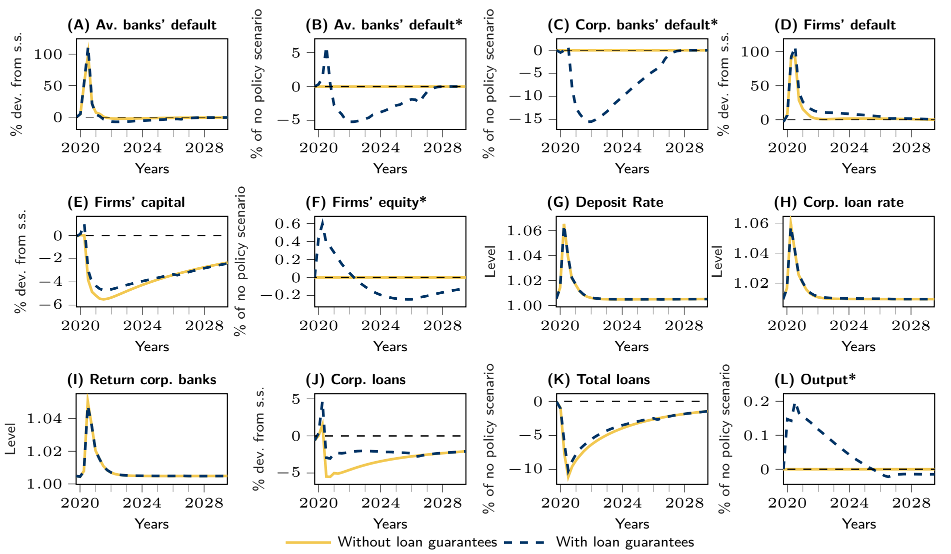
We assume that the loan guarantee scheme is a shock to agents at the time of its introduction. But, once the scheme is introduced, we assume that agents perfectly foresee the dynamics of the share of guaranteed loans.

4. Results

Figure 3 and Table 1 present the main results of the impact of the sovereign loan guarantee scheme. The yellow lines describe the dynamics of key variables after the COVID-19 shock in a setting without loan guarantees. In what follows all the measurements of the effects of the scheme refer to the period between 2020Q1 and the quarter in which the scheme ends, 2027Q1.

5. Source: Portuguese banks' Common Reporting (COREP) reports.

When a temporary total factor productivity shock hits the economy, the losses of firms increase, and so does their default rate. The entrepreneurs' net wealth decreases significantly because they are leveraged. Since the shock is temporary, the optimal physical capital falls by less than the wealth of entrepreneurs. Firm leverage thus increases while entrepreneurs replenish their net wealth. Higher firm leverage increases the likelihood that firms default, which put the banks' portfolios at a risk of higher losses. The increase in the firms' default rate erodes the capital of banks and the banks' capacity to provide new loans.



Note: * In panel (B), (C), (F) and (L), the lines correspond to $(IRFs_t^1 - IRFs_t^0)/IRFs_t^0 \cdot 100$, where $IRFs_t^1$ are the IRFs after the introduction of the loan guarantee scheme, and $IRFs_t^0$ are the IRFs in a setting without loan guarantees.

Figure 3: The impact of the loan guarantee scheme after the COVID-19 shock

Effect on:							
Corp. loans		Av. banks' default		Output		Direct transfers (% of 2019Q4 output)	
(cum. impact)	(av. impact of 1% g_t)	(cum. impact)	(av. impact of 1% g_t)	(cum. impact)	(av. impact of 1% g_t)	(cum. impact)	(av. impact of 1% g_t)
44%	0.32%	-2.3%	-0.48%	1.9%	0.01%	0.7%	0.02%

Note: "cum." stands for cumulative, "av." for average. The average impact of 1% g_t is computed over one year.

Table 1. The impact of the loan guarantee scheme after the COVID-19 shock

Firm funding. The introduction of the loan guarantee scheme in this setting (blue lines), reduces the banks' loan losses and required capital. Since banks operate in a competitive environment, the combination of lower required capital and loan losses makes its way to firms in the form of increased lending (panel J). The beneficial cumulative effect on corporate credit is around 44 percent. The same effect on total credit is only 15 percent (panel K), as guarantees on firm loans crowd-out mortgage lending. The qualitative impact of the scheme on lending is in line with the empirical results in Bonfim *et al.* (2023).

While one of the scheme's objectives is to support the economy through additional credit, some guaranteed loans are just replacing loans that firms would have received in the absence of the guarantees. Each euro of loan guarantees generates an average of 31 cents of additional credit to firms. This result is qualitatively in line with Laeven *et al.* (2022) and Cascarino *et al.* (2022). Cascarino *et al.* (2022) document for Italy a credit additionality ranging between 50 and 84 cents per euro of guarantees.

The loan guarantee scheme increases the firms' equity at the beginning of the scheme and decreases it afterward (panel F). The total funding available to firms, which includes equity and loans, increases as the result of the scheme, and so do the firms' assets – physical capital (panel E).

Bank and firm default. The average over time of the corporate bank default rate in the presence of sovereign loan guarantees is around 8 percent lower than without the scheme (panel C). On average, one percent of guaranteed credit reduces the default probability of corporate banks by 1.72 percent. The sovereign loan guarantee scheme mitigates the link between the default of firms and corporate banks: while the scheme increases the firms' leverage and default, the likelihood of corporate bank default decreases, as the burden of guaranteed loans' losses is passed on to the sovereign. Moreover, since the elasticity of the banks' capital to regulatory requirements is smaller than one, banks reduce capital by less than the increase in the share of guaranteed loans. There is thus more bank capital for each unit of non-guaranteed credit. Corporate banks become more resilient to credit losses and default less.

The average default probability across corporate and mortgage banks is 2.3 percent lower than without the scheme (panel B). One percent of guaranteed credit reduces the average default probability of banks by 0.48 percent. The introduction of loan guarantees initially increases the default rate of mortgage banks due to a crowding-out effect, where the capital available for banks is attracted to corporate banks. This leads mortgage banks to reduce loans, causing a decline in housing demand, lower house prices, and an increased default rate among households, ultimately affecting the default rate of mortgage banks.[6]

The loan guarantee scheme increases the firms' leverage and default (panel D). The increase in the firms' default increases the economy's deadweight losses. This effect is compensated with the decrease in deadweight costs associated with lower bank default, so that the aggregate deadweight costs cumulatively decrease by 3 percent over the duration of the scheme.

6. The effects on the mortgage market that we document are solely driven by the loan guarantees and do not correspond to what we observed in Portugal between 2020 and 2021. This discrepancy is possibly attributable to other policy measures at the time – e.g. monetary policy – which are not considered in our analysis.

Investment and output. The presence of sovereign loan guarantees speeds up the recovery, as output, physical capital and credit are not falling as much as in the scenario without the scheme (panels E, K and L). This result reverses – in what we call a phasing-out effect – as the scheme approaches its end. The overall impact of the scheme on the economy is positive: the average quarterly output growth is 0.06 percent higher than the average output growth without the scheme, with a cumulative effect around 1.9 percent. Comparing our results with the euro area estimates in Rancoita *et al.* (2020), we obtain smaller values: a 0.66 percent cumulative impact on output in 2020 and a 0.56 percent cumulative impact on output in 2021.

4.1. Fiscal costs

Figure 4 depicts the evolution of the transfers from the sovereign to banks as a consequence of the loan guarantee scheme. These transfers are also the taxes charged on patient households as given in equation 1.

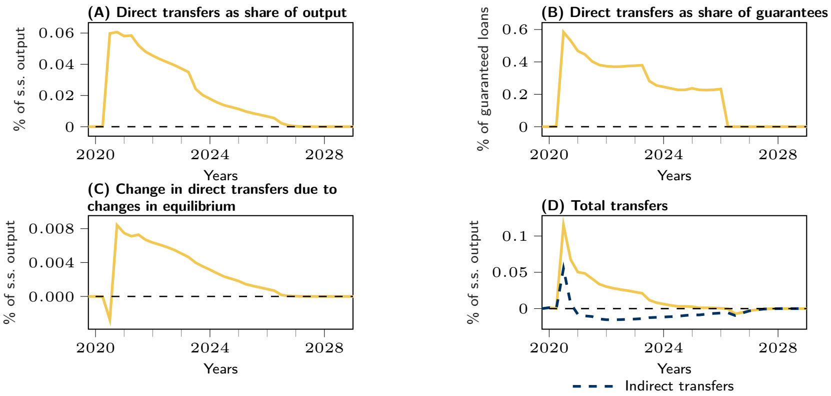


Figure 4: The costs of the sovereign loan guarantee scheme

Cumulatively, the expected direct fiscal cost of the scheme amounts to 0.7 percent of the 2019Q4 output (panel A), with the sovereign losing an average of 7.7 cents for each euro of guaranteed credit (panel B).

The scheme's fiscal cost is in part driven by the default rate of firms before the sanitary crisis. The default rate of firms prior to the crisis is calibrated so that, in steady state, the model's loan losses match the 2017Q1-2019Q4 average of the observed write-off rate for corporate loans. One may argue that we underestimate the default rate of firms. Firms that received loan guarantees may be riskier than the average firm. The evidence indicates otherwise. Mateus and Neugebauer (2022) show that lower credit-risk firms were the main recipients of Portuguese loan guarantees and obtained larger loans than riskier firms. Using Banco de Portugal's in-house credit assessment system, we also find that the probability of default of firms that received loan guarantees is 61.5 percent lower than our calibrated value.

Our estimates of costs may also be biased because firms that received loan guarantees experienced a different drop in output and had a higher share of their loans guaranteed compared to the average firm. Moreover, these firms were concentrated in specific sectors, making the fiscal cost of the scheme a non-linear function of changes in output and of each firm's share of guaranteed loans.[7]

Table 2 addresses these concerns. Row B shows results for direct fiscal costs under an alternative calibration where we match the default rate of firms that received the loan guarantees. In row C, we also calibrate the COVID-19 shock and the share of guaranteed loans as sector-weighted averages. The direct costs decrease, ranging between 0.1 and 0.3 percent of 2019Q4 output.

		Cumulative effect on: Direct transfers (% of 2019Q4 output)
A.	Baseline	0.7
B.	2017-2019 calibration + matched default of firms	0.1 (-83)
C.	2017-2019 calibration + matched default of firms + sector-adjusted COVID-19 and g_t shocks	0.3 (-62)

Note: Percentage deviation from the 2017-2019 calibration values are in parenthesis.

Table 2. Direct and total fiscal costs of the loan guarantee scheme: cumulative effects of alternative calibrations

The value of the sovereign loan guarantee fee also affects the costs of the scheme. The sensitivity analysis for different values of the fee is reported in row B and C of Table 3. Smaller values of the fee significantly increase the expected direct transfers. When the fee decreases from an average of 0.66 percent to zero, the cumulative expected direct fiscal cost as a share of 2019Q4 output increases by 47 percent compared to the baseline scenario. On the other hand, a fee higher than the one used in the baseline calibration has the opposite effect.

A fee that makes the scheme fiscally neutral is on average 1.5 percentage points higher than the one used in the baseline calibration. Such a fee reduces the impact of the scheme on corporate loans and output by 23 and 52 percent compared to the baseline scenario, and it has about the same effect on the banks' default rate. This result highlights how a non-negligible part of the scheme's effects is driven by an implicit subsidy to firms. Increasing the fee to attain a fiscally neutral policy considerably reduces the effect of the scheme on economic activity.

Other effects, namely, equilibrium effects have little impact on the scheme's cost. Panel C in Figure 4 illustrates this point. It shows a small difference between the guarantee fund's transfers and the transfers that would be generated in a

7. From a financial stability perspective, this non-linearity is possibly less relevant, as we verified that the negative correlation between the 2019 probabilities of default of firms that received the guarantees and their guaranteed loan amount is homogeneous across sectors.

scenario in which entrepreneurs and banks take decisions ignoring the existence of the loan guarantee scheme.

The indirect fiscal costs of sovereign loan guarantees – the additional costs borne by the deposit insurance agency after the implementation of the guarantees – are often negative. Loan guarantees reduce the banks' default rate, thus reducing the compensation paid to depositors by the deposit insurance agency. From mid-2026 onward, the indirect costs are so low that the total fiscal cost of the loan guarantees scheme becomes negative (panel D).

4.2. Sensitivity analysis

Alternative calibrations of the sensitivity of the banks' capital to capital requirements. Row D and E of Table 3 show results under two alternative calibrations of the elasticity of the banks' capital, ε^F, to required capital, $\bar{\phi}^F b_t^e$. The first alternative elasticity is set to 0.3. Such value results from our summary analysis of the historical relation between the banks' observed and required capital. Table C.1 in Appendix has the details of this analysis. An elasticity of 0.3 is in line with other similar estimates documented in the literature on bank capital (Francis and Osborne 2012; Gropp *et al.* 2018; Juelsrud and Wold 2020; Couaillier 2021). The second alternative elasticity is set to 1. An elasticity of 1 corresponds to the extreme case in which the banks' capital proportionally reacts to changes in capital requirements. This reaction is more likely in banks with lower capital buffers or in banks that perceive that this policy will last for a long period of time.

		Cumulative effect on:				
		Corp. loans (%)	Av. banks' default (%)	Output (%)	Direct transfers (% of 2019Q4 output)	Total transfers (% of 2019Q4 output)
A.	Baseline	44	-2.3	1.9	0.7	0.5
Alternative calibrations of the sovereign loan guarantee fee						
B.	$f_t = 0$	47 (9)	-2.3 (1)	2.3 (17)	1.1 (47)	0.9§ (65)
C.	$f_t = f_t^{T^0}$	34 (-23)	-2.2 (-4)	0.9 (-52)	0.0 (-100)	-0.2 (-137)
Alternative calibrations of the sensitivity of the banks' capital to capital requirements						
D.	$\varepsilon^F = 0.3$	47 (8)	-8.3* (263)	1.9 (-4)	0.7 (0)	-0.2 (-134)
E.	$\varepsilon^F = 1$	43 (-2)	0.4 (-116)	2 (4)	0.7 (0)	0.9 (59)
Alternative specification of the COVID-19 shock						
F.	Baseline + vol. shock	51 (18)	-2.2 (-2)	2.1 (9)	0.7 (0)	0.5 (-1)

Note: Percentage deviation from the baseline are in parenthesis. $f_t^{T^0}$ is equal to a value ensuring that in every period the expected direct transfers are equal to 0. ε^F is the elasticity of the banks' capital to required capital. "Vol. shock" corresponds to a 2.5 times increase in the volatility of the firms' idiosyncratic shocks. The superscripts $*$ and $\S$ correspond to average yearly impacts of 1% of g_t equal to 1.9% and 0.035%, respectively.

Table 3. Sensitivity analysis: cumulative effects of alternative calibrations

The elasticities of 0.3 and 1 are lower and higher than the elasticity of 0.81 used in the baseline calibration, respectively. A lower elasticity of the banks' capital to required capital makes their capital less sensitive to the loan guarantee scheme. The drop in the banks' capital following the introduction of loan guarantees is thus smaller than in the baseline calibration. A smaller drop in the banks' capital entails lower banks' default rates, with small impact on credit and output. The total expected fiscal cost of the scheme decreases because banks default less, thus reducing the costs of the deposit insurance agency. On the other hand, a higher elasticity than the one used in the baseline calibration has the opposite effect.

Alternative specification of the COVID-19 shock. Uncertainty about the earnings of firms increased with the COVID-19 pandemic outbreak. In row F of Table 3 we analyze a different specification of the COVID-19 shock to capture such an increase. We model the COVID-19 shock as a combination of negative productivity shocks and positive shocks to the volatility of the firms' earnings. To calibrate the increase in the earnings' uncertainty, we use the VSTOXX index, a measure of the volatility of the Eurostoxx 50 equity index.[8]

We increase the volatility of the firms' idiosyncratic shocks by 2.5 times the baseline level. This increase is based on the change in the VSTOXX index between 2019Q4 and 2020Q2. The volatility shock is relatively short-lived. Its persistence is calibrated so that the volatility of the firms' idiosyncratic shocks converges to its steady-state level in one year.

The role of the loan guarantee scheme in protecting banks from loan losses is strengthened in this specification of the COVID-19 shock. The impact of the loan guarantee scheme on corporate loans and output is slightly higher than in the baseline specification. Finally, the expected fiscal cost of loan guarantees is similar in both specifications of the COVID-19 shock.

4.3. Alternative designs of the loan guarantee scheme

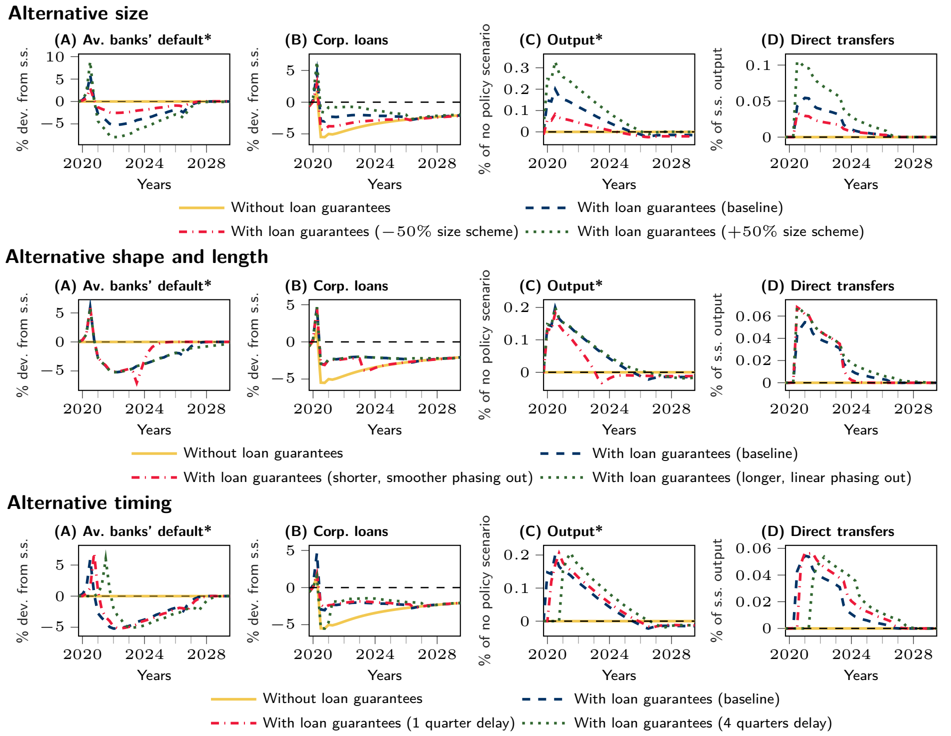
In this subsection, we explore alternative designs of the loan guarantee scheme to evaluate the effect of its size, dynamics, and timing.

Alternative size. The first row in Figure 5 presents the results for two scheme sizes. The share of guaranteed loans, g_t, is either 50 percent lower (red line) or 50 percent higher (green line) than its value in the baseline calibration.

The size of the scheme significantly affects the impact of the loan guarantees. The effects on key variables are higher with a larger scheme and vice-versa. Cumulatively, a 50 percent increase in the size of the scheme decreases the banks' default probabilities by 54 percent, increases credit to firms by 163 percent, and increases output by 89 percent. All these benefits come at the price of a 58 percent higher expected direct fiscal cost.

In our setting, size has a convex effect on financial stability and economic recovery. The impact of increasing the size of the scheme is higher the larger the scheme. Figures D.1 and D.2 in Appendix illustrate this point.

8. Source: https://www.stoxx.com/index-details?symbol=V2TX



Note: * In panels (A) and (C), the lines correspond to $(IRFs_t^1 - IRFs_t^0)/IRFs_t^0 \cdot 100$, where $IRFs_t^1$ are the IRFs after the introduction of the loan guarantee scheme, and $IRFs_t^0$ are the IRFs in a setting without loan guarantees.

Figure 5: Alternative timing of the loan guarantee scheme

Alternative shape and length. In the second row of Figure 5 we show the impact of a (i) longer scheme with a linear decrease in the share of guaranteed loans, and of a (ii) shorter scheme with a smoother decrease in the share of guaranteed loans. This analysis stems from two policy questions. First, we want to assess whether a scheme with shorter maturities would have achieved results similar to the baseline scheme. Second, we are interested in the changes that different end-of-scheme dynamics would lead to, given that an abrupt end of the loan guarantee scheme may generate cliff-effects. Our answer to these questions is with hindsight, as we know how long the COVID-19 shock lasted.

We observe that a shorter and smoother scheme (red line) – a scheme in which most of the loan guarantees have short maturity – has milder effects on the banks' default rate and credit. Despite reducing the expected direct costs of the scheme, a shorter length entails larger and earlier phasing-out effects for output growth. A shorter scheme cumulatively reduces the beneficial effects on the banks' default probabilities and output by 31 and 47 percent, respectively. The expected direct fiscal costs of the scheme decrease by 19 percent.

On the other hand, a linear increase of the scheme length (green line) extends the increase in credit over time, contributes to a greater reduction in bank default rate, and postpones the time of the phasing-out effect. Expected direct costs increase only slightly because the guarantee fee reaches its maximum levels as the end of the scheme approaches.

Alternative timing. In the third row of Figure 5 we quantify the costs of delaying the beginning of the loan guarantee scheme. A 1-quarter delay in the implementation of the scheme (red line) has minor consequences on the bank default rate and output growth but entails less credit to firms. A 1-year delay in the implementation (blue line) fails to counteract the increase in the banks' default rate observed between 2020 and 2022 in the absence of the loan guarantee scheme. Moreover, a 1-year delayed implementation of the scheme is unable to promptly stimulate credit. This lack of timeliness keeps capital investment and corporate loans' interest rates at the levels of the no-policy scenario until 2021.

5. Conclusion

In this paper, we measure the financial stability effects of the COVID-19 sovereign loan guarantee scheme and explore the impact of its size, duration, and timeliness.

The scope for improvement of our analysis is twofold. Modeling heterogeneous firms would allow us to capture the fact that the scheme is mainly designed for small and medium enterprises operating in specific sectors. Including a sovereign balance sheet would shed light on the feedback loop between firms, banks, and the sovereign. Capturing this loop would allow us to measure the effect of sovereign guarantees on financial stability that works through the credit risk of the sovereign when guarantees are funded with debt. It would also allow us to conduct a meaningful welfare analysis, one that has deadweight losses arising either from the sovereign debt or the taxes needed to fund the policy.

The expected fiscal cost of the scheme hinges on the steady-state default probability of firms. This default probability is an input parameter that reflects expectations at the time of the model's calibration. We have evidence to believe that the calibrated default probability overestimates the credit risk of firms that received loan guarantees. When we match their specific default probability, we obtain a lower fiscal cost than the one we measure with our baseline calibration. The fiscal costs become small after changing our COVID-19 shock specification to match the drop in activity of the firms that received loan guarantees.

The expected fiscal cost of the scheme that results from our analysis should be interpreted with a couple of caveats in mind. We measure the fiscal cost with hindsight, using the realized output path to calibrate the COVID-19 shock, and calibrating some of the model's parameters to match the characteristics of the firms that received guaranteed loans. At the time the policy was implemented, it was uncertain how the sanitary crisis would unfold and what type of firms would receive guaranteed loans. The expected fiscal cost of the policy could have been much higher, had the crisis been more severe and had firms receiving guaranteed loans been of worse credit quality. In addition, our measure of the policy's fiscal cost ignores the possible impact of other policies implemented at the time of the sanitary crisis or of other shocks unrelated to the sanitary crisis. It is, after all, an *expected* cost. But shocks unrelated to the sanitary crisis (e.g. higher interest rates) can suddenly increase the default probability of firms. If firms' default probability does increase, so do the *realized* fiscal costs of the scheme.

References

Banco de Portugal (2020a). "Box 3 - A general equilibrium view on GDP projections." Economic Bulletin, June 2020.

Banco de Portugal (2020b). "Projections for the Portuguese economy: 2020-22." Economic Bulletin, June 2020.

Bodenstein, Martin, Pablo Cuba-Borda, Jay Faris, and Nils Goernemann (2021). "Forecasting During the COVID-19 Pandemic: A structural Analysis of Downside Risk." FEDS Notes 2021/056, FED, Washington: Board of Governors of the Federal Reserve System.

Bonfim, Diana, Cláudia Custódio, and Clara Raposo (2023). "Supporting small firms through recessions and recoveries." *Journal of Financial Economics*, 147(3), 658–688.

Budnik, Katarzyna, Ivan Dimitrov, Johannes Groß, Martina Jančoková, Max Lampe, Bianca Sorvillo, Anze Stular, and Matjaž Volk (2021). "Policies in support of lending following the coronavirus (COVID 19) pandemic." Occasional Paper Series 257, European Central Bank.

Cascarino, Giuseppe, Raffaele Gallo, Francesco Palazzo, and Enrico Sette (2022). "Public guarantees and credit additionality during the Covid-19 pandemic." Temi di discussione (Economic working papers) 1369, Bank of Italy, Economic Research and International Relations Area.

Clerc, Laurent, Alexis Derviz, Caterina Mendicino, Stephane Moyen, Kalin Nikolov, Livio Stracca, Javier Suarez, and Alexandros P. Vardoulakis (2015). "Capital Regulation in a Macroeconomic Model with Three Layers of Default." *International Journal of Central Banking*, 11(3), 9–63.

Couaillier, Cyril (2021). "What are banks' actual capital targets?" Working Paper Series 2618, European Central Bank.

De Lorenzo Buratta, Ivan, Diana Lima, and Duarte Maia (2023). "Prudential policy treatments to the COVID-19 economic crisis: an assessment of the effects." Working Papers 2023/14, Banco de Portugal.

Demmou, Lilas and Guido Franco (2021). "From hibernation to reallocation: Loan guarantees and their implications for post-COVID-19 productivity." OECD Economics Department Working Papers 1687, OECD Publishing.

Falagiarda, Matteo, Algirdas Prapiestis, and Elena Rancoita (2020). "Public loan guarantees and bank lending in the COVID-19 period." *Economic Bulletin Boxes*, 6.

Fornaro, Luca and Martin Wolf (2021). "Covid-19 Coronavirus and Macroeconomic Poli." CEPR Discussion Paper DP14529, CEPR.

Francis, William and Matthew Osborne (2012). "Capital requirements and bank behavior in the UK: Are there lessons for international capital standards?" *Journal of Banking & Finance*, 36(3), 803–816.

Gropp, Reint, Thomas Mosk, Steven Ongena, and Carlo Wix (2018). "Banks Response to Higher Capital Requirements: Evidence from a Quasi-Natural Experiment." *The Review of Financial Studies*, 32(1), 266–299.

Guerrieri, Veronica, Guido Lorenzoni, Ludwig Straub, and Iván Werning (2020). "Macroeconomic Implications of COVID-19: Can Negative Supply Shocks Cause Demand Shortages?" NBER Working Papers 26918, NBER.

Juelsrud, Ragnar E. and Ella Getz Wold (2020). "Risk-weighted capital requirements and portfolio rebalancing." *Journal of Financial Intermediation*, 41(C).

Laeven, Luc, Gabriel Jiménez, David Martinez-Miera, and José-Luis Peydró (2022). "Public Guarantees, Relationship Lending and Bank Credit: Evidence from the COVID-19 Crisis." CEPR Discussion Papers 17110, C.E.P.R. Discussion Papers.

Lima, Diana, Duarte Maia, and Ana Pereira (2023). "Structural and cyclical capital instruments in the 3D model: a simulation for Portugal." Working Papers 2023/15, Banco de Portugal.

Mateus, Márcio and Katja Neugebauer (2022). "Stayin' alive? Government support measures in Portugal during the Covid-19 pandemic." Working Papers 2022/12, Banco de Portugal.

Rancoita, Elena, Maciej Grodzicki, Hannah Hempell, Christoffer Kok, Julian Metzler, and Algirdas Prapiestis (2020). "Financial stability considerations arising from the interaction of coronavirus-related policy measures." Financial Stability Review, Special features A, ECB.

Appendix A: Entrepreneurs' problem and first order conditions

Entrepreneurs' problem

$$\max_{k_t, R_t^F} E_t \left[\left(1 - \Gamma^e \left(\frac{R_t^F \left(q_t^K k_t - n_t^e \right)}{R_{t+1}^K q_t^K k_t} \right) \right) R_{t+1}^K \right] q_t^K k_t +$$
$$\xi_t^e \left(E_t \left[\left(1 - \Gamma^F \left(\bar{\omega}_{t+1}^F \right) \right) \left(\Gamma^e \left(\frac{R_t^F \left(q_t^K k_t - n_t^e \right)}{R_{t+1}^K q_t^K k_t} \right) \right.\right.\right.$$
$$\left.\left.\left. - \mu^e G^e \left(\frac{R_t^F \left(q_t^K k_t - n_t^e \right)}{R_{t+1}^K q_t^K k_t} \right) \right) R_{t+1}^K \right] q_t^K k_t \left(1 - g_t \right) - \rho_t \left(\bar{\kappa}^F + \bar{\phi}^F \left(1 - g_t \right) \right) \left(q_t^K k_t - n_t^e \right) \right)$$

with

$$\bar{\omega}_{t+1}^F = \frac{1}{\tilde{R}_{t+1}^F} \frac{R_t^D \left[1 - \left(\bar{\kappa}^F + \bar{\phi}^F \left(1 - g_t \right) \right) \right] - \left(R_t^F - f_t \right) g_t}{1 - g_t}$$
$$= \frac{\frac{R_t^D \left[1 - \left(\bar{\kappa}^F + \bar{\phi}^F \left(1 - g_t \right) \right) \right] - \left(R_t^F - f_t \right) g_t}{1 - g_t}}{\left(\Gamma^e \left(\frac{R_t^F \left(q_t^K k_t - n_t^e \right)}{R_{t+1}^K q_t^K k_t} \right) - \mu^e G^e \left(\frac{R_t^F \left(q_t^K k_t - n_t^e \right)}{R_{t+1}^K q_t^K k_t} \right) \right) \frac{R_{t+1}^K q_t^K k_t}{q_t^K k_t - n_t^e}}$$

First-order conditions

First-order condition with respect to interest rate:

$$E_t \left[\Gamma'^e \left(\bar{\omega}_{t+1}^e \right) \right] = \xi_t^e \left(1 - g_t \right) \times$$
$$E_t \left[\left(1 - G \left(\bar{\omega}_{t+1}^F \right) \right) \left(\Gamma'^e \left(\bar{\omega}_{t+1}^e \right) - \mu^e G'^e \left(\bar{\omega}_{t+1}^e \right) \right) + \left(1 - F \left(\bar{\omega}_{t+1}^F \right) \right) \frac{g_t}{1 - g_t} \right].$$

First-order condition with respect to capital:

$$E_t \left[\left(1 - \Gamma^e \left(\bar{\omega}_{t+1}^e \right) \right) R_{t+1}^K \right] +$$
$$\xi_t^e \left(1 - g_t \right) \left(E_t \left[\left(1 - G \left(\bar{\omega}_{t+1}^F \right) \right) \left(\left(\Gamma'^e \left(\bar{\omega}_{t+1}^e \right) - \mu^e G'^e \left(\bar{\omega}_{t+1}^e \right) \right) \frac{R_t^F n_t^e}{q_t^K k_t} - \frac{n_t^e}{q_t^K k_t} \tilde{R}_{t+1}^F \right) \right] \right) +$$
$$\xi_t^e \left(1 - g_t \right) \left(E_t \left[\left(1 - \Gamma^F \left(\bar{\omega}_{t+1}^F \right) \right) \left[\left(\Gamma'^e \left(\bar{\omega}_{t+1}^e \right) - \mu^e G'^e \left(\bar{\omega}_{t+1}^e \right) \right) \frac{R_t^F n_t^e}{q_t^K k_t} + \right.\right.\right.$$
$$\left.\left.\left. \left(\Gamma^e \left(\bar{\omega}_{t+1}^e \right) - \mu^e G^e \left(\bar{\omega}_{t+1}^e \right) \right) R_{t+1}^K \right] \right] - \rho_t \left(\frac{\bar{\kappa}^F}{1 - g_t} + \bar{\phi}^F \right) \right) = E_t \left[\Gamma'^e \left(\bar{\omega}_{t+1}^e \right) \frac{R_t^F n_t^e}{q_t^K k_t} \right].$$

Appendix B: Optimality of the sovereign loan guarantees

To obtain the condition determining the use of the sovereign loan guarantees, we differentiate the entrepreneurs' problem w.r.t. to the share of guaranteed loans, use the envelope theorem, and note that the multiplier ξ_t^e is positive:

$$\begin{aligned} & - E_t\left[\left(1-\Gamma^F\left(\bar{\omega}_{t+1}^F\right)\right)\left(\Gamma^e\left(\bar{\omega}_{t+1}^e\right)-\mu^e G^e\left(\bar{\omega}_{t+1}^e\right)\right) R_{t+1}^K\right] q_t^K k_t + \\ & + \rho_t \bar{\phi}_F\left(q_t^K k_t - n_t^e\right) + \\ & + E_t\left[-\Gamma'^F\left(\bar{\omega}_{t+1}^F\right) \frac{R_t^D\left(1-\bar{\kappa}^F\right)-\left(R_t^F-f_t\right)}{\left(1-g_t\right)^2}\left(q_t^K k_t - n_t^e\right)\left(1-g_t\right)\right]\Bigg) > 0 \end{aligned}$$

which simplifies to:

$$f_t < R_t^F - R_t^D - \bar{\kappa}^F\left(\frac{\rho_t}{E_t\left[\Gamma'^F\left(\bar{\omega}_{t+1}^F\right)\right]} - R_t^D\right)$$

by noting that the following equality holds:

$$\begin{aligned} & E_t\left[\left(1-\Gamma^F\left(\bar{\omega}_{t+1}^F\right)\right)\left(\Gamma^e\left(\bar{\omega}_{t+1}^e\right)-\mu^e G^e\left(\bar{\omega}_{t+1}^e\right)\right) R_{t+1}^K\right] q_t^K k_t = \\ & = \rho_t\left(\frac{\bar{\kappa}^F}{\left(1-g_t\right)} + \bar{\phi}_F\right)\left(q_t^K k_t - n_t^e\right) \end{aligned}$$

because bankers' participation constraint is binding. Figure B.1 shows the maximum fee that would make the loan guarantee scheme optimal on a given quarter and the actual fee. The average over time of their difference is positive.

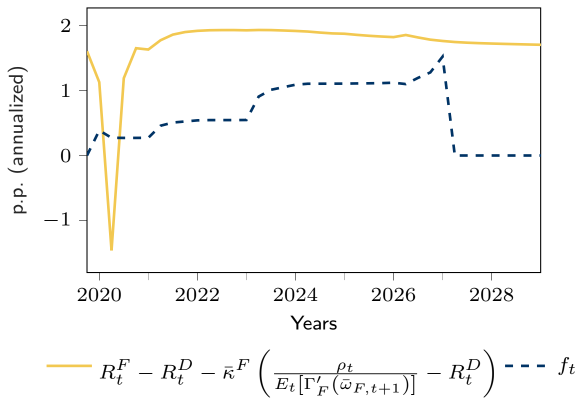


Figure B.1: Optimality of the sovereign loan guarantees

Appendix C: Historical relation between the banks' observed and required capital

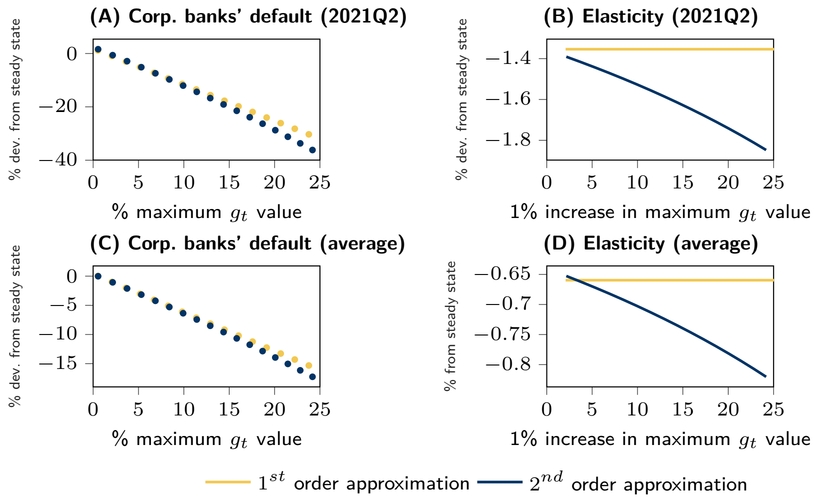
	Dependent variable:	
	Capital	$\frac{\text{Capital}}{\text{Credit}}$
Required Capital	0.454***	
	(0.126)	
Required $\frac{\text{Capital}}{\text{Credit}}$		0.538
		(0.458)
Constant	21,879.160***	0.057*
	(2,804.893)	(0.028)
Observations	45	45
R^2	0.230	0.031
Adjusted R^2	0.212	0.009
Residual Std. Error (df = 43)	2,273.829	0.009
F Statistic (df = 1; 43)	12.870***	1.383

*p<0.1; **p<0.05; ***p<0.01

Note: Results from regressing the banks' capital on required capital and the capital-to-credit ratio on the ratio of required capital to credit. We use aggregate data at a quarterly frequency from 2008Q4 to 2019Q4. The data includes the Portuguese banks' capital, risk-weighted assets, loans, and securities. The source of the data is Banco de Portugal. The time series of capital requirements is the sum of micro and macroprudential capital requirements and results from the authors' computations. The regression coefficients represent the derivatives of the dependent variable w.r.t. the independent variable. To obtain elasticities, multiply these coefficients with the ratio of the averages of the relevant variables. We obtain an elasticity of capital to capital requirements of 0.313, and an elasticity of the capital ratio to the ratio of required capital ratio of 0.369.

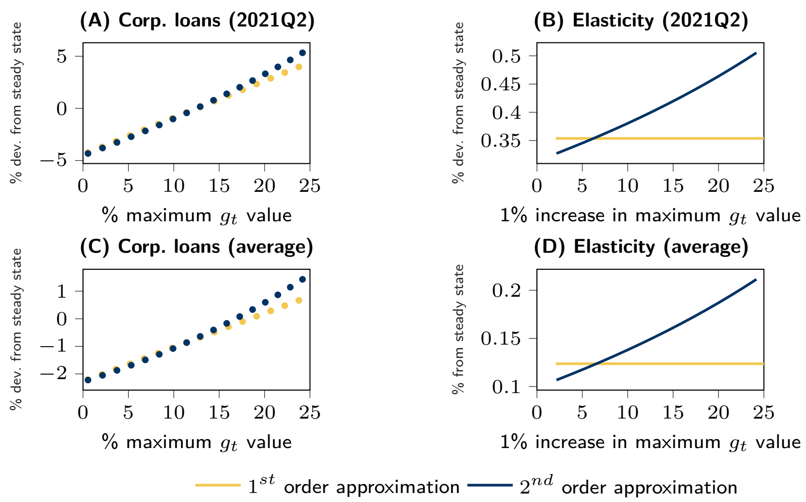
Table C.1. Elasticity of banks' capital to required capital

Appendix D: First and second order effects



Note: The elasticities in panel B and D are computed as $\frac{\Delta\% PD^F_{2021Q2}}{\Delta g_{2021Q2}}$ and $\frac{\Delta\% \overline{PD^F}}{\Delta g_{2021Q2}}$ respectively, where PD^F_t is corporate bank's default rate and $\overline{PD^F}$ is its mean over the sample period.

Figure D.1: Impact of the size of the loan guarantee scheme on the corporate banks' default: comparison between 1^{st} and 2^{nd} order effects



Note: The elasticities in panel B and D are computed as $\frac{\Delta\% b^e_{2021Q2}}{\Delta g_{2021Q2}}$ and $\frac{\Delta\% \overline{b^e}}{\Delta g_{2021Q2}}$ respectively, where b^e_t are corporate loans and $\overline{b^e}$ is their mean over the sample period.

Figure D.2: Impact of the size of the loan guarantee scheme on the corporate loans: comparison between 1^{st} and 2^{nd} order effects

Appendix E: Calibration of the model

Description	Definition	Data	Model	Diff.
	(A) Means			
Fraction of impatient households (%)	$[1-1/(1+n^m)]\cdot 100$	45.93	45.93	-
Return on average bank equity (%, ann)	$\rho\cdot 400$	4.01	4.15	0.14
CET1 capital ratio (%)	$\varphi\cdot 100$	13.87	13.87	-
Write-off rate for mortgage loans (%, ann)	$\Upsilon^m\cdot 400$	0.32	0.66	0.34
Write-off rate for corporate loans (%, ann)	$\Upsilon^e\cdot 400$	1.33	2.11	0.78
Mortgage loans to GDP (ratio)	$n^m b^m/GDP$	2.11	3.20	1.09
Corporate loans to GDP (ratio)	$n^e b^e/GDP$	1.44	1.64	0.20
Housing investment to GDP (ratio)	I^H/GDP	0.03	0.04	0.01
Impatient HH housing wealth share	$n^m q^H h^m$	0.55	0.57	0.02
Spread mortgage loans (pp., ann)	$(R^H-R^d)\cdot 400$	0.01	0.01	-
Spread corporate loans (pp., ann)	$(R^F-R^d)\cdot 400$	0.03	0.02	0.01
Average bank default (%)	$\mathcal{F}^{H,F}(\bar{\omega}^{H,F})\cdot 100$	1.22	1.22	-
	(B) Standard deviations $[\sigma(\cdot)]$			
STD(House prices)/STD(GDP)	$\sigma(q_t^H)/\sigma(GDP_t)$	0.03	0.03	-
STD(Mortgage loans)/STD(GDP)	$\sigma(b_t^m)/\sigma(GDP_t)$	1.34	1.57	0.22
STD(Corporate loans)/STD(GDP)	$\sigma(b_t^e)/\sigma(GDP_t)$	0.74	0.84	0.19
STD(Mortgage spreads)/STD(GDP)	$\sigma(R_t^M-R_t^d)/\sigma(GDP_t)$	0.02	0.02	-
STD(Corporate spreads)/STD(GDP)	$\sigma(R_t^F-R_t^d)/\sigma(GDP_t)$	0.03	0.03	-
STD(GDP)	$\sigma(GDP_t)\cdot 100$	2.77	2.77	-

Note: The variable Return on Average Bank Equity (ROAE) is based on positive values of the return on equity (ROE) and results from taking the time series average of the cross-sectional median ROE. Aggregate values for the banking sector are obtained considering a weighted average across banks, with weights given by the share of each individual bank's assets in total assets. HH stands for households, GDP for Gross Domestic Product, CET1 for Common Equity Tier 1, STD for standard deviation and Ann is short for annualized. (*Diff.* column) are in absolute terms. Data is obtained from the ECB Statistical Data Warehouse, Statistics Portugal, the Household Finance and Consumption Survey, the Bank for International Settlements, and own calculations. The data sample ranges from 2017Q1 to 2019Q4.

Table E.1. Calibration targets

Description	Par.	Value	Description	Par.	Value
		(A) Preset parameters			
Housing weight in s utility	υ^s	0.1	Entrep. bankruptcy cost	μ^e	0.3
Disutility of labor ($\varkappa = s, m$)	$\varphi^{\varkappa}$	1	Bank M bankruptcy cost	μ^H	0.3
Frisch elasticity of labor	η	1	Bank F bankruptcy cost	μ^F	0.3
Physical Cap. share in prod.	α	0.3	Productivity shock persistence	ρ^A	0.565
Physical Cap. depreciation	δ^K	0.03	Cap. ratios for mortgage loans	ϕ^H	6.93%
Patient HH discount factor	β^s	0.995	Cap. ratios for corporate loans	ϕ^F	13.87%
HH bankruptcy cost	μ^m	0.3			
		(B) Calibrated parameters			
Share of impatient HH	n^m	0.8496	HH transaction cost	γ	0.0002
Impatient HH discount factor	β^m	0.9801	Entrepreneurs' endowment	χ^e	0.0263
Housing weight in m utility	υ^m	0.3766	Bankers' endowment	χ^b	0.0026
Housing adjustment cost	ξ^H	0.25	Physical Cap. adjust. cost	ξ^K	6.8164
Housing depreciation	δ^H	0.0037			

Note: The disutility of labour is the same for patient and impatient households. HH stand for households, STD stands for standard deviation s and m stand for the households' type, patient and impatient, respectively.

Table E.2. Parameters

Working Papers

2021

1|21 Optimal Social Insurance: Insights from a Continuous-Time Stochastic Setup
João Amador | Pedro G. Rodrigues

2|21 Multivariate Fractional Integration Tests allowing for Conditional Heteroskedasticity withan Application to Return Volatility and Trading
Marina Balboa | Paulo M. M. Rodrigues | Antonio Rubia | A. M. Robert Taylor

3|21 The Role of Macroprudential Policy in Times of Trouble
Jagjit S. Chadha | Germana Corrado | Luisa Corrado | Ivan De Lorenzo Buratta

4|21 Extensions to IVX Methodsnof Inference for Return Predictability
Matei Demetrescu | Iliyan Georgiev | Paulo M. M. Rodrigues | A.M. Robert Taylor

5|21 Spectral decomposition of the information about latent variables in dynamic macroeconomic models
Nikolay Iskrev

6|21 Institutional Arrangements and Inflation Bias: A Dynamic Heterogeneous Panel Approach
Vasco Gabriel | Ioannis Lazopoulos | Diana Lima

7|21 Assessment of the effectiveness of the macroprudential measures implemented in the context of the Covid-19 pandemic
Lucas Avezum | Vítor Oliveiral | Diogo Serra

8|21 Risk shocks, due loans, and policy options: When less is more!
Paulo Júlio | José R. Maria | Sílvia Santos

9|21 Sovereign-Bank Diabolic Loop: The Government Procurement Channel!
Diana Bonfim | Miguel A. Ferreira | Francisco Queiró | Sujiao Zhao

10|21 Assessing the effectiveness of the Portuguese borrower-based measure in the Covid-19 context
Katja Neugebauer | Vítor Oliveira | Ângelo Ramos

11|21 Scrapping, Renewable Technology Adoption, and Growth
Bernardino Adão | Borghan Narajabad | Ted Temzelides

12|21 The Persistence of Wages
Anabela Carneiro | Pedro Portugal | Pedro Raposo | Paulo M.M. Rodrigues

13|21 Serial Entrepreneurs, the Macroeconomy and top income inequality
Sónia Félix | Sudipto Karmakar | Petr Sedláček

14|21 COVID-19, Lockdowns and International Trade: Evidence from Firm-Level Data
João Amador | Carlos Melo Gouveia | Ana Catarina Pimenta

15|21 The sensitivity of SME's investment and employment to the cost of debt financing
Diana Bonfim | Cláudia Custódio | Clara Raposo

16|21 The impact of a macroprudential borrower based measure on households' leverage and housing choices
Daniel Abreu | Sónia Félix | Vítor Oliveira | Fátima Silva

17|21 Permanent and temporary monetary policy shocks and the dynamics of exchange rates
Alexandre Carvalho | João Valle e Azevedo | Pedro Pires Ribeiro

18|21 On the Cleansing Effect of Recessions and Government Policy: Evidence from Covid-19
Nicholas Kozeniauskas | Pedro Moreira | Cezar Santos

19|21 Trade, Misallocation, and Capital Market Integration
Laszlo Tetenyi

20|21 Not All Shocks Are Created Equal: Assessing Heterogeneity in the Bank Lending Channel
Laura Blattner | Luísa Farinha | Gil Nogueira

21|21 Coworker Networks and the Labor Market Outcomes of Displaced Workers: Evidence from Portugal
Jose Garcia-Louzao | Marta Silva

22|21 Markups and Financial Shocks
Philipp Meinen | Ana Cristina Soares

2022

1|22 Business cycle clocks: Time to get circular
Nuno Lourenço | António Rua

2|22 The Augmented Bank Balance-Sheet Channel of Monetary Policy
Christian Bittner | Diana Bonfim | Florian Heider | Farzad Saidi | Glenn Schepens | Carla Soares

3|22 Optimal cooperative taxation in the global economy
V. V. Chari | Juan Pablo Nicolini | Pedro Teles

4|22 How Bad Can Financial Crises Be? A GDP Tail Risk Assessment for Portugal
Ivan De Lorenzo Buratta | Marina Feliciano | Duarte Maia

5|22 Comparing estimated structural models of different complexities: What do we learn?
Paulo Júlio | José R. Maria

6|22 Survival of the fittest: Tourism Exposure and Firm Survival
Filipe B. Caires | Hugo Reis | Paulo M. M. Rodrigues

7|22 Mind the Build-up: Quantifying Tail Risks for Credit Growth in Portugal
Ivan de Lorenzo Buratta | Marina Feliciano | Duarte Maia

8|22 Forgetting Approaches to Improve Forecasting
Robert Hill | Paulo M. M. Rodrigues

9|22 Determinants of Cost of Equity for listed euro area banks
Gabriel Zsurkis

10|22 Real effects of imperfect bank-firm matching
Luísa Farinha | Sotirios Kokas | Enrico Sette | Serafeim Tsoukas

11|22 The solvency and funding cost nexus – the role of market stigma for buffer usability
Helena Carvalho | Lucas Avezum | Fátima Silva

12|22 Stayin' alive? Government support measures in Portugal during the Covid-19 pandemic
Márcio Mateus | Katja Neugebauer

13|22 Cross-Sectional Error Dependence in Panel Quantile Regressions
Matei Demetrescu | Mehdi Hosseinkouchack | Paulo M. M. Rodrigues

14|22 Multinationals and services imports from havens: when policies stand in the way of tax planning
Joana Garcia

15|22 Identification and Estimation of Continuous-Time Job Search Models with Preference Shocks
Peter Arcidiacono | Attila Gyetvai | Arnaud Maurel | Ekaterina Jardim

16|22 Coworker Networks and the Role of Occupations in Job Finding
Attila Gyetvai | Maria Zhu

17|22 What's Driving the Decline in Entrepreneurship?
Nicholas Kozeniauskas

18|22 The Labor Share and the Monetary Transmission
André Silva | João Gama | Bernardino Adão

19|22 Human capital spillovers and returns to education
Pedro Portugal | Hugo Reis | Paulo Guimarães | Ana Rute Cardoso

20|22 Learning Through Repetition? A Dynamic Evaluation of Grade Retention in Portugal
Emilio Borghesan | Hugo Reis | Petra E. Todd

21|22 Retrieving the Returns to Experience, Tenure, and Job Mobility from Work Histories
John T. Addison | Pedro Portugal | Pedro Raposo

2023

1|23 A single monetary policy for heterogeneous labour markets: the case of the euro area
Sandra Gomes | Pascal Jacquinot | Matija Lozej

2|23 Price elasticity of demand and risk-bearing capacity in sovereign bond auctions
Rui Albuquerque | José Miguel Cardoso-Costa | José Afonso Faias

3|23 A macroprudential look into the risk-return framework of banks' profitability
Joana Passinhas | Ana Pereira

4|23 Mortgage Borrowing Caps: Leverage, Default, and Welfare
João G. Oliveira | Leonor Queiró

5|23 Does Green Transition promote Green Innovation and Technological Acquisitions?
Udichibarna Bose | Wildmer Daniel Gregori | Maria Martinez Cillero

6|23 Tail Index Estimation in the Presence of Covariates: Stock returns' tail risk dynamics
João Nicolau | Paulo M.M. Rodrigues | Marian Z. Stoykov

7|23 The impact of ICT adoption on productivity: Evidence from Portuguese firm-level data
João Amador | Cátia Silva

8|23 To use or not to use? Capital buffers and lending during a crisis
Lucas Avezum | Vítor Oliveira | Diogo Serra

9|23 First passage times in portfolio optimization: a novel nonparametric approach
Gabriel Zsurkis | João Nicolau | Paulo M. M. Rodrigues

10|23 Remote Work, Foreign Residents, and the Future of Global Cities
João Guerreiro | Sérgio Rebelo | Pedro Teles

11|23 Trends and cycles during the COVID-19 pandemic period
Paulo Júlio | José R. Maria

12|23 Gone with the wind: A structural decomposition of carbon emissions
Fátima Cardoso | António Rua

13|23 The Covid-19 Pandemic, Sovereign Loan Guarantees, and Financial Stability
Ivan De Lorenzo Buratta | Tiago Pinheiro