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Doubling Down: The Synergy of CCyB Release and Monetary Policy Easing

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ABSTRACT

At the height of the COVID-19 crisis, many countries have reduced their countercyclical capital buffer (CCyB) and cut key policy rates. We exploit this quasi-natural experiment to gauge the combined effects of these two policies on bank lending rates (BLRs). First, we theoretically show that the joint action of CCyB release and monetary policy easing lowers BLRs by more than the sum of their individual effects. We then empirically confirm this synergy by a difference-in-difference analysis. Notably, for a one percentage point release of the CCyB, corporate BLRs decreased by around 11 basis points more compared to countries without CCyB relief.

Keywords: Countercyclical Capital Buffer, Monetary Policy, Policy Complementarity, Lending Rates, Covid-19.

JEL classification: G21, G28, E52, E44.

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Non-Technical Summary

Macroprudential policy has been extensively developed for more than a decade now, with the purpose of preserving financial stability. In particular, capital requirements have been essential to the macroprudential policy toolkit, with key innovations introduced by the Basel III framework like the countercyclical capital buffer (CCyB). This measure requires banks to hold additional capital (up to 2.5%) during expansion periods, in order to limit credit growth. In adverse times, supervisors may allow banks to draw on this buffer during downturns, in order to avoid deleveraging and an excessive tightening of credit conditions, which could further depress activity.

In addition to the question of their effectiveness, the increasing use of countercyclical macroprudential tools has raised the issue of their interaction with monetary policy, especially in influencing bank financing conditions. Whether the two policies could reinforce each other appears critical in times of crisis, when financing conditions may dramatically tighten.

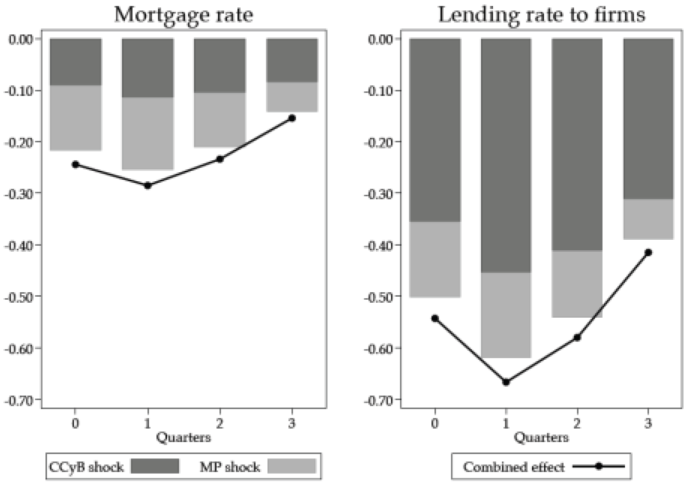
In this regard, the COVID-19 crisis provides a convenient quasi-natural experiment to study the individual and combined effects of macroprudential and monetary policies on credit conditions. Starting in March 2020, central banks across the globe eased their monetary policy, while macroprudential authorities reduced the CCyB buffer for the first time since its implementation.

In this paper, we investigate whether the interaction of monetary policy easing and CCyB relief has significantly eased credit conditions at the height of the COVID-19 crisis. To this end, we follow a two-step approach. First, we theoretically assess the transmission of a CCyB release and its complementarity with monetary policy through the lens of a New Keynesian model including a banking sector and financial frictions. Second, we empirically study the predictions of the model through a difference-in-difference (DID) approach across a sample of 54 countries.

In our theoretical model, we show that individually, both monetary policy easing and CCYB release lowers bank lending rates. However, as shown in Figure 1, their joint action lowers BLRs by more than the sum of their individual effects, thus suggesting complementarity. Nonetheless, the effect on mortgage rates to households appears lower compared to lending rates to firms.

We empirically confirm this finding by a difference-in-difference analysis comparing countries that released their CCyB with countries that did not. Results confirm that the CCyB release and monetary easing have complemented each other to put downward pressure on BLRs during the pandemic, albeit modestly. On average, for countries having released the CCyB, every 1 pp of release translates into an additional 11 bps decrease of corporate BLRs, compared to countries that did not. Importantly, the lower the policy rate the greater this effect, suggesting that the CCyB gave policy space to economies close to the effective lower bound. Mortgage rates also react to CCyB release, but to a much smaller extent. Additionally, the CCyB relief improved the pass-through of monetary policy easing to corporate BLRs. In countries having released their CCyB (compared to countries that did not), BLRs decreased by 18 bps more for any 100 bps cut in the policy rate.

Figure 1. Cumulative vs combined effects of monetary policy easing and CCyB release



Note: The grey bars represent the cumulative response of lending rates to a single 50 bps cut in the policy rate and to a single exogenous CCyB release of 0.5 pp. The solid line represents the combined impact of these two policies implemented simultaneously. The horizontal axis represent quarters.

Analyse de la synergie entre relâchement du CCyB et assouplissement monétaire

RÉSUMÉ

Au plus fort de la crise du COVID-19, de nombreux pays ont autorisé leurs banques à réduire leur volant de fonds propres contracyclique (CCyB) et ont abaissé leurs taux directeurs. Nous exploitons cette expérience quasi-naturelle pour évaluer les effets combinés de ces deux politiques sur les taux des prêts bancaires. Tout d'abord, notre analyse théorique montre que l'effet conjoint de l'assouplissement du CCyB et de la politique monétaire est supérieur à la somme des effets des deux politiques lorsqu'elles sont considérées indépendamment l'une de l'autre. Cette synergie est ensuite validée empiriquement par une analyse en double différence. Nous trouvons qu'une baisse d'un point de pourcentage du CCyB coïncide avec une réduction supplémentaire d'environ 11 points de base du taux débiteur aux entreprises, par rapport aux pays qui n'ont pas bénéficié d'un tel assouplissement macroprudentiel. En outre, plus le taux directeur est bas, plus les avantages de l'assouplissement du CCyB sont importants. Enfin, le relâchement du CCyB a permis d'améliorer la transmission de la baisse des taux directeurs.

Mots-clés : fonds propres, coussins contracycliques, politique monétaire, complémentarité, taux débiteurs, Covid-19

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1 Introduction

Macroprudential policy has been extensively developed for more than a decade, particularly in the wake of the great financial crisis. Designed to preserve financial stability by containing systemic risk, macroprudential tools now benefit from a broad theoretical support (Farhi and Werning, 2016; Bianchi and Mendoza, 2018), confirmed by empirical studies (see, e.g., Akinci and Olmstead-Rumsey, 2018; Galati and Moessner, 2018). Capital requirements, in particular, have been essential to the macroprudential policy toolkit since the first Basel Accord in the late 1980s, further evolving with the introduction of the countercyclical capital buffer (CCyB) in Basel III. By requiring banks additional capital during expansion periods (up to 2.5%), the CCyB is destined to prevent the buildup of systemic risk due to excessive credit growth. Adversely, by allowing banks to draw on this buffer during downturns, its aim is to avoid excessive tightening of credit conditions, which could further depress economic activity.

The development of countercyclical macroprudential tools has also raised the issue of their interaction with monetary policy, and in particular of their ability to support the transmission of monetary policy. This appears critical in times of crisis, when financing conditions may tighten despite monetary easing. In this regard, the exogenous COVID-19 crisis provides a convenient quasi-natural experiment to study the individual and combined effects of macroprudential and monetary policies on credit conditions. As a response to this unanticipated and unprecedented shock in March 2020, central banks around the world eased their monetary policy, by cutting key policy rates and/or implementing unconventional measures. At the same time, macroprudential authorities allowed banks to reduce their CCyB for the first time since its implementation.

Against this background, the aim of this paper is to investigate whether the interaction of the policy rate cut and CCyB relief has significantly eased credit conditions at the height of the COVID-19 crisis. At the time, high credit demand[1] and (expected) bank capital erosion, due to the deterioration of borrowers' solvency, have put upward pressure on funding and borrowing conditions. Banks were facing a rise in systemic risk (Borri and di Giorgio, 2022), despite better capital and liquidity positions compared to past crises (Igan et al., 2022; Giese and Haldane, 2020).[2] In response, authorities have implemented several policy measures to contain the increase in banks' funding costs, and mitigate the negative second-round effects of the crisis through the banking system.

In March 2020, authorities lowered the CCyB for the first time[3] in all countries where it had been implemented[4], most often to zero. The rationale for this policy response was summarized by Luis de Guindos[5]: "*Prudential buffers are designed to be used, or drawn down, in periods of stress. ECB analysis shows that economic outcomes can be considerably better when banks use their buffers while maintaining lending to the real economy, rather than deleveraging in order to preserve them. While using the buffers can have initial negative effects on bank solvency ratios, it ultimately reduces bank losses as the economy can remain healthier due to the easing of credit constraints*". The CCyB release was sudden and drastic, and intervened in a crisis context, with no previous notice. This contrasts with previous decisions, consisting of CCyB hikes only, which occurred during economically stable periods, were announced well in advance and in incremental mode.

[1]For example, in the euro area, the increase in lending to firms reached a record of around 250 billion euros from March to May 2020. Then, the annual growth rate of loans reached an unprecedented 7.3% in May.

[2]According to Lewrick et al. (2020), banks in the world globally entered the COVID-19 crisis with roughly US$ 5 trillion of capital above their Pillar 1 regulatory requirements

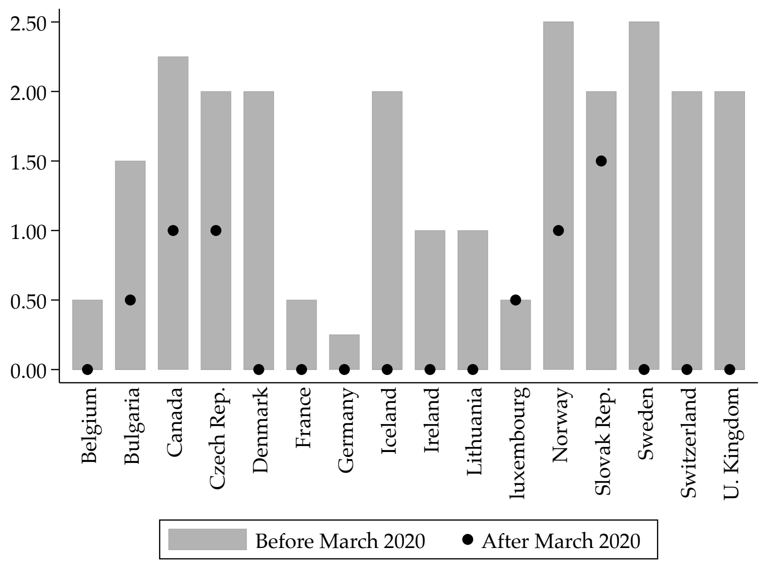
[3]As an exception, the CCyB in the UK fell from 0.5 to 0% in 2016, before rising again.

[4]Except for Luxembourg, where a CCyB increase was announced in December 2018 and then in 2019, but no release was operated in 2020.

[5]Speech at the Frankfurt Finance Summit, 22 June 2020.

Figure 1 shows the evolution of the CCyB rate all the countries having adopted this instrument. All but Luxembourg relaxed their CCyB in March 2020, with the majority even revoking it, like Sweden (where the CCyB rate was at its regulatory maximum) or the UK, Switzerland, Iceland and Denmark, where the CCyB rate was initially at 2%.[6] Additionally, dividend bans were installed in most countries, in order to incentives banks to increase lending following CCyB relief instead of distributing dividends.

Figure 1: CCyB before and after March 2020 (in percent)



At the same time, monetary policy was eased in most countries, both through conventional and unconventional measures. Some central banks have cut their policy rates to the zero lower bound, like the Federal Reserve (Fed) or the Bank of England (BoE), while others have implemented funding for lending schemes, offering banks favourable borrowing conditions to stimulate lending to the real economy.[7] Finally, a significant number of central banks have restarted or extended their asset purchase programmes, destined to lower interest rates along the yield curve and alleviate financial pressures for firms and households.

In this paper, we follow a two-step approach to gauge the combined effect of CCyB release and key rate cut on credit conditions, namely bank lending rates (BLRs) to corporates and households.

First, we theoretically assess the transmission of a CCyB release and its complementarity with monetary policy through the lens of a New Keynesian model with a detailed banking sector and financial frictions. We show that such a measure lowers bank lending rates to firms and, to a lesser extent, mortgage rates to households. The CCyB release also strengthens the transmission of a policy rate cut. As a consequence, the joint action of CCyB release and conventional monetary policy easing lowers BLRs by more than the sum of their individual effect.

Second, we empirically examine these predictions through a difference-in-difference (DID) approach, where we compare countries having released their CCyB with countries that did not. The results confirm that the CCyB release and conventional monetary easing have complemented each other to put downward pressure on BLRs during the pandemic, albeit modestly. On average, for a one percentage point (pp) release of the CCyB, corporate BLRs decreased around 11 basis points (bps) more (up to 21 bps in advanced countries). The lower the policy rate the greater this effect, suggesting that the

[6] Further details on the measures implemented in each jurisdiction and links to official announcements are provided in Appendix A.

[7] The ECB, for example, has implemented TLTRO III operations, in which banks' borrowing rates can be lowered by up to 50 bps depending on the banks' lending portfolio to businesses and households.

CCyB gave policy space to economies close to the effective lower bound. Additionally, the CCyB relief improved the pass-through of conventional monetary policy easing to corporate BLRs. Any 100 bps cut in the policy rate translated into an additional easing of about 18 bps of BLRs in countries having released their CCyB. In the rest of the countries, the transmission of policy rate cut was seemingly dampened at the height of the crisis. We find this policy-mix to have a much smaller effect on the mortgage rates, since the CCyB has eased a constraint that was less binding. Results are robust to different specifications and are not questioned by the numerous placebo tests we perform.

Our contribution fits into three branches of a sparse literature on (i) the effects of CCyB on credit conditions in general, as well as (ii) during the COVID-19 in particular, and (iii) the interaction of CCyB with monetary policy.[8]

First, an extensive body of literature has attempted to assess the impact of regulatory capital requirements on credit conditions. According to surveys by the Basel Committee on Banking Supervision (2010, 2019), based on estimates made since the 2010s, a 1 pp increase in the mandatory capital ratio would generate a 10 to 25 bps increase in BLRs[9], depending on the extent to which the Modigliani-Miller theorem is supposed to apply. Specifically on CCyB, empirical investigations conclude that increasing the CCyB reduces excessive lending (Drehmann and Gambacorta, 2012; Aikman et al., 2015), dampens banks' exposure to riskier assets (Derrick et al., 2020), strengthens banks' balance sheets (De Jonghe et al., 2020), and insures overall financial system resilience (Bui et al., 2017).[10] The impact of CCyB on lending rates has only been examined by a limited number of studies. Basten (2020) finds that banks raised mortgage rates by up to 8 bps following CCyB activation in Switzerland. If tighter capital requirements lead banks to increase their lending rates and reduce their risk-weighted assets[11], capital relief should ease credit conditions and stimulate lending, at least in the short run. Benetton et al. (2021) find that each 1 pp lower risk-weighted capital requirements applied to residential mortgages in the United Kingdom led to a reduction in mortgage rates by 10 to 16 bp. Finally, assessing the impact of a specific measure mirroring a capital buffer release in Slovenia in 2008, Sivec and Volk (2023) support the benefits of a CCyB release in terms of loan supply. Overall, most of these studies rely on microeconomic analysis, which leads the Basel Committee on Banking Supervision (2022) in its October 2022 Report to deplore the lack of conclusions regarding the macroeconomic effects of CCyB.

Second, considering a context of crisis, it is worth noting that according to the theoretical contributions of Gertler et al. (2020), Faria-e Castro (2021) and Elenev et al. (2021), lowering counter-cyclical capital buffers can avoid the amplification of the downturn. Most of the empirical studies addressing capital relief during the COVID-19 pandemic focused on the supply of loans and not on lending rates. Borsuk et al. (2020), the Basel Committee on Banking Supervision (2021b), Barbieri et al. (2022), Couaillier et al. (2022b) and Dursun-de Neef et al. (2023) find that the buffer release had an expansionary impact on credit supply.[12] However, banks that entered the pandemic with capital ratios

[8]We do not address the effects of the CCyB on financial stability, which is beyond the scope of this paper. See for instance Basel Committee on Banking Supervision (2021a) for a broad assessment on this point.

[9]Among the most recent studies, Benetton (2021) finds that a 1 pp higher risk-weighted capital requirements raises lenders' marginal costs of originating mortgages by about 26 bps (11%) on average in the United Kingdom. Damen and Schildermans (2022) find that the tightening of capital requirements in the Belgian real estate sector, corresponding to an increase in risk weights by 5 pp, has led banks to increase their mortgage rates by 19 bp. Bonaccorsi di Patti et al. (2023) find that a 1 percent drop in capital requirements causes an average 13 basis points reduction in the cost of credit in Italy.

[10]Only Illueca et al. (2022) and Auer et al. (2022) question the macroeconomic benefits of such a policy.

[11]See Noss and Toffano (2016); Meeks (2017); Juelsrud and Wold (2020); Gropp et al. (2019); Fraisse et al. (2020); Conti et al. (2022).

[12]The Basel Committee on Banking Supervision (2022) is more mixed, but recognizes that its estimated effect of the CCyB release may be diluted by the use of half-yearly data.

close to the regulatory limit appear to have been reluctant to lend or even decreased their lending (Couaillier et al., 2022a; Berrospide et al., 2021). There is no consensus regarding the effects of CCyB easing on the cost of borrowing. Initial stricter capital requirements mitigated the negative financial effects of the COVID-19 pandemic (Darracq Paries et al., 2020a; Colak and Oztekin, 2021). However, banks may have faced an unintended tightening of credit conditions as they were considered riskier in the wake of capital buffer depletion (Demirguc-Kunt et al., 2021). Moreover, pandemic-related labor market frictions and operational bottlenecks may have contributed to unusually inelastic mortgage supply (Fuster et al. (2021)), driving lender markups at peaks comparable to the 2008 financial crisis.

Third, a limited number of studies address the interaction between macroprudential and monetary policies. Overall, an emerging empirical literature finds evidence of complementarity (Kim and Mehrotra, 2018; Gambacorta and Murcia, 2020; Garcia Revelo et al., 2020), while some find no meaningful interaction (Aiyara et al., 2016). In particular, the question of the effectiveness of monetary policy conditional on banks' capitalization is not clear-cut. Stein and Kashyap (2000) and Kishan and Opiela (2000) find that banks with weak balance sheets have a stronger response to monetary policy shocks compared to healthier banks. On the contrary, Li (2022) shows that monetary policy is more effective when banks are better capitalized. However, Darracq Paries et al. (2020a) suggest that the macroprudential space created by enhancing countercyclical capacity can complement monetary policy actions during a crisis. In the same way, Gambacorta and Shin (2018) show that capital buffers facilitate the transmission of monetary policy easing to lending rates. This is in line with the theoretical findings of Darracq Paries et al. (2020b), although complementarity is not guaranteed in all circumstances (Angelini et al., 2014; Silvo, 2019; Garcia Revelo and Levieuge, 2022). Aikman et al. (2023) find that the CCyB and monetary policy are substitutes. Last, only Altavilla et al. (2023) find a complementarity between monetary policy (TLTROs) and capital release during the pandemic in the euro area.

Our contribution complements this existing literature in several aspects. First, this is among the first papers to investigate the effects of a widespread easing of CCyB, while so far most of the studies have focused on policy tightening in a stable context, with pre-announced and incremental decisions. Second, we focus on the impact on bank lending rates, instead of credit volumes. Volumes are less prompt to react than interest rates and thus more difficult to capture during short time periods like the Covid context. Also, interest rates are crucial to capture potential amplification effects, as shown by a large body of literature in line with Bernanke et al. (1999). Third, we assess the way the CCyB relief and conventional monetary policy easing may complement each other to maintain favorable credit conditions. For the first time, we provide an estimate of the macroeconomic impact of this new policy mix on bank lending rates. To this end, we adopt a two step approach. We first theoretically investigate the complementarity between macroprudential and monetary policies in a New Keynesian (NK) dynamic general equilibrium model. We then empirically validate the predictions drawn from the model through a DID approach. As such, we rely on the the COVID-19 crisis as a quasi-natural experiment.

The rest of the paper is organized as follows. Section 2 exhibits the main features of the macroeconomic model used to analyse the transmission of macroprudential and monetary policies on bank lending rates. In Section 3, we qualitatively investigate the individual and combined effects of CCyB relief and key policy rate cut on lending rates. Section 4 presents the DID methodology and the data used to empirically examine the impact of this policy mix. The results are presented and discussed in Section 5. Finally, Section 6 concludes.

2 The theoretical framework

In this section, we present the main features of the model used to understand the combined effects of CCyB release and monetary policy rate cut. Our analysis builds on the New Keynesian dynamic stochastic general equilibrium model developed by Gerali et al. (2010) and amended by Angelini et al. (2014) and Garcia Revelo and Levieuge (2022). This model has several interesting features that serve our purpose. In particular, it embeds a banking sector and reproduces the stickiness of bank interest rates in a tractable and realistic way, therefore allowing for a gradual pass-through of monetary policy. Moreover, it incorporates bank capital and can thus be used to simulate the role of macroprudential policy. Finally, as a general equilibrium model, it allows for a rigorous analysis of the effect of CCyB on financing conditions.

2.1 Overview of the model

The economy is populated by two groups of households (patient P and impatient I), who work, consume final goods and accumulate housing. Impatient households borrow from banks to finance their housing purchases, at a mortgage rate denoted r_t^{bH}. Entrepreneurs produce homogeneous intermediate goods using labour and capital bought from capital-good producers. They are net borrowers, at lending rate denoted r_t^{bE}. Lending is granted by monopolistically competitive banks, which set interest rates on deposits and loans to maximize their profits. The loans offered to households and entrepreneurs are financed by deposits and bank capital. The latter comes from retained earnings. The banking activity is regulated by the macroprudential authorities, so that banks must comply with a regulatory capital to risk-weighted assets ratio. Last, banks face adjustment costs while changing their deposit and lending rates, which results in interest rate stickiness.

The way macroprudential and monetary policies may impact bank lending rates is fundamentally embedded in the banks' program, which is detailed below. The rest of the model, in particular the household and firms programs, from which wage and price rigidities arise, are provided in Appendix B. The full set of equations is provided in the Online Appendix OA1.

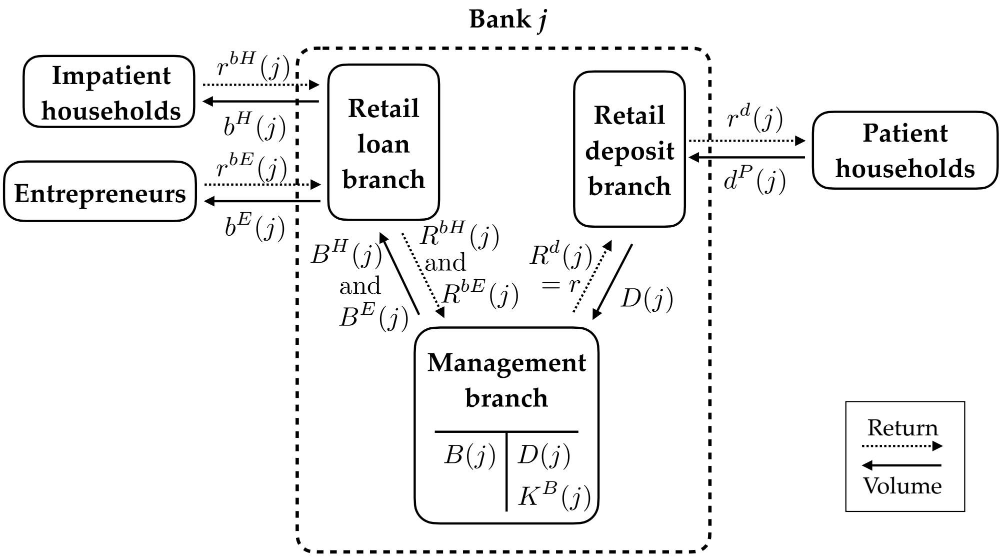
2.2 The banking sector

The banking sector is composed of a continuum of banking groups $j \in [0\ 1]$, which carry out their intermediation activities under monopolistic competition. As represented in Figure 2, each group is made up of a wholesale unit (management branch) and two retail branches. This framework allows to introduce both interest rate rigidity and capital management in a tractable way.

The retail loan branch is in charge of granting loans to impatient households and firms, while the deposit branch collects deposits from patient households, on behalf of the banking group. In doing so, both units face adjustment costs, which trigger realistic lending and deposit interest rate stickiness.

The banking group balance sheet is subject to a mandatory capital adequacy ratio. The wholesale unit manages the bank's capital position in accordance. Following Basel III, the regulatory ratio includes a countercyclical capital buffer (CCyB) modulated on excess credit. Any deviation from this regulatory capital ratio implies quadratic costs for banks. In this way, regulation on bank capital has a key role in determining credit conditions. For example, if the regulator increases capital requirements, the management branch is encouraged to charge higher lending rates to the retail loan branch (denoted R^{bH} and R^{bE} in Fig. 2), to increase its earnings, and so its capital. In turn, the retail loan branch passes on this tightening of internal credit condition to borrowers, through an increase in the mortgage rate (denoted r_t^{bH}) and the lending rate to firms (denoted r_t^{bE}). On the contrary, in case of bank capital release, the same mechanism should lead to higher lending and an easing of credit conditions, especially under a dividend ban as it was the case in 2020.

Figure 2: Schematic representation of banks in the model



The rest of the section describes this transmission mechanism by providing formal details on the optimization programs of each unit of the banking groups.

The retail deposit branch. The retail deposit branch of the banking group j, operating under monopolistic competition, collects deposits $d_t^P(j)$ from households at rates $r_t^d(j)$ and transfers quantity $D_t(j)$ to the management branch, which remunerates these funds at the internal rate $R_t^d(j)$. Each deposit retail unit faces quadratic adjustment costs for changing its deposit rate over time, denoted $\mathcal{A}_d(r_t^d(j))$. Hence, denoting the discount factor $\Lambda_{0,t}^P$, the objective of the retail deposit branch j is to solve :

$$\max_{\{r_t^d(j)\}} \mathrm{E}_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^P \left[R_t^d(j) D_t(j) - r_t^d(j) d_t^P(j) - \mathcal{A}_d(r_t^d(j)) \right] \quad (1)$$

subject to a Dixit-Stiglitz deposit demand curve $d_t^P(j) = \left(r_t^d(j) \;\; r_t^d\right)^{-\varepsilon^d} d_t$, where d_t represents aggregate deposits and $^d < -1$ the elasticity of demand for deposits. The first-order condition of this program defines the way the retail deposit branch optimally sets the retail deposit rate with respect to the adjustment costs, the policy rate and a markdown over the wholesale deposit rate, denoted $\xi^d \equiv {}^d \; ({}^d - 1)$.

The management branch. The management branch is perfectly competitive. It combines bank capital (K_t^b) with retail deposits $D_t(j)$ on the liability side, and total wholesale funds $B_t(j)$ to the retail loan branch on the asset side. In doing so, the management branch pre-allocates wholesale funds for mortgages $B_t^H(j)$ and corporate lending $B_t^E(j)$, with $B_t^H(j) + B_t^E(j) = B_t(j)$. Moreover, this branch manages the capital position of the group. Bank capital is accumulated out of retained earnings, following:

$$K_t^b(j) = (1 - \delta^b) \frac{K_{t-1}^b(j)}{\pi_t} + \frac{\mathcal{P}_{t-1}^b(j)}{\pi_t} \quad (2)$$

where $\pi_t \equiv P_t \;\; P_{t-1}$ is the gross inflation, with P_t the price of final goods, δ^b measures the resources used in managing bank capital, and $\mathcal{P}^b_t$ represents overall bank profits. One may be concerned about the assumption of capital coming only from retained earnings, whereas in normal times banks could also accumulate capital based on equity issuance. However, in a turmoil situation like the COVID-19 crisis banks are usually reluctant to raise equity, all the more that financial markets had collapsed at the time. Note that dividend distribution to patient households is absent from Eq. (2). That is due to our specific focus on the Covid-19 episode, when banks benefiting from lower CCyB rates were asked to refrain from paying dividends.

Bank activity and profits are influenced by macroprudential policy. In line with Basel III regulation, each bank is supposed to meet capital adequacy ratio (CAR) requirements. More precisely, banks' capital to risk-weighted assets ratio must be equal to υ_t, a contingent mandatory level set by the macroprudential authority (according to modalities that are developed below). Any deviation of a bank's capital-to-risk weighted assets ratio from this policy target induces quadratic costs, denoted $\mathcal{D}^{\upsilon}_t(K^b_t(j))$, proportional to outstanding bank capital and parameterized by κ_{car}, such as:

$$\mathcal{D}^{\upsilon}_t(K^b_t(j)) \equiv \frac{\kappa_{car}}{2}\left(\frac{K^b_t(j)}{\;{}^H_t B^H_t(j) + \;{}^E_t B^E_t(j)} - \upsilon_t\right)^2 K^b_t(j) \tag{3}$$

with ${}^E_t$ and ${}^H_t$ being the risk weights relative to entrepreneurs and household loans, respectively.[13] In the case of negative deviations, the adjustment costs correspond to a penalty, whereas for positive deviations, they indicate that it is costly and inefficient to have idle capital. Following Angelini et al. (2014), these weights are procyclical, decreasing (increasing) when annual output growth $(Y_t - Y_{t-4})$ increases (decreases) :

$${}^s_t = (1-\rho_s)\;\; {}^s + (1-\rho_s)\,\chi_s\,(Y_t - Y_{t-4}) + \rho_s\;\; {}^s_{t-1} \tag{4}$$

with $s = H$ for households and $s = E$ for entrepreneurs. $\chi_s < 0$ represents the sensitivity of risk weights to the business cycle, ρ_s is the parameter of persistence, and ^{s} (without time subscript) is the steady-state value of the corresponding weights. For the sake of realism, we also include requirements for the leverage ratio of banks. Any deviation from the regulatory level (lev) implies a quadratic cost parameterized by κ_{lev}, proportional to outstanding bank capital and denoted $\mathcal{D}^{lev}_t(K^b_t(j))$. Details are provided in Appendix B.5.

Then, considering the balance-sheet constraint $B_t(j) = D_t(j) + K^b_t(j)$ and subtracting intra-group transactions, the problem for the wholesale branch in charge of maximizing the profit of the whole banking group reads as :

$$\max_{\{B_t(j),D_t(j)\}} \mathrm{E}_0 \sum_{t=0}^{\infty} \Lambda^P_{0,t}\left[\sum_{s=H,E} R^{bs}_t(j)B^s_t(j) - R^d_t(j)D_t(j) - \mathcal{D}^{\upsilon}_t(K^b_t(j)) - \mathcal{D}^{lev}_t(K^b_t(j))\right] \tag{5}$$

with $s = \{H \;\; E\}$, and where R^{bH}_t and R^{bE}_t are the internal wholesale loan rates to the households and firms retail loan branches, respectively. We assume a monetary policy environment of fixed-rate full allotment, with policy rate denoted r_t. Hence, by arbitrage, the wholesale deposit rate paid by the management branch to the retail deposit unit, $R^d_t(j)$, is equal to r_t, $\forall t$. In this context, the first-order

[13] Note that differences in the risk weights for households and firms explain the differences in wholesale allocations $B^H(j)$ and $B^E(j)$ towards retail branches. Moreover, note that if $\omega^E_t = \omega^H_t$, then $B^H_t(j) = B^E_t(j)$ and $R^{bH}_t(j) = R^{bE}_t(j) = R^b_t$, as in Gerali et al. (2010).

conditions (FOC) of the wholesale bank's program translate into :

$$R_t^{bs}(j) = r_t - \kappa_{car}\left(\frac{K_t^b(j)}{{}_t^E B_t^E(j) + {}_t^H B_t^H(j)} - \upsilon_t\right)\left(\frac{K_t^b(j)}{{}_t^E B_t^E(j) + {}_t^H B_t^H(j)}\right)^2 {}_t^s$$
$$- \kappa_{lev}\left(\frac{K_t^b(j)}{B_t^E(j) + B_t^H(j)} - lev\right)\left(\frac{K_t^b(j)}{B_t^E(j) + B_t^H(j)}\right)^2 \quad \text{for } s = \{H \ E\} \tag{6}$$

These FOCs give the internal wholesale loan rates to the households (R_t^{bH}) and firms (R_t^{bE}) retail loan branches, conditional on the monetary policy rate (r_t) and the capital requirements (υ). When loans increase, ceteris paribus, the actual CAR falls below υ_t, which requires banks to raise lending rates. Similarly, any tightening in capital requirement (i.e., increase in υ_t) leads to a tightening of credit conditions. These wholesale credit conditions are finally passed on by the retail branches of the banking groups to retail lending rates to households and entrepreneurs (r^{bs}).

The retail loan branch. Retail loan branches operate under monopolistic competition. As indicated in Figure 2, they obtain wholesale loans $B_t^s(j)$ at rates $R_t^{bs}(j)$ from the management branch, given regulatory constraints on the balance sheet. They resell the wholesale funds at mortgage rate $r_t^{bH}(j)$ to households and corporate rate $r_t^{bE}(j)$ to firms, after differentiating them at no cost but facing quadratic adjustment costs for changing the rates. These adjustment costs are noted $\mathcal{A}_{bs}(r_t^{bs}(j))$. Thus, the objective of the retail loan branch j is to solve :

$$\max_{\{r_t^{bH}(j), r_t^{bE}(j)\}} \mathrm{E}_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^P \left[\sum_{s=H,E}\left(r_t^{bs}(j) b_t^s(j) - \mathcal{A}_{bs}(r_t^{bs}(j))\right) - \sum_{s=H,E} R_t^{bs}(j) B_t^s(j)\right] \tag{7}$$

with Dixit-Stiglitz loan demand curves given by $b_t^s(j) = \left(r_t^{bs}(j) \ \ r_t^{bs}\right)^{-\varepsilon^{bs}} b_t^s$, where b_t^s represents aggregate loans, and ${}^{bs} > 1$ the elasticities of demand for loans, for $s = \{H \ E\}$. Further details are provided in Appendix B.5. The corresponding two first-order conditions are given by Eq. (OA39) in Appendix OA1. Noting $\xi^{bs} \equiv {}^{bs} \ \left({}^{bs} - 1\right)$ the markup over the wholesale lending rate, the log-linearized version of these FOCs, where interest rates are expressed in terms of deviations from their steady-state value, is given by :

$$r_t^{bs} = \mathcal{F}_1^{bs} R_t^{bs} + \mathcal{F}_2^{bs} r_{t-1}^{bs} + \mathcal{F}_3^{bs} E_t\left(r_{t+1}^{bs}\right) \quad \text{for } s = \{H \ E\} \tag{8}$$

with $\mathcal{F}_1^{bs} \equiv \frac{(\xi^{bs}-1)}{\xi^{bs}-1+(1+\beta_P)\kappa_{bs}}$, $\mathcal{F}_2^{bs} \equiv \frac{\kappa_{bs}}{\xi^{bs}-1+(1+\beta_P)\kappa_{bs}}$, and $\mathcal{F}_3^{bs} \equiv \frac{\beta_P \kappa_{bs}}{\xi^{bs}-1+(1+\beta_P)\kappa_{bs}}$, where β_P is the subjective discount factor of patient households.

Eq. (8) describes the dynamics of lending rates. First, it states that retail BLRs depend on the wholesale rates. Second, monetary and macroprudential policies influence the cost of credit following Eq. (6), through r_t and υ_t, respectively. Third, as a consequence of the rigidities implied by the adjustment costs, the bank lending rate depends on both its expected and past values.

The next section is devoted to the monetary and macroprudential policy rules.

2.3 Macroprudential and monetary policies

The objective of the macroprudential authorities is to dampen the credit cycle. To this end, they manage the countercyclical part of the capital requirements, i.e. the CCyB, in line with the Basel III standards. The CCyB forces banks to accumulate a capital buffer during good times, which they can draw down during a crisis to absorb losses and ensure that credit does not collapse. In our model, CAR requirement is defined by a fixed component denoted υ, augmented by a state-contingent component corresponding to the CCyB. Following Garcia Revelo and Levieuge (2022), this time-varying buffer depends on the credit-to-GDP gap, or "Basel gap", denoted $\widetilde{\frac{B_t}{Y_t}}$ and computed by applying a model-consistent Hodrick-Prescott filter to the credit/GDP ratio. Hence, the CAR rule is given by:

$$\upsilon_t = (\upsilon_{t-1})^{\rho_\upsilon} \left[\upsilon \left(\widetilde{\frac{B_t}{Y_t}} \right)^{\chi_{ccyb}} \right]^{(1-\rho_\upsilon)} {}_{\upsilon,t} \tag{9}$$

where $\chi_{ccyb} > 0$ represents the strength of the response of the CAR requirements to the Basel gap. The parameter ρ_υ captures the gradual adjustment of CAR requirements observed in practice. ${}_{\upsilon,t}$ is a white noise exogenous macroprudential shock, representing discretionary changes in the CCyB. Note that capital requirements would not be countercyclical if $\chi_{ccyb} = 0$.

The objective of monetary policy is to stabilize inflation and the business cycle. To this end, the central bank sets the nominal policy rate r_t following a Taylor-type rule such as :

$$\frac{1+r_t}{1+r} = \left(\frac{1+r_{t-1}}{1+r} \right)^{\rho_r} \left(\frac{\pi_t}{\pi} \right)^{\chi_\pi (1-\rho_r)} \left(\widetilde{Y}_t \right)^{\chi_y (1-\rho_r)} {}_{r,t} \tag{10}$$

where χ_π and χ_y are the response parameters to deviations of inflation π_t from its steady state π and to the model-consistent HP-based output gap $\widetilde{Y}_t$, respectively. The parameter ρ_r captures the degree of interest-rate smoothing, and r is the steady-state value of the policy rate. Last, ${}_{r,t}$ represents a white noise monetary policy shock.

2.4 Calibration

In order to have realistic behaviour of the model, it is important to retain plausible values for its parameters (even if our purpose is not to provide a quantitative assessment, nor to determine optimal policies). Hence, the calibration of the structural parameters, reported in Table C1 in Appendix C, strictly follows the estimates of Gerali et al. (2010). The only exception concerns the adjustment cost parameters related to the leverage ratio and the CAR requirements, which are absent from the original model. They are fixed to 7.63 and 50, respectively, in line with Gambacorta and Karmakar (2018).

The calibration of the policy framework is reported in Table C2. Following empirical evidence, the loan-to-value caps for households and firms are set to 0.8 and 0.9, respectively. In line with the Basel III recommendations, the steady-state capital adequacy ratio (υ) is set to 10.5%, which includes a capital conservation buffer of 2.5% over the regulatory minimum capital requirements of 8%.[14] In line with the standardized approach formulated by the Basel Committee on Banking Supervision for computing risk-weighted assets, the steady-state risk weights for claims on residential property and corporations, ^{H} and ^{E}, are equal to 0 35 and 1 0, respectively. Following Angelini et al. (2014), the sensitivities of household and firm risk weights to the business cycle (χ_s) are set to -15 and -10, respectively, with respective parameters of persistence (ρ_s) equal to 0 94 and 0 92. The policy parameters of the monetary policy rule are those estimated by Gerali et al. (2010). Finally, to match the very high gradualism that is observed in practice on the conduct of the CCyB policy, the reaction parameter to the Basel gap in the CAR rule (χ_{ccyb}) is set to 0.5, with a smoothing parameter ρ_υ equal to 0.99.[15]

[14] Given the simplicity of the bank balance sheet, this implies a leverage ratio of 9% at the steady state, as demonstrated by Eq. (B16) of Appendix B.5. Moreover, this calibration implies that about 10% of bank resources are used in managing capital ($\delta^b = 0.101$).

[15] As studies on macroprudential rules are very scarce, benchmarks are missing. However, this value is in line with Lozej et al. (2022) for example.

3 Theoretical impact of easing CCyB and monetary policy

Following the outline of the model, the objective of this section is to qualitatively investigate the potential individual and combined effects on corporate and household lending rates from a reduction in CCyB and a cut in the policy rate. Section 3.1 depicts the main transmission mechanism of these two policies in the model. In a nutshell, a lower policy rate entails lower borrowing costs for banks (i.e. lower deposit rates). In a competitive environment, banks need to pass on the lower borrowing costs to lending rates (at least partly). As such, they are incentivized to distribute more loans in order to maintain their profit levels. This dynamic also prevails in the case of a lower policy rate and CCyB relief, but to a lower extent, as banks have no incentive to hold excess capital. Idle capital is supposed to be costly and, in line with the March 2020 context, banks are not allowed to pay dividends. The theoretical impact of this policy mix, and these two hypotheses in particular, will be discussed in Section 3.2.

3.1 Theoretical responses of lending rates to easing policies

Figure 3 shows the impulse response functions (IRFs) of different key variables of the model to a macroprudential policy shock corresponding to an exogenous bank capital release of 0.5 pp. As banks are no longer required to hold as much capital as they did initially, they can afford to accumulate less profit (the only source of bank capital formation in the model). In a competitive market, this translates into lower borrowing rates for households and firms.[16] Then, we observe both a decrease in actual bank capital and an increase in loans, i.e. a decrease (increase) in the numerator (denominator, respectively) of the solvency ratio, which falls in line with the reduction of capital requirements. Note that the monetary policy tightening – in response to the stimulative macroeconomic impact of the CCyB relief – partly counteracts the expected benefit of the macroprudential easing.

The mortgage rate decreases less than the lending rate to firms because the (steady state) risk weight for claims on residential property (^{H}) is lower than the weight for claims on firms (^{F}), in accordance with banking regulations. In the light of Eq. (6) this entails a lower sensitivity of the mortgage rate to changes in capital requirements. In other words, the loosening of capital requirements relaxed a constraint that is less binding for mortgage rates relative to corporate rates. We also observe that the decrease in capital requirements is highly inertial, due to the high value of the autoregressive parameter ρ_υ and the rather low value of the policy parameter χ_{ccyb}. Not only does it correspond to the inertia observed in practice for this policy instrument, but it is also consistent with the forward guidance that has sometimes accompanied CCyB reduction announcements in March 2020.[17]

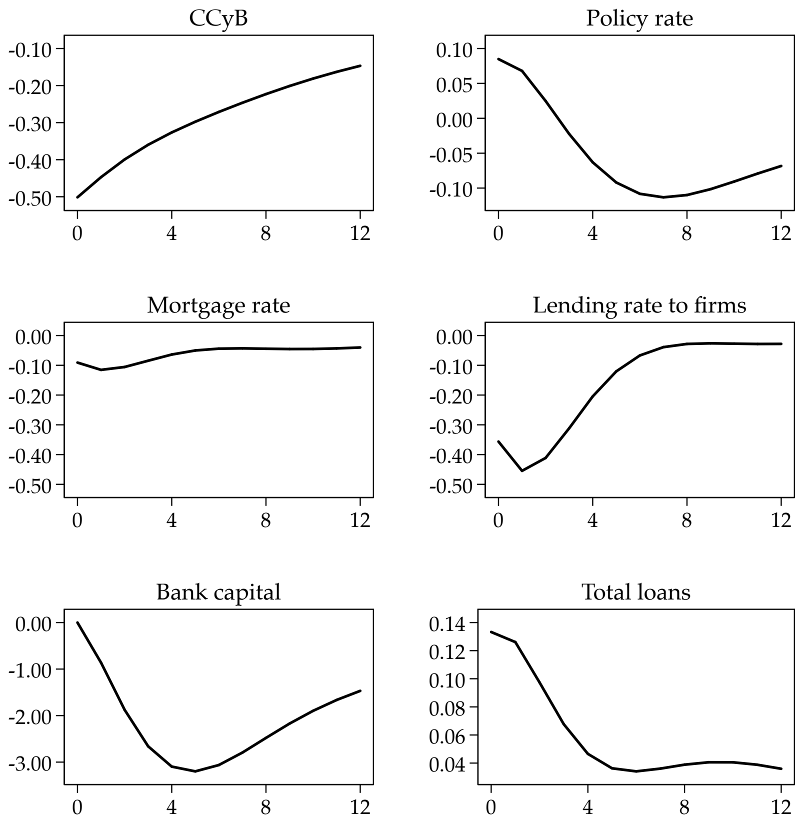
Next, the response of the model to a monetary policy easing shock – corresponding to a policy rate cut of 50 bp – is represented by the dashed lines in Figure 4. It translates into a reduction of the cost of funding for the banking groups, as $R_t^d = r_t$ in Eq. (5). As a result, in the absence of any change in macroprudential policy (and therefore in the banking group's balance sheet constraint), the internal lending rates R_t^{bs} are lower (See Fig. 2). This ultimately lowers banks' lending rates to households and firms and stimulates credit activity. However, the interest rate pass-through is incomplete. This realistic feature reflects the effect of adjustment costs, but also in part the response of macroprudential policy: according to the CAR rule (9), the increase in the Basel gap leads macroprudential authorities to raise the CCyB, pushing up lending rates (Eq. 6). The downward effect of monetary policy easing

[16] More formally, the fall in υ_t makes R_t^{bs} decrease in Eq. (6), which in turns causes r_t^{bs} to fall according to Eq. (8).

[17] Fritsch and Siedlarek (2022) emphasize the importance of macroprudential policy announcements in shaping bank behavior.

on lending rates can therefore be expected to be even stronger, if countercyclical capital requirements are relaxed instead of being tightened.

Figure 3: Responses to CCyB release



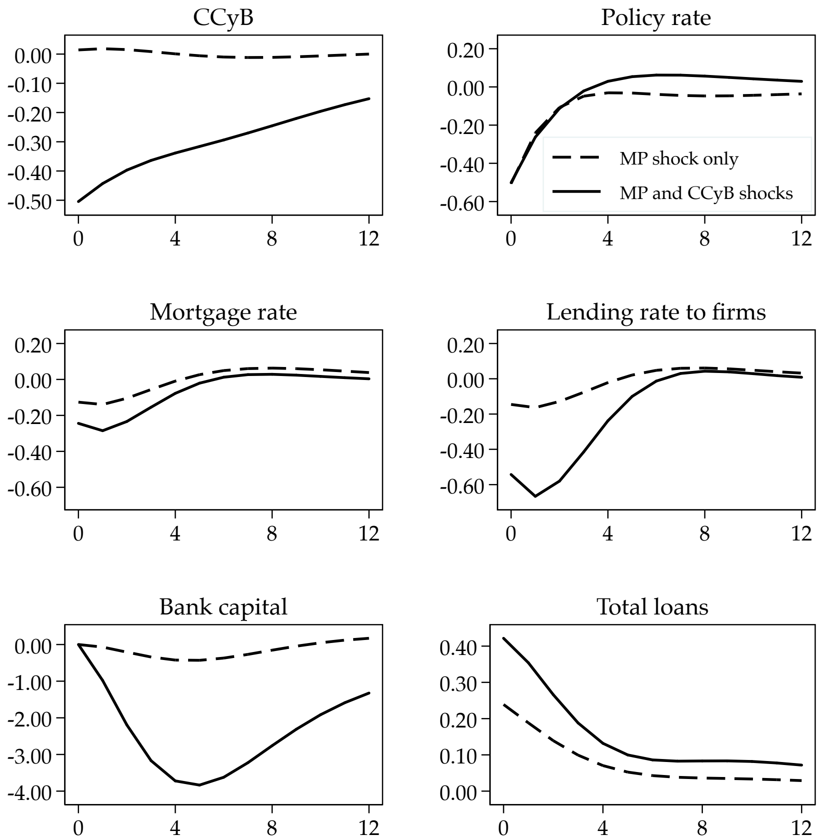
Note: These plots represent the responses of different key variables to an exogenous CCyB release of 0.5 pp. Interest rates are represented in terms of deviations from steady state in pp. The other variables are percentage deviations from steady state.

The solid lines in Figure 4 precisely show the responses of the model to simultaneous macroprudential and monetary shocks, corresponding to a capital release of 0.5 pp and a policy rate cut of 50 bp. Compared to the scenario with only the monetary shock, we can see that the easing of macroprudential policy strengthens the impact of monetary policy: the maximum decrease in lending rates, which is reached two quarters after the initial shock, goes from -14 bps to -28 bps for the mortgage rate, and from -17 bps to -66 bps for the lending rate to firms. In the same way, we can see in Fig. 4 that the impact of a CCyB relief is stronger when monetary policy is jointly eased, compared to when the CCyB is independently conducted. For example, comparing the solid lines in Fig. 3 and 4 two quarters after the initial shock, the mortgage and business rates are respectively 17 and 21 bps lower when monetary policy is jointly eased compared to the CCyB only shock.

Finally, as an evidence of synergy, Figure 5 shows that the combined impact on lending rates is greater than the simple cumulative effect of the two policies considered independently. The difference between cumulative and combined responses can be more or less important, depending on the calibration of the model in general, and on the parameters of the policy rules in particular.[18] Nevertheless, the exploration presented here clearly shows that, with standard calibration and without forcing the policy responses, the two easing policies can reinforce each other to further ease financing conditions.

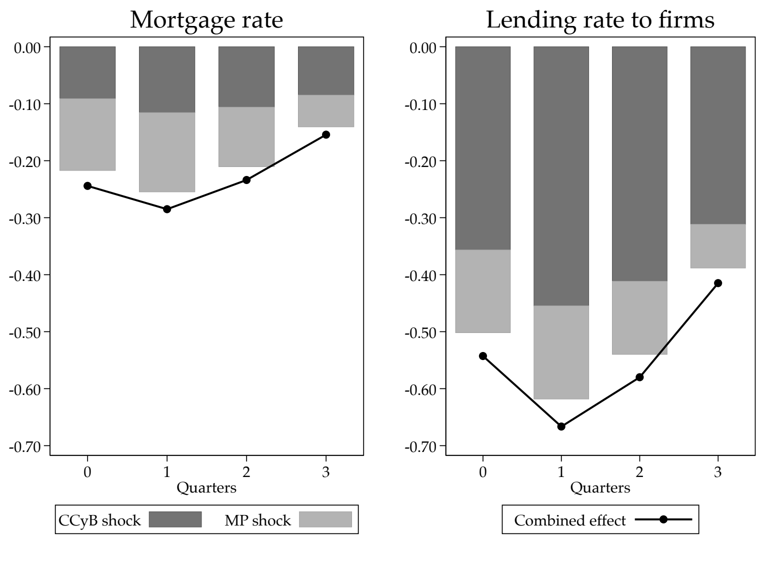
[18]Determining which policy rules may be conducive of a higher or lower combined responses is beyond the scope of this investigation, but could be an interesting avenue for further research.

Figure 4: Responses to monetary policy easing and CCyB release



Note: These plots represent the responses of different key variables to an exogenous monetary policy shock corresponding to a 50 bps cut in the policy rate, with / without an exogenous CCyB release of 0.5 pp. Interest rates are represented in terms of deviations from steady state in pp. The other variables are percentage deviations from steady state.

Figure 5: Cumulative vs combined effects of monetary policy easing and CCyB release



Note: The grey bars represent the cumulative response of lending rates to a single 50 bps cut in the policy rate and to a single exogenous CCyB release of 0.5 pp. The solid line represents the combined impact of these two policies implemented simultaneously. The horizontal axis represent quarters.

The greater cumulative effect is explained by different channels. First, a decrease in the capital requirement during a crisis reduces the need for banks to raise their retained earnings through increases in BLRs. Moreover, by giving leeway to banks, such a measure prevents lenders from deleveraging. Instead, it creates incentives for them to extend the supply of credit, which leads to a decrease in BLRs. Conversely, in the absence of a simultaneous discretionary easing of the policies, each policy by its own, be it monetary or macroprudential, would tighten – following its reaction function – in response to the stimulus generated by the easing of the other policy.

Moreover, in practice, the positive effect of the CCyB relief could be reinforced to the extent that policymakers, by lowering capital requirements, send a signal about their willingness to ensure favourable financing conditions. This *signalling* channel may help to restore confidence and reduce uncertainty during crisis.

3.2 Discussion on possible mitigating factors

Several mitigating factors may explain why, in practice, the combined impact of CCyB release and monetary policy easing may not be as straightforward as the model would suggest. In particular, we identify three main factors concerning (i) banks' capital reaction, (ii) the efficiency of the CCyB policy, and (iii) the reaction of BLRs.

Banks' capital reaction Banks may adjust their capital differently than the model assumes. The reduction in CCyB in 2020 may have raised concerns about the future ability of banks to absorb losses. Hence, riskier banks may have faced higher funding costs (more or less depending on the extent to which the Modigliani-Miller theorem applies), leading to a contradictory tightening of credit conditions. Such a stigma effect could discourage banks from using their capital buffer. In addition, according to Matyunina and Ongena (2022), the dividend ban implemented in the wake of the CCyB release diminished the banking sector's attractiveness for investors. This could have raised expected funding costs and contributed to banks' reluctance to make use of their capital buffers. Last, even if the policy mix had led to a decrease in banks' financing costs, as authorities had hoped, banks might have preferred to increase their capital (wealth effect) rather than grant more loans at lower rates, especially in a context of high uncertainty. Overall, this suggests that accumulating or keeping (excess) buffers would not be as costly as assumed in the model.

CCyB policy efficiency As shown in Figure 1, initial capital buffers were not at their maximum, implying limited capital leeway and counter-cyclicality capacity (Van Oordt, 2023). Also, many banks entered the crisis with excess capital above the regulatory minimum. Hence, the buffer release loosened a constraint that was not actually binding. Moreover, even banks not subject to CCyB were able to mobilize their excess capital, which could bring little comparative advantage to CCyB. Altavilla et al. (2023) show that banks are less (more) sensitive to increases in capital requirements when they have large enough (close to zero) excess capital. Finally, even if policymakers sometimes communicated on the duration of the easing policies[19], the CCyB relief might have raised uncertainty about future capital requirements and the risk to quickly replenish the buffers post-crisis. This policy uncertainty may have acted as an obstacle to "buffer usability" (Couaillier et al., 2022b).

[19]See, e.g. Villeroy de Galhau (2021): "After the crisis, supervisors will provide banks with sufficient time to rebuild their buffers, taking account of economic, market and bank-specific conditions".

Reaction of BLRs The model may overstate the reaction of BLRs. First, the IRFs measure the deviation from steady state attributable to exogenous economic policy shocks, but ignoring the negative COVID-19 shock, which caused the economy to fall below steady state. Second, according to Levieuge and Sahuc (2021), bank lending rates are downward rigid: banks tend to adjust their rates more slowly and less completely to policy easing than to policy tightening. Thus, credit conditions may not decmine as much as predicted by a linear model.

It is important to keep in mind these mitigating factors when empirically assessing the combined effects of CCyB relief and monetary policy easing undertaken at the height of the COVID-19 crisis. The next section is precisely dedicated to this investigation.

4 Empirical analysis: method and data

4.1 Difference-in-difference method

In this empirical exercise, we seek to validate the lessons drawn from the theoretical model developed in section 3. To this end, we rely on a difference-in-difference approach (DID). We consider the CCyB release as a treatment and we compare the evolution of interest rates in countries having released their CCyB in March 2020 (treated countries) to countries that did not (non-treated or control countries)[20]. The logic behind DID is that outcome in non-treated countries can, under certain conditions, provide a counterfactual for outcome in treated countries in the absence of treatment.

We define a treatment dummy variable T_i such as $T_i = 1$ for treated countries i and $T_i = 0$ for non-treated. We consider as outcome variable both the lending rate to non-financial corporates ($BLR^E_{i,t}$) and the mortgage rate to households ($BLR^H_{i,t}$). We evaluate the effect of the treatment on these two outcomes over six months, three months before and three months after the CCyB relief, which occurred in March 2020. This allows us to control that results are not driven by a temporary shock specific to a time period, as a simple two periods DID might yield. Hence, we define P_t as a dummy variable, such as $P_t = 0$ for pre-treatment if $t = \{\text{January to March}\}$, and $P_t = 1$ for post-treatment if $t = \{\text{April to June}\}$. Finally, we define $D_{i,t} = P_t \times T_i$, which equals 1 for treated countries post-treatment and 0 otherwise.

Moreover, as we focus on the combined effect of lower CCyB and key rates (denoted $r_{i,t}$), given the lessons from section 2.3, we also consider the interaction term $D_{i,t} \times r_{i,t}$. The policy rate is also introduced on its own to purge the differences between the treated and the control group that are due to monetary policy changes that happened at the same time as the CCyB release in March 2020. Hence, our DID estimation follows:

$$BLR^s_{i,t} = \alpha + \beta P_t + \gamma T_i + \delta D_{i,t} + \quad (D_{i,t} \times r_{i,t}) + \rho r_{i,t} + \Phi X_{i,t} + u_{i,t} \qquad (11)$$

where X represents a set of control variables and $u_{i,t}$ is the error term. The coefficient α is the average BLR in the control group before treatment. The coefficient β shows the average change in the outcome variable before and after treatment for countries in the control group. This change along the time dimension is common among the two groups of countries and thus represents a time fixed

[20] Here we focus on a discrete treatment. One may also imagine a continuous treatment, in order to exploit the heterogeneity in the CCyB release, ranging from 0.25 to 2 pp (see Fig. 1). However, constructing control groups at the macro-level for a continuous treatment would be challenging, as we already only have a total of 15 countries having released their CCyB. Such an exercise could potentially be performed through a multi-country micro-level analysis, which is left for further extension.

effect. The γ coefficient shows the systematic difference between the treated and the control group. This difference exists even in the absence of treatment and is assumed constant, representing a group fixed effect (further allowing to formally perform a parallel trends test). As such, the DID controls for unobservable time and group characteristics that confound the effect of the treatment on the outcome. Coefficients δ and   represent the change in the outcome variable that is specific to the treated group in the post-treatment period, or put it another way, the causal effect of treatment for treated countries compared to non-treated ones.

By rearranging the terms we can write:

$$BLR^{s}_{i,t} = \alpha + \beta P_t + \gamma T_i + (\delta + \quad r_{i,t})\, D_{i,t} + \rho r_{i,t} + \Phi X_{i,t} + u_{i,t} \tag{12}$$

As such, the effect of the CCyB release (the treatment) on lending rates is given by

$$\frac{BLR^{s}_{i,t}}{D_{i,t}} = \delta + \quad r_{i,t} \tag{13}$$

suggesting that the CCyB release can impact BLRs directly, but also indirectly, conditional on the policy rate. In turn, the transmission of monetary policy to bank lending rates is conditional on the CCyB treatment :

$$\frac{BLR^{s}_{i,t}}{r_{i,t}} = \rho + \quad D_{i,t} \tag{14}$$

where ρ measures the policy rate pass-through to lending rates in the absence of CCyB relief (when $D_{i,t} = 0$), while   captures the additional pass-trough of the policy rate to BLRs for treated countries.

The validity of the DID estimation relies on two assumptions. The first is the parallel trends assumption, which requires trends in BLRs for the treated and the control group to be similar prior to treatment. By extending the parallel trends to the post treatment period, one can use the control group as a counterfactual for the outcome of the treated group in the absence of treatment. We formally check this assumption by performing parallel-trend tests. The second assumption ensures no anticipation of treatment - that is that banks did not anticipate the CCyB release and therefore did not change their BLRs prior to treatment. In this sense, the COVID-19 crisis offers a "natural experiment", as it sanitary nature and rapid unfolding ensure that the policy change was unexpected. We still formally check this assumption through Granger causality tests.

4.2 Data

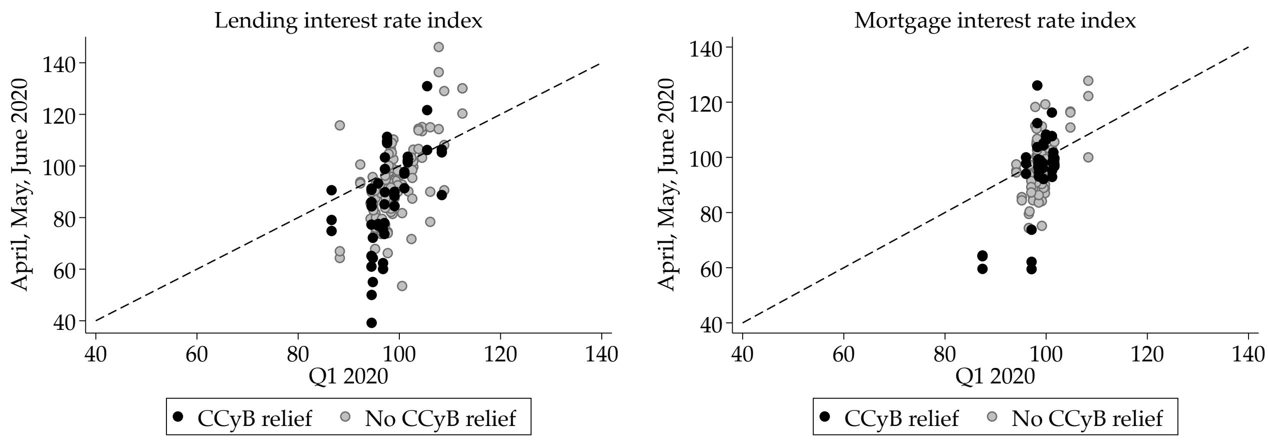
Our DID estimation relies on monthly financial and macroeconomic data for a sample of up to 54 countries. The treated group is represented by 15 countries that have lowered their CCyB in March 2020 in response to the COVID-19 crisis. The control group is represented by 39 countries that did not have a CCyB instrument or have not lowered it in March 2020. The list of treated and control countries can be found in Table D1 in Appendix D. Further details are provided in Fig. 1 and Appendix A.

For our outcome variables (the lending rate to corporates and the mortgage rate to households) we rely on data provided by national central banks for new lending. A first challenge we are facing is the different level of the interest rates among countries. Some have very low interest rates, like France or Germany, with 1.5% for the corporate BLR in the spring of 2020, while others have higher rates, like New Zealand, with a BLR of 8% in the same period. Treated countries, which are mostly developed ones and generally applying highly accommodative monetary polices, tend to have lower interest rates compared to control countries: 2.4% on average for the corporate BLR in the treated group compared to 5.6% in the control group (see Table D3 in Appendix D). A same 50 bps cut in the policy rate does not translate into the same policy easing if the starting point is 1.5% or 8%. As this may be problematic for DID analysis, we circumvent this issue by rescaling the interest rates with respect to the start of the year. We thus construct interest rates indexes equal to 100 in January 2020.

A summary statistics of interest rates before and after the CCyB release in treated and non-treated countries in presented in Table D4 in Appendix D. One may be concerned about potential endogeneity in the attribution of treatment - that is regulatory authorities releasing CCyB in countries where it was most needed – i.e where BLRs were relatively higher to start with. On the contrary, as shown in Table D4, the average BLR for treated countries before treatment is significantly lower than for non-treated countries (2.62% vs 5.80%). The same holds true if we look only at advanced countries. Moreover, among advanced countries, one may also suspect that countries close to the zero lower bound could rely more on CCyB release to help put a downward pressure on lending conditions. Instead, we observe the opposite: the policy rate is actually close to zero for the control group and is strictly positive for the treated group (0% vs 0.49%). As such, treated countries were not self-selected based on constrained monetary policy, therefore rejecting the idea of a endogenous attribution of the CCyB treatment.

The scatter plots in Fig. 6 links the average lending rates in Q1 2020 (on the x-axis) to the individual values reached throughout April, May and June 2020 (y-axis). Black (grey) circles refer to countries that have (not) released their CCyB. We observe in the left-hand plot an overall decrease in corporate BLRs in Q2 compared to Q1, as most of the circles are below the 45° line. Corporate BLRs in treated countries appear more concentrated below the 45° line and lower compared to BLRs in non-treated countries. As shown in right-hand plot, the evolution of mortgage rates is less clear-cut. The scatter points are concentrated around the 45° line, with poor evidence of lower mortgage rates for countries having decreased their CCyB.

Figure 6: Interest rates index before / after March 2020



Note: The dash line represents the 45° line. Interest rate index = 100 in January 2020.

In our DID estimation, we are interested in isolating the impact of the CCyB and quantifying its interaction with monetary policy. As the policy rate in some countries was at the time constrained by the zero lower bound, we rely on the three-month inter-bank rate to proxy conventional monetary policy.

Several control variables that may also have an influence on BLRs are introduced into the regressions. Importantly, to better assess their potential influence, we take into account vintage data, i.e. data as it was available and announced at that time. A first control variable concerns the size of the asset purchase programs announced by central banks in the spring of 2020, as a measure of unconventional monetary policy (denoted QE). In addition, as governments have also responded to the COVID-19 crisis with a battery of fiscal measures, we include in our estimation the announced fiscal packages and the size of public loan guarantees. Moreover, we control for the sovereign borrowing costs as measured by the 10 year yield on government bonds, which may trigger an overall reassessment of risk with consequences for the private sector's cost of borrowing. Lending rates may also have been influenced by expectations about the future macroeconomic environment. Therefore, we include the growth and inflation forecasts for the current year, as they appear in the vintage projections of the Consensus Forecast that were available from January to June 2020. Finally, the demand for credit may have been dampened by the confinement measures taken in the spring of 2020. Hence, we have also considered the Oxford index of stringency of lockdown measures. The definitions and the data sources for all the variables can be found in tables D2 and D3 in Appendix D.

5 Empirical results

5.1 Baseline results

Based on the theoretical considerations in section 3 and the empirical setting laid out in section 4.1, we present here the results of our DID estimations, run on the entire sample of 54 countries. Table 1 reports the results of DID with the corporate lending rate as an outcome variable, while Table 2 considers the mortgage rate. The first column starts with the most parsimonious estimation, considering only CCyB release, monetary policy and their interaction. The following columns progressively add controls, like the expected growth and inflation, the size of asset purchase programs, the stringency of confinement measures, the size of fiscal stimuli and the sovereign interest rate. These factors influence BLRs as well as potentially explain the differences in BLRs between treated and control countries.

The results in Table 1 indicate that the corporate lending rate has declined significantly more in countries having reduced their CCyB compared to countries that did not. More precisely, based on column (1) and in reference to Eq. (13), the CCyB relief impacts the corporate BLR by $-21\ 84 + 0\ 184 r_{i,t}$ (in percent), with $r_{i,t}$ representing the policy rate index. Both coefficients are significant at the 5% or 1% level. The lower the policy rate, the greater the benefit of the CCyB relief. This interaction is quite appealing from a policy complementarity perspective: it suggests that the releasing the CCyB has allowed countries whose policy rate was already low (e.g., at or close to the effective lower bound) to regain some room to manoeuvre. This conclusion is valid for all the specifications (1) to (8), regardless of the control variables included.

Based on the estimates in column (1) and the summary statistics in Table D4 in Appendix D, we can infer that for a policy rate index of 90.4, corresponding to the post treatment mean index for treated countries, the CCyB release implies an additional decrease of 5,21% of the BLR index, compared to the control group. When translating that to actual values of interest rates, for an average BLR of 2,62% in treated countries before the treatment, the CCyB relief explains an additional decrease for these countries of about 13 bps post-treatment. This represents about one third of the total decrease in BLRs observed for the treated group before and after the treatment (i.e. from Q1 to Q2 2020). Finally, relative to the average CCyB *decrease* of 1.20 pp observed in 2020, this estimate implies that a 1 pp cut in the CCyB translates into a 11 bps decline in the corporate BLR. Compared to the empirical literature, our result is in the lower range of estimates for a 1 pp *increase* in capital requirements. Several mitigating factors discussed in Section 3.2 are likely to explain the relatively smaller effect of the CCyB release in the context of the COVID-19 crisis, compared to previous CCyB increases.

Table 1: DID estimations of the effect of CCyB and policy rate on corporate BLRs (baseline)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CCyB	-21.84***	-21.31***	-20.51***	-21.65***	-21.25***	-21.61***	-21.86***	-21.18***
	(6.463)	(6.473)	(6.643)	(7.050)	(6.859)	(7.263)	(7.145)	(7.016)
policy rate	0.011	0.014	0.016	0.017	0.015	0.018	0.017	0.018
	(0.038)	(0.044)	(0.044)	(0.046)	(0.048)	(0.048)	(0.046)	(0.047)
CCyB ×	0.184**	0.182**	0.174**	0.180**	0.177**	0.179**	0.180**	0.171**
policy rate	(0.069)	(0.069)	(0.072)	(0.073)	(0.072)	(0.075)	(0.075)	(0.076)
inflation		0.143	0.708	0.775	0.495	0.795	0.792	0.191
		(2.291)	(2.180)	(2.289)	(2.404)	(2.323)	(2.317)	(2.700)
growth		0.320	0.593	0.524	0.518	0.537	0.571	0.523
		(0.674)	(0.648)	(0.661)	(0.673)	(0.689)	(0.667)	(0.675)
QE			0.168	0.127	0.152	0.126	0.124	0.124
			(0.118)	(0.122)	(0.125)	(0.122)	(0.121)	(0.129)
stringency				-0.096*	-0.097*	-0.094	-0.093	-0.099*
				(0.057)	(0.057)	(0.059)	(0.060)	(0.058)
stimulus					-0.178			
					(0.363)			
liquidity						0.027		
						(0.229)		
guarantees							0.071	
							(0.246)	
gov_rate								0.008
								(0.013)
Treated	15	15	15	15	15	15	15	15
Control	39	36	36	36	36	36	36	36
Obs.	324	306	306	306	306	306	306	288

Note: The dependent variable is the corporate lending rate. Regressions include monthly time fixed effects. Standard errors in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$. The first three lines correspond respectively to coefficients δ, ρ and ω in Eq. (11) to (14).

Moreover, while the interaction term between CCyB release and monetary policy is significant, the policy rate by itself does not appear as a significant driver of BLRs in Table 1. In reference to Eq. (14), this means that the interest rate channel was seemingly dampened during the COVID crisis in the absence of CCyB release. Put in another way, only countries that lowered their CCyB have benefited from a meaningful pass-through of monetary policy to lending rates in the short run. The estimation suggests that any 100 bps cut in the policy rate would translate into an easing of about 18 bps of the BLR on average in treated countries only (slightly more or less depending on the specifications (1) to (8)).

The parallel trends test and the Granger test of no-anticipation of treatment confirm the validity of our DID analysis (reported in Table D6 in Appendix). The null hypothesis of parallel trends and no change in behavior prior to treatment are never rejected at usual significance levels.

Regarding the control variables, we note that asset purchase programs, announced by central banks in March and April 2020, does not seem to have significantly put downward pressure on lending rates in the short run.[21] Fiscal stimulus measures, and namely public loan guarantees, may have influenced the volume of corporate loans but not so much the cost of borrowing.[22]

Results presenting the effects of CCyB release on the mortgage rate[23] are presented in Table 2. In reference to column (1), both the CCyB and the interaction are significant at least at the 5% level. Hence, the mortgage rate index has decreased by $-17\ 15 + 0\ 171 r_{i,t}$ (in percent) more in countries having release their CCyB compared to countries that did not. Given the average policy rate index of 90.4 for treated countries in the post treatment period, the CCyB release implies an additional decrease of 1,69% of the mortgage rate index. Hence, relative to the actual value of the mortgage rate of 2,06% for treated countries before treatment, the CCyB relief explains an additional decrease of around 3 bps after the treatment, compared to the non-treated countries. We thus find a very modest effect of the CCyB release on mortgage rates. This appears in line with the predictions or our theoretical model summarized in Figure 5 and confirms the intuition from Figure 6 of a very slight decrease in mortgage rates in the spring of 2020 (see Table D4 in Appendix for additional descriptive statistics).

Table 2: DID estimations of the effect of CCyB and policy rate on mortgage rates (baseline)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CCyB	-17.15**	-18.09**	-17.63**	-17.61**	-17.15**	-17.58**	-16.81**
	(7.565)	(7.690)	(7.575)	(7.581)	(7.872)	(7.147)	(7.723)
policy rate	0.005	0.003	0.004	0.004	0.000	0.007	0.006
	(0.015)	(0.015)	(0.015)	(0.015)	(0.017)	(0.013)	(0.017)
CCyB ×	0.171***	0.177***	0.174***	0.174***	0.169**	0.167***	0.169**
policy rate	(0.062)	(0.063)	(0.062)	(0.062)	(0.065)	(0.057)	(0.063)
inflation		0.654	0.912	0.913	0.243	1.138	1.082
		(1.847)	(1.918)	(1.927)	(1.997)	(1.911)	(2.199)
growth		-0.400	-0.280	-0.281	-0.282	-0.244	-0.256
		(0.511)	(0.525)	(0.528)	(0.507)	(0.545)	(0.586)
QE			0.060	0.061	0.102	0.047	0.084
			(0.108)	(0.107)	(0.093)	(0.105)	(0.116)
stringency				0.003	0.003	0.021	-0.010
				(0.048)	(0.046)	(0.049)	(0.051)
stimulus					-0.321		
					(0.193)		
liquidity						0.200	
						(0.202)	
gov_rate							0.001
							(0.004)
Treated countries	14	14	14	14	14	14	14
Non-treated countries	32	31	31	31	31	31	28
Observations	276	270	270	270	270	270	252

Note: The dependent variable is the household mortgage rate. Regressions include monthly time fixed effects. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The first three lines correspond respectively to coefficients δ, ρ and ω in Eq. (11) to (14).

[21] We also estimated the combined impact of CCyB relief and measures of unconventional monetary policy (instead of the policy rate). The results were never significant, regardless of the unconventional measure considered.

[22] We have tested several fiscal stimulus variables, from different sources, and we obtain similar results. For example, we get the same results when replacing the stimulus by the change in the projected public deficit for 2020, as measured by net lending/net borrowing as share of GDP (source: IMF Fiscal Monitor Oct 2019 and April 2020).

[23] Control variables are the same except for public loan guarantees which are excluded as they are destined to corporates and should not influence the mortgage rate. The number of observations is slightly lower due to missing data on the mortgage rate for some countries.

As for the lending rates, the transmission of the key rate cut to mortgage rates seems to have operated only in countries having released their capital buffer. Estimations in Table 2 show that any 100 bps cut in the policy rate would translate into an easing of about 17 bps of the mortgage rate in treated countries only. This conditional pass-trough of monetary policy, around 17-18%, appears similar for the BLRs and the mortgage rates.

Finally, the different response of corporate and mortgage rates could be explained by demand-side divergences. While banks were reluctant to lend, due to high uncertainty and rapid deterioration of borrowers' solvency, corporates expressed a sustained demand for loans, in particular to finance working capital. On the contrary, the demand for mortgages was low, as households postponed or cancelled house purchases (ECB, 2020). Thus, CCyB and monetary policy easing have loosened a constraint that was more binding for corporate lending than for mortgages.

The analyses conducted in the following sections aim to test the robustness of these findings.

5.2 Results with advanced countries only

A concern one may have when running DID analysis is that the results might be driven by unobserved heterogeneity between the country groups - that is differences between the treated and the control groups that are unobservable, or at least unaccounted for. In our case, most of the treated group consists of advanced countries (except for for Bulgaria and Lithuania), whereas the control group contains both advanced and emerging countries. As one may be concerned about a potential selection bias, we perform a robustness check by restricting the sample to advanced countries only, based on the IMF classification. We are left with a total of 30 countries (54 in the original sample), with 13 countries in the treated group and 17 in the control group (sometimes 16 depending on the specification).

Tables 3 and 4 present the effects of CCyB relief on the corporate BLR and the mortgage rate in advanced countries. Overall, the results are very similar to what we find in the baseline estimations for the entire sample, meaning that the mechanism we are describing is broad and not specific to advanced countries only.

Based on column (1) of Table 3 and in reference to Eq. (13), the CCyB relief impacts the corporate BLR by $-24\ 00 + 0\ 155 r_{i,t}$ (in percent). Both coefficients for CCyB and the interaction are highly significant, regardless of the specification. For an average (post treatment) policy rate index of 88.2 for the treated advanced countries (see Table D4), the CCyB release results in an additional decrease of 10% of the corporate BLR index, compared to the control group. Given the observed average BLR value of 2,57% for treated advanced countries post-treatment, it implies that the CCyB has explained an additional decrease of 26 bps of the BLR, compared to the non-treated countries. This additional effect represents about two thirds of the total decrease in BLR actually observed in advanced countries that released their CCyB. Relative to the average CCyB decline of 1.25 pp in this sample, we can infer that a 1 pp cut in the CCyB translates into a 21 bps decrease of corporate BLRs in advanced countries. This result corresponds to the upper range of the estimates for capital requirement increases in the literature.

The main change from the baseline estimations is that the policy rate now appears as a significant driver of BLRs. This suggests that monetary policy easing has passed on to BLRs in developed countries, even in the absence of CCyB release. The pass-through is however modest, with a low coefficient ranging from 0.06 to 0.08 in specifications (1) to (8). Still, in the light of the significant interaction term, between 0.13 and 0.15, treated countries do benefit from a stronger pass-through of monetary policy. For example, according to column (1), a 100 bps cut to the policy rate would translate into a decline of 21 bps of the BLR in treated advanced countries, against only a modest decrease of 6 bps in non-treated advanced countries.

Table 3: DID estimations of the effect of CCyB and policy rate on corporate BLRs (advanced countries)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CCyB	-24.00***	-22.73***	-22.84***	-20.98***	-20.99**	-20.62***	-20.88***	-20.83***
	(6.837)	(6.297)	(7.397)	(7.182)	(7.653)	(7.431)	(7.085)	(7.212)
policy rate	0.060*	0.071*	0.071**	0.082**	0.082**	0.085**	0.083**	0.080**
	(0.033)	(0.035)	(0.035)	(0.033)	(0.038)	(0.033)	(0.035)	(0.033)
CCyB ×	0.155**	0.139**	0.140*	0.132*	0.132*	0.127*	0.132*	0.131*
policy rate	(0.071)	(0.065)	(0.069)	(0.069)	(0.070)	(0.067)	(0.070)	(0.071)
inflation		-3.548	-3.564	-5.363	-5.368	-5.444	-5.317	-5.355
		(3.355)	(3.340)	(3.816)	(3.950)	(3.882)	(3.829)	(3.855)
growth		1.160	1.138	1.370	1.369	1.414	1.337	1.373
		(0.978)	(0.916)	(1.004)	(1.010)	(1.031)	(1.055)	(1.012)
QE			-0.011	0.047	0.048	0.045	0.049	0.038
			(0.219)	(0.228)	(0.225)	(0.226)	(0.228)	(0.231)
stringency				-0.132*	-0.132*	-0.127	-0.134*	-0.135*
				(0.077)	(0.076)	(0.077)	(0.078)	(0.079)
stimulus					-0.005			
					(0.375)			
liquidity						0.074		
						(0.215)		
guarantees							-0.037	
							(0.260)	
gov_rate								0.004
								(0.010)
Treated	13	13	13	13	13	13	13	13
Control	17	16	16	16	16	16	16	16
Obs.	180	174	174	174	174	174	174	174

Note: The dependent variable is the corporate lending rate. It includes monthly time fixed effects. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The first three lines correspond respectively to coefficients δ, ρ and ω in Eq. (11) to (14).

Results presenting the effects of CCyB release on the mortgage rate in advanced countries are reported in Table 4. They are similar to the baseline estimates. The CCyB relief significantly impacts the mortgage rate by $-18\ 98 + 0\ 183 r_{i,t}$ (in percent) more in treated advanced countries compared to non-treated ones. In the light of a post treatment average policy rate index of 88.2 for treated advanced countries, the CCyB release implies an additional decrease of about 3% of the mortgage rate index, compared to the control group. Thus, given the actual mortgage rate of 1.95% for treated countries before treatment (see Table D4), the CCyB relief explains an additional decrease of the mortgage rate of around 5.5 bps after the treatment. Last, as in previous estimations, we confirm that the interest rate cut has transmitted to mortgage rates only in treated countries, with a similar pass-though of around 17%.

DID estimations at the macro level may sometimes suffer from a small sample bias, or an imbalance between the number of treated and control observations. Our sample of more than 50 countries is not particularly small, and the share of treated countries of around a third of the sample is satisfactory. Still, we want to make sure results are not driven by certain countries in particular. Therefore, we re-run estimations by removing each country one by one, treated or control. Results remain the same, comforting us in the idea that we do not capture a particular case and conclusions are valid throughout the sample.

Table 4: DID estimations of the effect of CCyB and policy rate on mortgage rates (advanced countries)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
CCyB	-18.98**	-20.69**	-19.65**	-20.46**	-22.19***	-19.77**	-20.44**
	(8.644)	(8.473)	(7.865)	(8.153)	(7.890)	(7.255)	(8.169)
policy rate	0.003	0.003	0.005	0.001	-0.023	0.009	0.001
	(0.043)	(0.045)	(0.045)	(0.048)	(0.044)	(0.041)	(0.048)
CCyB ×	0.183**	0.189**	0.183***	0.187***	0.197***	0.174***	0.187***
policy rate	(0.071)	(0.068)	(0.065)	(0.067)	(0.064)	(0.058)	(0.067)
inflation		6.006	6.194	6.786	6.006	6.341	6.789
		(4.970)	(5.161)	(5.068)	(4.763)	(4.895)	(5.065)
growth		-0.372	-0.172	-0.283	-0.463	-0.226	-0.283
		(0.624)	(0.598)	(0.604)	(0.567)	(0.634)	(0.607)
QE			0.086	0.065	0.096	0.054	0.064
			(0.153)	(0.156)	(0.145)	(0.150)	(0.157)
stringency				0.050	0.074	0.067	0.050
				(0.055)	(0.052)	(0.058)	(0.055)
stimulus					-0.548**		
					(0.253)		
liquidity						0.227	
						(0.264)	
gov_rate							0.000
							(0.004)
Treated countries	12	12	12	12	12	12	12
Control countries	17	16	16	16	16	16	16
Observations	174	168	168	168	168	168	168

Note: The dependent variable is the household mortgage rate. It includes monthly time fixed effects. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. The first three lines correspond respectively to coefficients δ, ρ and ω in Eq. (11) to (14).

5.3 Placebo tests

In order to ensure the robustness of the baseline estimations and verify that results are not driven by other factors that the CCyB relief may confound, we have performed various placebo tests. They consist in simulating alternative and competing "treatments" supposed to occur in March 2020.[24] In our baseline estimations we have concluded that the CCyB release has a twofold effect: on one hand it leads to a BLR decrease ($\delta < 0$) and on the other hand it improves the pass-through of policy rate cuts (> 0). We thus examine the placebo treatments in the light of the same dual properties. Results are laid out in Table 5 for the corporate BLR and Table 6 for the mortgage rate. The composition of the treated and control groups for all the placebo tests are reported in Table D1 in Appendix.

First of all, as the CCyB has been implemented mainly in developed countries, one may think that results might in fact reflect a distinction related to the level of development (e.g., economic resilience, financial development, institutional quality, etc.). Therefore, a first placebo test consists of considering advanced countries as "treated" and emerging markets (EMs) as the control group. As this is a placebo test, countries having actually released their CCyB are excluded from the sample. Panels *(a)* of Tables 5 and 6 show that this particular "treatment" has no significant effect on BLRs.

[24]For each placebo treatment, we require that the number of treated countries be at least equal to the number of treated countries in the baseline estimate.

Table 5: Results of placebo tests for BLRs

Specification	(1)	(5)	(6)	(7)	(1)	(5)	(6)	(7)
	(a) Advanced vs EMD Economies				(b) Other macroprudential measures			
Placebo	2.118	6.654	3.306	3.404	11.628**	10.885**	11.015**	10.963**
	(3.031)	(6.645)	(3.819)	(3.765)	(4.525)	(4.561)	(4.715)	(4.657)
Policy rate	-0.023	-0.020	-0.022	-0.022	0.169***	0.172***	0.177***	0.177***
	(0.019)	(0.025)	(0.027)	(0.027)	(0.047)	(0.050)	(0.051)	(0.052)
Interaction	0.071**	0.058*	0.077**	0.076**	-0.153***	-0.150***	-0.152***	-0.151***
	(0.027)	(0.033)	(0.031)	(0.033)	(0.079)	(0.071)	(0.076)	(0.076)
Treated	17	16	16	16	23	21	21	21
Control	22	20	20	20	31	30	30	30
Obs.	234	216	216	216	324	306	306	306
	(c) Number of activated instruments				(d) DTI and/or leverage ratio limits			
Placebo	-5.645	-6.320	-4.649	-4.638	-0.538	0.161	0.405	0.233
	(7.344)	(6.615)	(7.079)	(6.900)	(6.207)	(6.255)	(6.056)	(6.120)
Policy rate	0.062**	0.065**	0.078***	0.081***	0.073*	0.088**	0.093**	0.091**
	(0.028)	(0.026)	(0.027)	(0.029)	(0.041)	(0.042)	(0.039)	(0.042)
Interaction	-0.034	-0.033	-0.044	-0.047	-0.058	-0.067	-0.070	-0.069
	(0.079)	(0.071)	(0.076)	(0.076)	(0.062)	(0.060)	(0.058)	(0.060)
Treated	25	24	24	24	22	21	21	21
Control	29	27	27	27	32	30	30	30
Obs.	324	306	306	306	324	306	306	306
	(e) Loan-to-Value				(f) Prompt corrective action			
Placebo	0.465	-0.809	0.802	0.019	9.512*	8.597*	8.839	8.814*
	(7.469)	(6.275)	(7.124)	(6.895)	(4.827)	(4.879)	(5.406)	(5.061)
Policy rate	0.064	0.067*	0.076*	0.079*	0.108**	0.100**	0.108***	0.110**
	(0.048)	(0.036)	(0.038)	(0.040)	(0.041)	(0.039)	(0.040)	(0.043)
Interaction	-0.040	-0.039	-0.046	-0.048	-0.085*	-0.074*	-0.078	-0.080
	(0.078)	(0.071)	(0.076)	(0.077)	(0.044)	(0.043)	(0.053)	(0.048)
Treated	29	28	28	28	21	19	19	19
Control	22	21	21	21	26	26	26	26
Obs.	306	294	294	294	282	270	270	270

Note: The dependent variable is the corporate lending rate. Estimations include monthly fixed effects. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Specifications correspond to columns (1) and (5) to (7) in table 1. "Placebo" refers to the treatment as indicated at the top panels from (a) to (f): (a) advanced country status according to IMF classification, excluding all CCyB countries; (b) countries with at least one macroprudential measure being eased in the spring of 2020 other than CCyB; (c) countries with above median number of active macroprudential instruments (median at 8); (d) countries with either debt-to-income (DTI) or leverage ratio limits activated; (e) countries with a loan to value (LTV) limit activated; (f) countries where the regulator can automatically intervene when certain regulatory thresholds are breached. All references are with respect to 2019 before the unfolding of the COVID-19 crisis. We source these indicators in 2019 IMF iMaPP database (Alam et al., 2019) and the 2019 World Bank Regulation and Supervision Survey (Anginer et al., 2019). Table D1 in Appendix reports the composition of the treated and control groups for all the placebo tests presented here. Tests of parallel trends and non-anticipation of treatment confirm the validity of DID estimations in all cases.

Table 6: Results of placebo tests for the mortgage rate

Specification	(1)	(5)	(6)	(7)	(1)	(5)	(6)	(7)
	(a) Advanced vs EMD Economies				(b) Other macroprudential measures			
Placebo	2.929	12.251*	3.665	5.787	4.040	3.860	2.922	4.023
	(5.834)	(6.372)	(6.564)	(6.874)	(5.352)	(5.477)	(4.931)	(5.870)
Policy rate	0.011	0.017	0.010	0.013	0.068	0.065	0.069*	0.076
	(0.017)	(0.013)	(0.017)	(0.022)	(0.041)	(0.041)	(0.041)	(0.046)
Interaction	-0.015	-0.065	-0.017	-0.024	-0.049	-0.049	-0.045	-0.054
	(0.047)	(0.040)	(0.051)	(0.051)	(0.037)	(0.042)	(0.034)	(0.042)
Treated	17	16	16	16	18	18	18	16
Control	15	15	15	12	28	27	27	26
Obs.	192	186	186	168	276	270	270	252
	(c) Number of activated instruments				(d) DTI and/or leverage ratio limits			
Placebo	-3.756	-5.087	-2.530	-2.633	-5.891	-5.783	-5.253	-5.674
	(6.739)	(6.082)	(6.490)	(6.846)	(5.771)	(5.596)	(5.309)	(5.915)
Policy rate	-0.001	-0.014	0.006	0.002	0.018	0.012	0.026	0.021
	(0.030)	(0.027)	(0.023)	(0.033)	(0.039)	(0.038)	(0.032)	(0.041)
Interaction	0.036	0.047	0.031	0.033	0.014	0.019	0.009	0.012
	(0.066)	(0.061)	(0.066)	(0.068)	(0.049)	(0.045)	(0.046)	(0.050)
Treated	23	22	22	21	19	18	18	17
Control	23	23	23	21	27	27	27	25
Obs.	276	270	270	252	276	270	270	252
	(e) Loan-to-Value				(f) Prompt corrective action			
Placebo	-1.397	-2.638	1.033	-0.806	11.111**	11.277**	11.353**	11.819**
	(6.420)	(5.842)	(5.679)	(6.324)	(4.694)	(4.811)	(4.526)	(4.800)
Policy rate	0.002	-0.007	0.013	0.003	0.088**	0.077**	0.088**	0.090**
	(0.042)	(0.038)	(0.031)	(0.039)	(0.039)	(0.037)	(0.039)	(0.039)
Interaction	0.029	0.036	0.021	0.029	-0.076*	-0.069	-0.072*	-0.077*
	(0.061)	(0.055)	(0.057)	(0.061)	(0.040)	(0.042)	(0.037)	(0.040)
Treated	25	24	24	23	17	16	16	15
Control	21	21	21	19	24	24	24	24
Obs.	270	264	264	252	246	240	240	234

Note: The dependent variable is the household mortgage rate. Estimations include monthly fixed effects. Standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Specifications correspond to columns (1) and (5) to (7) in table 2. "Placebo" refers to the treatment as indicated at the top panels from (a) to (f): (a) advanced country status according to IMF classification, excluding all CCyB countries; (b) countries with at least one macroprudential measure being eased in the spring of 2020 other than CCyB; (c) countries with above median number of active macroprudential instruments (median at 8); (d) countries with either debt-to-income (DTI) or leverage ratio limits activated; (e) countries with a loan to value (LTV) limit activated; (f) countries where the regulator can automatically intervene when certain regulatory thresholds are breached. All references are with respect to 2019 before the unfolding of the COVID-19 crisis. We source these indicators in the 2019 IMF iMaPP database (Alam et al., 2019) and the 2019 World Bank Regulation and Supervision Survey (Anginer et al., 2019). Table D1 in Appendix reports the composition of the treated and control groups for all the placebo tests presented here. Tests of parallel trends and non-anticipation of treatment confirm the validity of DID estimations in all cases.

Next, we examine whether the baseline results globally capture the package of macroprudential measures undertaken in March 2020, and not specifically the impact of the CCyB release. In this perspective, we consider the "treated" countries to be those that have implemented at least one macroprudential measure other than CCyB relief in March 2020. These other measures include: increase in loan-to-value caps (Turkey, Israel), reduction of systemic risk buffers (Brazil, Estonia, Finland, Greece, Hungary, Netherlands, Poland), reduction of the capital conservation buffer[25] (Japan, Malaysia, Morocco, Russia), exceptional and temporary possibility to operate below some capital and liquidity requirements (Italy, Portugal, South Africa, United States), deferral of macroprudential decisions (Canada, India, New Zealand, Ukraine). The results are reported in panels *(b)* of Tables 5 and 6. They do not challenge our baseline results: the effect of the other prudential measures on interest rates is either of opposite sign to that of the CCyB (for corporate BLRs), or not significant at all (for mortgage rates).

Last, one might think that having CCyB in one's macroprudential toolkit is actually an indication of a stronger concern of national authorities for financial stability. If that were the case, our CCyB treatment may account for this overall concern, more than the effect of the CCyB itself. Therefore, we further consider "treated" countries to be those particularly preoccupied with financial stability. We capture this concern by four alternative measures of financial regulatory stringency. The first one is the number of macroprudential instruments actually activated in each country as of December 2019. Following Aizenman et al. (2020) and Avril et al. (2022), this extensity measure of macroprudential stringency is based on information from the integrated Macroprudential Policy Database (iMaPP) provided by Alam et al. (2019). Countries with a number of active instruments above the sample median are reasonably expected to have a stronger concern for financial stability, and are thus considered "treated" in March 2020. Second, although the introduction of a debt-to-income ratio limit or a minimum bank leverage ratio reveals a real concern of authorities for financial stability, the individual implementation of these two instruments is not frequent enough to be treated as an independent placebo treatment. We therefore merge them into a second proxy for financial stability concern and consider "treated" countries to be those where at least one of these two macroprudential tools was implemented before the crisis (according to the survey of Anginer et al. (2019)). A third proxy, stemming from the iMaPP database, is the presence of a loan-to-value cap (LTV). Countries where a LTV cap was active in December 2019 are considered "treated". A fourth and last proxy for financial regulation stringency, labelled *prompt corrective action*, refers to the ability of regulators to deal with troubled financial institutions (based on the survey of Anginer et al. (2019)). We consider "treated" countries where automatic intervention by regulators is authorized when some pre-determined levels of solvency deterioration are breached.

The corresponding results for these placebo tests are reported in panels *(c)* to *(f)* of Tables 5 and 6. We can see that none of these four placebo treatments exhibits the dual properties characterizing the CCyB release. Therefore, we are confident that our baseline results do indeed reflect the effects of the CCyB policy on interest rates and not some other competing treatment. Furthermore, the placebo tests highlight the importance of relying on the CCyB in times of crisis, as the other macroprudential measures do not seem to have had a meaningful impact on credit conditions during COVID-19.

Finally, the preceding analysis brings to light an additional consideration. Given that all countries having the CCyB opted for its release in March 2020 (with the exception of Luxembourg), constructing

[25]Reduction of the capital conservation buffer corresponds to an easing of bank capital requirements that might have the same effect on BLRs as a CCyB relief. However, this measure has not been adopted by enough countries to be studied as such.

a control group of countries implementing the CCyB without releasing it during the Covid crisis is unfeasible. Consequently, the question arises: do our findings solely reflect the effects of the release of CCyB or just the fact of having CCyB as a macroprudential instrument? Various arguments pledge for the former explanation. Firstly, our structural model demonstrates that reducing the CCyB rate − rather than just holding it as a idle instrument − results in both a decline in BLRs and a better transmission of monetary policy. Furthermore, there is no inherent reason to assume that merely having the CCyB as a macroprudential instrument would be enough to benefit from this dual effect. Lastly, placebo tests confirm that our results are not influenced by other factors that the CCyB may confound.

6 Concluding remarks

The COVID-19 pandemic acted as an exogenous shock that forced policymakers to respond with a battery of measures to restore proper functioning of credit markets. Central banks eased their monetary policies and many macroprudential authorities unexpectedly reduced CCyB buffers in March 2020 for the first time ever. This paper builds on this quasi-natural experiment to study the combined effect of CCyB relief and policy rate cut on bank lending rates at the macroeconomic level.

First, we rely on a New Keynesian macroeconomic model with a banking sector and financial frictions to study the individual and combined effects of macroprudential and monetary policies on credit conditions. We show that the CCyB release lowers bank lending rates to firms and, to a lesser extent, mortgage rates. We also reveal that a CCyB relief strengthens the impact of a policy rate cut, thus improving the transmission of conventional monetary policy. Similarly, a policy rate cut enhances the impact of a CCyB relief on lending rates. As evidence of complementarity, the joint action of these two policy instruments has a greater impact than the sum of their individual effects.

In a second step, we empirically validate these theoretical predictions through a DID analysis performed on a sample of 54 countries. Results confirm that the CCyB release and, in some cases, lower policy rates, have put downward pressure on BLRs during the COVID-19 crisis. Even more important, as an evidence of synergy, their joint effect further accentuates the decline of BLRs. On one hand, the lower the policy rate, the greater the benefit of CCyB relief (with an average additional decline in corporate BLRs of around 11 bps for any 1 pp decline in CCyB). This suggests that macroprudential easing gave leeway to economies close to their effective lower bound. On the other hand, releasing the CCyB has acted as a catalyst for a better transmission of policy rate cuts. While the transmission of policy rates to BLRs appears seemingly dampened in non-treated economies at the height of the crisis, releasing the CCyB allows an additional easing of about 18 bps for corporate BLRs for every 100 bps cut in the policy rate. We find the effect of the policy-mix to hold for mortgage rates as well, but to a much smaller extent. The housing market has actually came to a halt with the containment measures in the spring of 2020, thus being less responsive to policy measures. These results are robust to different specifications and purged from the influence of other policy measures taken in 2020, like the quantitative easing, liquidity programs, fiscal stimulus, loan guarantee schemes etc. They are also validated by the numerous placebo tests we carry out.

While most of the literature has focused on micro-level evidence, we are able to provide a first macroeconomic estimate of impact of a joint CCyB release and a monetary policy easing on bank lending rates. While statistically significant, this macroeconomic impact is rather small. In absolute terms, it corresponds to the lower range of estimations for capital requirements *increases* typically found in the literature. This modest impact may be due to insufficient room for manoeuvre, as CCyB was in many jurisdictions far from the maximum of 2.5%. In this case our results support the adoption of a positive neutral rate for CCyB, as already done in the UK, Sweden and the Netherlands. Additional mitigating factors may explain this weak effect: a stigma effect, the dissuasive consequences of the dividend ban associated with the CCyB release, banks' wealth effects, the fact that the CCyB constraint was not truly binding for many banks when the crisis emerged, regulatory uncertainty, or the downward rigidity of BLRs. A micro-level analysis based on bank data could allow us to disentangle these different explanations, and identify which banks actually passed on the CCyB relief and the monetary policy easing to their lending rates. The conclusions drawn here from this COVID-19 experiment and further work on bank level data can provide valuable lessons as to the policy mix to be implemented in response to future crises.

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A CCyB release: Additional information and sources

Information on policy measures, and in particular on the CCyB release, was collected from national central banks or macroprudential authorities, and was cross-checked from various publications and trackers, including:

- The European Central Bank: https://www.ecb.europa.eu/pub/financial-stability/macroprudential-measures/html/index.en.html
- The International Monetary Fund: https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19
- The European Systemic Risk Board: https://www.esrb.europa.eu/national_policy/ccb/html/index.en.html
- The Yale Program on Financial Stability (YPFS): https://som.yale.edu/faculty-research-centers/centers-initiatives/program-on-financial-stability/covid-19-crisis
- Bruegel website: https://www.bruegel.org/publications/datasets
- PwC blog: https://blogs.pwc.de/en/regulatory

Below is the list of countries that implemented a CCyB release in March 2020, with corresponding dates and links to official announcement.

- **Belgium**: March 11, announcement of reduction of the CCyB to 0% (an increase to 0.5% was to become effective by June).
https://www.nbb.be/en/articles/national-bank-belgium-releases-full-countercyclical-buffer
- **Bulgaria**: March 19, announcement of measures including cancellation of planned CCyB increases to 1.5% in 2021. Thus, the CCyB was maintained at the level of 0.5%.
http://www.bnb.bg/PressOffice/POPressReleases/POPRDate/PR_20200319_EN
- **Canada** : March 13, the Bank Regulator (OSFI) announced the decrease of Domestic Stability Buffer for D-SIBs to 1 percent of risk weighted assets (previously 2.25 percent).
https://www.osfi-bsif.gc.ca/Eng/osfi-bsif/med/Pages/nr_20200313.aspx
- **Czech Republic**: March 26, announcement of a reduction of the countercyclical capital buffer rate to 1 percent (effective April 1).
https://www.cnb.cz/en/financial-stability/macroprudential-policy/the-countercyclical-capital-buffer/provision-of-a-general-nature-ic-2020/index.html
- **Denmark**: March 12, the Danish authorities decided to preemptively release the countercyclical capital buffer and cancel the planned increases meant to take effect later.
http://www.nationalbanken.dk/en/pressroom/Pages/2020/03/DNN202005367.aspx
- **France**: March 18, decision to reducing the counter-cyclical bank capital buffer to 0 percent (an increase from 0.25 percent to 0.5 percent was to become effective by April).
https://www.economie.gouv.fr/files/files/directions_services/hcsf/HCSF_20200318_Communique_de_presse_de_seance.pdf
- **Germany**: March 18, Announcement of a decrease in the CCyB, with (as a forward guidance) no potential increase envisaged before 1 January 2021.

https://www.bafin.de/SharedDocs/Veroeffentlichungen/EN/Aufsichtsrecht/Verfuegung/vf_200331_allgvfg_antizykl_kapitalpuffer_en.html

- **Iceland**: March 18, the CBI Financial Stability Committee announced the reduction of the countercyclical capital buffer from 2 percent to 0 percent.

https://www.cb.is/publications/news/news/2020/03/18/Statements-of-Monetary-Policy-Committee-and-Financial-Stability-Committee/

- **Ireland** : March 18, The Central Bank of Ireland (CBI) announced the release of the countercyclical capital buffer, from 1% to 0% (effective in April, 1).

https://www.centralbank.ie/news/article/press-release-statement-central-bank-of-ireland-18-march-2020

- **Lithuania** : March 18, the Bank of Lithuania announced the decrease of its CCyB from 1 to 0%.

https://www.lb.lt/en/news/bank-of-lithuania-releases-the-countercyclical-capital-buffer-requirement-amid-covid-19-disruptions

- **Luxemburg**: March 12, the Systemic Risk Board recommends maintaining the countercyclical capital buffer rate at 0.5%, previously announced for January 1, 2021.

http://data.legilux.public.lu/file/eli-etat-leg-rcsf-2020-04-15-a322-jo-fr-pdf.pdf

- **Norway**: March 13, announcement of an easing of countercyclical capital buffer by 1.5 pp (from 2.5 to 1%).

https://www.regjeringen.no/en/aktuelt/reduction-of-the-countercyclical-buffer/id2693388/

- **Slovac Republic**: March 13 (and April 28), announcement of several easing measures concerning bank capital requirements (including a decrease in the CCyB from 2% to 1.5%)

https://www.nbs.sk/_img/Documents/_Dohlad/Makropolitika/WEB_rozhodnutie_vankus__TRA-EN_April_2020.pdf

- **Sweden**: March 16, announcement of an easing of countercyclical capital buffer by 2.5 pp.

https://www.fi.se/en/published/news/2020/decision-by-fis-board-of-directors-the-countercyclical-buffer-rate-is-lowered-to-zero/

- **Switzerland**: March 19, the Swiss National Bank announced to examine "whether a relaxation of the countercyclical capital buffer would be possible". Its request for deactivation of the CCyB was approved by the Federal Council on March 27.

https://www.regjeringen.no/en/historical-archive/solbergs-government/Ministries/fin/press-releases/2020/reduction-of-the-countercyclical-buffer/id2693388/

- **United Kingdom**: March 11, announcement of a reduction of the countercyclical buffer rate to 0 percent from a pre-existing path toward 2 percent by December 2020, with guidance that it will remain there for at least 12 months.

https://www.bankofengland.co.uk/news/2020/march/boe-measures-to-respond-to-the-economic-shock-from-covid-19

B The rest of the model

B.1 Households

There are two groups of households (patient P and impatient I) of unit mass, who consume final goods, work and accumulate housing.

The representative household j maximizes its expected utility given by

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta_i^t \left[\left(1 - a^i\right) \log \left(c_t^i(j) - a^i c_{t-1}^i \right) + \log h_t^i(j) - \frac{l_t^i(j)^{1+\phi}}{1+\phi} \right] \quad \text{for } i = \{P \ I\} \tag{B1}$$

where E_t denotes the mathematical expectation operator upon information available at t, $a^i \in [0 \ 1]$ denotes the degree of habit formation, and $\phi > 0$ is the inverse of the Frisch labour supply elasticity. $c_t^i(j)$ denotes individual consumption, c_{t-1}^i is lagged aggregate consumption, $h_t^i(j)$ is housing services and l_t^i represents hours worked. The subjective discount factor for the patient households is higher than that of the impatient ones, i.e., $\beta_P > \beta_I$. This implies positive financial flows in equilibrium, with patient households as savers and impatient households as net borrowers.

Patient household i's period budget constraint is given by

$$c_t^P(i) + q_t^h \Delta h_t^P(i) + d_t^P(i) \leq w_t^P l_t^P(i) + (1 + r_{t-1}^d) d_{t-1}^P(i) \ \ \pi_t + \tau_t^P(i) \tag{B2}$$

Its expenses in period t include consumption, accumulation of housing with q_t^h designating the real house price, and real deposits. Its resources consist of real wage earnings, gross interest income on the last period's deposits, with $\pi_t \equiv P_t \ \ P_{t-1}$ as gross inflation, and lump-sum transfers (τ_t^P). The latter include labour union membership net fees and dividends from firms and banks (of which patient households are the owners).

Impatient household i's period budget constraint is given by

$$c_t^I(i) + q_t^h \Delta h_t^I(i) + (1 + r_{t-1}^{bH}) b_{t-1}^I \ \ \pi_t \leq w_t^I l_t^I(i) + b_t^I(i) + \tau_t^I(i) \tag{B3}$$

where the flow of expenses is partly composed of gross reimbursement of the last period's borrowing b_{t-1}^I, with r_{t-1}^{bH} being the corresponding lending rate. Its resources include new loans, as well as lump-sum transfers $\tau_t^I(i)$ that are only composed of union membership net fees. In addition, impatient households face a borrowing constraint stating that they cannot borrow more (in terms of repayment amount plus interest) than a given proportion m_H of the expected value of their housing, which can be pledged as collateral:

$$(1 + r_t^{bH}) b_t^I(i) \leq m_H \ \mathrm{E}_t \left[q_{t+1}^h h_t^I(i) \pi_{t+1} \right] \tag{B4}$$

B.2 Employment agencies

Households supply their labour services through unions that set nominal wages, subject to adjustment costs and partial indexation to inflation. This allows to reproduce realistic wage stickiness. Labour services are finally sold to employment agencies that assemble them into a homogeneous labour input and sell it to entrepreneurs.

More precisely, workers provide differentiated labour types sold by unions to perfectly competitive employment agencies, which assemble them in a CES aggregator and sell homogeneous labour to entrepreneurs. For each labour type m, there are two unions, one for patient households and one for impatient households. Each union sets nominal wages $W_t^i(m)$ for its members, with $i \in \{P \; I\}$, by maximizing their utility subject to downward-sloping demand and to quadratic adjustment costs (parameterized by κ_w), with indexation ι_w to lagged inflation and $(1 - \iota_w)$ to steady-state inflation (denoted π). Unions charge their members lump-sum fees to cover adjustment costs with equal split. Hence, they seek to maximize the following expression:

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta_i^t \left\{ U_{c_t^i}(j \;\, m) \left[\frac{W_t^i(m)}{P_t} l_t^i(j \;\, m) - \frac{\kappa_w}{2} \left(\frac{W_t^i(m)}{W_{t-1}^i(m)} - \pi_{t-1}^{\iota_w} \pi^{1-\iota_w} \right)^2 \frac{W_t^i}{P_t} \right] - \frac{l_t^i(j \;\, m)^{1+\phi}}{1+\phi} \right\} \tag{B5}$$

subject to demand from employment agencies

$$l_t^i(i \;\, m) = l_t^i(m) = \left(\frac{W_t^i(m)}{W_t^i} \right)^{-\varepsilon^l} l_t^i \tag{B6}$$

with ^{l} being the elasticity of labour demand.

B.3 Entrepreneurs

Entrepreneurs produce homogeneous intermediate goods. They sell these goods to final good producers that slightly differentiate them before selling them to consumers. They are subject to adjustment costs when prices are revised. For the sake of realism, this introduces price rigidity in the model.

Entrepreneur i's utility only depends on her own consumption $c_t^E(i)$ and on lagged aggregate consumption:

$$\mathrm{E}_0 \sum_{t=0}^{\infty} \beta_E^t \log \left(c_t^E(i) - a^E c_{t-1}^E \right) \tag{B7}$$

where a^E measures the degree of consumption habits, with a discount factor β_E that is supposed to be the same as for impatient households. Entrepreneur i maximizes her lifetime utility under the budget constraint:

$$c_t^E(i) + w_t^P l_t^{E,P}(i) + w_t^I l_t^{E,I}(i) + (1 + r_{t-1}^{bE}) b_{t-1}^E(i) \;\; \pi_t + q_t^k k_t^E(i) \leq \frac{y_t^E(i)}{x_t} + b_t^E(i) + q_t^k (1-\delta) k_{t-1}^E(i) \tag{B8}$$

where expenses are composed of consumption, labour inputs from patient $l_t^{E,P}(i)$ and impatient households $l_t^{E,I}(i)$, gross repayment of the last period's borrowing $b_{t-1}^E(i)$, with r_{t-1}^{bE} being the corresponding lending rate, and physical capital k_t^E, whose price in terms of consumption is denoted q_t^k. Her resources consist of new loans, non-depreciated physical capital resold to capital producers (with δ being the depreciation rate of physical capital), and wholesale good y_t^E, which is sold at the inverse relative competitive price $x_t = P_t \;\; P_t^W$ and produced according to the following technology:

$$y_t^E(i) = \left[k_{t-1}^E(i) \right]^{\alpha} \left[l_t^E(i) \right]^{1-\alpha} \tag{B9}$$

The labour of the two types of households is combined as $l_t^E = (l_t^{E,P})^{\mu} (l_t^{E,I})^{1-\mu}$, where μ measures the labour income share of patient households. Finally, like mortgage borrowers, entrepreneurs are subject to a borrowing constraint, given by

$$(1 + r_t^{bE}) b_t^E(i) \leq m_E \, \mathrm{E}_t \left((1-\delta) q_{t+1}^k \pi_{t+1} k_t^E(i) \right) \tag{B10}$$

which states that the gross borrowing of entrepreneur i cannot exceed a proportion m_E of the expected value of her (depreciated) physical capital, which can be considered as the value of the collateral that can be pledged.

B.4 Capital and final goods producers

Capital-producing firms act in a perfectly competitive market. They are owned by the entrepreneurs. They purchase last period's undepreciated capital $(1-\delta)k_{t-1}$ from the entrepreneurs at a price Q_t^k and i_t units of final goods from retail firms at a price P_t. They combine them to produce new capital. The transformation of the final goods into capital is subject to quadratic adjustment costs. The new capital is then sold back to the entrepreneurs at the same price Q_t^k. Hence, capital producers maximize their expected discounted profits such as

$$\max_{\{k_t(j),i_t(j)\}} \mathrm{E}_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^e \left(q_t^k [k_t(j) - (1-\delta)k_{t-1}(j)] - i_t(j) \right) \tag{B11}$$

subject to

$$k_t(j) = (1-\delta)k_{t-1}(j) + \left[1 - \frac{\kappa_i}{2} \left(\frac{i_t(j)}{i_{t-1}(j)} - 1 \right)^2 \right] i_t(j) \tag{B12}$$

where κ_i denotes the cost of adjusting investment, $q_t^k = Q_t^k \;\, P_t$ is the real price of capital, and $\Lambda_{0,t}^e$ is the entrepreneurs' discount factor.

Final good producers are owned by patient households. They act in monopolistic competition, and their prices are sticky because of the existence of quadratic adjustment costs when prices are revised. They purchase the wholesale good from entrepreneurs in a competitive market and then slightly differentiate it at no additional cost. Each firm j chooses its price to maximize the expected discounted value of profits:

$$\max_{\{P_t(j)\}} \mathrm{E}_0 \sum_{t=0}^{\infty} \Lambda_{0,t}^P \left[\left(P_t(j) - P_t^W\right) y_t(j) - \frac{\kappa_P}{2} \left(\frac{P_t(j)}{P_{t-1}(j)} - \pi_{t-1}^{\iota_p} \pi^{1-\iota_p} \right)^2 P_t y_t \right] \tag{B13}$$

subject to the demand derived from consumers' maximization

$$y_t(j) = \left(\frac{P_t(j)}{P_t} \right)^{-\varepsilon^y} y_t \tag{B14}$$

where κ_p designates the cost of adjusting prices, $\iota_p \in [0 \;\, 1]$ is the degree of indexation to past inflation, ^{y} is the demand price elasticity, P_t^W is the wholesale price and $\Lambda_{0,t}^P$ is the patient households' discount factor.

B.5 Additional details on banks

Adjustment costs related to changes in deposit rates. They are parameterized by κ_d and are supposed to be proportional to the aggregate interest paid on deposits, such as $\mathcal{A}_d(r_t^d(j)) \equiv \frac{\kappa_d}{2}\left(r_t^d(j) \;\, r_{t-1}^d(j) - 1\right)^2 r_t^d d_t$, with $r_t^d = [\int_o^1 r_t^d(j)^{1-\varepsilon^d} dj]^{\frac{1}{1-\varepsilon^d}}$, where d_t represents aggregate deposits and $^d < -1$ represents the elasticity of demand for deposits.

Adjustment costs related to changes in lending rates. They are parameterized by κ_{bH} and κ_{bE} and are proportional to aggregate returns on loans, such as $\mathcal{A}_{bs}(r_t^{bs}(j)) \equiv \frac{\kappa_{bs}}{2}\left(r_t^{bs}(j) \;\, r_{t-1}^{bs}(j) - 1\right)^2 r_t^{bs} b_t^s$.

Dixit-Stiglitz loan demand curves of households and entrepreneurs are given by $b_t^s(j) = \left(r_t^{bs}(j)\ \ r_t^{bs}\right)^{-\varepsilon^{bs}} b_t^s$, with $r_t^{bs}(j) = [\int_o^1 r_t^{bs}(j)^{1-\varepsilon^{bs}} dj]^{\frac{1}{1-\varepsilon^{bs}}}$ and b_t^s representing aggregate loans, for $s = \{H\ \ E\}$. This means that units of loan contracts bought by households and entrepreneurs are a composite constant elasticity of substitution basket of differentiated financial products, with elasticity terms equal to $^{bH} > 1$ and $^{bE} > 1$, respectively.

Leverage ratio. In line with Basel III, we assume that banks have to meet a regulatory leverage ratio denoted lev. Any deviation from this target implies a quadratic cost parameterized by κ_{lev}, proportional to outstanding bank capital, such that:

$$\mathcal{D}_t^{lev}(K_t^b(j)) \equiv \frac{\kappa_{lev}}{2} \left(\frac{K_t^b(j)}{B_t^E(j) + B_t^H(j)} - lev \right)^2 K_t^b(j) \tag{B15}$$

Note that the calibration of lev is set consistently with the CAR requirements, following

$$lev \equiv \frac{K_t^b(j)}{B_t^H(j) + B_t^E(j)} = \frac{K_t^b(j)}{{}_t^H B_t^H(j) + \ {}_t^E B_t^E(j)} \times \frac{{}_t^H B_t^H(j) + \ {}_t^E B_t^E(j)}{B_t^H(j) + B_t^E(j)} \tag{B16}$$

B.6 Market clearing and shocks

The market clearing conditions for the final good market are given by $y_t = c_t + q_t^k\,[k_t - (1-\delta)k_{t-1}]$, with $c_t = c_t^P + c_t^I + c_t^E$. Equilibrium in the housing market is given by $\bar{h} = h_t^P(i) + h_t^I(i)$, where $\bar{h}$ is the exogenous fixed housing supply. Monetary policy and macroprudential shocks are defined such as $_{x,t} \sim i\ i\ d\ \ \mathcal{N}(0\ \ \sigma_x^2)$, with $x = \{r\ \ v\}$, respectively.

C Calibration

Table C1: Structural parameters

Parameter	Description	Value
β_P	Patient households' discount factor	0.9943
β_I	Impatient households' discount factor	0.975
β_E	Entrepreneurs' discount factor	0.975
ϕ	Inverse of the Frisch elasticity	1.0
^{h}	Steady state of housing in households' utility function	0.2
a^P a^I a^E	Degree of habit formation in consumption	0.856
α	Capital share in the production function	0.25
μ	Labour income share of patient households	0.8
ι_p	Indexation of prices to past inflation	0.16
ι_w	Indexation of nominal wages to past inflation	0.276
δ	Depreciation rate of physical capital	0.025
δ^b	Cost of managing the bank's capital position	0.101
κ_w	Cost of adjusting nominal wages	99.89
κ_i	Cost of adjusting investment	10.18
κ_P	Cost of adjusting good prices	28.65
κ_{car}	Cost of adjusting capital-asset ratio	50.0
κ_{lev}	Cost of adjusting leverage ratio	7.63
κ_{bE}	Cost of adjusting BLR to entrepreneurs	9.36
κ_{bH}	Cost of adjusting BLR to households	10.09
κ_d	Cost of adjusting deposit rate	3.50
^{l}	^{l} ($^{l}-1$) is the steady-state markup in the labour market	5.0
^{y}	^{y} ($^{y}-1$) is the steady-state markup in the goods market	6.0
^{bE}	^{bE} ($^{bE}-1$) is the steady-state markup on BLR to entrepreneurs	3.12
^{bH}	^{bH} ($^{bH}-1$) is the steady-state markup on BLR to households	2.79
^{d}	^{d} ($^{d}-1$) is the steady-state markdown on deposit rate	-1.46
λ_{HP}	Smoothing parameter of HP filter for output gap and credit gap	1600

Note: values are based on the original calibration and estimates of Gerali & Al. (2010, Tab. 1 and 2A p. 124).

Table C2: Policy framework

Parameter	Description	Value
^{H}	Steady-state risk weight on household credit	0.37
ρ_H	Persistence of the risk weight on household credit	0.94
χ_H	Sensitivity of ^{H} to the business cycle	-15
^{E}	Steady-state risk weight on entrepreneur credit	1.0
ρ_E	Persistence of the risk weight on entrepreneur credit	0.92
χ_E	Sensitivity of ^{E} to the business cycle	-10
m_H	LTV ratio for impatient households	0.7
m_E	LTV ratio for entrepreneurs	0.8
υ	Steady state of capital adequacy ratio	0.105
lev	Steady state of leverage ratio	0.09
ρ_υ	Smoothing parameter in the capital adequacy ratio rule	0.99
χ_{ccyb}	Reaction parameter in capital adequacy ratio rule	0.5
ρ_r	Smoothing parameter in monetary policy rule	0.768
χ_π	Reaction parameter to inflation in monetary policy rule	1.98
χ_y	Reaction parameter to output gap in monetary policy rule	0.35

Note: values are based on Gerali & Al. (2010), Angelini & Al. (2014), empirical evidence and regulatory requirements. See explanations in the text.

D Empirical analysis: descriptive statistics and data sources

Table D1: Treated and control countries

CCyB release	No CCyB release		
Belgium[d]	Australia[a,b]	Japan[a,b,f]	Russia[b,c,f]
Bulgaria	Austria[a,f]	Korea[a,c,d,e,f]	Slovenia[a,c,d,e,f]
Canada[c,d,e]	Botswana[b,f]	Latvia[a,c]	South Africa[b,d]
Czech Rep.[c,e,f]	Brazil[b,c,e,f]	Luxembourg[a]	Spain[a,f]
Denmark[c,e,f]	Cabo Verde[b]	Malaysia[b,c,e,f]	Sri Lanka[b,c]
France[b,c,d]	Chile[d,e,f]	Malta[a,c,d,e,f]	Turkey[c,d,e]
Germany	Colombia[d,e]	Mexico[f]	Ukraine[b]
Iceland[d,e,f]	Cyprus[a,b,e]	Morocco[b]	United States[a,b,d,f]
Ireland[c,d,e]	Estonia[b,c,d,e,f]	Netherlands[a,b,d]	Uruguay[d]
Lithuania[c,e,f]	Finland[a,b,e]	New Zealand[a,e]	
Norway[c,d,e]	Greece[a]	Paraguay	
Slovak Rep.[b,c,d,e]	Hungary[b,c,d,e,f]	Peru[f]	
Sweden[e]	India[b,c,d,e]	Poland[b,c,e]	
Switzerland[d]	Indonesia[c,f]	Portugal[a,b,c,e]	
United Kingdom[c,d]	Italy[a,b]	Romania[c,e]	

Note: The column "CCyB release" corresponds to the treated group in the baseline estimation column 1 of Table 1, while the "No CCyB release" column lists the control group.
Superscripts a b c d e and f correspond to the various treated groups in the placebo tests presented in Tables 5 and 6: a for advanced vs emerging countries, b for the use of at least another macroprudential tool other than CCyB, c for above median (8) number of activated macroprudential instruments, d for when either debt-to-income (DTI) or the leverage ratio limit activated, e for when a loan-to-value cap is activated, and f for countries where the regulator can automatically intervene when certain regulatory thresholds are breached.
If a superscript is present, the country is in the treated group for that specific placebo test, otherwise it is in the control group. For the first placebo test a opposing advanced to emerging countries, the control group also excludes advanced countries already listed in the column CCyB release. When using the mortgage rate as an outcome variable we lose up to eight countries overall (Botswana, Cabo Verde, Colombia, Iceland, India, Malaysia, Morocco and Peru) across the placebo samples due to missing mortgage data at monthly frequency.

Table D2: Variables' description and data sources

Variables	Description	Sources
lending rate	Average new business corporate lending rate, for medium term loans	national central banks
mortgage rate	Average new business mortgage rate	national central banks
policy rate	3 months interbank interest rate	national central banks, Refinitiv, IMF
gov_rate	The 10Y sovereign bond yield	national central banks, Refinitiv, IMF
QE	The size of asset purchase programs announced in the spring of 2020, as a share of 2019 GDP	national central banks
inflation	Projected inflation rate for 2020	Consensus Forecast, Bloomberg Consensus
growth	Projected real GDP growth for 2020	Consensus Forecast, Bloomberg Consensus
stimulus	The size of the fiscal stimulus package (above the line measures) in response to the COVID crisis, as a share of 2019 GDP	IMF
liquidity	Liquidity measures announced in response to the COVID crisis (including guarantees), as a share of 2019 GDP	IMF
guarantees	The size of public loan guarantees offered in response to the COVID crisis, as share of 2019 GDP	IMF
stringency	Index measuring the stringency of COVID lockdown measures	Oxford University

Table D3: Descriptive statistics

Variable	Obs	Total		Treated		Control	
		Mean	Std. dev.	Mean	Std. dev.	Mean	Std. dev.
lending rate	324	4.7	3.6	2.4	1.3	5.6	3.9
mortgage rate	276	3.9	3.4	2.0	0.7	4.7	3.8
policy rate	324	1.7	2.9	0.2	1.0	2.2	3.2
gov_rate	301	2.5	3.2	0.4	0.8	3.4	3.5
QE	324	6.3	9.6	6.7	9.1	6.2	9.7
inflation	306	2.1	2.0	1.4	0.9	2.4	2.3
growth	324	-1.4	4.0	-2.1	4.0	-1.1	4.1
stimulus	324	3.5	4.9	3.9	4.7	3.3	5.0
liquidity	324	3.3	6.1	4.5	6.8	2.9	5.7
guarantees	324	2.5	5.1	3.8	6.3	2.0	4.6
stringency	324	49.3	32.4	46.3	29.5	50.5	33.4

Table D4: Average interest rates before and after CCyB release

Sample	Period	Corporate BLR	Mortgage rate	Policy rate	Corporate BLR index	Mortgage rate index	Policy rate index
All countries	before	4.92	3.95	1.89	98.7	98.8	97.3
	after	4.49	3.80	1.45	91.4	96.8	89.3
Treated	before	2.62	2.06	0.36	97.7	98.5	97.4
	after	2.24	1.94	0.04	86.7	95.6	90.4
Control	before	5.80	4.78	2.47	99.1	99.0	97.3
	after	5.36	4.61	1.99	93.2	97.3	88.9
Advanced countries	before	2.60	2.08	0.20	98.1	98.9	94.6
	after	2.37	1.98	-0.01	92.3	97.0	85.0
Treated	before	2.57	1.95	0.49	96.6	98.3	97.1
	after	2.16	1.81	0.12	84.9	95.1	88.2
Control	before	2.63	2.17	-0.01	99.3	99.3	92.8
	after	2.54	2.10	-0.11	97.9	98.3	82.6

Note: Before treatment corresponds to the average of January to March 2020. After treatment corresponds to the average of April to June 2020. The interest rate indexes correspond to January 2020 = 100.

Table D5: Correlation table

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) lending rate	1									
(2) mortgage rate	0.86	1								
(3) policy rate	0.80	0.88	1							
(4) gov_rate	0.88	0.91	0.92	1						
(5) QE	-0.36	-0.36	-0.39	-0.37	1					
(6) inflation	0.75	0.71	0.78	0.80	-0.41	1				
(7) growth	0.23	0.18	0.20	0.17	-0.52	0.29	1			
(8) stimulus	-0.20	-0.19	-0.24	-0.21	0.52	-0.31	-0.69	1		
(9) liquidity	-0.28	-0.25	-0.20	-0.17	0.38	-0.27	-0.60	0.53	1	
(10) guarantees	-0.27	-0.23	-0.18	-0.17	0.36	-0.23	-0.56	0.43	0.89	1
(11) stringency	0.03	0.05	0.01	0.10	0.33	-0.05	-0.45	0.34	0.26	0.26

Table D6: Identifying assumptions for DID estimations

Lending rate (Baseline)	Mortgage rate (Baseline)	Lending rate (Adv. Economies)	Mortgage rate (Adv. Economies)
Parallel-trends test (pre-treatment time period) H0: Linear trends are parallel			
F(1, 260) = 0.49 Prob > F = 0.482	F(1, 220) = 0.41 Prob > F = 0.521	F(1, 140) = 1.52 Prob > F = 0.220	F(1, 135) = 0.41 Prob > F = 0.522
Granger causality test H0: No effect in anticipation of treatment			
F(2, 260) = 0.48 Prob > F = 0.620	F(2, 220) = 0.29 Prob > F = 0.745	F(2, 140) = 1.11 Prob > F = 0.332	F(2, 135) = 0.28 Prob > F = 0.758

Note: Tests are applied to the estimates in column (1) of Tables 1 to 4.

For online appendix only

OA1 Equilibrium conditions

This part of the appendix reports the first-order conditions for the agents (optimizing problems and the other relationships that define the equilibrium of the model). The variables λ^x_{t+j}, $\forall x = \{I \;\; P \;\; E\}$ and $j = \{0 \;\; 1\}$, s^I_t and s^E_t are Lagrange multipliers. $\mathcal{P}^R_t$ and $\mathcal{P}^b_t$ represent the profits of final good producers and banks in t, respectively. Note that $L^i(x_t) = x_{t-i}$ and $F^i(x_t) = \mathrm{E}_t(x_{t+i})$, $\forall x_t$. Finally, a variable without a time subscript designates steady-state value.

OA1.1 Patient households

$$c^P_t + q^h_t\left(h^P_t - h^P_{t-1}\right) + d^P_t = w^P_t l^P_t + \left(1 + r^d_{t-1}\right) d^P_{t-1} \;\; \pi_t + t^P_t \tag{OA1}$$

$$\frac{1 - a^p}{c^p_t - a^p c^p_{t-1}} = \lambda^p_t \tag{OA2}$$

$$\lambda^P_t q^h_t = \frac{1}{h^P_t} + \beta_P \mathrm{E}_t\left(\lambda^P_{t+1} q^h_{t+1}\right) \tag{OA3}$$

$$\lambda^P_t = \beta_P \mathrm{E}_t\left[\lambda^P_{t+1}\frac{(1 + r^d_t)}{\pi_{t+1}}\right] \tag{OA4}$$

OA1.2 Impatient Households

$$c^I_t + q^h_t\left(h^I_t - h^I_{t-1}\right) + \left(1 + r^{bH}_{t-1}\right) b^I_{t-1} \;\; \pi_t = w^I_t l^I_t + b^H_t + t^I_t \tag{OA5}$$

$$\left(1 + r^{bH}_t\right) b^H_t \leq m_H E_t\left[q^h_{t+1} h^I_t \pi_{t+1}\right] \tag{OA6}$$

$$\frac{1 - a^I}{c^I_t - a^I c^I_{t-1}} = \lambda^I_t \tag{OA7}$$

$$\lambda^I_t q^h_t = \frac{1}{h^I_t} + \beta_I \mathrm{E}_t\left[\lambda^I_{t+1} q^h_{t+1}\right] + \beta_I m_H \mathrm{E}_t\left[s^I_t q^h_{t+1}\pi_{t+1}\right] \tag{OA8}$$

$$\lambda^I_t = \beta_I \mathrm{E}_t\left[\lambda^I_{t+1}\frac{(1 + R^{bh}_t)}{\pi_{t+1}}\right] + s^I_t\left(1 + r^{bh}_t\right) \tag{OA9}$$

OA1.3 Entrepreneurs

$$c^E_t + w^P_t l^{E,P}_t + w^I_t l^{E,I}_t + \left(1 + r^{bE}_{t-1}\right) b^E_{t-1} \;\; \pi_t + q^k_t k^E_t = \frac{y^E_t}{x_t} + b^E_t + q^k_t(1 - \delta) k^E_{t-1} \tag{OA10}$$

$$\left(1 + r^{bE}_t\right) b^E_t \leq m_E E_t\left[q^k_{t+1} k^E_t \pi_{t+1}(1 - \delta)\right] \tag{OA11}$$

$$\frac{1 - a^E}{c^E_t - a^E c^E_{t-1}} = \lambda^E_t \tag{OA12}$$

$$\lambda_t^E = \beta_E \mathrm{E}_t \left[\lambda_{t+1}^E \frac{\left(1 + r_t^{bE}\right)}{\pi_{t+1}} \right] + s_t^I \left(1 + r_t^{bE}\right) \tag{OA13}$$

$$\begin{aligned} \lambda_t^E q_t^k =& \beta_E \mathrm{E}_t \lambda_{t+1}^E \left[r_{t+1}^k + q_{t+1}^k (1-\delta) \right] \\ &+ m_E \mathrm{E}_t \left[s_t^E q_{t+1}^k \pi_{t+1} (1-\delta) \right] \end{aligned} \tag{OA14}$$

$$y_t^E = \left[k_{t-1}^E\right]^\alpha \left[\left(l_t^{E,P}\right)^\mu \left(l_t^{E,I}\right)^{1-\mu} \right]^{1-\alpha} \tag{OA15}$$

$$w_t^P = \mu(1-\alpha) \frac{y_t^E}{l_t^{E,P}} \frac{1}{x_t} \tag{OA16}$$

$$w_t^I = (1-\mu)(1-\alpha) \frac{y_t^E}{l_t^{E,I}} \frac{1}{x_t} \tag{OA17}$$

$$r_t^k = \alpha \frac{y_t^E}{k_{t-1}^E} \frac{1}{x_t} \tag{OA18}$$

OA1.4 Capital Goods Producers

$$k_t = (1-\delta) k_{t-1} + \left[1 - \frac{\kappa_i}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 \right] i_t \tag{OA19}$$

$$\begin{aligned} 1 =& q_t^k \left[1 - \frac{\kappa_i}{2} \left(\frac{i_t}{i_{t-1}} - 1 \right)^2 - \kappa_i \left(\frac{i_t}{i_{t-1}} - 1 \right) \frac{i_t}{i_{t-1}} \right] \\ &+ \beta_E E_t \left[\frac{\lambda_{t+1}^E}{\lambda_t^E} q_{t+1}^k \kappa_i \left(\frac{i_{t+1}}{i_t} - 1 \right) \left(\frac{i_{t+1}}{i_t} \right)^2 \right] \end{aligned} \tag{OA20}$$

OA1.5 Final Goods Producers

$$\mathcal{P}_t^R = y_t \left(1 - \frac{1}{x_t} \right) - \frac{\kappa_P}{2} \left(\pi_t - \pi_{t-1}^{l_P} \bar{\pi}^{1-t_P} \right)^2 \tag{OA21}$$

$$\begin{aligned} & 1 - \quad {}^{y} + \frac{{}^{y}}{x_t} - \kappa_P \left(\pi_t - \pi_{t-1}^{t_P} \bar{\pi}^{1-t_P} \right) \pi_t \\ &+ \beta_P E_t \left[\frac{\lambda_{t+1}^P}{\lambda_t^P} \kappa_P \left(\pi_{t+1} - \pi_t^{t_P} \bar{\pi}^{1-t_P} \right) \pi_{t+1} \frac{y_{t+1}}{y_t} \right] = 0 \end{aligned} \tag{OA22}$$

OA1.6 Labour unions

Patient households

$$\begin{aligned} \kappa_w \left(\pi_t^{wP} - \pi_{t-1}^{\iota_w} \bar{\pi}^{1-\iota_w} \right) \pi_t^{wP} =& \beta_P E_t \left[\frac{\lambda_{t+1}^P}{\lambda_t^P} \kappa_w \left(\pi_{t+1}^{wP} - \pi_t^{\iota_w} \bar{\pi}^{1-\iota_w} \right) \frac{\left(\pi_{t+1}^{wP}\right)^2}{\pi_{t+1}} \right] \\ &+ \left(1 - \quad {}^{l} \right) l_t^P + \frac{{}^{l} \left(l_t^P\right)^{1+\phi}}{w_t^{wP} \lambda_t^P} \end{aligned} \tag{OA23}$$

$$\pi_t^{wP} = \frac{w_t^{wP}}{w_{t-1}^{wP}} \pi_t \tag{OA24}$$

Impatient households

$$\begin{aligned}\kappa_w\left(\pi_t^{wI}-\pi_{t-1}^{\iota_w}\bar{\pi}^{1-\iota_w}\right)\pi_t^{wI}=&\beta_I E_t\left[\frac{\lambda_{t+1}^I}{\lambda_t^I}\kappa_w\left(\pi_{t+1}^{wI}-\pi_t^{\iota_w}\bar{\pi}^{1-\iota_w}\right)\frac{\left(\pi_{t+1}^{wI}\right)^2}{\pi_{t+1}}\right]\\&+\left(1-{}^{l}\right)l_t^I+\frac{{}^{l}\left(l_t^I\right)^{1+\phi}}{w_t^{wI}\lambda_t^I}\end{aligned}\tag{OA25}$$

$$\pi_t^{wI}=\frac{w_t^{wI}}{w_{t-1}^{wI}}\pi_t\tag{OA26}$$

OA1.7 Banks

Wholesale unit

$$\begin{aligned}R_t^{bH}=R_t-\kappa_{car}&\left(\frac{K_t^b}{{}_t^E B_t^E+{}_t^H B_t^H}-\upsilon_t\right)\left(\frac{K_t^b}{{}_t^E B_t^E+{}_t^H B_t^H}\right)^2{}_t^H\\-\kappa_{lev}&\left(\frac{K_t^b}{B_t^E+B_t^H}-lev\right)\left(\frac{K_t^b}{B_t^E+B_t^H}\right)^2\end{aligned}\tag{OA27}$$

$$\begin{aligned}R_t^{bE}=R_t-\kappa_{car}&\left(\frac{K_t^b}{{}_t^E B_t^E+{}_t^H B_t^H}-\upsilon_t\right)\left(\frac{K_t^b}{{}_t^E B_t^E+{}_t^H B_t^H}\right)^2{}_t^E\\-\kappa_{lev}&\left(\frac{K_t^b}{B_t^E+B_t^H}-lev\right)\left(\frac{K_t^b}{B_t^E+B_t^H}\right)^2\end{aligned}\tag{OA28}$$

$$\pi_t K_t^b=\left(1-\delta^b\right)K_{t-1}^b+\mathcal{P}_{t-1}^b\tag{OA29}$$

$$B_t^H+B_t^E=D_t+K_t^b\tag{OA30}$$

$${}_t^H=(1-\rho_H)\,\bar{w}^H+(1-\rho_H)\,\chi_H\,(Y_t-Y_{t-4})+\rho_H\;{}_{t-1}^H\tag{OA31}$$

$${}_t^E=(1-\rho_E)\,\bar{w}^E+(1-\rho_E)\,\chi_E\,(Y_t-Y_{t-4})+\rho_E\;{}_{t-1}^E\tag{OA32}$$

$$\mathcal{P}_t^b=r_t^{bH}b_t^H+r_t^{bE}b_t^E-r_t^d d_t-\mathcal{D}_t^{\upsilon}(K_t^b)-\mathcal{D}_t^{lev}(K_t^b)-\sum_{s=H,E}\mathcal{A}_{bs}(r_t^{bs})-\mathcal{A}_d(r_t^d)\tag{OA33}$$

$$\mathcal{D}_t^{\upsilon}(K_t^b)=\frac{\kappa_{car}}{2}\left(\frac{K_t^b}{{}_t^E B_t^E+{}_t^H B_t^H}-\upsilon_t\right)^2K_t^b\tag{OA34}$$

$$\mathcal{D}_t^{lev}(K_t^b)=\frac{\kappa_{lev}}{2}\left(\frac{K_t^b}{B_t^E+B_t^H}-lev\right)^2K_t^b\tag{OA35}$$

$$\mathcal{A}_{bs}(r_t^{bs})\equiv\frac{\kappa_{bs}}{2}\left(\frac{r_t^{bs}}{r_{t-1}^{bs}}-1\right)^2r_t^{bs}b_t^s\qquad\text{with }\;s=\{H\;\;E\}\tag{OA36}$$

$$\mathcal{A}_d(r_t^d)\equiv\frac{\kappa_d}{2}\left(\frac{r_t^d}{r_{t-1}^d}-1\right)^2r_t^d d_t\tag{OA37}$$

Retail units

$$\xi^d \frac{R_t^d}{r_t^d} = \xi^d - 1 - \kappa_d \left(\frac{r_t^d}{r_{t-1}^d} - 1\right) \frac{r_t^d}{r_{t-1}^d} + \beta_P E_t \left[\frac{\lambda_{t+1}^P}{\lambda_t^P} \kappa_d \left(\frac{r_{t+1}^d}{r_t^d} - 1\right) \left(\frac{r_{t+1}^d}{r_t^d}\right)^2 \frac{d_{t+1}^P}{d_t^P}\right] \tag{OA38}$$

$$\xi^{bs} \frac{R_t^{bs}}{r_t^{bs}} = \xi^{bs} - 1 + \kappa_{bs} \left(\frac{r_t^{bs}}{r_{t-1}^{bs}} - 1\right) \frac{r_t^{bs}}{r_{t-1}^{bs}} - \beta_P E_t \left[\frac{\lambda_{t+1}^P}{\lambda_t^P} \kappa_{bs} \left(\frac{r_{t+1}^{bs}}{r_t^{bs}} - 1\right) \left(\frac{r_{t+1}^{bs}}{r_t^{bs}}\right)^2 \frac{b_{t+1}^s}{b_t^s}\right] \tag{OA39}$$

with $s = \{H \;\; E\}$

OA1.8 Monetary policy and macroprudential policy

$$\frac{1+r_t}{1+r} = \left(\frac{1+r_{t-1}}{1+r}\right)^{\rho_r} \left(\frac{\pi_t}{\pi}\right)^{\chi_\pi(1-\rho_r)} \left(\widetilde{Y}_t\right)^{\chi_y(1-\rho_r)} \quad {}_{r,t} \tag{OA40}$$

$$\upsilon_t = (\upsilon_{t-1})^{\rho_\upsilon} \left[\upsilon \left(\frac{\widetilde{B_t}}{Y_t}\right)^{\chi_{ccyb}}\right]^{(1-\rho_\upsilon)} \quad {}_{\upsilon,t} \tag{OA41}$$

$$\widetilde{Y}_t + \lambda_{HP} (1-L)^2 (1-F)^2 \widetilde{Y}_t = \lambda_{HP} (1-L)^2 (1-F)^2 Y_t \tag{OA42}$$

$$\left(\frac{\widetilde{B_t}}{Y_t}\right) + \lambda_{HP} (1-L)^2 (1-F)^2 \left(\frac{\widetilde{B_t}}{Y_t}\right) = \lambda_{HP} (1-L)^2 (1-F)^2 \left(\frac{B_t}{Y_t}\right) \tag{OA43}$$

OA1.9 Market clearing conditions

$$Y_t = c_t^P + c_t^I + c_t^E + k_t - (1-\delta)k_{t-1} \quad y_t^E = y_t \quad l_t^{E,P} = l_t^P \quad l_t^{E,I} = l_t^I \quad 1 = h_t^P + h_t^I \quad b_t^E = B_t^E$$
$$b_t^H = B_t^H \quad B_t = B_t^E + B_t^H \quad d_t^P = D_t \quad k_t^E = K_t \tag{OA44}$$