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System-wide Dividend Restrictions: Evidence and Theory*

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Abstract

We provide evidence that the ECB system-wide dividend recommendation (SWDR) of March 2020 contributed to sustain lending, had a negative but moderate and transitory impact on bank stock prices and largely operated as a deferral of dividend payouts rather than as a dividend cut. Then, we develop a quantitative macro-banking DSGE model that accounts for this evidence and captures the key mechanism through which SWDRs operate to study the general equilibrium effects of the ECB SWDR. The measure contributed to sustain aggregate bank lending and mitigate the adverse impact of the COVID-19 shock on economic activity by safeguarding euro area banks' capitalization. Welfare-maximizing SWDRs stabilize the economy regardless of the shock type but they only induce significant welfare gains in response to financial shocks.

Keywords: dividend recommendation, dividend prudential target (DPT), COVID-19, usable capital buffers, welfare.

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1 Introduction

During the COVID-19 crisis competent authorities all around the world encouraged credit institutions to make full use of their capital buffers to help support aggregate credit provision. However, the evidence shows that banks remained hesitant to use those buffers, among other reasons, because of a fear of triggering microprudential dividend restrictions that activate when individual regulatory capital ratios fall below a given threshold (i.e., the so-called Basel III Maximum Distributable Amount or MDA). During systemic crises those restrictions can stigmatize an individual bank as an institution with particularly weak financial conditions (Acharya et al. 2011) as well as may go against a general reluctance of corporate businesses to cut back on dividends in downturns (Wu 2018).

Against this backdrop, central banks all over the world issued system-wide recommendations on bank dividend distributions to ensure that banks would continue funding the real economy amid the crisis. We define a system-wide dividend restriction or recommendation (henceforth SWDR) as the provision of supervisory guidance on how banks should conduct their payout policies in order to sustain lending in bad times. In contrast to MDAs, a SWDR is: (i) system-wide (rather than institution-specific), as the measure is activated under the same terms for all or most of the banks in the economy; (ii) state-contingent (rather than capital-contingent), since the activation of the measure depends on the state of the economy rather than on the capital position of individual credit institutions; and (iii) macroprudential (rather than microprudential), as it is aimed at smoothing the financial cycle.

This paper studies one example of such a SWDR policy. On March 27th 2020 the ECB (SSM) recommended euro area banks to refrain from distributing dividends for the financial years 2019 and 2020 until at least October 1st 2020, with the aim of preserving bank capital to continue funding the real economy amid the COVID 19 crisis. The period for which the recommendation (henceforth, ECB SWDR) applied was extended on two occasions and the dividend ban period ended up lasting for six quarters (2020:II - 2021:III). The recommendation was unprecedented to the extent that it was the first time the ECB–and many other central banks–asked banks to refrain from distributing dividends even if they were complying with their capital requirements.

The main contribution of this paper is to develop a comprehensive analysis of the macroeconomic benefits and costs of SWDRs based on this case study. First, we use micro-level data to provide evidence on the effects of the ECB SWDR on bank lending, paid and expected dividends and stock prices. Then, we propose an euro area quantitative DSGE model that accounts for this evidence, captures the main transmission mechanism of SWDRs and matches the first and second moments of key selected macroeconomic and banking aggregates. Such model is applied to study the general equilibrium effects of the ECB SWDR and the features of the welfare-maximizing SWDR, also referred to as the optimal dividend prudential target or optimal DPT (Muñoz 2021).

The potential macroeconomic benefits of SWDRs in terms of sustained credit provision need to be weighted against their potential costs associated with a possible dampening effect on bank stock prices and dividends. In Section 2, we use micro-level data for a large sample of euro area banks to evaluate the main effects of the ECB SWDR. First, we document the patterns of market expectations for future bank dividend paths around the dividend ban period, which suggest that the measure was interpreted as a deferral of dividend payouts to the post-recommendation period rather than as a pure dividend cut. Second, we perform an event study to assess the impact of the SWDR on bank stock prices. Even if it was moderate and transitory (i.e., it tended to reverse once the ban was lifted), we identify a negative effect that, arguably, was largely driven by the unanticipated nature of the measure. Third, we follow a difference-in-difference approach to study the impact of this measure on lending to firms by using transaction-level data from the European Credit Register (Anacredit). We find that, on average, banks which did not distribute dividends increased their lending by 5% more than those which distributed dividends.

Then, we complement our empirical analysis by studying the macroeconomic effects of the ECB SWDR with a quantitative euro area DSGE model. This allows us to study the general equilibrium effects of the SWDR not only on bank dividends and lending but also on other key aggregates such as real GDP and private consumption. Due to the limited experience with the adoption of this measure, available data does not allow performing a meaningful empirical study of the general equilibrium effects induced by the ECB SWDR. The model also permits us to characterize the welfare-maximizing SWDR.

To this aim, Section 3 describes a quantitative DSGE model with bank intermediation calibrated to the euro area economy to study SWDRs. Households (net savers), non-financial corporations or NFCs (net borrowers), banks, and capital goods producing firms interact in a real, closed, decentralized and time-discrete economy in which all markets are competitive. Banks intermediate funds by borrowing from households (in the form of one-period deposits) and lending to NFCs (in the form of one-period loans). Their borrowing is limited by a standard regulatory capital requirement. NFCs take up loans to finance the production of a final good. Households consume the good and own the firms in the economy.

We assume that both, banks and NFCs, maximize a weighted average of their owners' objective (i.e., the value of present and future dividends discounted with the households' stochastic discount factor) and their manager's objective (defined as a CES function of dividends, discounted with managers' own subjective discount factor). We make this assumption for both empirical and technical reasons. First, it is well-documented in the literature that a significant part of firms' dividend smoothing is driven not by owners' preferences but by managers' own career concerns

(Wu 2018). This is a consequence of an agency problem between firm managers and firm owners in both non-financial and financial companies. Second, parameters associated with the agency problem—namely, the managers' elasticity of intertemporal substitution in dividend payouts—allow us to accurately match the volatility of dividends, without compromising the matching of standard targets in quantitative analysis (Muñoz 2021). Third, concavity in the bank managers' objective with respect to dividends implies a unique solution for the dividend payout scheme, which can then be affected by policy interventions such as those under a SWDR. Fourth, as discussed in the literature review, this assumption simplifies the welfare analysis.

Then, we calibrate the model to quarterly data of the euro area for the (pre-COVID 19) period 2002:I - 2018:II. The model matches a number of first and second moments of banking and macroeconomic aggregates, including those that play a key role in the transmission of SWDR effects to the macroeconomy.

In Section 4, we use the quantitative DSGE model to study the general equilibrium effects of the ECB SWDR. In particular, we analyze the responses of key selected aggregates to the March 2020 COVID-19 shock under the ECB SWDR and compare them against those that would have prevailed under two counterfactual scenarios. The baseline scenario, under which no SWDR applies, and a hypothetical scenario in which banks not only follow the dividend recommendation but also that of fully using their capital buffers.

Our findings are complementary to and consistent with our empirical evidence. First, the ECB SWDR sustained aggregate bank lending to the real economy by safeguarding the euro area banking sector's degree of capitalization, ultimately mitigating the adverse impact of the COVID-19 shock on economic activity. The general equilibrium effect of the ECB SWDR on bank lending captured by the DSGE model is larger and more persistent than the one estimated by means of a diff-in-diff approach. Second, once the dividend ban is lifted, bank dividends recover more swiftly and tend to compensate for what has not been distributed during the ban period. Third, bank equity values are, if anything, only moderately and temporarily affected by the recommendation. Due to easier financing conditions, NFCs perform (in equity markets) comparatively better than banks during the SWDR period. The related positive impact on demand for housing collateral also helps sustain housing prices during such period. Fourth, if euro area banks had followed not only the SWDR but also the recommendation to fully use their capital buffers, the additional gains in terms of bank credit and real GDP stabilization would not have been significantly larger.

Section 5 completes our quantitative analysis by studying the welfare effects of SWDRs and the main features of the SWDR that maximizes social welfare over the business cycle (i.e., the optimal DPT).

This optimal rule effectively stabilizes the economy regardless of the nature of the exogenous shocks (supply, demand, or financial shocks). However, due to the fact that the main source of distortions in this economy are borrowing limits, the optimal DPT only induces significant welfare gains in response to financial shocks. The optimal DPT is characterized by a high degree of enforcement and a high degree of countercyclical responsiveness, with the latter reflecting that welfare gains induced by this policy rule under financial shocks more than compensate for the welfare losses generated under non-financial shocks.

Related Literature This paper builds on various studies that provide empirical and theoretical support for banks' dividend smoothing, banks' reluctance to use capital buffers in bad times, and the relevance of MDAs:

Banks' dividend smoothing: According to the evidence, large and established corporations (including banks) distribute a significant percentage of their profits in the form of dividends and tend to smooth them over the cycle (Lintner 1956; Allen and Michaely 2003; DeAngelo et al. 2009), with banks being particularly reluctant to cut back on dividends during the downturn (Acharya et al. 2011; Muñoz 2021). Importantly, Wu (2018) finds that firms' dividend smoothing is driven not only by owners' preferences but also by managers' own career concerns.

Banks' reluctance to use capital buffers in bad times: Berrospide et al. (2021), Couaillier et al. (2022), and Abad and Garcia Pascual (2022) provide evidence on the reluctance of banks to use their capital buffers during the pandemic crisis and the reasons behind such behaviour.

Relevance of MDAs: According to existing bank capital regulation and for solvency purposes, banks cannot distribute earnings if their capital ratios fall below a certain threshold: the Maximum Distributable Amounts (MDAs). Goodhart et al. (2010) and Acharya et al. (2017) provide theoretical rationale for the existence of this type of microprudential dividend restrictions as it prevents excessive dividends and inefficiently low bank capitalization. Svoronos and Vrbaski (2020) explain how MDAs discourage banks to use their capital buffers.

We show that SWDRs can overcome this issue. As opposed to usable capital buffers, SWDRs are a tool that: (i) successfully aligns the incentives of public authorities and banks, and (ii) effectively helps to sustain lending in bad times by strengthening banks' capital positions (rather than by "weakening" them).[1]

Regarding empirical studies that focus on the evaluation of SWDRs, Gambacorta et al. (2020) offer a preliminary quantitative assessment of the lending capacity created by SWDRs. For a large cross-section of countries, Hardy (2021) documents that bank capitalization and lending to the real

[1] As shown in Muñoz (2021), the optimal SWDR (or optimal DPT) simply amplifies the volatility of bank dividends without affecting their procyclicality or steady state levels. Thus, banks and public authorities benefit from stronger bank capital positions in bad times and a smoother credit cycle that does not compromise the long-run levels of dividends distributed to bank owners.

economy performed comparatively better in those jurisdictions in which a SWDR was adopted in response to the COVID-19 economic crisis. Focusing on the euro area, Dautović et al. (2023) provide evidence based on bank-level data on the positive effects of the ECB recommendation of March 2020 on bank lending to NFCs.[2] Andreeva et al. (2023) provide estimates of the effects on bank valuations triggered by the ECB recommendation. Compared to theirs, our analysis focuses on shorter time windows (to avoid capturing the effect of other potential confounding factors) and also accounts for the effect of the recommendation withdrawal.

From a purely modelling perspective, our paper builds on the literature that incorporates banking in otherwise standard DSGE models. Among others, Gertler and Kiyotaki (2010), Gertler and Karadi (2011), Brunnermeier and Sannikov (2014), Christiano et al. (2014), Clerc et al. (2015), and Van der Ghote (2021). In general, these models make assumptions which imply that banks' dividend payout ratio is very low and/or constant over the cycle, aspects that are sharply at odds with the evidence. By combining two types of frictions that propagate and amplify shocks to the macroeconomy through wider fluctuations in bank credit flows, our model captures the empirical patterns in bank dividends and other aggregates that play a role in the transmission of SWDRs. First, in the tradition of Kiyotaki and Moore (1997) and Bernanke et al. (1999), borrowing is subject to collateral requirements. These requirements limit credit flows both from the household to the bank and from the bank to the NFC. Second, a dimension of the owner-manager agency problem that crucially affects bank lending dynamics is captured by allowing for NFCs and banks' dividend smoothing to be jointly driven by owners' preferences and managers' career concerns.[3] This implies that the objective of managers is concave in dividends, which is reflected in the overall objective function of the bank and further amplifies business cycles through aggregate volatility in bank retained earnings and lending.

In this regard, our closest antecedent is Iacoviello (2005) and its version with banks, Iacoviello (2015), who captures important aspects of bank intermediation dynamics by also allowing for borrowing constraints and concavity in the managers' objective with respect to dividends. In their model, there are credit flows in equilibrium thanks to the assumption that subjective discount factors are heterogeneous across agent types (patient and impatient households, banks and NFCs). In contrast, in our model it is the assumption that owners' and managers' objectives differ and both weigh in banks' and NFCs' objective functions that allows for having heterogeneous effective discount factors across agent types with households being owners of all the firms in the economy. This allows for a more tractable model that simplifies the welfare analysis (See Muñoz (2021) and Burlon et al. (2023) for a comparison).

[2] Martinez-Miera and Vegas (2021) conduct a similar exercise looking only at Spanish banks, for which they also document a positive effect on lending coming from the recommendation.

[3] Nielsen and Vissers (2021) shows the importance of capturing the agency problem between bank owners and managers in order to assess the effects of bank dividend restrictions.

Interestingly, rather than by assuming managers' objective concavity in dividends, others have attempted to match the second moment of dividends in macro-finance models by means of a quadratic adjustment cost that penalizes deviations of dividend payouts from a target set by the private entity (see, e.g., Jermann and Quadrini 2012 and Begenau 2020).

Our specification and study of SWDRs builds on Muñoz (2021), who first studies the use of a SWDR (referred to in the paper as the dividend prudential target or DPT), a design for such policy tool, and its macroeconomic and welfare effects in a similar environment. Other contributions that study the effects of the dividend prudential target in alternative set-ups include the Fischer and Kessler (2022) banking model for stress testing analysis and the work by Di Virgilio (2023) based on a DSGE model with bank defaults. Ours is the first paper that builds on this strand of the literature to model the type of SWDR that central banks implemented worldwide in response to the pandemic crisis as a rule according to which, the economy switches to a regime in which the authority issues a binding SWDR if and only if the cyclical position of the economy falls below a given threshold. To solve and simulate this model economy with different regimes we rely on the Occbin toolbox (Guerrieri and Iacoviello 2015).

The paper is organized as follows. Section 2 provides empirical evidence on the effects of the ECB SWDR on bank lending, equity prices and expected bank dividends. Section 3 proposes a quantitative DSGE model that is particularly suitable for SWDR analysis. Section 4 applies the model to study the general equilibrium effects of the ECB SWDR. Section 5 uses the DSGE model to characterize the optimal dividend prudential target. Section 6 performs some robustness checks. Section 7 concludes.

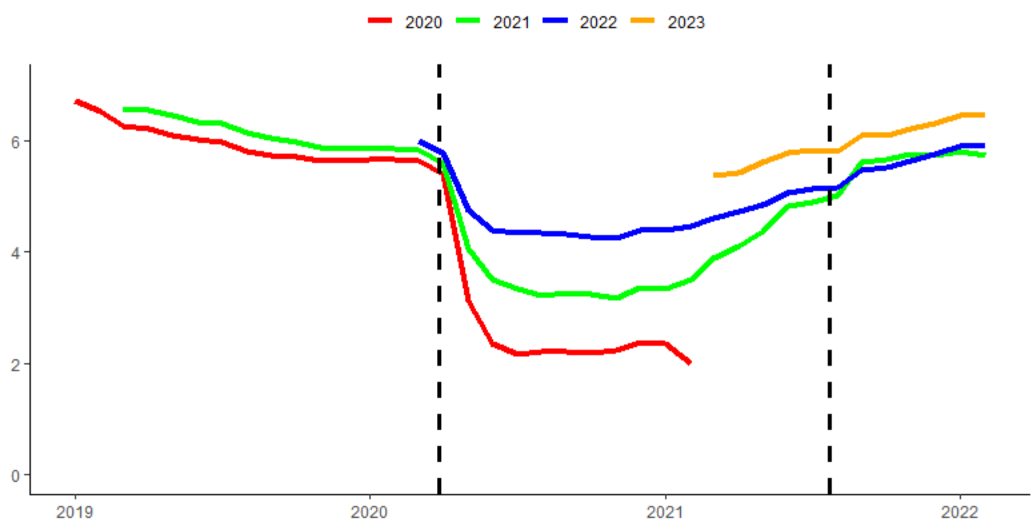
2 Empirical Evidence

This section presents evidence on the effects of the ECB SWDR on the path of paid and expected dividends, bank valuations and lending. The methodology and data used are specific to each variable of interest. We present these in the next subsections.

2.1 Impact of the ECB SWDR on bank dividends

It is clear that the immediate effect of the ECB SWDR is to reduce (theoretically up to zero) the amount of dividends paid out during the relevant period. But once the restriction is lifted banks can behave in different ways. They could go back to paying out the dividend amount which they intended to pay before the restriction was implemented; they could "compensate" for the unpaid dividends by increasing the payments once the restriction is lifted or they could keep dividends down for a longer period of time. It is complicated to determine how banks altered their dividend policy in response to the foregone dividends after the restriction was lifted, since they were at the same time reacting to the concurrent economic developments. However, two pieces of descriptive evidence point to the scenario in which banks increased dividends in a compensatory way after the restriction was lifted.

Figure 1: EURO STOXX Banks Dividend-per-share calendar year forecasts

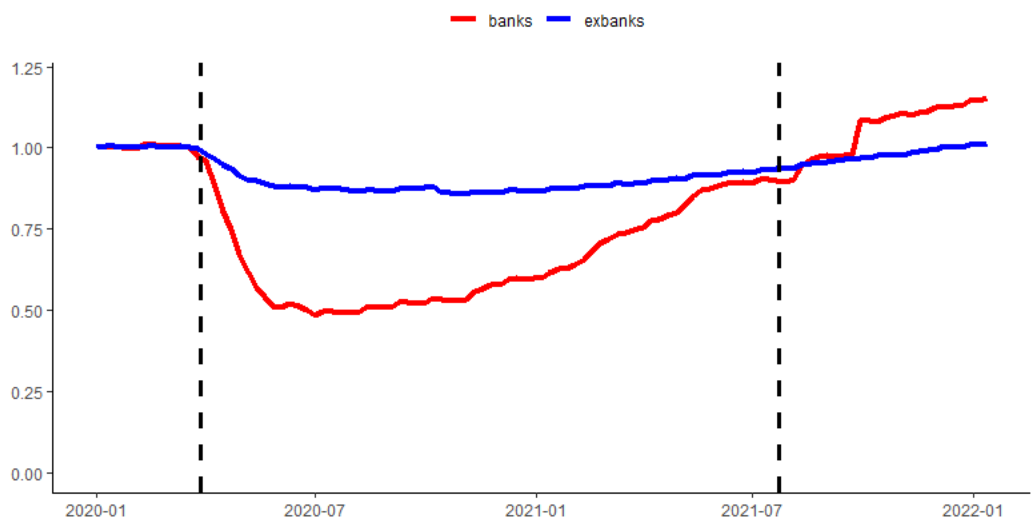


Notes: Each line shows the EURO STOXX Banks index dividend-per-share forecasts for a particular calendar year. Forecasts come from the Institutional Broker's Estimate System (IBES). Vertical dashed lines correspond to the dates of the system-wide dividend restriction recommendation issuance (27-03-2020) and final lifting of the restriction (23-07-2021).

First, Figure 1 shows the evolution of the EURO STOXX Bank index Dividend per Share (DPS) forecasts by analysts for several calendar years. The implementation of the SWDR triggered a sharp downward revision in DPS forecasts for the years 2020, 2021 and 2022. Realised dividends in 2020 were, obviously, lower than what was forecasted at the beginning of that year. But forecasts for 2021 and 2022 recovered as the restriction on dividend payments was lifted and by the beginning of 2022 they were at the same level as in March 2020 and on an increasing path (in February 2022 the Russian invasion of Ukraine drastically changed the economic environment).

Second, Figure 2 plots the 12-month forward DPS for the EURO STOXX Bank index and the EURO STOXX index excluding banks. Not surprisingly, banks cut dividends way more aggressively than NFCs in March 2020 (while NFCs were not affected by the SWDR they also reduced dividend payments due to effect of the COVID crisis). But banks 12-month forward DPS started to increase in the latter part of 2020 and by the beginning of 2022 they were above the level prevailing in March 2020. NFCs, on the other hand, did not overreacted in this manner.

Figure 2: 12-months forward DPS: EURO STOXX Banks vs EURO STOXX excluding banks



Notes: Lines show the 12-months forward DPS estimate for the EURO STOXX Bank index (red) and the EURO STOXX index excluding banks (blue). Forecasts come from the Institutional Broker's Estimate System (IBES). Vertical dashed lines correspond to the dates of the system-wide dividend restriction recommendation issuance (27-03-2020) and final lifting of the restriction (23-07-2021).

Overall, these pieces of evidence suggest that market participants interpreted the SWDR as a deferral of dividend payments rather than as a pure dividend cut. In other words, they anticipated that banks would partially compensate for the undistributed dividends to the extent possible and as soon as it would be possible.

2.2 Impact of the ECB SWDR on bank lending

The stated objective of the ECB SDWR was to preserve capital and sustain lending in a period of economic turmoil. By the time the ECB SWDR was announced (March 27th 2020), some banks had already distributed dividends or they had approved the payment of dividends in their annual shareholder meetings. These firms carried on with the dividend payment. The entities that had not approved the payment of dividends followed the ECB recommendation and cancelled their payment. Our empirical exercise relies on this set-up for identification since the date at which the annual shareholders meeting took place can be considered exogenous. This allows us to divide banks into a treatment group, those which suspended their dividend payment, and a control group, those which did not. We can then use the diff-in-diff methodology to evaluate the impact of the SWDR on banks' lending.

We use data from Anacredit, a euro area wide credit registry containing detailed harmonised information on individual bank loans. The use of a credit registry allows us to control for demand effects in our estimations. We compare banks whose dividend pay-outs were affected by the policy (treatment group) to banks which did not change their dividend policy (control group). In particular, treated banks suspended their dividend payment at least partially and control banks either paid the dividend in full or were not planning to distribute any dividend in the first place. To classify banks into treatment and control we use the information provided in their annual statements, supported by any additional communication made by the banks regarding the ECB dividend recommendation.

The analysis is based on a sample of 86 institutions under the direct supervision of the Single Supervisory Mechanism (SSM) and ranges over the second quarter of 2019 to the first quarter of 2021, i.e. the four quarters prior to and the four quarters after the ECB recommendation was announced. There are 54 banks in the treatment group and 32 banks in the control group. [4]

Formally, we run the following regression:

$$\Delta \ln credit_{b,i,t} = \beta_0 + \beta_1\, treated_b + \beta_2\, post_t + \beta_3\, (treated * post)_{b,t} + \beta_4\, X_{b,t-1} + \gamma_b + \theta_{i,t} + \varepsilon_{b,i,t}, \quad (1)$$

where $\Delta \ln credit_{b,i,t}$ is the quarterly change in the logarithm of credit from bank b to firm i at time t, $treated_b$ is a dummy that takes the value 1 if the bank belongs to the treatment group and 0 otherwise, $post_t$ is a dummy that takes the value 1 for quarters after the ECB recommendation was issued and 0 otherwise, $(treated * post)_{b,t}$ is the interaction of the two dummies specified before, $X_{b,t-1}$ contains a series of bank-specific characteristics including total assets, total equity and total deposits, γ_b are bank fixed effects and $\theta_{i,t}$ accounts for firm-time fixed effects capturing time-variant firm level changes, in particular credit demand à la Khwaja and Mian (2008). The coefficient of interest is thus β_3 which corresponds to the diff-in-diff estimate. All variables are winsorized at the 1st and 99th percentiles.

We find that banks that cancelled dividend payments following the ECB recommendation increased lending by around 5% compared to banks which didn't change their distribution plans according to our preferred specification, which controls for bank and firm-time fixed effects (see Table 1). This means that the recommendation was useful in supporting bank lending to the real economy. We also look at the precise timing of the effect by interacting quarter dummies with the diff-in-diff coefficient. As shown in Table 2, all the effect took place in the quarter right after the recommendation was issued (2020 Q2).

[4] Table A.1 lists the institutions belonging to each group

Table 1: Impact of SWDR on bank lending

Dependent variable: Growth rate of loans	(1)	(2)	(3)	(4)
Treated*post	0.0582*	0.0486**	0.0376	0.0523***
	(0.0311)	(0.018)	(0.0229)	(0.0158)
Treated	-0.0130		-0.0392***	
	(0.0302)		(0.0107)	
Post	-0.3778***	0.027**		
	(0.0118)	(0.0114)		
Constant	0.6743***	0.3250***	0.2138	0.5574***
	(0.0271)	(0.1035)	(0.0084)	(0.1588)
Bank controls	NO	YES	YES	YES
Bank FE	NO	YES	NO	YES
Firm-time FE	NO	NO	YES	YES
Observations	19,566,008	16,575,211	5,516,661	5,516,661
Number of banks	86	86	86	86
Number of firms	2,339,109	2,171,884	367,813	367,813
R-squared	0.025	0.030	0.482	0.486

Notes: Dependent variable is the quarterly growth rate in loans. Treated banks are those who reduce their dividend payment following the ECB recommendation. Bank controls include total assets, total equity and total deposits, all lagged by one quarter. Standard errors clustered at the bank level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

2.3 Impact of the ECB SWDR on bank valuations

A reduction in the dividends paid by a firm can potentially reduce the value of its equity since the latter corresponds to the sum of all present and future discounted dividends.[5] A side effect of the SDWR could have therefore been to reduce bank equity values. While, as we showed in the last section, the recommendation was effective in boosting lending, future lending could suffer if bank valuations were permanently depressed by the SDWR.

We conduct a diff-in-diff study to analyse banks' stock price reactions to the introduction of the SWDR on March 27th 2020 and its repeal on July 23th 2021. We look at the equity returns of all euro area listed banks before and after those two dates and compare them with the evolution of non-financial firms equity returns around the same dates. Formally, we estimate the following model:

$$R_{i,t} = \beta_0 + \beta_1\, bank_i + \beta_2\, post_t + \beta_3\, (bank * post)_{i,t} + \gamma_i + \mu_t + \varepsilon_{i,t}, \tag{2}$$

where $R_{i,t}$ is a firm daily return, $bank_i$ is a dummy that takes the value 1 if the firm is a bank and 0 otherwise, $post_t$ is a dummy that takes the value 1 for any day taking place after any of the two events and 0 otherwise, $(bank * post_{i,t})$ is the interaction of the two dummies specified before, γ_i are

[5] This effect will be counteracted if investors expect that all unpaid dividends will be paid after the recommendation is lifted and they are compensated for the time delay in the payment. Even in this case, stock prices could suffer due to selling pressure coming from dividend paying funds, which are required to deliver a certain dividend yield on a continuous basis. See Cáceres and Lamas (2022) for evidence of this effect.

Table 2: Impact of SWDR on bank lending: timing of effects

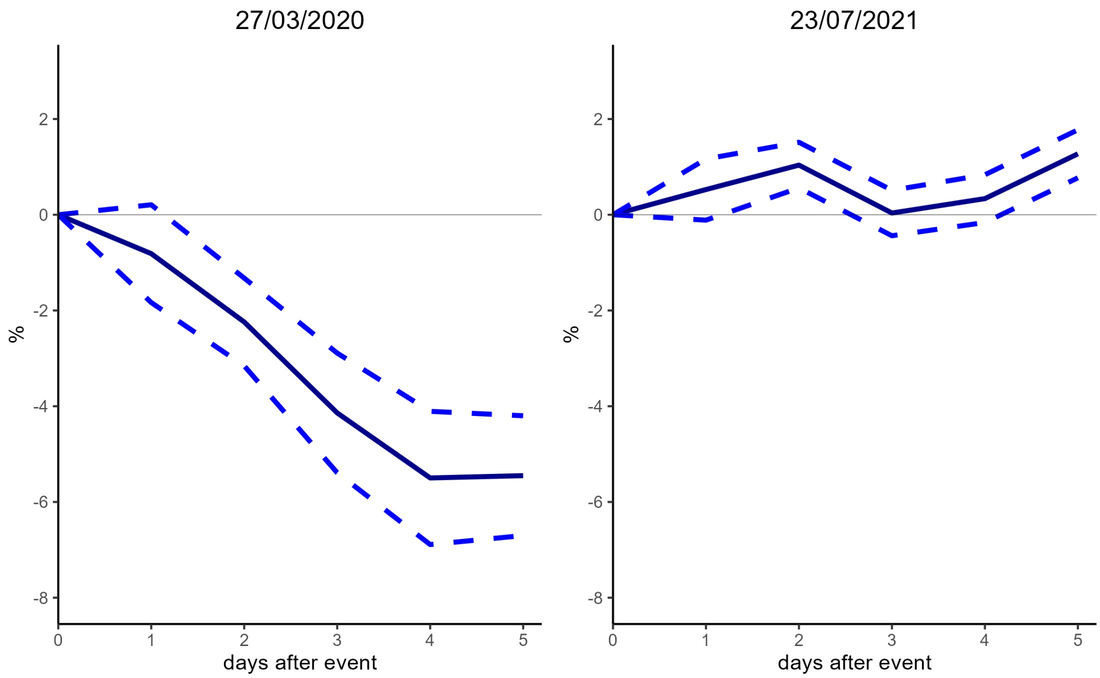
Dependent variable: Growth rate of loans	(1)	(2)
Treated	-0.0384***	
	(0.0102)	
Treated*post*2020Q2	0.1140**	0.0953**
	(0.0440)	(0.0389)
Treated*post*2020Q3	0.0336	0.0210
	(0.0219)	(0.0231)
Treated*post*2020Q4	-0.0023	0.0024
	(0.0382)	(0.0258)
Constant	0.2135***	0.4794***
	(0.0086)	(0.1409)
Bank controls	YES	YES
Bank FE	NO	YES
Firm-time FE	YES	YES
Observations	5,516,661	5,516,661
Number of banks	86	86
Number of firms	367,813	367,813
R-squared	0.482	0.486

Notes: Dependent variable is the quarterly growth rate in loans. Treated banks are those who reduce their dividend payment following the ECB recommendation. Bank controls include total assets, total equity and total deposits, all lagged by one quarter. Standard errors clustered at the bank level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

firm fixed effects and μ_t accounts for time fixed effects. The coefficient of interest is thus β_3 which corresponds to the diff-in-diff estimate. We estimate the effects around the two dates of interest: the introduction of the restriction, which should in principle bring banks' stock prices down, and the repeal of the restriction, which should have a positive effect on the former. It is worth noting that while the first event can be considered totally unanticipated, the repeal of the restriction was somewhat expected by the market, since the ECB had announced in December 2020 its intention to repeal the recommendation in September 2021 in the absence of materially adverse developments. In this sense, we consider our estimates an upper bound of the negative effects, since we are most likely not capturing well the positive effect that the repeal of the recommendation should have had on equity prices.

We also need to determine the number of days before and after the event that we take into consideration for the exercise. The choice of window size depends on how fast the market digests the information contained in the particular announcement. The information in European financial markets is transmitted almost immediately to all market participants. This would call for a short window. However, given the novelty of the announcement, market participants might have taken a longer time to properly assess its impact on equity valuations. For that reason we show results for data windows going from 1 to 5 days. Extending the window further in time would compromise

Figure 3: Impact of SWDR on euro area bank equity values



Notes: The chart shows the diff-in-diff coefficient and 95% confidence interval coming from the estimation of equation 2. The same equation is estimated for time windows between 1 and 5 days before and after the two events: announcement of SWDR (27/03/2020) and repeal of SWDR (23/07/2021). Dependent variable is the daily firm return. Sample consists on 90 banks and 2732 non-financial firms. Clustered standard errors at the firm level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

the identification of the effects, specially given the highly turbulent economic situation at the time.

Figure 3 summarizes the estimates of the diff-in-diff regression for different time windows (1 to 5 days). The SDWR had a negative effect of at most around 5% on euro area bank equity values on its announcement. When it was repealed the positive effect was around 1%. Table 3 shows that the results are robust to different specifications regarding the inclusion or exclusion of fixed effects. Therefore, our results indicate that the negative impact on bank equity values was relatively limited and transitory. [6]

[6] Andreeva et al. (2023) provides evidence of a negative impact on bank valuations in the order of magnitude around 7%. The main difference with our empirical exercise is that their study only considers the announcement of the SDWR, and not its withdrawal, in addition to consider a 4-week time window.

Table 3: Impact of SDWR on bank equity values

	(1)	(2)	(3)
Bank	-0.0010		
	(0.0010)		
Post	-0.0034***	-0.0036***	
	(0.0007)	(0.0007)	
Bank*Post	-0.0042**	-0.0043**	-0.0043**
	(0.0016)	(0.0017)	(0.0016)
Date FE	NO	NO	YES
Bank FE	NO	YES	YES
Observations	42,871	42,871	42,871
R-squared	0.001	0.066	0.100

Notes: Dependent variable is the daily firm return. Sample consists on 90 banks and 2732 non-financial firms. Days included are 4 days before and after the two events: announcement of SWDR (27/03/2020) and repeal of SWDR (23/07/2021). Clustered standard errors at the firm level in parentheses. *** p<0.01, ** p<0.05, * p<0.1

3 The Model

This section proposes a quantitative macro-banking DSGE model that accounts for the empirical findings presented in Section 2 to study the general equilibrium effects of the ECB SWDR and carry out a counterfactual analysis. The model builds on Iacoviello (2005) and Iacoviello (2015).

3.1 Environment

Time is discrete and has infinitely many periods. There is a final output good, physical capital, and a housing stock. A representative household consumes the good and the service flows tied to housing. Moreover, the household supplies labor hours and saves in a debt security issued by a representative bank (i.e., deposits). The bank lends its own net worth as well as channels the deposits to a representative producer, who uses the funding to buy housing, purchase physical capital, and hire labor hours to produce the good. Lastly, another representative producer uses the good to produce physical capital, but this producer does not need to borrow.

In the model, the bank is purposely set at the core of credit intermediation. As usual in the literature, credit intermediation is subject to financial frictions, which in the model take two forms. First, because of moral hazard problems in credit markets, borrowing is subject to collateral requirements. These requirements limit credit flows both from the household to the bank and from the bank to the final goods producer. Second, because of agency problems between firm managers and firm owners, the producers and the bank (i.e., firm managers) pay out dividends to the household (i.e., the owner) in a manner that may prioritize their own career concerns rather than the latter's interest.

A SWDR states a dividend recommendation to the bank that may depend only on aggregate economic conditions. The SWDR is set by a macroprudential authority. Sections 4 and 5 consider the ECB SWDR and the optimal SWDR rule, respectively.

The equilibrium is competitive. We set the final good as the numeraire, without loss of generality. In what follows, we formally lay out the optimization problems of the private agents and describe the SWDR policy rule. We display the full list of general equilibrium conditions of the model in Appendix C.

3.1.1 The household

Let $\{B_{h,-1}, H_{h,-1}\}$ denote the holdings on deposits and housing stock, respectively, of the household at the beginning of the initial period. In addition, let $\{W_t, Q_t, R_t\}$ be the wage bill, the housing price, and the gross deposit rate, in that order. Taking these variables as given, the household chooses consumption of the final good, C_t, consumption of housing services, $H_{h,t}$, supply of labor hours, $N_{h,t}$, and deposit holdings $B_{h,t}$ to maximize lifetime utility,

$$\max_{C_t, N_{h,t}, H_{h,t}, B_{h,t}} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t \left[\frac{1}{1-\sigma_h} \left(C_t - \frac{N_{h,t}^{1+\phi}}{1+\phi} \right)^{1-\sigma_h} + \chi_t \log H_{h,t} \right] , \tag{3}$$

subject to the sequence of budget constraints,

$$C_t + Q_t H_{h,t} + B_{h,t} = W_t N_{h,t} + Q_t H_{h,t-1} + R_t B_{h,t-1} + d_{f,t} + d_{b,t} + \Pi_t + T_t \ , \tag{4}$$

where $\beta_h \in (0,1)$ is the household's subjective discount factor, $\sigma_h > 0$ is the risk aversion coefficient, $\phi > 0$ is the inverse of the Frisch elasticity, and $\chi_t > 0$ denotes a possibly time-varying preference parameter for housing services.[7] Regarding the budget constraint, $d_{f,t}$ and $d_{b,t}$ denote dividend payouts to the household by the final goods producer and the bank, respectively, and Π_t and T_t are lump-sum transfers, to be specified below.

Define λ_t as the Lagrange multiplier associated with the budget constraint. Then, the stochastic discount factor (SDF) of the household is $\Lambda_{t,t+1} \equiv \lambda_{t+1}/\lambda_t$. This SDF is required for laying out the problems of the producers and the bank—to which we next turn the attention.

[7] The households has GHH preferences in consumption and hours worked (See Greenwood et al. 1988). This type of preferences - under which wealth effects on labor supply are arbitrarily close to zero - has been extensively used in the business cycle literature as a useful device to match several empirical regularities. As in this paper, GHH preferences have been formulated by other authors when evaluating macroeconomic policies to prevent a counterfactual increase in labor supply during crises (see, e.g., Bianchi and Mendoza 2018). Concerning the preference parameter for housing services, $\chi_t \equiv \chi \varepsilon_{h,t}$, where $\chi > 0$ is a parameter and $\varepsilon_{h,t}$ is an exogenous housing preference shock.

3.1.2 The final goods producer (NFC)

This producer uses housing stock $H_{f,t-1}$, physical capital $K_{f,t-1}$ and labor hours $N_{f,t}$ to produce the good, Y_t, according to a Cobb-Douglas production technology

$$Y_t = A_t(u_t K_{f,t-1})^{\alpha} H_{f,t-1}^{\eta} N_{f,t}^{1-\alpha-\eta}, \tag{5}$$

where A_t is total factor productivity (TFP), u_t is capacity utilization of physical capital, and α and η are the shares of output of physical capital and of housing, respectively. Physical capital depreciates at a rate $\delta_{k,t}$ that reflects quadratic costs in capacity utilization. Formally,

$$\delta_{k,t} \equiv \delta_0^k + \delta_1^k (u_t - 1)^2 + \frac{\delta_2^k}{2} (u_t - 1)^2 \,, \tag{6}$$

where $\delta_0^k > 0$, $\delta_1^k < 0$ and $\delta_2^k < 0$ are parameters.

Let $L_{f,t}$ be the loans taken by the producer. These loans must satisfy a standard collateral constraint that limits loan repayment by a fraction of the value of future housing holdings. That is,

$$L_{f,t} \leq m_{f,t} \mathbb{E}_t \left(\frac{Q_{t+1} H_{f,t}}{R_{L,t}} \right), \tag{7}$$

where $R_{L,t}$ is the bank loan rate and $m_{f,t} \in [0,1]$ is an exogenous fraction that is given by $m_{f,t} \equiv m_f \varepsilon_{mf,t}$, with m_f being interpreted as a structural loan-to-value ratio and $\varepsilon_{mf,t}$ being interpreted as a housing collateral shock.

Define P_t as the price of physical capital. Taking initial holdings $\{H_{f,-1}, K_{f,-1}\}$ and prices $\{P_t, Q_t, W_t, R_{L,t}\}$ as given, the producer solves

$$\max_{u_t, N_{f,t}, d_{f,t}, L_{f,t}, H_{f,t}, K_{f,t}} \mathbb{E}_0 \sum_{t=0}^{\infty} \left[(1-\omega) \underbrace{\Lambda_{t,t+1} d_{f,t}}_{\text{owner's obj.}} + \underbrace{\omega \beta_f^t \frac{1}{1-\frac{1}{\sigma}} d_{f,t}^{1-\frac{1}{\sigma}}}_{\text{manager's obj.}} \right], \tag{8}$$

subject to the sequence of budget constraints

$$Q_t(H_{f,t} - H_{f,t-1}) + P_t \left[K_{f,t} - (1-\delta_{k,t}) K_{f,t-1} \right] = Y_t + L_{f,t} - W_t N_{f,t} - R_{L,t} L_{f,t-1} - d_{f,t}, \tag{9}$$

and the sequence of collateral constraints (7).

The objective function in (8) reflects an agency problem between firm managers and firm owners. Specifically, the household would like to maximize the value of the firm, defined as the present discounted value—under its own SDF—of firm profits. By contrast, the producer would like to maximize the value of its career profile, defined as the present discounted value under its own subjective discount factor β_f of a CES function of dividend payouts. CES parameter $\sigma \geq 0$ indicates a preference bias for excessively smoothing dividend payouts relative to what would be consistent with maximizing shareholders value. Wu (2018) finds empirical evidence in favour of the bias for both non-financial (NFCs) and financial corporate firms. For NFCs, the agency problem directly influences their retained earnings, the pace of accumulation of their internal equity, and the aggregate demand of credit, as will become apparent in the model simulations. Lastly, parameter $\omega \in [0, 1]$ indicates the relative weight of the agency problem in the objective function.

As in Iacoviello (2005) and Iacoviello (2015), we assume $\beta_f < \beta_h$. This implies that the producer is more impatient than the household, or equivalently, that firm managers in the NFC sector are less forward looking than firm owners. In equilibrium, therefore, the producer hits the collateral constraint to borrow as much as possible and accumulates internal equity only by holding housing stock or physical capital.

3.1.3 The bank

The balance sheet of the bank is

$$L_{b,t} = E_t + B_{b,t}, \tag{10}$$

where $L_{b,t+1}$ is its supply of loans, $B_{b,t}$ is its supply of deposits, and E_t is its net worth (also referred to as bank capital or bank equity).

The net worth evolves according to

$$E_t - E_{t-1} = R_{L,t} L_{b,t-1} - R_{t-1} B_{b,t-1} - \delta E_{t-1} - T(d_{b,t}, d_t^\star) - d_{b,t} \ , \tag{11}$$

where penalty function $T(d_{b,t}, d_t^\star)$ is specified below and $\delta \in [0, 1]$ are exogenous operating costs as a fraction of net worth.[8] The sum of all the terms on the RHS but the last are operating profits. The last term are dividend payouts. Note that net worth can only be accumulated out of retained earnings which implies that E_t equals internal equity.

The bank is subject to a standard borrowing constraint that limits debt by a multiple of assets. Thus,

$$B_{b,t} \leq \gamma L_{b,t}, \tag{12}$$

where parameter $1 - \gamma$ is interpreted as the bank's regulatory capital ratio.

[8]These operating costs are standard in the literature (see, e.g., Gerali et al. (2010), Angelini et al. (2014), Muñoz (2021), Burlon et al. (2023)). They can be interpreted in several manners: (i) own resources the bank devotes to manage bank capital and to play its role as a financial intermediary, or (ii) equity that erodes due to a variety of factors which are not explicitly accounted for in the model and which may relate to specific characteristics of capital such as its quality.

Taking initial net worth E_0 and interest rates $\{R_{L,t}, R_t\}$ as given, the bank solves

$$\max_{d_{b,t},L_{b,t},B_{b,t}} \mathbb{E}_0 \sum_{t=0}^{\infty} \left[(1-\omega) \underbrace{\Lambda_{t,t+1} d_{b,t}}_{\text{owner's obj.}} + \omega \underbrace{\beta_b^t \frac{1}{1-\frac{1}{\sigma}} d_{b,t}^{1-\frac{1}{\sigma}}}_{\text{manager's obj.}} \right], \tag{13}$$

subject to the sequence of law of motions of net worth (11) and the sequence of collateral constraints (12).

The bank is subject to the same owner-manager agency problem as the final goods producer. Thus, the agency problem also directly influences bank dividend payouts, bank retained earnings, the pace of accumulation of bank internal equity, and the aggregate supply of credit.[9] As it will become clearer in Section 3.2, the common $\sigma > 0$ is set to match the volatility of dividend payouts. As standard in Iacoviello (2015), we assume $\beta_b < \beta_h$, which renders the bank more impatient than the household. In equilibrium, therefore, the bank hits its regulatory capital ratio to scale up its operations as much as possible.

3.1.4 The capital goods producer

Lastly, the capital goods producer invests I_t units of the good to create new units of physical capital according to

$$K_t - (1-\delta_{k,t})K_{t-1} = I_t \left[1 - \Gamma\left(\frac{I_t}{I_{t-1}}\right)\right] \quad \text{with} \quad \Gamma\left(\frac{I_t}{I_{t-1}}\right) = \frac{\psi_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2, \tag{14}$$

where $\Gamma(I_t/I_{t-1})$ is an standard quadratic investment cost function and ψ_I is a parameter. The producer faces no collateral constraint or agency problem. Thus, it solves

$$\max_{I_t} \mathbb{E}_0 \sum_{t=0}^{\infty} \Lambda_{t,t+1} \left[P_t I_t \left[1 - \Gamma\left(\frac{I_t}{I_{t-1}}\right)\right] - I_t \right]. \tag{15}$$

The producer transfers its profits to the household on the spot, according to

$$\Pi_t = P_t I_t \left[1 - \Gamma\left(\frac{I_t}{I_{t-1}}\right)\right] - I_t. \tag{16}$$

[9] For a detailed description and interpretation of the optimality condition of the bank's problem in a very similar set-up, see Muñoz (2021).

3.1.5 The macroprudential authority

The macroprudential authority sets the SWDR according to a rule that may incorporate information on the state of the economy. Sections 4 and 5 detail the rules under consideration. As in Muñoz (2021), the SWDR is enforced by a penalty that is quadratic in the deviation of the dividend payout from the prescribed recommendation. Formally,

$$T(d_{b,t}, d_t^{\star}) \equiv \frac{\kappa_t}{2} \left(d_{b,t} - d_t^{\star}\right)^2, \tag{17}$$

where $T(\cdot,\cdot)$ is the penalty function, $d_t^{\star}$ is the recommendation on the dividend payout, and $\kappa \geqslant 0$ measures the degree of enforcement of the prescribed recommendation. Revenues accrued from the penalty—if any—are transferred to the household on the spot, which implies that $\tau_t = T(d_{b,t}, d_t^{\star})$.

3.1.6 Market clearing

In equilibrium, the markets for goods, housing, physical capital, labor hours, deposits, and loans clear. The clearing condition for the goods market is

$$Y_t = C_t + I_t + \delta E_t. \tag{18}$$

The corresponding conditions for housing and physical capital are $\bar{H} = H_{h,t} + H_{f,t}$ and $K_{f,t} = K_t$, respectively, where for simplicity a fixed housing supply $\bar{H}$ is assumed—as in Iacoviello (2005) and Iacoviello (2015). The clearing condition for labor hours is $N_{h,t} = N_{f,t}$. Lastly, market clearing for deposits is $B_{h,t} = B_{b,t}$, while market clearing for loans is $L_{f,t} = L_{b,t}$.

3.2 Calibration

We follow a three-stage strategy in order to calibrate the model to quarterly euro area data for the (pre-COVID 19) period 2002:I-2018:II.[10] First, several parameters are set following convention (Table 4A). The inverse of the Frisch elasticity of labor is set to a value of $\varphi = 1$, the risk aversion parameter of household preferences is fixed to a standard value of $\sigma = 2$, the structural loan-to-value ratio on housing is set equal to $m_f = 0.8$, and physical capital depreciation rate parameters δ_1^k and δ_2^k are defined as specific fractions of the steady state interest rate on physical capital. The weight of bank and NFC managers' objective in the corresponding objective functions is fixed to a value of $\omega = 0.39$ to roughly capture the empirically relevant fact that 39% of firms'

[10] All time series expressed in Euros are seasonally adjusted and deflated. With regards to the matching of second moments, the log value of deflated time series has been linearly detrended before computing standard deviation targets. All details on data description and construction are available in Appendix B.

dividend smoothing is driven not by owners' preferences but by managers' own career concerns (Wu (2018)).[11]

Table 4: Baseline parameter values

Parameter	Description	Value	Source/Calibration target
(A) Pre-set params			
φ	Inverse of the Frisch elasticity	1	Standard
σ_h	HH Risk aversion param	2	Standard
m_f	LTV ratio on housing collateral	0.8	Standard
$\delta_1^k;\delta_2^k$	Endogenous capital depr. rate params	$r_{k_f}^{ss}$;0.1*$r_{k_f}^{ss}$	Standard
ω	Manager´s weight in NFC & bank obj.	0.39	Wu (2018)
(B) First moments			
β_h	Households' discount factor	0.9943	$R_h^{ss} = (1.023)^{1/4}$
β_b	Bank managers' discount factor	0.9345	$(R_f^{ss} - R_h^{ss})400 = 3.4$
β_f	NFC managers' discount factor	0.9650	$B^{ss}/(Y^{ss}) = 3.8933$
χ	Households' housing weight	0.0481	$(Q^{ss}H_h^{ss})/(4Y^{ss}) = 1.6128$
α	Capital share in production	0.3470	$I^{ss}/Y^{ss} = 0.2119$
δ_0^k	Depreciation rate of physical capital	0.0330	$C^{ss}/Y^{ss} = 0.7607$
η	Real estate share in production	0.0710	$(Q^{ss}H^{ss})/(4Y^{ss}) = 2.802$
γ	Bank debt-to-assets ratio	0.895	$S_h^{ss}/D_f^{ss} = 0.105$
δ	Erosion rate of bank capital	0.0341	$d_b^{ss}/J_b^{ss} = 0.5625$
(C) Second moments			
ψ_I	Investment adj. cost param	0.092	$\sigma_I/\sigma_Y = 2.642$
σ	Managers' EIS in dividends	3.200	$\sigma_{d_b}/\sigma_Y = 15.050$
σ_h	Std. housing pref. shock	0.1980	$\sigma_B/\sigma_Y = 6.473$
σ_{m_f}	Std. housing collateral shock	0.0148	$\sigma_C/\sigma_Y = 0.748$
σ_A	Std. productivity shock	0.0008	$\sigma_Y = 2.138$

Notes: Parameters in (A) are set to standard values in the literature, whereas those in (B) and (C) are calibrated to match data targets. Abreviations HH, NFC, and LTV refer to households, non-financial corporations, and loan-to-value, respectively.

Second, another group of parameters is calibrated by using steady state targets (Tables 4B and 5A). Households' discount factor, $\beta_h = 0.9943$, is chosen such that the annual deposit interest rate equals 2.3%. Bank managers' discount factor is set to $\beta_b = 0.95$, in order to generate an annualized bank spread of 3.4%. NFC managers' discount factor is fixed to a value of $\beta_f = 0.9650$ to match a bank loans-to-GDP ratio of 3.893. Households' weight on housing utility, $\chi = 0.0481$, has been calibrated to match the residential real estate wealth-to-GDP ratio.

The shares in final-good-production of physical capital $\alpha = 0.347$ and commercial real estate $\eta = 0.071$ are set to match an investment-to-GDP ratio of 21.19% and an aggregate real estate wealth-to-annual output of 280.2%, respectively. The steady state physical capital depreciation rate is fixed to a value of $\delta_0^k = 0.033$ to match the final consumption-to-GDP ratio. The erosion rate of bank capital is set to $\delta = 0.0341$, which is consistent with a banks' payout ratio of 0.563.[12] The bank debt-to-assets ratio, γ, is set to generate a bank capital ratio of 10.5%.[13]

[11]This is one of the parameters for which we perform some robustness checks in Section 6.

[12]This result is aligned with Lintner (1956), and subsequent literature, who found that corporations target a payout ratio of roughly 55%.

[13]According to existing bank capital legislation, in general terms, the authority cannot impose any microprudential restriction on dividend payouts (i.e., MDA) as long as the bank meets the minimum capital requirement (0.08) plus a conservation buffer of 0.025.

Third, some other parameters are calibrated to improve the fit of the model to the data in terms of relative volatilities (see Tables 4C and 5B). The investment adjustment cost parameter ψ_I is set to target a relative standard deviation of investment in physical capital of 2.642 %. Bank managers' elasticity of intertemporal substitution in dividends is fixed to a value of $\sigma = 3.2$ to match the relative volatility of bank dividends. The size of housing preference shocks, collateral shocks, and technology shocks have been calibrated to match the second moment of bank assets, final consumption and real GDP, respectively. The autoregressive parameters of all the shocks that hit this model economy are fixed to a value of 0.9.

Table 5: Model fit

Variable	Description	Model	Data
(A) First moments			
C^{ss}/Y^{ss}	Total consumption-to-GDP ratio	0.7661	0.7607
I^{ss}/Y^{ss}	Gross fixed capital formation-to-GDP ratio	0.2200	0.2119
N^{ss}/D_f^{ss}	Regulatory bank capital ratio	0.1050	0.1050
$D_f^{ss}/(Y^{ss})$	Bank loans-to-GDP ratio	3.8615	3 .8933
d_b^{ss}/J_b^{ss}	Bank dividend payout-ratio	0.5622	0.5625
$(Q^{ss}H_h^{ss})/(4Y^{ss})$	Residential housing wealth-to-GDP ratio	1.6111	1.6128
$(Q^{ss}H^{ss})/(4Y^{ss})$	Housing wealth-to-GDP ratio	2.8339	2.8018
$400 \times R_f^{ss}$	Annualized bank rate on loans (percent)	5.3237	5.6
$400 \times R_h^{ss}$	Annualized bank rate on deposits (percent)	2.2931	2.3
(B) Second moments			
$\sigma_{d_b} \ / \ \sigma_Y$	Std. bank dividends	15.0704	15.050
$\sigma_N \ / \ \sigma_Y$	Std. bank capital	6.3991	6.554
$\sigma_{D_f} \ / \ \sigma_Y$	Std. bank assets	6.3991	6.473
$\sigma_I \ / \ \sigma_Y$	Std. investment	2.4883	2.642
$\sigma_C \ / \ \sigma_Y$	Std. consumption	0.6385	0.748
σ_Y	(Std.GDP) x 100	2.1327	2.138

Notes: All series in Euros are seasonally adjusted and deflated. Data targets have been constructed from euro area quarterly data for the period 2002:I-2018:II. The exceptions are the following: annualized bank rates, which have been taken from constructed series presented in Gerali et al. (2010), and the target for capital requirements, which has been based on the Basel III regime. Data sources are Eurostat, ECB and Bloomberg.

4 General equilibrium effects of the ECB SWDR

This section uses the quantitative DSGE model to study the general equilibrium effects of the ECB SWDR on aggregates such as bank dividends, lending and real GDP in response to the March 2020 COVID-19 shock. In order to do so, we first characterize the shock and describe the scenarios.

We characterize the March 2020 COVID-19 shock that hit the euro area economy as a negative TFP shock. The reason for this choice is twofold. First, a negative productivity shock has certain similarities to the COVID-19 shock to the extent that both translate into a lower output level for a given combination of productive factors. In the case of the COVID-19 shock, the decline in total factor productivity was driven by the constraints a long period of quarentine imposes on the use and combination of inputs (limited labor mobility, more restricted combination of labor and physical capital, etc). Closures, travel bans and other human reactions to the virus had a direct supply-side impact on the economy.[14] Second, the shock decomposition of real GDP in the baseline (calibrated) model suggests that the bulk of the impact on economic activity induced by the COVID-19 event was driven by a negative TFP shock.

Then, we construct a COVID-19 type of SWDR scenario - which generalizes the empirically relevant case of the ECB SWDR - and two counterfactual scenarios for comparison.

Scenario I: ECB SWDR In this case, the authority issues a particular system-wide dividend recommendation if the cyclical position of the economy falls below a certain threshold. To construct this scenario we define the following two regimes:

Regime A: normal times The indicator that captures the change in the cyclical position of the economy, $\mu_{x,t} = \left(\frac{x_t}{x^{ss}} - 1\right)$, does not fall below the threshold for which the SWDR is activated (or $\mu_{x,t} \geq \overline{\mu}_{x,t}$). Therefore, under this regime individual bank's choice for $d_{b,t}$ is independent from $d_t^{\star A}$ since $\kappa^A = 0$, where $d_t^{\star A}$ and κ^A denote the SWDR and the degree of enforcement under regime "A", respectively. Nevertheless, we refer to the level of dividends paid by banks when $\kappa = 0$ as the "shadow SWDR" or the recommendation that would prevail when the macroprudential authority does not request banks to deviate from their internal payout policy plans. In the remainder of the paper we assume that $x_t = Y_t$.

Regime B: extremely severe economic downturn (e.g., COVID-19 crisis) In this regime, the indicator that captures the cyclical position of the economy falls below the relevant threshold, $\mu_{x,t} < \overline{\mu}_x$. A SWDR is activated and the degree of enforcement is sufficiently high so as to ensure that bank dividends do not deviate from the recommendation over the period for which $\mu_{x,t} < \overline{\mu}_x$. That is, the value of penalty parameter $\kappa^B > 0$ and is sufficiently high, thereby ensuring that $d_t^{\star B} = \overline{d_b} = d_{b,t}$, $\forall\ t = 0, 1, 2, ...$ during which the SWDR remains active.

Scenario II: Counterfactual A (baseline scenario) In this case, the macroprudential authority does not issue any SWDR. To model this, we simply assume that $\kappa_t = 0,\ \ \forall\ t = 0, 1, 2, ...$ This parameterization implies that individual bank's choice for $d_{b,t}$ is not affected by d_t^* regardless of the value taken by the latter.

Scenario III: Counterfactual B (ECB SWDR & CB) This scenario only differs from Scenario I in that banks do fully use their capital buffer when the authority issues a particular SWDR

[14] Even if different authors have modelled the COVID-19 shock differently, many of them have characterized it as a supply-side and factor productivity-related shock. For instance, Guerrieri et al. (2022) consider a MIT shock on labor supply, Fornaro and Wolf (2020) a shock to the growth rate of technology, and Muñoz (2020) a standard TFP shock.

(i.e., when the economy switches to regime B). To capture this we augment the bank debt-to-assets ratio, γ, with a cyclical component

$$\gamma_t = \gamma + \gamma_x \mu_{x,t}, \tag{19}$$

where $\gamma_x \in [\overline{\gamma}_{x,t}, 0]$ is the sensitivity parameter associated with the regulatory capital ratio implied by expression (19) and measures the extent to which the capital buffer is used in response to deviations of x_t from its steady state level, x^{ss}. The time-varying lower bound for the usable capital buffer, $\overline{\gamma}_{x,t}$, ensures that banks meet their minimum regulatory capital requirements at all points in time or $(1-\gamma_t) \geq 0.08$, for all $t = 0, 1, 2, ...$ While under regime "A" it holds that $\gamma_x = 0$, under regime "B" we have that $\gamma_x < 0$.

We refer to the "shadow SWDR" as the recommendation that would prevail under a scenario or regime in which the policy measure is not active. In other words, under Scenarios I (regime A), II, and III (regime A)

Table 6: Calibration of COVID-19 shock and ECB SWDR

Parameter	Description	Value	Calibration target
σ_A	Std. productivity shock	0.05	$\left(\frac{Y_t}{Y^{ss}} - 1\right)$x100 in 2020:II: $(-13.30\%) - (-13.01\%)$
κ^A	Penalty parameter (regime A)	0.00	Absence of SWDR in normal times
κ^B	Penalty parameter (regime B)	300.00	Enforcement of ECB SWDR: $d_{b,t} = d_t^{\star}$
$\overline{\mu}_x$	Threshold parameter	-7.00%	Duration of ECB SWDR (2020:II-2021:III): 6 *quarters*
$\overline{d_b}$	SWDR (regime B)	0.00	ECB SWDR: Recommended payout: $d_t^{\star} = 0$
γ_x^A	CB's use (regime A)	0.00	No use of CB: $(\gamma_t - 1)$x100 in 2020:II: 10.50%
γ_x^B	CB's use (regime B)	-0.20	Full use of CB: $(\gamma_t - 1)$x100 in 2020:II: 8.00%

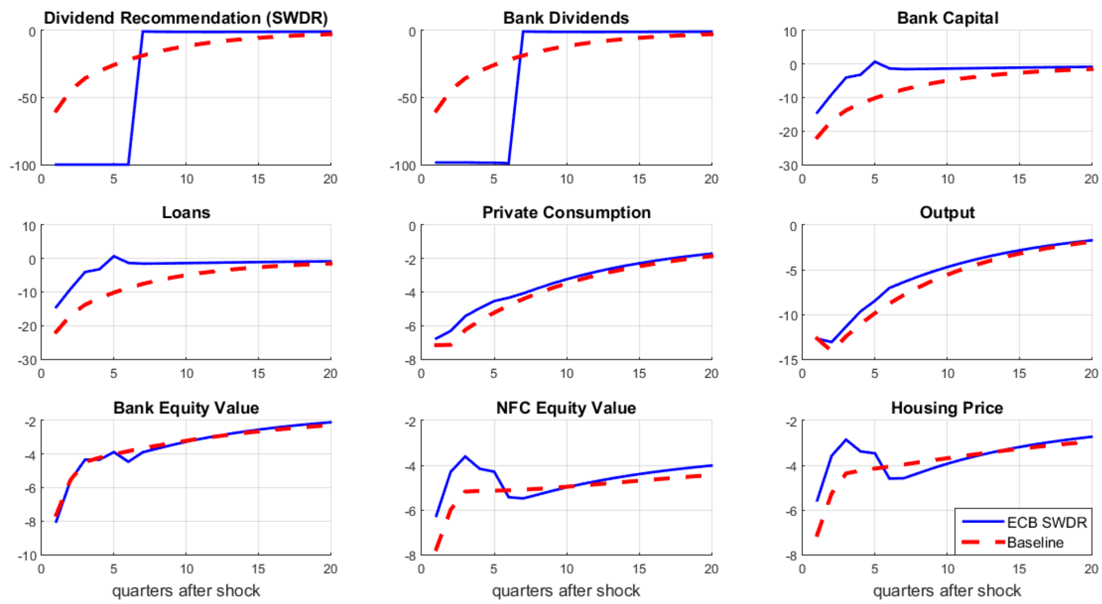
Notes: Values to which parameters σ_A and κ^A are set apply to all three scenarios. The calibration of parameters κ^B, $\overline{\mu}_x$, and $\overline{d_b}$ applies to scenarios I and III. The values to which parameters γ_x^A and γ_x^B are fixed are relevant under scenario III. Abbreviations SWDR and CB refer to system-wide dividend recommendation and capital buffer, respectively.

Next, we calibrate all the relevant parameters (σ_A, κ^A, κ^B, $\overline{\mu}_x$, $\overline{d_b}$, γ_x^A, γ_x^B) to study the aggregate general equilibrium effects of the ECB SWDR and those under counterfactual scenarios "A" and "B". The size of the negative TFP shock is set to a value of 0.05 to produce a fall in quarterly real GDP that lies within the range of estimates for the change in the cyclical component of euro area real GDP in 2020:II.[15] We calibrate parameters $\overline{\mu}_x$ and $\overline{d_b}$ to match the number of quarters during which the ECB recommendation was active (i.e., 2020:II - 2021:III) and the level at which the central bank requested banks to maintain their dividend payouts (i.e., $\overline{d_b} = 0$), respectively.

[15] We estimate the percentage change in the cyclical component of euro area real GDP for 2020:II- by de-trending the time series of quarterly real GDP for the period 2002:I-2021:IV. The linear de-trending method yields a variation of -13.30% for that quarter, whereas the HP filter de-trending method with a standard smoothing parameter value of 1,600 yields a change of -13.01%.

Parameter κ^B is sufficiently high, such that $d_t^{*B} = \overline{d_b} = d_{b,t}$, $\forall\ t = 0, 1, 2, ...$[16] Given the calibrated size of the TFP shock, we set γ_x^B to a value of -0.2 so that banks fully use their capital buffer without breaching their minimum capital requirement during the COVID-19 dividend ban period.

Figure 4: Impulse-responses to the (COVID-19) negative TFP shock under the ECB SWDR



Notes: Variables are expressed in percentage deviations from the steady state. The solid line makes reference to the ECB SWDR scenario. The dashed line refers to the baseline scenario. The impulse-responses plotted for the dividend recommendation under Scenarios I (regime A) and II correspond to the "shadow SWDR" or the value taken by bank dividends when $\kappa = 0$. Bank and NFC equity values are defined each as the sum of all the corresponding present and future dividends discounted with the households' stochastic discount factor (i.e., the owners' objective).

Given the calibration presented in Table 6, under scenarios I and III the negative TFP shock forces the economy to switch from regime "A" to regime "B". To solve and simulate the model under these scenarios we rely on the occbin toolkit (Guerrieri and Iacoviello 2015).

Figure 4 displays the impulse responses of key selected aggregates to this calibrated negative TFP shock under scenarios I (COVID-19 SWDR) and II (baseline scenario). In the first quarter, the output gap growth rate falls below threshold $\overline{\mu}_x$ and the economy under scenario I switches from regime "A" to regime "B". The SWDR gets activated and bank dividends move one for one with it and remain at their zero lower bound until the end of the sixth quarter. Despite banks' preference for smoothing dividends, the high degree of enforcement of the SWDR incentivizes banks to make the adjustment in the face of a shock that also hits bank profits via dividends (to the extent possible), thereby helping to sustain retained earnings, bank capital and lending. Through this

[16] As documented in Section 2, all banks followed the recommendation with the exception of those which had legal impediments to do so. The latter are those credit institutions which already had approved dividend distributions for 2020 at pre-COVID 19 shareholder meetings.

mechanism, the supervisory measure ameliorates the impact on real economic activity and cushions the fall in NFC valuations (through increased lending supply) and housing prices (through increased demand for housing collateral) during the SWDR period.[17] Since the recommendation operates more as a dividend deferral than as a dividend cut, bank valuations are roughly unaffected and any SWDR-induced impact is marginal and transitory.

Table 7: Differences relative to scenario II (baseline) in average impulse-responses over time

Scenario	Bank dividends Q1:Q6	Bank dividends Q7:Q12	Loans	Consumption	Output	Bank Equity Value	Housing Price
I. ECB SWDR	−62.3	12.1	6.4	0.5	1.0	−0.1	0.3
III. ECB SWDR & CB	−62.9	−9.7	7.1	0.6	1.2	−1.5	0.4

Notes: Differences (expressed in percentage points) relative to the baseline scenario in average impulse-responses over the first twelve quarters after the shock. For bank dividends, the difference is broken down between regime "A" and the first six quarters of regime "B". As an example, a −62.3 percentage points (p.p.) difference in bank dividends over Q1:Q6 under ECB SWDR means that on average over that time horizon bank dividends fall by 62.3 p.p. more under scenario I than what they do under scenario II with respect to the steady-state values of the dividends. (See Figure 4 for the impulse-response of each of the variables in the table at each quarter.)

Our quantitative assessment is consistent with and complementary to the empirical findings presented in Section 2. First, the recommendation is effective in sustaining bank lending and supporting overall economic activity. Notably, as shown by Table 7, the ECB SWDR (scenario I) reduces the average fall in bank lending over the first three years after the shock by around 6.4 percentage points (p.p.) with respect to steady-state values relative to the baseline scenario (scenario II). The corresponding reductions in the fall of consumption and of output are around 0.5 p.p. and 1.0 p.p., respectively. The impact of the SWDR on lending captured with the DSGE model is larger than that estimated by following a diff-in-diff approach (Section 2.2). While the latter only accounts for the partial-equilibrium effect of the measure on bank lending supply, the former captures the general equilibrium impact on aggregate bank lending.[18]

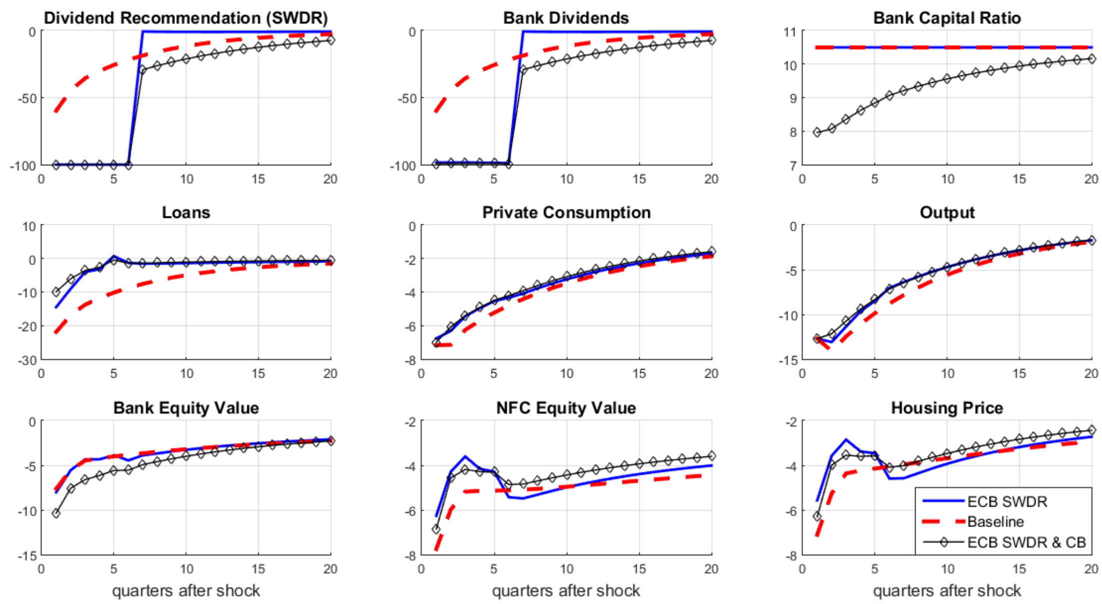
Second, once the SWDR is lifted bank dividends quickly recover and tend to compensate for what has not been distributed during the dividend ban period. Both Figures 2 and 4 suggest that, in the quarters that followed the end of the ban period, bank dividends evolved above the levels that would have prevailed had the recommendation not been issued. As shown by Table 7, in the DSGE model, the average increase in bank dividends over the first six quarters after the lift of the SWDR is of around 12.1 p.p. with respect to steady state values relative to the baseline scenario. Third, due to this "compensation effect", bank valuations are not materially affected by the SWDR and any impact is transitory. In particular, in the model, bank equity values fall by almost the same

[17] Note that the impulse responses of NFC valuations and housing prices are very similar precisely because they are notably influenced by the patterns of lending and NFCs' demand for housing collateral, which are similar, given expression (7).

[18] The direct SWDR-induced positive impact on bank lending supply favours real economic activity, which at the same time exerts an upward pressure on bank lending demand that further amplifies the initial effect, and so on.

amount in the two scenarios. Lastly, the model reveals that the ECB SWDR helps support NFC equity values and housing prices during the ban period.[19]

Figure 5: SWDR & CB: Impulse-responses to the (COVID-19) negative TFP shock



Notes: Variables are expressed in percentage deviations from the steady state with the exception of the bank capital ratio, which is expressed in percentage points. The diamond and solid lines make reference to the ECB SWDR scenario with and without the use of capital buffers, respectively. The dashed line refers to the baseline scenario. The impulse-responses plotted for the dividend recommendation under Scenarios I (regime A), II, and III (regime A) correspond to the "shadow SWDR" or the value taken by bank dividends when $\kappa = 0$. Bank and NFC equity values are defined each as the sum of all the corresponding present and future dividends discounted with the households' stochastic discount factor (i.e., the owners' objective).

Figure 5 plots, along with the impulse responses displayed in Figure 4, the responses of the same variables to the negative TFP shock under scenario III. The combined action of the SWDR and the usable capital buffer (diamond line) sustains bank lending and real economic activity only marginally more than the SWDR in isolation (scenario I) and the difference between the two scenarios only appears to be evident in the first few quarters. That is, according to our quantitative analysis, would euro area banks have followed not only the SWDR but also the recommendation to fully use their capital buffers, the additional gains in terms of bank credit and real economic activity stabilization would not have been significantly larger.

[19] This result is consistent with the empirical fact that the fall in NFC equity valuations in response to the COVID-19 shock was relatively lower, when compared to: (i) the decline in bank stock prices during the same period, and (ii) the drop in NFC valuations at the height of previous crises (e.g., the GFC) despite the fact that the fall in the cyclical component of real GDP in 2020:II was comparatively larger.

5 Dividend prudential target: An optimal SWDR

This section complements the study of the general equilibrium effects of system-wide dividend restrictions based on our quantitative macro-banking model by assessing the aggregate effects of a welfare-maximizing SWDR referred to in the literature as the optimal dividend prudential target or optimal DPT (Muñoz 2021).

We define optimal DPT as the SWDR that maximizes social welfare from those within the class that are set and implemented according to expressions (17) and:

$$d_t^{\star} = d_b^{ss} + \rho_x \mu_{x,t}, \tag{20}$$

where d_b^{ss} denotes the steady state bank dividend payout, ρ_x measures the degree of countercyclical responsiveness of $d_t^{\star}$, and $\mu_{x,t} = \left(\frac{x_t}{x^{ss}} - 1\right)$ captures the change in the cyclical position of the economy. More precisely, the optimal DPT is a SWDR which, operating according to expressions (20) and (17), solves for

$$\arg\max_{\Theta} V_h = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t U\left(C_{h,t}, H_{h,t}, N_{h,t}\right), \tag{21}$$

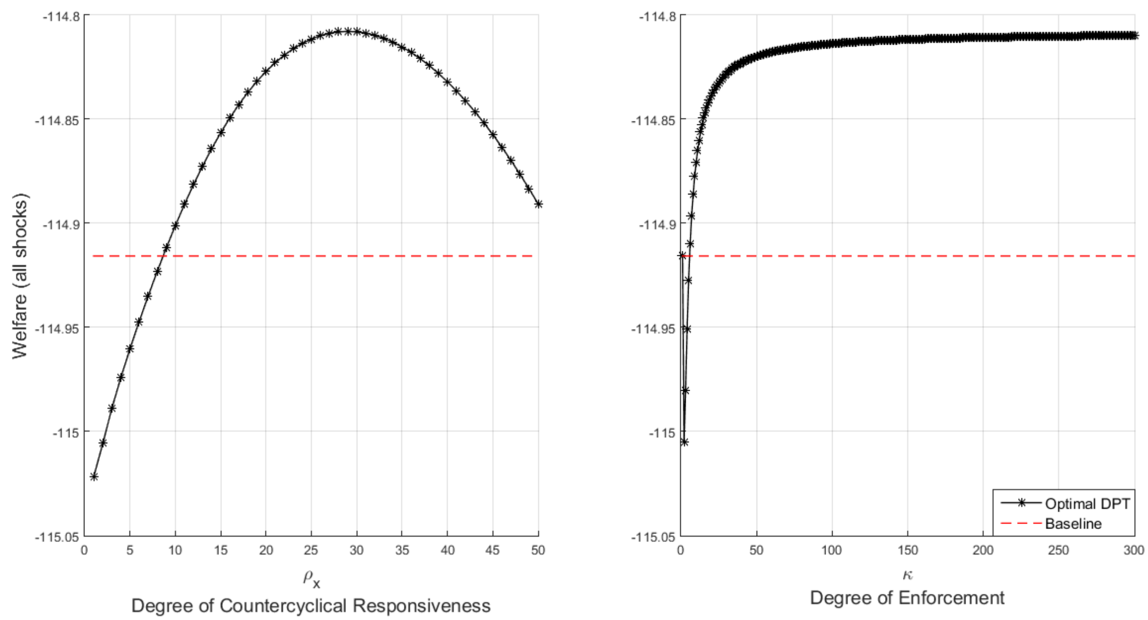
where V_h denotes households' life-time expected utility, the measure of social welfare, and $\Theta = \{\rho_x, \kappa\}$ refers to the vector of SWDR parameters with respect to which the objective function is maximized. Problem (21) is subject to all the competitive equilibrium conditions of the model. As in Schmitt-Grohé and Uribe (2007), welfare gains are defined as the implied permanent differences in consumption between two different scenarios. Formally, consumption equivalent gains can be specified as a constant λ, that satisfies:

$$\mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t U\left(C_{h,t}^a, H_{h,t}^a, N_{h,t}^a\right) = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta_h^t U\left[(1+\lambda)\, C_{h,t}^b, H_{h,t}^b, N_{h,t}^b\right], \tag{22}$$

where superscripts a and b refer to the optimal DPT scenario and the baseline case, respectively. We numerically solve problem (21) by searching over the following grid of parameter values: ρ_x $\{0-100\}$ and κ $\{0-30,000\}$.[20] The optimal DPT induces significant welfare gains, $\lambda^* = 0.30\%$ (expressed in percentage permanent consumption), by forcefully responding in a countercyclical fashion, $\rho_x^* = 29$, with a degree of enforcement that is high enough to ensure that bank dividends

[20] In each case, the model is solved by using second-order perturbation techniques in Dynare (Adjemian et al. (2011)). Unconditional lifetime utility is computed as the theoretical mean based on first-order terms of the second-order approximation to the nonlinear model, resulting in a second-order accurate welfare measure (see e.g. Kim et al. (2008)). This approach ensures that the effects of aggregate uncertainty are taken into account.

Figure 6: Aggregate welfare effects of the dividend prudential target



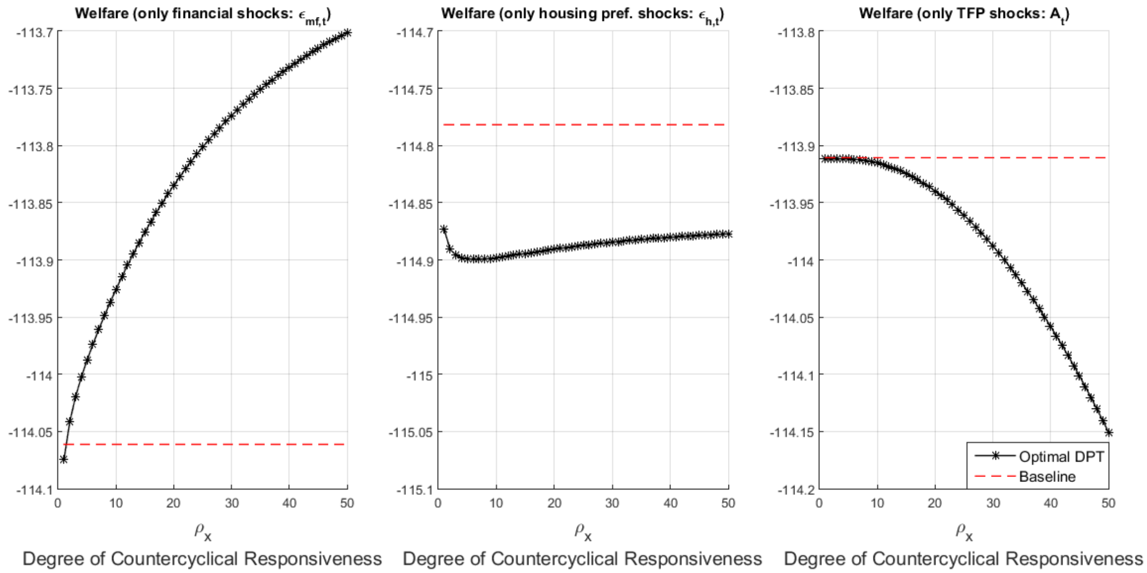
Notes: Second-order approximation to the unconditional welfare of the household as a function of SWDR policy parameter ρ_x while κ remains at its optimized parameter value vs that under the baseline scenario, under which $\kappa = 0$ (panel A); and second-order approximation to the unconditional welfare of the household as a function of SWDR policy parameter κ while ρ_x remains at its optimized parameter value vs that under the baseline scenario (panel B).

move one for one with the SWDR, $\kappa^* \approx 30,000$.[21]

Figure 6 plots the welfare effects of changing the value of parameter ρ_x while all other parameters remain at their baseline calibration values with the exception of κ, which is fixed to its optimized value (panel A), and those of changing the value of parameter κ while all other parameters remain at their baseline calibration values and ρ_x is set to its optimized value (panel B). Several conclusions on the welfare effects of the dividend prudential target can be drawn from this analysis. First, there is a wide range of parameter combinations ρ_x - κ that satisfy $\rho_x > 0$ and $\kappa > 0$ for which welfare gains are strictly positive. Or, put it differently, there is a wide range of calibrations for which having this type of dynamic SWDR in place is welfare improving. Second, the calibration of ρ_x is particularly important since the welfare gains induced by this policy rule are heterogeneous across shock types. Due to the fact that the main source of distortions in this economy are borrowing constraints, a countercyclical DPT (i.e., $\rho_x > 0$ and $\kappa > 0$) only induces welfare gains in response to financial shocks (see Figure 7). Third, the optimal degree of enforcement, κ^*, is very high and implies that in each period, banks closely follow the SWDR or $d_{b,t} = d_t^\star$, $\forall\ t = 0, 1, 2, ...$Figure 6B

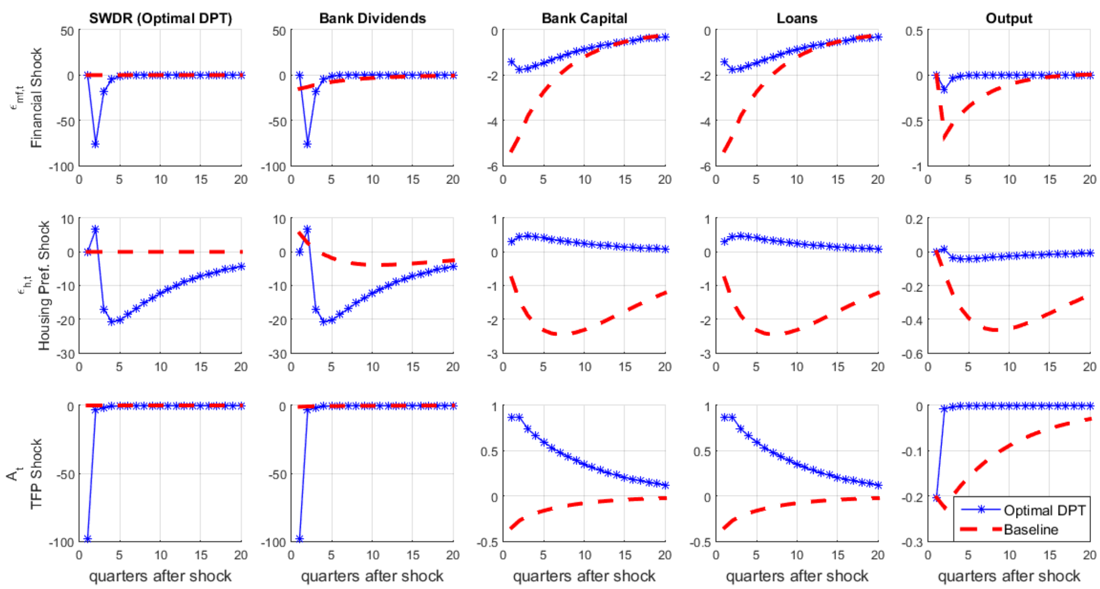
[21]Superscript "*" indicates the value that the corresponding parameter or variable takes under the optimal DPT scenario.

Figure 7: Welfare effects of the dividend prudential target by shock type



Notes: For each type of shock, the figure plots the second-order approximation to the unconditional welfare of the household as a function of SWDR policy parameter ρ_x while κ remains at its optimized parameter value vs that under the baseline scenario, under which $\kappa = 0$.

Figure 8: Optimal DPT: Impulse responses to all shocks



Notes: Variables are expressed in percentage deviations from the steady state. The starred line refers to the optimal DPT scenario. The dashed line makes reference to the baseline (i.e., no SWDR) scenario.

makes clear that, given $\rho_x^* = 29$, SWDR-induced welfare gains remain roughly invariant for the range of κ values for which this parameter is sufficiently high and above a certain threshold (which in this case is around 200).

Then, we compare the responses of key selected aggregates to each of the three types of shocks that hit this model economy under the optimal DPT scenario with those under the baseline scenario (Figure 8). By providing banks with incentives to tolerate a higher dividend volatility, the optimal DPT effectively sustains bank capital, lending, asset prices and real economic activity regardless of the nature of the shock and without materially affecting bank dividends' steady state level.

6 Robustness Checks

This section investigates the robustness of the main findings presented in Sections 4 and 5. First, we study how the effectiveness of the ECB SWDR to sustain bank lending varies with key selected prudential regulatory parameters. Our main conclusion is that such effectiveness increases with the volume of bank credit to be sustained. In particular, Appendix D shows that the capacity of the ECB SWDR in sustaining bank lending increases with the degree of bank capitalization (i.e., decreases with γ) and with the leverage degree of the private sector (i.e., increases with m_f).

Then, we evaluate the robustness of our results on the optimal DPT. Taking $\kappa^* \approx 30,000$ as given, Table 8 reports the optimized responsiveness degree of the optimal DPT, ρ_x^*, and the corresponding welfare gains, λ^*, for different values of key selected parameters. The welfare gains induced by the optimal DPT decrease with the degree of capital buffer usability, γ_x. This is the case since both, the SWDR and the CB, are effective in smoothing bank lending and real economic activity and complement each other by operating through different channels. As welfare gains induced by the optimal DPT mainly originate from a bank lending smoothing effect, their size are increasing in aggregate credit volumes. Thus, such welfare gains increase with the leverage of banks, γ, and with that of NFCs, m_f.

Most of macro-banking models tend to underestimate the magnitude of banks' dividend smoothing by assuming that the behaviour of the bank is fully determined by the owners' objective or $\omega = 0$. Bank owners indirectly have a preference for smoothing their income sources, including dividends, to the extent that they have a preference for consumption (leisure, and housing services) smoothing. Bank managers have a more direct preference for bank dividend smoothing since their career concerns crucially depend on the patterns of distributed earnings. This is captured by expression (13). Consequently, the magnitude of banks' dividend smoothing and the corresponding trade-off between bank dividend smoothing and lending stability increases with ω. Therefore, welfare gains induced by the optimal DPT decrease with parameter ω (see panel (d) of Table 8).

Table 8: Robustness checks: Optimal DPT and welfare gains

Parameter	Optimal responsiveness	Welfare gains
(a) γ_x		
(i) $\gamma_x = 0.00$	$\rho_x^* = 29.00$	$\lambda^* = 0.2995$
(ii) $\gamma_x = -0.10$	$\rho_x^* = 29.55$	$\lambda^* = 0.3377$
(iii) $\gamma_x = -0.20$	$\rho_x^* = 30.26$	$\lambda^* = 0.3736$
(b) γ		
(i) $\gamma = 0.895$	$\rho_x^* = 29.00$	$\lambda^* = 0.2995$
(ii) $\gamma = 0.91$	$\rho_x^* = 27.23$	$\lambda^* = 0.3327$
(iii) $\gamma = 0.925$	$\rho_x^* = 25.05$	$\lambda^* = 0.3818$
(c) m_f		
(i) $m_f = 0.80$	$\rho_x^* = 29.00$	$\lambda^* = 0.2995$
(ii) $m_f = 0.70$	$\rho_x^* = 13.12$	$\lambda^* = 0.1633$
(iii) $m_f = 0.60$	$\rho_x^* = 9.94$	$\lambda^* = 0.1559$
(d) ω		
(i) $\omega = 0.39$	$\rho_x^* = 29.00$	$\lambda^* = 0.2995$
(ii) $\omega = 0.65$	$\rho_x^* = 34.26$	$\lambda^* = 0.2871$
(iii) $\omega = 0.90$	$\rho_x^* = 35.89$	$\lambda^* = 0.2150$

Notes: Second-order approximation to the welfare gains associated with the optimal dividend prudential target (DPT) and the corresponding optimal degree of responsiveness for alternative parameterizations. Welfare gains are expressed in percentage permanent consumption.

7 Conclusion

In response to the pandemic crisis in 2020, many central banks all over the world provided supervisory guidance to banks on how they should conduct their payout policies during the crisis in order to sustain lending. What we refer to as "system-wide dividend recommendations" or SWDRs. Our empirical analysis on the recommendation issued by the ECB (SSM) in March 2020 finds that: (i) on average, banks which followed the SWDR increased their lending by 5% more than those which did not follow it; (ii) the negative impact on bank valuations was moderate, transitory and, arguably, largely driven by the unanticipated nature of the measure; and (iii) market participants generally understood this measure as a deferral of dividend payouts to the post-recommendation period, rather than as a dividend cut.

Against this background, we propose a quantitative macro-banking DSGE model that accounts for this evidence and incorporates the key mechanism through which SWDRs operate in order to study the general equilibrium effects of the ECB SWDR. Such recommendation contributed to sustain lending and mitigate the adverse impact of the COVID-19 shock on economic activity by safeguarding the euro area banks' degree of capitalization. SWDRs induce significant welfare gains through this mechanism. If euro area banks had followed not only this ECB recommendation but also that of using their capital buffers, the stabilization effects would not have been significantly larger.

Given the novelty of this policy tool, the tractability of the model and the fact that this strand of the literature is in its infancy, we consider that there are various extensions of our analysis that represent promising avenues for future research. On the one hand, it would be useful to extend the model to better understand the interactions between a macroprudential policy framework with SWDRs and other macroeconomic policies such as fiscal and monetary policies. On the other hand, one could further refine the modelling of the banking sector by allowing for imperfect competition, heterogeneous banks (e.g., in their size, payout policies, capital ratios), or the probability of bank default, among many others.

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A Additional Empirical Evidence

Table A.1: Treatment and control groups

Bank name	Country	Treatment
Aareal Bank AG	DE	1
AB SEB bankas	LT	1
ABN AMRO Bank N.V.	NL	1
AS "SEB banka"	LV	1
AXA Bank Belgium SA	BE	1
Banco Comercial Português, SA	PT	1
Banco de Sabadell, S.A.	ES	1
Banco Santander, S.A.	ES	1
Bank of Ireland Group plc	IE	1
Bank of Valletta plc	MT	1
Bankinter, S.A.	ES	1
Banque Degroof Petercam SA	BE	1
Banque et Caisse d'Epargne de l'Etat, Luxembourg	LU	1
Bayerische Landesbank	DE	1
Belfius Banque SA	BE	1
BNG Bank N.V.	NL	1
BNP Paribas S.A.	FR	1
BPCE S.A.	FR	1
BPER Banca S.p.A.	IT	1
Caixa Geral de Depósitos, SA	PT	1
CaixaBank, S.A.	ES	1
COMMERZBANK Aktiengesellschaft	DE	1
Crédit Agricole S.A.	FR	1
DekaBank Deutsche Girozentrale	DE	1
Deutsche Apotheker- und Ärztebank eG	DE	1
Deutsche Bank AG	DE	1
Deutsche Pfandbriefbank AG	DE	1
DZ BANK AG Deutsche Zentral-Genossenschaftsbank	DE	1
Erste Group Bank AG	AT	1
HSBC Bank Malta p.l.c.	MT	1
HSBC France	FR	1
Intesa Sanpaolo S.p.A.	IT	1
Kutxabank, S.A.	ES	1
La Banque Postale	FR	1
Landesbank Baden-Württemberg	DE	1
Landesbank Hessen-Thüringen Girozentrale	DE	1
Liberbank, S.A.	ES	1
Mediobanca - Banca di Credito Finanziario S.p.A.	IT	1
Münchener Hypothekenbank eG	DE	1
Nederlandse Waterschapsbank N.V.	NL	1
Nordea Bank Abp	FI	1
Nova Ljubljanska Banka d.d. Ljubljana	SI	1
Raiffeisen Bank International AG	AT	1
RCB Bank LTD	CY	1
RCI Banque SA	FR	1
Slovenská sporiteľňa, a.s.	SK	1
Société Générale S.A.	FR	1
Swedbank AS	LV	1
Tatra banka, a.s.	SK	1
UBS Europe SE	DE	1
Ulster Bank Ireland Designated Activity Company	IE	1
Unicaja Banco, S.A.	ES	1
UniCredit S.p.A.	IT	1
Všeobecná úverová banka, a.s.	SK	1
„Swedbank", AB	LT	0
Akcinė bendrovė Šiaulių bankas	LT	0
Alpha Bank AE	GR	0

Table A.1: Treatment and control groups (continued)

Bank name	Country	Treatment
AS SEB Pank	EE	0
Banca Carige S.p.A. - Cassa di Risparmio di Genova e Imperia	IT	0
BANCA MONTE DEI PASCHI DI SIENA S.p.A.	IT	0
Banca Popolare di Sondrio, Società Cooperativa per Azioni	IT	0
Banco Bilbao Vizcaya Argentaria, S.A.	ES	0
Banco BPM S.p.A.	IT	0
Bank of America Merrill Lynch International Designated Activity Company	IE	0
Banque Internationale à Luxembourg S.A.	LU	0
Barclays Bank Ireland PLC	IE	0
Cassa Centrale Banca - Credito Cooperativo Italiano S.p.A.	IT	0
Coöperatieve Rabobank U.A.	NL	0
Eurobank Ergasias S.A.	GR	0
Goldman Sachs Bank Europe SE	DE	0
Hamburg Commercial Bank AG	DE	0
Hellenic Bank Public Company Limited	CY	0
Ibercaja Banco, S.A.	ES	0
Iccrea Banca S.p.A. - Istituto Centrale del Credito Cooperativo	IT	0
J.P. Morgan AG	DE	0
Kuntarahoitus Oyj	FI	0
National Bank of Greece S.A.	GR	0
Norddeutsche Landesbank -Girozentrale-	DE	0
Piraeus Bank S.A.	GR	0
RBC Investor Services Bank S.A.	LU	0
Sberbank Europe AG	AT	0
SFIL S.A.	FR	0
Swedbank AS	EE	0
The Bank of New York Mellon SA	BE	0
Volksbank Wien AG	AT	0
Volkswagen Bank GmbH	DE	0

Notes: Column 'Treatment' shows banks banks whose dividend pay-outs were affected by the policy (1) and banks which did not change their dividend policy (0).

B Data and Sources

This section presents the full data set employed to calibrate the model presented in Section 3.

Gross Domestic Product: Gross domestic product at market prices, Chain-linked volumes (rebased), Domestic currency (may include amounts converted to the current currency at a fixed rate), Seasonally and working day-adjusted. Source: Eurostat.

GDP Deflator: Gross domestic product at market prices, Deflator, Domestic currency, Index (2010 = 100), Seasonally and calendar adjusted data - ESA 2010 National accounts. Source: Eurostat.

Final Consumption: Final consumption expenditure at market prices, Chain linked volumes (2010), Seasonally and calendar adjusted data. Source: Eurostat.

Gross Fixed Capital Formation: Gross fixed capital formation at market prices, Chain linked volumes (2010), Seasonally and calendar adjusted data. Source: Eurostat.

Households Housing Wealth: Housing wealth (net) of Households and non profit institutions serving households sector (NPISH), Current prices, Euros, Neither seasonally adjusted nor calendar adjusted - ESA 2010. Source: European Central Bank.

Housing Prices: Residential property prices; New and existing dwellings, Residential property in good and poor condition. Neither seasonally nor working day adjusted. Source: European Central Bank.

Loans: Outstanding amounts at the end of the period (stocks) of loans from MFIs excluding ESCB reporting sector to Non-Financial corporations sector (S.11) sector and Households and non-profit institutions serving households sector (S.14 & S.15), denominated in Euros. Source: MFI Balance Sheet Items Statistics (BSI Statistics), Monetary and Financial Statistics (S/MFS), European Central Bank.

Dividend Payout Ratio: Fraction of net income payed to shareholders in dividends, in percentage. Calculated as: Total Common Dividends*100 / Income Before Extraordinary Items Less Minority and Preferred Dividends. Capitalization-weighted sum of the SX7E members. Source: Bloomberg.

Dividends: Dividends paid to common shareholders from the profits of the company. Includes regular cash as well as special cash dividends for all classes of common shareholders. Excludes return of capital and in-specie dividends. For the cases in which dividends attributable to the period are not disclosed, dividends are estimated by multiplying the Dividend per Share by the number of Shares Outstanding. Simple sum of the SX7E members. Source: Bloomberg.

Total Equity: Bank's total assets minus its total liabilities. Calculated as: Common Equity + Minority Interest + Preferred Equity. Simple sum of the SX7E members. Source: Bloomberg.

Total Assets: Bank's total assets. Calculated as: Cash and bank balances + Fed funds sold and resale agreements + Investments for Trade and Sale + Net loans + Investments held to maturity + Net fixed assets + Other assets + Customers' Acceptances and Liabilities. Simple sum of the SX7E members. Source: Bloomberg.

C Equations of the Model

This section presents the full set of equilibrium equations of the model presented in Section 3.

C.1 Household

Households seek to maximize their objective function subject to the following budget constraint:

$$C_t + Q_t H_{h,t} + B_{h,t} = W_t N_{h,t} + Q_t H_{h,t-1} + R_t B_{h,t-1} + d_{f,t} + d_{b,t} + \Pi_t + T_t \ , \tag{C.1}$$

Their choice variables are C_t, $H_{h,t}$, $N_{h,t}$ and $B_{h,t}$. The optimality conditions of the problem read

$$\lambda_t = \left(C_t - \frac{N_{h,t}^{1+\phi}}{1+\phi} \right)^{-\sigma_h} \ , \tag{C.2}$$

$$W_t = N_{h,t}^{\phi} \ , \tag{C.3}$$

$$\lambda_t = \beta_h R_t \mathbb{E}_t \lambda_{t+1} \ , \tag{C.4}$$

$$Q_t \lambda_t = \frac{\chi_t}{H_{h,t}} + \beta_h \mathbb{E}_t \left(Q_{t+1} \lambda_{t+1} \right) \ , \tag{C.5}$$

where λ_t is the Lagrange multiplier on the budget constraint of the household.

C.2 Final goods producer (NFC)

Final goods producers maximize their objective function subject to a budget constraint, the available technology and a collateral constraint

$$Q_t (H_{f,t} - H_{f,t-1}) + P_t \left[K_{f,t} - (1 - \delta_{k,t}) K_{f,t-1} \right] = Y_t + L_{f,t} - W_t N_{f,t} - R_{L,t} L_{f,t-1} - d_{f,t}, \tag{C.6}$$

$$Y_t = A_t (u_t K_{f,t-1})^{\alpha} H_{f,t-1}^{\eta} N_{f,t}^{1-\alpha-\eta}, \tag{C.7}$$

$$L_{f,t} \leq m_{f,t} \mathbb{E}_t \left(\frac{Q_{t+1} H_{f,t}}{R_{L,t}} \right). \tag{C.8}$$

Physical capital depreciates at a rate that reflects quadratic costs in capacity utilization, $\delta_{k,t} \equiv \delta_0^k + \delta_1^k (u_t - 1)^2 + \frac{\delta_2^k}{2} (u_t - 1)^2$. The choice variables of final goods producers are u_t, $N_{f,t}$, $d_{f,t}$, $L_{f,t}$,

$H_{f,t}$, and $K_{f,t}$. The following optimality conditions can be derived from the first order conditions of the problem

$$\delta_1^k + \delta_2^k \left(u_t - 1\right) = \alpha \frac{Y_t}{u_t K_{f,t-1}} \ , \tag{C.9}$$

$$W_t = (1 - \alpha - \eta) \frac{Y_t}{N_{f,t}} \ , \tag{C.10}$$

$$\begin{aligned} &[(1-\omega) + \omega d_{f,t}^{-\frac{1}{\sigma}}] \left[Q_t - m_{f,t} \mathbb{E}_t \left(\frac{Q_{t+1}}{R_{L,t+1}} \right) \right] \\ &\qquad = \mathbb{E}_t \left\{ [(1-\omega)\, \Lambda_{t,t+1} + \omega \beta_f d_{f,t}^{-\frac{1}{\sigma}}] \left[Q_{t+1}(1 - m_{f,t}) + \eta \frac{Y_{t+1}}{H_{f,t}} \right] \right\}, \end{aligned} \tag{C.11}$$

$$[(1-\omega) + \omega d_{f,t}^{-\frac{1}{\sigma}}] P_t = \mathbb{E}_t \left\{ [(1-\omega)\, \Lambda_{t,t+1} + \omega \beta_f d_{f,t}^{-\frac{1}{\sigma}}] \left[P_{t+1} \left(1 - \delta_{t+1}^k\right) + \alpha \frac{Y_{t+1}}{K_{f,t}} \right] \right\} \ . \tag{C.12}$$

C.3 Bank

Banks seek to maximize their objective function subject to the law of motion for net worth and a borrowing constraint (capital adequacy constraint)

$$E_t - E_{t-1} = R_{L,t} L_{b,t-1} - R_{t-1} B_{b,t-1} - \delta E_{t-1} - T(d_{b,t}, d_t^\star) - d_{b,t} \ , \tag{C.13}$$

$$B_{b,t} \leq \gamma L_{b,t}, \tag{C.14}$$

where $E_t = L_{b,t} - B_{b,t}$. Their choice variables are $d_{b,t}$, $L_{b,t}$, and $B_{b,t}$. The resulting optimality condition reads

$$(1-\gamma) \frac{(1-\omega) + \omega d_{b,t}^{-\frac{1}{\sigma}}}{[1 + \kappa(d_{b,t} - d_t^\star)]} = E_t[r_{L,t+1} - \gamma r_t + (1-\delta)(1-\gamma)] \frac{(1-\omega)\, \Lambda_{t,t+1} + \omega \beta_b d_{b,t+1}^{-\frac{1}{\sigma}}}{\left[1 + \kappa(d_{b,t+1} - d_{t+1}^\star)\right]}. \tag{C.15}$$

C.4 Capital Goods Producer

Capital-good-producing firms seek to maximize their objective function with respect to net investment in physical capital, I_t. The resulting optimal condition is

$$1 = P_t \left[1 - \frac{\psi_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2 - \psi_I \left(\frac{I_t}{I_{t-1}} - 1\right)\frac{I_t}{I_{t-1}}\right] + \mathbb{E}_t \left[\Lambda_{t,t+1} P_{t+1} \psi_I \left(\frac{I_{t+1}}{I_t} - 1\right)\left(\frac{I_{t+1}}{I_t}\right)^2\right]. \quad \text{(C.16)}$$

As standard in the literature, the law of motion for physical capital reads

$$K_t = (1 - \delta_t^k) K_{t-1} + I_t \left[1 - \frac{\psi_I}{2}\left(\frac{I_t}{I_{t-1}} - 1\right)^2\right]. \quad \text{(C.17)}$$

C.5 Macroprudential Authority

The macroprudential authority sets the recommended bank dividend payout, $d_t^\star$, acoording to a particular rule. Such policy rule is associated to a sanctions regime that penalizes deviations from the recommended payout. In particular, $d_t^\star$ enters a penalty function of the form

$$T(d_{b,t}, d_t^*) = \frac{\kappa}{2}\left(d_{b,t} - d_t^\star\right)^2. \quad \text{(C.18)}$$

C.6 Aggregation and Market Clearing

Market clearing is implied by the Walras's law, by aggregating all the budget constraints. The aggregate resource constraint of the economy represents the equilibrium condition for the final goods market:$Y_t = C_t + I_t + \delta E_t$. The corresponding conditions for housing and physical capital are $\bar{H} = H_{h,t} + H_{f,t}$ and $K_{f,t} = K_t$, respectively, where for simplicity a fixed housing supply $\bar{H}$ is assumed. The clearing condition for labor hours is $N_{h,t} = N_{f,t}$. Lastly, market clearing for deposits is $B_{h,t} = B_{b,t}$, while market clearing for loans is $L_{f,t} = L_{b,t}$.

C.7 Shocks

The following zero-mean, AR(1) shocks are present in the model: $\varepsilon_{mf,t}$, $\varepsilon_{h,t}$, A_t. These shocks follow the processes given by:

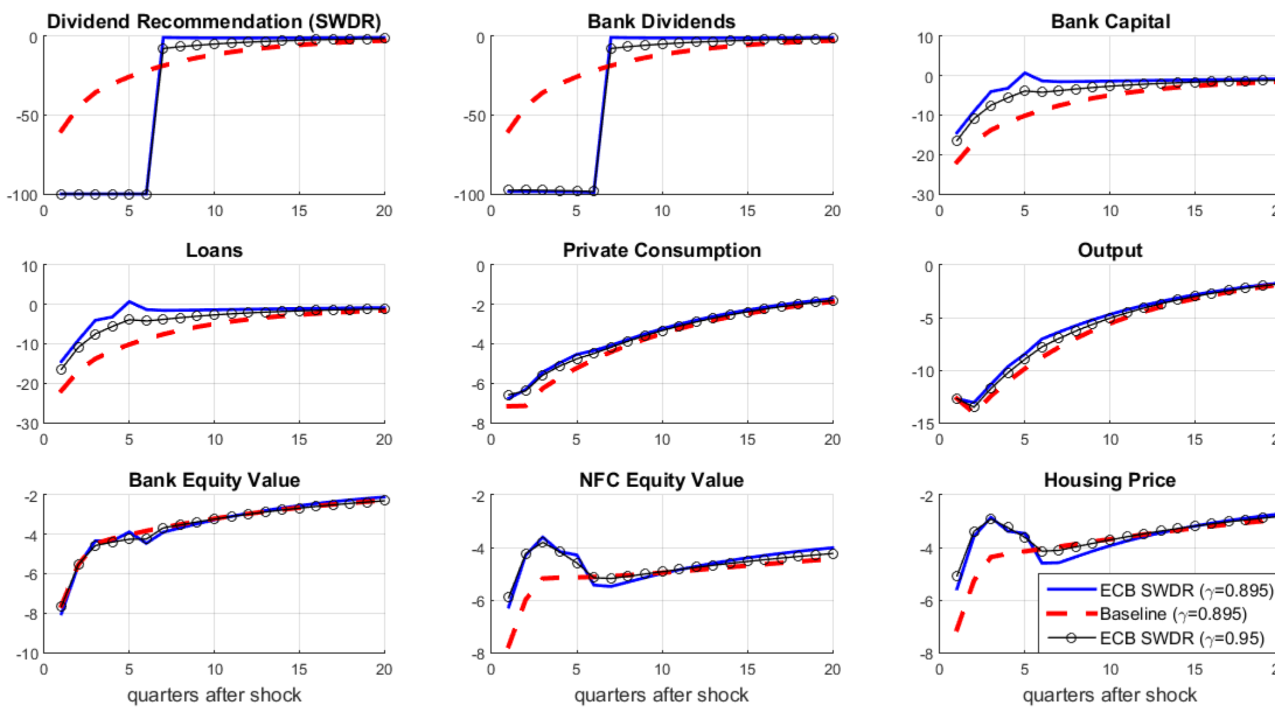
$$\log \varepsilon_{mf,t} = \rho_{mf} \log \varepsilon_{mf,t-1} + e_{mf,t},\;\; e_{mf,t} \sim N(0, \sigma_{mf}), \tag{C.19}$$

$$\log \varepsilon_{h,t} = \rho_h \log \varepsilon_{h,t} + e_{h,t},\;\; e_{h,t} \sim N(0, \sigma_h), \tag{C.20}$$

$$\log A_t = \rho_A \log A_{t-1} + e_{A,t},\;\; e_{A,t} \sim N(0, \sigma_A). \tag{C.21}$$

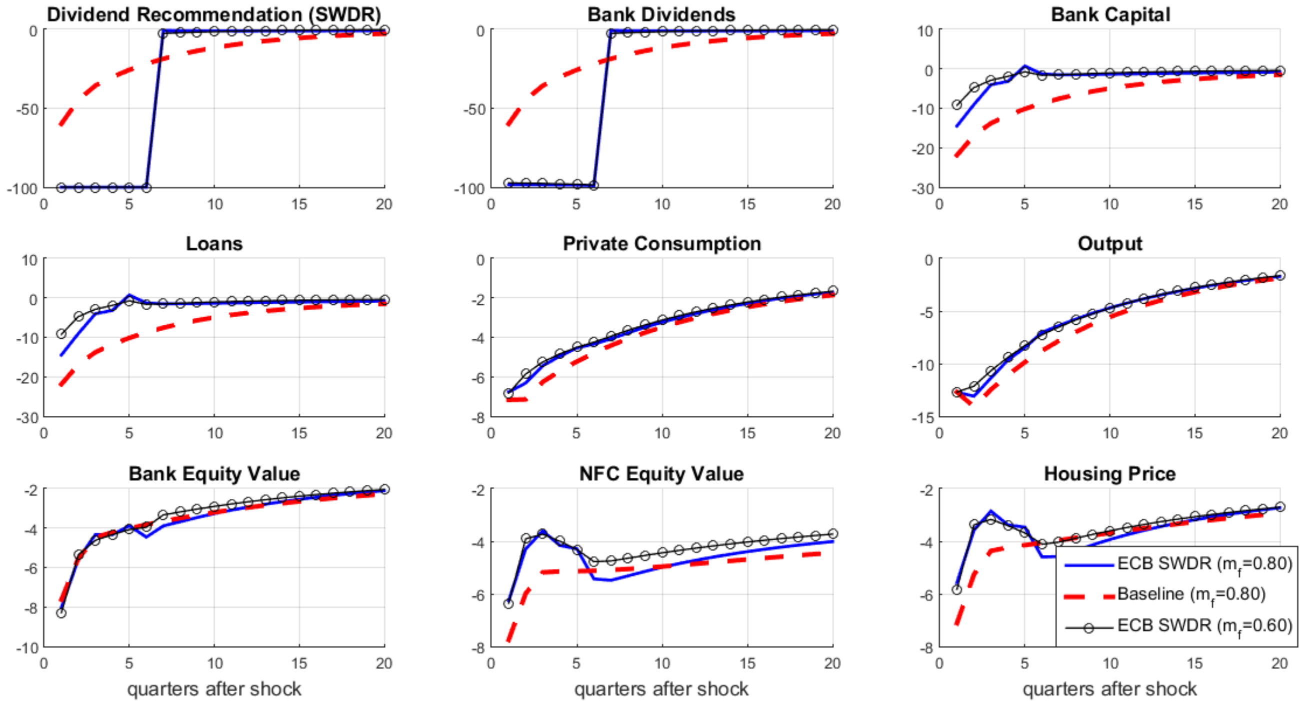
D Quantitative Analysis: Complementary Figures

Figure D.1: Robustness checks (γ): Impulse-responses to the (COVID-19) negative TFP shock



Notes: Variables are expressed in percentage deviations from the steady state. The solid line makes reference to the ECB SWDR scenario. The dashed line refers to the baseline scenario. The dotted line relates to the ECB SWDR scenario under an alternative parameterization of the bank capital adequacy requirement ($\gamma = 0.95$).

Figure D.2: Robustness checks (m_f): Impulse-responses to the (COVID-19) negative TFP shock



Notes: Variables are expressed in percentage deviations from the steady state. The solid line makes reference to the ECB SWDR scenario. The dashed line refers to the baseline scenario. The dotted line relates to the ECB SWDR scenario under an alternative parameterization of the LTV limit ($m_f = 0.6$).

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