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Reviewed by: Marc Gabarro (Erasmus University Rotterdam)
Eva Hromádková (Czech National Bank)
Project Coordinator: Simona Malovaná

Easing of Borrower-Based Measures: Evidence from Czech Loan-Level Data

Martin Hodula, Lukáš Pfeifer, and Ngoc Anh Ngo *

Abstract

We analyze how a large-scale easing of borrower-based measures affects residential mortgage credit and borrower characteristics. We exploit a case of the easing of the LTV limit and the complete abolition of DTI and DSTI limits in the Czech Republic in the first half of 2020. Our empirical evidence suggests that the households affected increased their borrowing and purchased more expensive houses while being able to decrease the collateral value. We also document a significant increase in borrowers' debt (service) but this was softened by the concurrent growth in borrowers' income. While exploring the heterogeneity in the transmission of the regulatory easing, we find that: (i) LTV-constrained borrowers showed signs of cash-retention behavior while DTI- and DSTI-constrained borrowers acted in line with the financial accelerator mechanism; (ii) relaxing the LTV limit had a larger effect in poorer districts while the abolition of DTI and DSTI limits affected borrowers in richer regions; (iii) younger borrowers were more affected by the easing of LTV and DTI limits, while the easing of the DSTI limit affected older borrowers; (iv) relaxing the LTV limit affected mostly first-time borrowers while abolishing the DTI and DSTI limits affected mostly second-time borrowers who obtained higher mortgages and purchased more expensive property.

Abstrakt

Analyzujeme, jak výrazné uvolnění nástrojů zaměřených na dlužníky ovlivňuje charakteristiky hypotečních úvěrů na nákup rezidenčních nemovitostí a příjemců těchto úvěrů. K analýze využíváme případ uvolnění limitu LTV a úplného zrušení limitů DTI a DSTI v České republice v první polovině roku 2020. Naše empirické poznatky naznačují, že domácnosti ovlivněné těmito rozhodnutími zvýšily své výpůjčky, zakoupily dražší nemovitosti a zároveň mohly snížit hodnotu zástavy. Rovněž dokládáme významný nárůst zadlužení a dluhové služby, který však zmírnilo souběžné zvýšení příjmů dlužníků. Naše zkoumání heterogenity transmise regulatorního uvolnění vede k následujícím zjištěním: (i) dlužníci, pro něž bylo omezením LTV, vykazovali známky ponechávání si hotovosti, zatímco dlužníci, pro něž bylo omezením DTI a DSTI, jednali v souladu s mechanismem finančního akcelerátoru; (ii) uvolnění limitu LTV mělo větší efekt v chudších okresech, zatímco zrušení limitů DTI a DSTI ovlivnilo dlužníky v bohatších regionech; (iii) na mladší dlužníky mělo větší dopad uvolnění limitů LTV a DTI, zatímco uvolnění limitu DSTI ovlivnilo starší dlužníky; (iv) uvolnění limitu LTV ovlivnilo převážně dlužníky, kteří si půjčovali poprvé, zatímco zrušení limitů DTI a DSTI hrálo roli zejména u dlužníků, kteří si půjčovali podruhé, získávali vyšší hypotéky a kupovali dražší nemovitosti.

JEL Codes: E58, G21, G28, G51.
Keywords: Borrower-based measures, household finance, loosening, macroprudential policy.

* Martin Hodula, Czech National Bank, martin.hodula@cnb.cz;
Lukáš Pfeifer, Czech National Bank, lukas.pfeifer@cnb.cz;
Ngoc Anh Ngo, Czech National Bank, ngoc.ngo@cnb.cz.

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1. Introduction

Rapid growth in mortgage loans and rising house prices tend to reinforce each other and pose a threat to financial sector stability (Mian and Sufi, 2011). An increasing number of countries have introduced borrower-based macroprudential policies to mitigate the negative consequences of the feedback loop between credit and house prices (Alam et al., 2019; Gatt, 2023). The policies commonly manifest as restrictions on loan-to-value (LTV) and debt service-to-income (DSTI) ratios (Alam et al., 2019).[1] These borrower-based macroprudential limits serve to minimize the vulnerability of mortgage loan portfolios by establishing explicit boundaries for prudential credit standards. Owing to the growing use of limits in policy practice, the literature has already accumulated rich evidence on their functioning and transmission to the mortgage and real estate market (see, for example, Akinci and Olmstead-Rumsey, 2018; Acharya et al., 2022; Hodula et al., 2023).

Up to now, however, the literature has predominantly examined the effects of introducing borrower-based limits, which has involved a "tightening" of mortgage credit conditions compared to a no-policy regime. The loosening of macroprudential policies has received far less attention, mainly because such policies have only been implemented in the period following the Global Financial Crisis (GFC) and have yet to undergo a loosening episode in most countries.

In this paper, we provide the first comprehensive analysis of the effects of the easing of different borrower-based macroprudential limits based on a cyclical approach. Specifically, we focus on the effects of the easing of policies that impose upper bounds on the LTV, DTI, and DSTI ratios of household mortgages. Combining loan-level data with detailed borrower, bank and spatial characteristics, we study the 2020 easing of the LTV limit and the complete abolition of DTI and DSTI limits in the Czech Republic. The borrower-based limits were cyclically eased at the beginning of the Covid-19 pandemic in order to support the residential mortgage loan market. All loans originating in the Czech Republic are subject to regulatory limits, and hence the 2020 change in policy represents a unique case of regulatory easing in terms of size. The nature of the data and the regulatory setup allows us not only to estimate the heterogeneous treatment effects but also to partially distinguish between the effects of the easing of individual borrower-based limits – providing a complete picture for policymakers. Our main set of results can be summarized as follows.

We document - somewhat intuitively - that the easing of borrower-based limits has contributed to growth in mortgage loans, as more borrowers were able to access mortgages. On average, affected borrowers have substantially increased their borrowing by about 8 pp and purchased more expensive houses (by 3 pp) relative to matched controls. Economically, however, the borrowers' reaction has led to the creation of a liquidity buffer given that the average mortgage size increased more than the average price of the property purchased. At the same time, however, the regulatory easing has allowed borrowers to obtain a mortgage backed by substantially lower collateral value (a decrease of about 11 pp). From a financial stability perspective, any increase in LTV driven by a large collateral decrease implies a potentially greater loss in the event of default on the loan. While focusing on adjustments to the DTI and DSTI ratios, we observe a significant increase in borrowers' debt (service). However, this was softened by concurrent growth in borrowers' income. So while more

[1] Other measures employed to mitigate the vulnerability of mortgage portfolios encompass restrictions on loan-to-income (LTI), loan-service-to-income (LSTI), and debt-to-income (DTI) ratios. Furthermore, capital buffers or limitations on the minimum risk weight assigned to the mortgage portfolio under Article 458 of the CRR can be utilized to enhance the resilience of mortgage portfolios.

indebted borrowers were granted a mortgage, these borrowers were also more solvent compared to the pre-easing control group.

Next, we distinguish between the effects of easing individual borrower-based limits by examining the adjustments in the balance sheets of LTV-, DTI-, and DSTI-constrained borrowers. We document significant differences in the way the respective groups of affected borrowers responded to the regulatory easing. LTV-constrained borrowers, for instance, went for higher mortgages but made significantly smaller down payments relative to the pre-easing control group when purchasing similar property – suggesting cash-retention behavior. On the contrary, DTI- and DSTI-constrained borrowers acted more in line with the classic financial accelerator – they went for higher mortgages to purchase more expensive properties while also making lower down payments, hence decreasing their liquidity buffer.

Last, we explore the heterogeneity in the transmission of regulatory easing to the mortgage loan market, focusing on three dimensions of heterogeneity that are potentially highly relevant to policy practitioners: the borrowers' location, age, and first/second mortgage identifier. We find that the easing of borrower-based measures has contributed to more equitable access to mortgages across districts with different levels of prosperity. Specifically, our estimates show LTV-constrained borrowers located in poorer districts were able to obtain higher mortgages and thus purchased more expensive property. While zooming in on borrowers' age, we find significant heterogeneity in the response of younger and older borrowers. Younger borrowers responded mainly to the easing of the LTV limit and the abolition of the DTI limit, while older borrowers were responsive to the abolition of the DSTI limit. These results provide evidence of natural intuition that younger borrowers are more constrained by the LTV and DTI limits, while older borrowers are bound by the DSTI limit. The last set of results concerns the heterogeneous treatment response with respect to the borrower mortgage identifier, e.g. whether the mortgage was the borrower's first mortgage or not. We show that abolishing the income-based limits have helped mostly second-time borrowers who were able to obtain higher mortgages and purchase more expensive properties. On the contrary, increasing the LTV limit helped mostly first-time borrowers to obtain higher mortgages.

Our findings have important implications for the literature on macroprudential policy and its impact. The use of macroprudential measures aimed at borrowers has been rationalized in the concurrent body of work by the existence of a negative feedback loop between property prices and mortgage loans (Iacoviello and Neri, 2010; Favara and Imbs, 2015; Justiniano et al., 2019). This stems from the fact that households tend to over-borrow in good times, not internalizing all of the costs of their financing choice (Bianchi, 2011; Bianchi and Mendoza, 2018). Empirically, the introduction or tightening of borrower-based measures has been shown to reduce mortgage debt (Aastveit et al., 2021) and household leverage (de Araujo et al., 2020). Further, borrowers facing tighter credit conditions are shown to buy cheaper properties (Félix et al., 2021) and even relocate to rural districts where houses are cheaper (Acharya et al., 2022). Households also tend to reduce their cash balances to satisfy the regulatory limits, generating a solvency-liquidity tradeoff (Van Bekkum et al., 2019).[2]

[2] The bulk of studies have focused on the aggregate effects of borrower-based measures. These studies capture macroprudential actions using dummy-type indices (Cerutti et al., 2017b; Alam et al., 2019) where 1 denotes macroprudential policy tightening, -1 macroprudential policy easing, and 0 no change at a given time. They focus on the intermediate targets of macroprudential policy, e.g. on credit growth (Lim et al., 2011; Cerutti et al., 2017a; Akinci and Olmstead-Rumsey, 2018; Morgan et al., 2019), house prices (Vandenbussche et al., 2015; Acharya et al., 2022) or both (Kuttner and Shim, 2016; Alam et al., 2019). The dummy-based approach allows for a partial normalization of policy shocks across countries and the papers provide useful insight into the functioning of the limits. However, studies relying on dummy-coded indices are not able to quantify the effect of macroprudential policies, which are of key importance for policymakers (Malovaná et al., 2023, 2024). In addition, studies at single-

Our analysis contributes to this literature by showing how an easing of the LTV limit and the abolition of the DTI and DSTI limits operate in practice. We show that while households tend to borrow more after credit conditions are eased, they also increase their liquidity buffers by making lower down payments. The notion that households would, in line with the financial accelerator mechanism, automatically purchase more expensive properties does not hold when the heterogeneity of borrowers is taken into account. Further, as household indebtedness generally rises in spite of the regulatory easing, so does borrower income level which lowers financial stability concerns. We do not observe borrower reallocation from cities to peripheries.

Our paper also complements the ongoing debate on whether to use and set borrower-based macroprudential tools as a structural or cyclical policy tool. Most countries are likely inclined towards a structural approach in setting borrower-based measures, where the calibration of the limits remains stable over time. The cyclical approach to calibrating borrower-based measures takes into account the macroeconomic conditions and the stage of the credit cycle and allows for flexible adjustments to the limits based on the prevailing economic conditions. A purely structural approach prevails in EU practice so far, and significant cyclical changes are more of an exception. However, there is currently no established best practice in this area, and individual countries may adopt different approaches based on specific economic situations. We offer insight into how the real estate market responds to a cyclical release of borrower-based measures.

Our evidence stands side-by-side with a handful of studies showing the effects of regulatory easing.[3] Based on Canadian data, Allen et al. (2020) find that after a relaxation of the LTV limit, there is a substantial increase in the fraction of households with no more than 5% equity at origination and that households tend to increase their leverage by making higher mortgage payments. McCann and Durante (2022) exploit a reform of the Irish borrower-based measures in 2017 that increased the LTV limits for a cohort of first-time buyers. They find no evidence that the easing would trigger a financial accelerator mechanism. The borrowers affected purchase properties of a similar price and make lower down payments, displaying a preference for cash retention once the opportunity arises.

Compared to the existing studies in terms of intensity, we track the effects of the highest easing of borrower-based measures on record. Further, we explore the effects of the easing of three different borrower-based limits – the LTV, DTI, and DSTI. Our evidence is mostly in line with McCann and Durante (2022) as we, too, find evidence of cash retention behavior amongst borrowers. However, this result holds mostly for borrowers who were previously constrained by the LTV limit, while DTI- and DSTI-constrained borrowers acted more in line with the standard financial accelerator. We also find evidence of an increase in borrowers' leverage in line with Allen et al. (2020) but found a concurrent increase in borrowers' solvency levels.

The remainder of this paper is organized as follows. Section 2 describes the Czech mortgage market as well as its regulatory environment and changes following the Covid-19 pandemic. Section 3 describes the data and estimation methodology. Section 4 contains our baseline results

or cross-country level using aggregate data may miss the complexity through which borrower-based measures impact borrower behavior (Kelly et al., 2018).

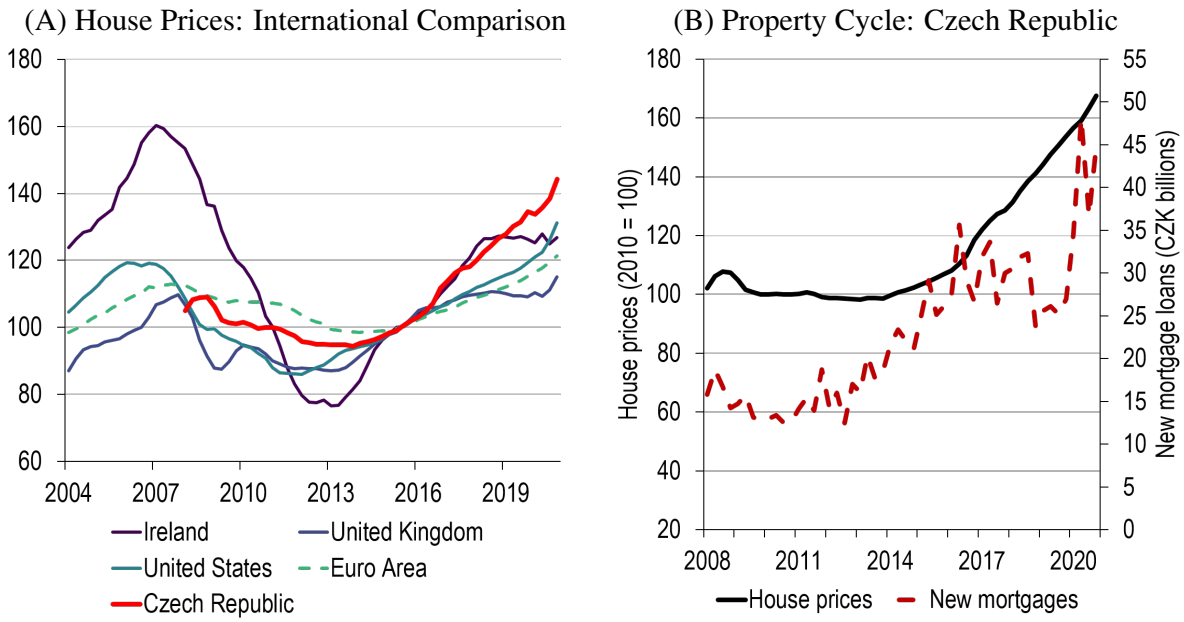
[3] The lack of empirical studies exploring the effects of regulatory easing stems from the fact that such policy actions are rare. In the most recent version of the Alam et al. (2019) database, 79 episodes of the loosening of LTV caps were recorded, while there were 180 tightening actions for the entire sample. For the DSTI, there have been 35 loosening episodes and 109 tightening actions. Further, a dominant share of easing actions has been of a qualitative nature (i.e. a change in regulatory conditions) and not of a quantitative nature (i.e. a numerical change to the limit).

whose robustness is tested in Section 5. Section 6 discusses the heterogeneity of conditional average treatment effects. Section 7 concludes.

2. The Czech Residential Mortgage Market

The Czech National Bank (CNB) has been applying credit ratio caps (LTV, DTI and DSTI) since 2015 to mitigate the risks associated with the provision of retail loans secured by residential property.[4] The decision to set borrower-based limits followed rapid developments in the Czech real estate market which, unlike other countries, did not experience any major bust during or after the GFC. From an international perspective, the boom in the real estate mortgage market following the GFC was more pronounced in the Czech Republic compared to the euro area average, the United Kingdom, Ireland, or the United States (Figure 1, Panel A). The growth in mortgage loans was also accompanied by a rapid increase in property prices (Figure 1, Panel B). In the absence of significant increases in non-performing mortgages or dry-ups in funding, mortgage lending grew, notably between 2015 and 2017 where the growth followed the concurrent easing of monetary policy. In response, borrower-based limits were introduced and gradually tightened during the boom phase of the financial cycle. The limits were the CNB's reaction to a spiral of rising amounts of mortgages and property prices related to relaxed credit standards and the over-optimistic expectations of economic agents (Figure A1).

Figure 1: House Prices and the Property Cycle



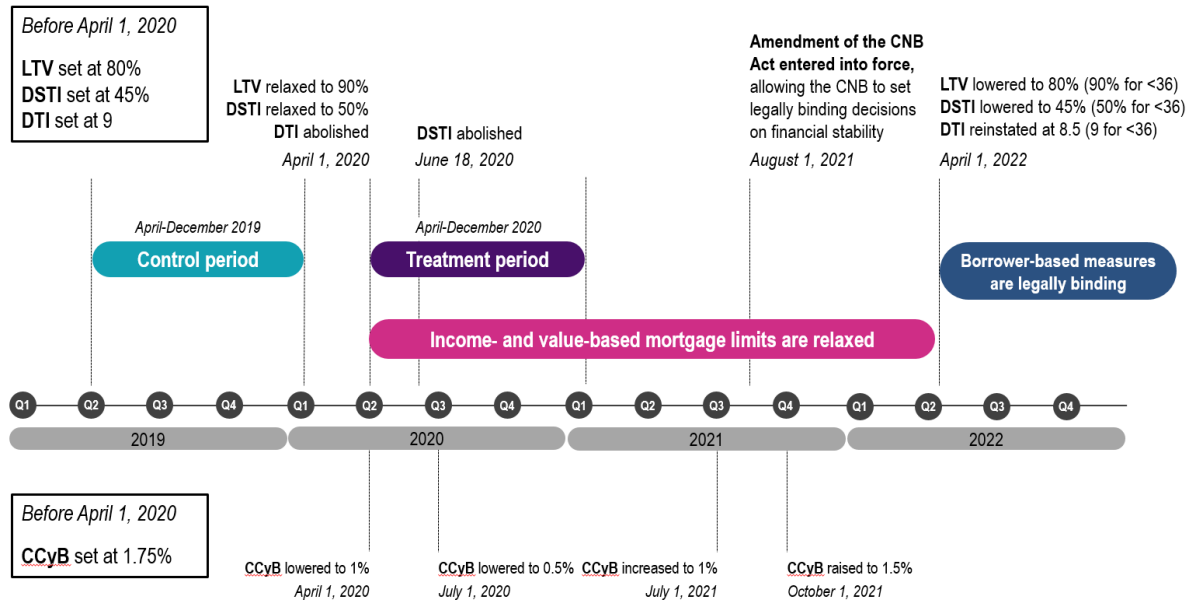
Note: The chart on the left shows real house prices (2015 = 100) obtained from the OECD database, as expressed by the ratio of nominal prices to the consumer expenditure deflator in each country, both seasonally adjusted.
Source: Czech National Bank, Czech Statistical Office and OECD.

[4] Due to the Czech legal system's limitations on the use of statutory limits, the CNB chose an alternative approach by issuing non-binding recommendations. Despite their non-binding nature, the CNB has effectively ensured compliance with the suggested borrower-based limits by clearly communicating to banks that failure to adhere could result in additional capital requirements under Pillar 2 of the Basel III framework. The monitoring of compliance was conducted through a mortgage loan survey, which demonstrated that banks fully complied with the regulatory limits. Consequently, the conclusions drawn in this paper can be extrapolated to markets where statutory limits are in place.

Before the easing took place, the CNB had imposed LTV, DTI, and DSTI limits. Specifically, providers had to ensure that the LTV ratio of retail loans secured by residential property did not exceed 80%, applicants' debt did not exceed nine times their net annual income (DTI ratio) and spent no more than 45% of their net monthly income on debt service (DSTI ratio). These levels could be exceeded in specific cases (the soft limit) but for no more than 10% of loans (in the case of the LTV)[5] and 5% of loans (in the case of the DTI and DSTI).

On April 1, 2020, the CNB Bank Board relaxed the borrower-based limits for new mortgages with immediate effect. Specifically, the LTV limit was relaxed to 90%, the DTI limit was abolished and the DSTI limit was first relaxed to 50% only to be abolished on June 18, 2020. These actions were in line with the forward guidance which had been provided by the CNB in the past, which stated that the borrower-based measures would be relaxed once an economic downturn occurred (ESRB, 2022). All macroprudential policy-related decisions in the Czech Republic are displayed in Figure 2.[6]

Figure 2: Macroprudential Policy Timeline for the Czech Republic



Note: The timeline displays the CNB Bank Board's main decisions on financial stability based on their date of entry into force.
Source: CNB.

Following the outbreak of the pandemic, the volume of new loans for house purchase accelerated. This was accompanied by an easing of the borrower-based limits and the related bank lending standards (Figure A1). The volume of mortgage loans reached record highs in 2020 and there

[5] Specifically, it was recommended that providers should ensure that new retail loans secured by residential property with an LTV of 80-90% did not exceed 15% of the total amount of retail loans secured by residential property provided in the current quarter

[6] The relaxation of borrower-based measures was complemented by similar actions regarding the capital-based measures. On March 16, 2020, the CNB cancelled its decision from the previous year to raise the countercyclical capital buffer rate (CCyB) for exposures located in the Czech Republic to 2% and left it at 1.75%. In the period under analysis, the CNB lowered the CCyB rate twice: to 1% with effect from April 1, 2020 and further to 0.5% with effect from 1 July 2020. These measures reacted to the downturn in economic activity which, according to the CNB, may have had an adverse effect on the quality of loan portfolios (Mora and Galuščák, 2022).

was renewed movement up the spiral between debt funding of property and optimistic expectations regarding future property price growth. This trend reflected favorable conditions for the credit financing of property and large excess demand for property.

2.1 Easing of Borrower-Based Measures During Covid-19: An International Comparison

During the Covid-19 pandemic, rather than encouraging banks to shore up their balance sheets and retrench, regulatory authorities encouraged them to partly draw down the capital buffers accumulated since the GFC in order to keep credit flowing (Borio, 2020). The loosening of value- and income-based mortgage limits was adopted in much fewer countries. According to Nier and Olafsson (2020), 71 countries eased the capital-based measures, while only 15 countries relaxed the borrower-based macroprudential tools until the end of August 2020.

The Czech 2020 easing of borrower-based macroprudential measures was unique in the international context, as only few other European regulatory authorities opted for changes in such measures. Moreover, the changes were on a smaller scale, affecting only a specific type of borrower (Table 1). Most of the countries temporarily loosened their borrower-based limits to ensure the provision of credit at the beginning of the crisis or to allow households to withstand a temporary loss of income without suffering any deterioration in their liquidity position (ESRB, 2022). In most countries, authorities did not adjust the borrower-based measures that were already in place, as they were considered to be prudent backstops for which adjustment had not been foreseen throughout the cycle.

Table 1: Relaxation of Borrower-Based Measures during the Covid-19 Pandemic in Europe

Country	Measure	Date	Description of the action
Czech Republic	LTV, DTI, DSTI	April 1, 2020	The LTV limit was relaxed from 80% to 90%, the DTI (<9) and DSTI (<45%) limits were abolished.
Finland	LTC	June 29, 2020	The maximum LTC ratio was adjusted and brought back to the statutory standard level of 90%. On October 1, 2021, the cap was restored to the pre-pandemic level (85%).
Malta	LTV	June 1, 2020	An extension of the reduction in LTVs from 85% to 75% was granted for borrowers taking out a loan for a secondary residence or buy-to-let. The extension ended in June 2021.
	DSTI	June 1, 2020	The DSTI limit was relaxed for six months, provided that the reason for the failure to meet the payment obligation was temporary.
Norway	LTV	April 1, 2020	The volume of new mortgages taken out in 2020 Q2 was allowed to deviate from the regulatory requirements. The LTV was temporarily increased from 8% (Oslo) and 10% (outside Oslo) to 20%.
Portugal	DSTI	April 1, 2020	New personal credit granted from April 1 until September 30, 2020 of up to two-year maturity did not have to comply with the DSTI ratio limit. The share of new loans granted to borrowers with a DSTI above 50% but below 60% was lowered to 10% (from 20%) of new credit.
Sweden	Amortization requirements	April 14, 2020	Until August 31, 2021, banks had the possibility to offer all new and existing mortgagors a temporary exemption from the amortization requirements.

Note: LTC = loan-to-collateral ratio. The dates given in the table are the dates of entry into force.
Source: ESRB (2022).

The lack of experience with the easing of borrower-based limits is partially due to the fact that in most jurisdictions, the local regulatory authorities perceive the limits as a structural policy tool. In contrast, under a cyclical approach, the calibration of borrower-based limits may change more

frequently in response to the development of cyclical indicators such as mortgage loan volumes or property prices. The structural approach to the setting of borrower-based limits is more stable and responds to the existing vulnerability of the mortgage loan portfolio. In the current practice of EU countries, the predominant approach in setting borrower-based measures is primarily structural.

2.2 Other Policy Responses to the Covid-19 Pandemic in the Czech Republic

The world economy experienced a sharp downturn during the Covid-19 pandemic. In the second half of 2020, real GDP in the Czech Republic dropped by almost 5% (approx. 4% in the EU) but the country did not experience any hike in the unemployment rate which stood at 2–3% in the pandemic year 2020 (compared to the EU average of 6–8%). Nevertheless, the adverse effects of the economic slowdown on household real disposable income have been tempered by government policy responses to the pandemic. As a result, there has not been an increase in mortgage portfolio defaults to the extent that was anticipated.

As a result, house prices and new mortgage credit volumes have decoupled from the rest of the economy and have continued to grow while being prone to overvaluation (Table 2). Growth in loans to households for house purchase and real price growth in residential property were higher in the Czech economy (8.0% and 5.2%) than in the EU (5.2% and 3.6%) in the period 2019 Q2-2022 Q2.

Table 2: Developments in the EU Mortgage Market

	Residential real estate price index, 36M average real growth	ECB econometric model (real estate price overvaluation)	Loans to households for house purchase, 36M average real growth	Household debt, % of income
CZ	8.1	30	5.2	59.6
EU average	5.3	6	3.6	98.3

Note: The latest observation is from 2021 Q2.
Source: European Systemic Risk Board.

In addition to public health protection measures, the Czech government announced and implemented various measures of a fiscal nature to provide some stimulus to the real economy. The CNB also introduced several monetary and macroprudential policy measures addressing the sudden disruption. The combination of unprecedented measures and their joint effects were vital in supporting the economy. We compiled a list of all policy measures based on official press releases and the meeting minutes of the CNB Bank Board and the Czech Government respectively in order to assess whether some of these measures could have spurred changes in the real estate market. We cross-checked our findings with the database described in Hale et al. (2020) and the Fiscal Policy Responses database maintained by the IMF to make sure we did not omit any important measures.

As regards monetary policy, the CNB cut all key interest rates in three steps. It first lowered the key two-week repo rate by 0.5 pp to 1.75% on March 16, 2020 and then by another 0.75 pp to 1% on March 26, 2020. On May 7, 2020, the CNB Bank Board decided to lower the two-week repo rate by 75 basis points to 0.25% and at the same time, it lowered the Lombard rate by 100 basis points to 1.00%. At the meeting, it was stated that such large interest rate cuts would make it possible to support the economy and subsequently move away from the zero lower bound again more quickly. While the interest rate cuts were substantial, they are still, in terms of their levels, at the lower end

of historical distribution and followed a prolonged period of record low interest rates. Together with the observed lagged transmission of central bank interest rates to mortgage rates (Gregor et al., 2022), we believe that the impact of monetary policy cuts on the mortgage loan market was minimal and was, for a major part, overshadowed by the easing of borrower-based measures. Nevertheless, we formally address this concern in our robustness checks.

In terms of fiscal policy, the Czech Government introduced various fiscal measures to mitigate the economic and social impacts of the pandemic[7]. On March 16, 2020, a loan moratorium was announced, which enabled clients to postpone their loan instalments by three or six months, in which case the loan repayment period would be extended accordingly. The legal act that established the moratorium entered into force on April 17, 2020. Because the moratorium was intended for loans agreed and drawn before March 26, 2020, it affected the stock of mortgages and not the new mortgages granted, which are the main focus of our paper. On April 30, 2020, it was announced that real estate transfer tax would be abolished for real estate where its transfer was registered in the cadaster in December 2019 or later, whereas the legal act entered into force on September 26, 2020. This measure was part of wider tax relief policies adopted by the Government to boost the economy. While the relaxation of the Real Estate Tax Act could have spurred additional borrowing in the real estate market, its delayed implementation in late September 2020 allowed us to perform a robustness check on our main estimates and focus on a narrower time span outside of the tax change. Other fiscal policy measures introduced during the pandemic year 2020 (e.g. support programs for businesses) are not likely to significantly affect the mortgage market.

Overall, we certainly acknowledge that some of these measures may have had an impact on the volume of new mortgage lending. Nevertheless, the aim of the paper is to provide evidence on the impact of the deregulation on client characteristics, not to analyze the effect on the volume of new lending. Had the borrower-based limits remained in place, numerous clients would have been unable to access the mortgage market, regardless of the aforementioned measures.

3. Data and Methodology

Section 3.1 describes our data treatment, section 3.2 sets out our identification strategy and section 3.3 presents the method we employ in our analyses.

3.1 Data

A major challenge in assessing the effects of macroprudential borrower-based policy is building an accurate picture of how banks and households respond. We overcome this challenge by analyzing non-public, detailed loan-level data from semi-annual surveys of mortgage lenders conducted by the CNB[8]. We use information from four rounds of surveys and our data span 2019–2020. Our data is a repeated cross-section covering the universe of housing transactions and balance sheet adjustments by all home-buyers in the Czech Republic. The CNB conducts regular assessments of mortgage lenders' compliance with its borrower-based limits. The sample contains information on more than 160,000 mortgages in total. However, in our analysis, we focus on new loans only, i.e. we discard mortgages refinanced at a different bank than the original provider since we lack information on the

[7] For a comprehensive overview of the measures adopted and a discussion of their impact and interaction with monetary policy, please refer to Mora and Galuščák (2022).

[8] The survey of mortgage lenders has been conducted since the latter half of 2015. Each survey is composed of anonymous individual data on all newly issued retail loans secured by residential property. All banks active in the mortgage business participate in the mandatory survey.

date and characteristics of the original mortgage contract. This ultimately reduces the sample of mortgages by about 48,000 observations.

The survey data contains information on individual mortgage contracts and borrower characteristics, with the latter being an aggregated value if the mortgage loan is granted to multiple applicants. Reported age, however, is available only for the main borrower. To ensure data accuracy, we exclude possible errors in reports, such as mortgages with a borrower age of less than 18 or more than 70 years, loan maturity of less than 5 years or more than 40 years, and the number of loan applicants greater than four. We also winsorize extreme values identified with the 1st and 99th percentiles. Incomplete information on mortgages causes some data loss. Specifically, the property postcode information is missing for approximately 17% of observations. However, the property price is given only for about 28% of observations causing substantial data loss for models encompassing this variable. For a dominant share of variables, the coverage in the survey is close to 100%,[9] To supplement the CNB's data, we match the loan-level data with other datasets such as regional unemployment rates and regional GDP per capita from the Czech Statistical Office, as well as the regional transaction prices of flats from Deloitte.

Table 3 shows summary statistics. We cut the data based on the time period before and after the easing of borrower-based limits. Overall, mortgages granted post-easing had higher average LTV, DTI, and DSTI values. Borrowers who applied for a mortgage after the regulatory easing appear also to receive higher mortgages on more expensive properties. Moreover, the liquidity of borrowers seems to decrease after the easing, as they post higher down payments while increasing their total indebtedness. We also observe a slight increase in loan maturity as well as a decrease in the length of interest rate fixation. The average interest rate was about 0.47 pp lower in the post-easing period.

The evolution of LTV, DTI, and DSTI distribution for newly originated loans suggests that the 2020 regulatory easing coincided with changes in the distribution (Figure 3). The share of loans with an LTV of 80%-90% increased from 11% to 13% of the volume provided in the last quarter of 2020. Despite the relaxation of the LTV limit, its distribution remains relatively stable. However, the situation is different in the case of DTI and DSTI limits. Banks provided over 15% of the reference amount of loans with a DSTI of over 45%, and 12% of loans with a DTI of over 9 in the last quarter of 2020. The volume exemptions for the pre-easing soft limits (5% of the mortgage portfolio could exceed the 45% DSTI limit and the 9% DTI limit) were thus markedly exceeded.

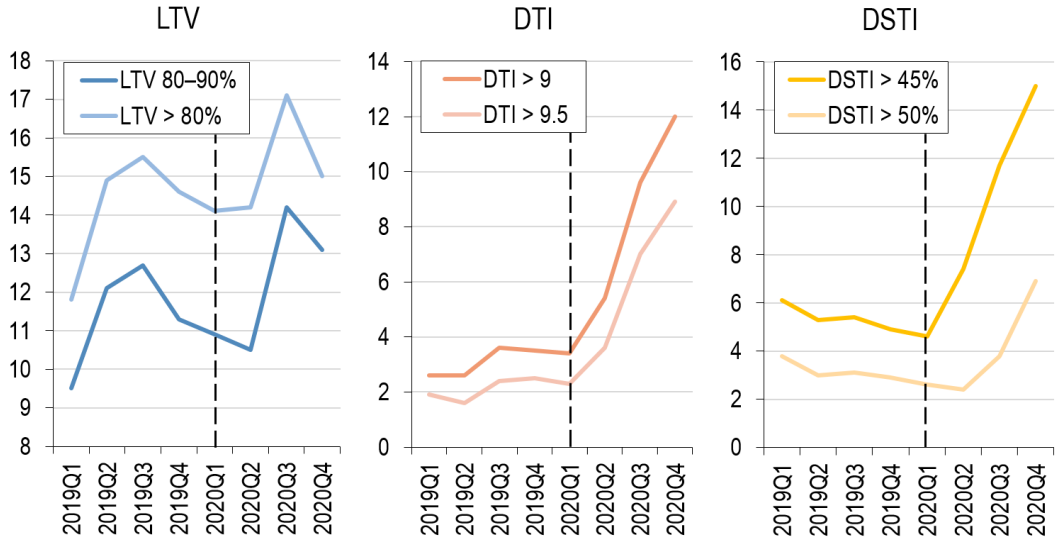
[9] The data quality and coverage has improved compared to the first rounds of the surveys. For instance, Hodula et al. (2023), who estimate the impact of the tightening of borrower-based limits in the Czech Republic and work with data spanning 2016–2019, record a 42% loss of observations due to missing information and data cleaning.

Table 3: Summary Statistics for Control and Treatment Period Mortgages

	Unit	**Before BBMs easing**		**After BBMs easing**		*Diff*
		Obs	*Mean*	*Obs*	*Mean*	
LTV	%	51,188	62.47	54,796	63.07	*0.60***
DTI	%	52,048	5.05	56,070	5.48	*0.43***
DSTI	%	52,064	31.77	56,070	32.00	*0.23***
Loan size	CZK	52,162	2,303,279	56,220	2,688,750	*385,471****
Collateral value	CZK	51,197	3,939,802	54,800	4,497,961	*558,159****
Property price	CZK	18,572	3,157,070	18,700	3,661,483	*504,413****
Down payment	CZK	18,572	784,459	18,700	865,208	*80,749***
Borrower debt (total)	CZK	51,326	760,876	46,803	941,367	*180,491****
Net income	CZK	52,075	647,926	56,071	748,592	*100,666****
Debt service (monthly)	CZK	52,162	10,053	56,216	11,626	1,573
Loan maturity	years	48,958	25.43	56,217	25.87	*0.44****
Fixation	months	51,372	79.31	56,006	78.95	*-0.36***
Age	years	52,160	36.54	56,194	36.42	-0.12
Probability of Default	Unit	51,236	0.77	55,440	0.67	*-0.10****
Interest rate	%	52,162	2.68	56,220	2.21	*-0.47****
First/Second+ mortgage	0/1	52,162	0.62	56,220	0.63	0.01
Regional GDP per capita	CZK	32,316	451,752	40,728	442,012	*-9,740****
House prices	CZK/m^2	38,019	48,963	46,005	54,548	*5,855****
City/periphery	0/1	38,755	0.25	47,658	0.25	0.00

Note: The table shows the means in the periods before and after the easing of borrower-based limits. The before period contains mortgages granted between April and December 2019 and the after period covers mortgages granted between April and December 2020. A t-test is used to test for the statistical significance of the difference. The statistical significance is denoted as * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.
Source: CNB.

Figure 3: Loan Distribution based on the LTV, DTI and DSTI Limits (in percent)



Source: CNB.

3.2 Identification Strategy

A common concern in the literature assessing the effects of macroprudential policy measures on the financial sector is that the regulatory shock is endogenously determined by the financial conditions. In our case however, we can confidently assume the strong exogeneity of the analyzed regulatory shock for two reasons. First, the CNB Board decision to ease borrower-based limits was a policy response to the outbreak and propagation of the Covid-19 pandemic – a purely exogenous force. Second, the Board's decision was largely unexpected by the market and there was no delay between the announcement and application of the relaxed limits.[10] As such, the 2020-easing of macroprudential policy represents an almost ideal setup for a quasi-natural experiment.

While the typical endogeneity of macroprudential policy actions are of no concern to us, we still need to deal with several issues that stem from the specificity of the regulatory setup and the period during which the easing took place. First, each mortgage in the Czech Republic is subject to the borrower-based limits. As a result, the exposure to treatment (treatment intensity) can be observed only before the introduction of the policy.[11] To overcome this challenge, we rely on matching estimators where mortgages after the policy change are matched to the closest mortgages before the change and we focus on what we call constrained borrowers, i.e. those borrowing precisely at or over the pre-easing limits. A second challenge we need to overcome stems from the fact that the 2020 regulatory easing took place during the COVID-19 pandemic which itself could have spurred changes in borrower and lender behavior, notwithstanding the potential confounding effects of other policy measures taking place. We devote special attention to mitigate concerns that the pandemic headwinds are polluting our estimates in our robustness check section.

3.3 Estimation Method

In our estimation framework motivated by Rubin (2005), each newly granted loan has two potential outcomes based on a binary treatment. We utilize the observed choices of households in the period following the regulatory easing to identify treated mortgages. Specifically, we consider affected ("treated") households as those borrowing at an LTV of 80 and above, and with a DTI of 9 and above and a DSTI of 45% and above in the period following the regulatory easing ($D_i = 1$). By revealed preference, we assume that these households are more likely to be affected by the regulatory shock. Candidate control households include all homebuyers from the year before the policy change, e.g. also those borrowing in the soft limits ($D_i = 0$). Further details on both the control and treatment periods are in Table 4. We deliberately choose to compare two exact periods to avoid seasonality driving the decision to take on a mortgage.[12]

[10] Our estimates are thus not likely to be polluted by front-loading in spite of new regulatory measures coming into force (see, for example, Basto et al., 2019).

[11] Given the application of the soft limit, we observe a small portion of mortgages more likely to be treated. We exploit this feature in our robustness check section.

[12] For example, systematic above-trend increases in prices and transactions during spring and summer and below-trend decreases during autumn and winter have been identified in household survey data in the U.S. and the U.K. (Ngai and Tenreyro, 2014; Scrimgeour, 2022).

Table 4: Control and Treatment Period

	Control group			Treatment group		
	minDate	maxDate	N	minDate	maxDate	N
2020-easing	1/4/2019	31/12/2019	52,162	1/4/2020	31/12/2020	24,084

Note: minDate/maxDate denotes the minimum/maximum date on which the mortgage was granted to be included in the control or treatment group. N denotes the number of mortgages included in each group.

Using this setup, $Y_i(D_i = 1)$ is the outcome variable for the ith treated mortgage. Then, $Y_i(D_i = 0)$ is the outcome if the unit was not treated. The causal effect of the 2020 easing of borrower-based limits could be estimated as the simple difference between the two potential outcomes.[13]. Hence, the average treatment effect (ATE) is estimated as follows:

$$ATE = E[Y_i(D_i = 1 - Y_i(D_i = 0)] \tag{1}$$

Since the borrower-based limits in the Czech Republic are imposed on the entire banking portfolio, there is no natural control group. The difference between the two observable statistics in eq. 1 is thus a combination of the ATE and a sampling bias which in our case could be substantial.[14]

To adjust for the sampling bias, we implement a matching estimator in the spirit of Abadie and Imbens (2006). In this setup, each household affected is matched to a household drawn from a set of 52,162 candidate control home-buying households borrowing in the before period. The matched candidate household must be in the same district and have the exact loan type (i.e. first/second-time homebuyers), and must be a nearest neighbor based on the borrower's income, age, loan fixation, and loan maturity, all expressed in deciles and regulatory exposure which is explained in the next paragraph (for details on the matching procedure, see the Appendix B). The matching achieves covariate balance between the two groups of mortgages, i.e., none of the differences between the matching variables are economically meaningful (nor are they statistically different from zero).

For the purpose of robustness, we consider a difference-in-difference framework proposed by Van Bekkum et al. (2019) that controls for potential time effects. We classify households into treatment and control groups based on the (unconstrained) LTV, DTI and DSTI choices made by households in the before period and relevant household and mortgage characteristics that we observe in both periods. Specifically, we follow the procedure proposed by Van Bekkum et al. (2019) and instead of relying on observed LTV, DTI and DSTI values, we use a simple OLS model to predict an LTV/DTI/DSTI choice for each household buying a house after the policy shock. Specifically, we estimate:

$$LIMIT_{it}^{LTV,DTI,DSTI} = \alpha_b + \alpha_t + \alpha_l + \beta_1 Income_{it} + \beta_2 Income_{it}^2 + \beta_3 Age_{it} + \beta_4 Z_{it} + \varepsilon_{it} \tag{2}$$

where $LIMIT_{it}^{LTV,DTI,DSTI}$ is a vector of the LTV, DTI and DSTI ratios, α_b, α_t, and α_l denotes bank, month, and postcode fixed effects respectively, $Income_{it}$ and Age_{it} denotes borrower's income and

[13] Since we cannot observe both the factual and the counterfactual at the same time, we need to make some assumptions (Rosenbaum and Rubin, 1983; Cox, 1992): a common support (Rosenbaum and Rubin, 1983), the stable unit treatment value assumption and unconfoundedness of the treatment assignment D_i with the potential conditional response: $D_i \perp (Y_i(1), Y_i(0)|X_i)$.

[14] The sampling bias is the difference in outcomes that is attributable to the differences in the two groups (e.g. the structural difference between the state of the mortgage loan market during the control and treatment periods.

age and vector Z_{it} holds quintiles of borrower debt and collateral value. We then calculate out-of-sample fitted values obtained from a regression model used to gradually predict a $\widehat{LTV}$, $\widehat{DTI}$ and $\widehat{DSTI}$ choice for each household buying a house after the regulatory easing. The fitted values are then used to sort borrowers into a treated group if they exceed the previously set limits ($d = 1$) and they are otherwise part of the control group ($d = 0$). Summary statistics for fitted and observed borrower-based limits are in Table A2. In our baseline matching framework, we use these estimated fitted values as matching covariates to capture the regulatory exposure of each household before and after the policy.[15]

Then, based on this classification of households, we estimate:

$$y_{it} = \beta After_t \times d(1) + \alpha_1 After_t + \alpha_2 d(1) + \alpha_l + \alpha_b + \alpha_t + \varepsilon_{it} \tag{3}$$

where β captures the incremental policy response of ex-ante more affected households, controlling for the trend in mortgage leverage choices among control households. α_l, α_b, and α_t are postal code, bank, and month fixed effects respectively.

4. Estimation Results

Table 5 shows the adjustments in the LTV, DTI and DSTI ratios and their components after the implementation of the 2020-easing. The estimates in panel A progressively track changes to four outcome variables: the LTV ratio and the (log) of the mortgage amount, collateral value, and property price. These variables represent the numerator and denominator of the LTV ratio.[16] The estimated ATEs indicate that following the easing of borrower-based measures in 2020, constrained (affected) households increased their average LTV by 10.4 pp. While examining the remaining outcome variables in panel A, we find that the households affected increased their borrowing by 11.2 percent and purchased more expensive houses (by 6.7 percent) relative to matched controls. The average collateral value increased only slightly, and for first-time borrowers not at all. From the (central) bank's perspective, an increase in LTV, driven especially by higher mortgages, implies a potentially greater loss in the event of default on the loan. Taking the average home value and mortgage amount before the 2020-easing, our estimates indicate that the average household affected borrows by about CZK 258k more to purchase a house that costs CZK 211k more. As is apparent, there is a positive funding gap of about CZK 47k. In the next section, we test whether this positive funding gap holds if we were to zoom in on borrower heterogeneity. Column 3 tracks the changes to unconstrained borrowers, i.e. those borrowing under the previously set limits even in the after period. Reassuringly, we record only minor adjustments in this group of (unaffected) borrowers.

[15] The idea is that before the policy, we only observe a few mortgages in breach of the limit (soft limit mortgages). By matching to the fitted values ("what if" constraint indicator), we aim to partially correct for our identification drawback that we do not have a natural control group. By matching using the fitted values, we bring together homebuyers that are ex-ante more likely to be "affected" by the regulation.

[16] We also consider the property price side-by-side with the collateral value given that the collateral value represents the estimated property value and not the realized market price.

Table 5: Average Treatment Effects of the Borrower-Based Measures Easing

	Nearest neighbor matching		
	Constrained		Unconstrained
	First-time buyers only		
	(1)	(2)	(3)
Panel A) LTV adjustments			
LTV	0.104***	0.113***	-0.013***
	(0.001)	*(0.001)*	*(0.002)*
Log (mortgage size)	0.112***	0.115***	0.027***
	(0.003)	*(0.003)*	*(0.003)*
Log (collateral value)	0.015***	0.002	0.031***
	(0.003)	*(0.004)*	*(0.003)*
Log (property price)	0.067***	0.069***	-0.008
	(0.006)	*(0.006)*	*(0.010)*
Panel B) DTI and DSTI adjustments			
DTI	0.011***	0.010***	-0.003***
	(0.000)	*(0.000)*	*(0.000)*
DSTI	0.042***	0.034***	-0.019***
	(0.001)	*(0.001)*	*(0.001)*
Log (borrower's debt)	0.172***	0.076***	0.007
	(0.018)	*(0.025)*	*(0.017)*
Log (monthly debt payments)	0.017***	0.008**	-0.014**
	(0.004)	*(0.004)*	*(0.005)*
Log (borrower's income)	0.008**	0.010***	0.015***
	(0.003)	*(0.003)*	*(0.004)*
Matching covariates			
Borrower	Y	Y	Y
Loan	Y	Y	Y
Spatial	Y	Y	Y
Regulatory distance	Y	Y	Y
N	66,037	40,758	43,475
Treated	18,683	11,883	14,600
Control	47,354	28,875	28,875

Note: This table shows the shift in borrower and mortgage characteristics among homebuyers that were granted a mortgage before and after the relaxation of the borrower-based limits. The unit of observation in each regression is a mortgage. The sample includes mortgages granted from April to December 2019 and April to December 2020. Constrained mortgages are those with an LTV of 80% and above, a DTI of 9 and above and a DSTI of 45% and above in the period following the regulatory easing (i.e. from April to December 2020). Each constrained mortgage is matched to a mortgage granted before the policy easing (from April to December 2019). Mortgages are matched to the characteristics described in Section 3. Panel A examines the components of LTV and panel B examines the components of DTI and DSTI. Column 1 considers a full sample of borrowers while columns 2 and 3 focus on first-time borrowers only. Column 3 serves as a robustness check as it shows the difference between the matched control group and "unconstrained" mortgages (e.g. those granted in the after period with limit characteristics below the previously set limits). We use Robust Abadie-Imbens standard errors. The statistical significance is denoted as *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Next, we examine the estimated ATEs in panel B where we gradually focus on changes to the DTI and DSTI ratios and their components, the log of borrower's debt, monthly debt payments and income. We record a significant increase in the DTI and DSTI ratios and the average household debt as a result of the 2020-easing – the borrowers affected are granted a mortgage with a higher level of indebtedness. For instance, the average DTI increased by 1.1 pp after the easing took place. The increase in DSTI was 4.2 pp in the after period. The increase in debt(service)-to-income ratios is driven solely by the increase in borrowers' debt – a 17.8 percent increase when we consider all constrained borrowers and 7.6 percent for just first-time constrained borrowers. As evidenced by the difference between constrained borrowers and constrained first-time borrowers, the increase in household leverage appears to be driven by second-time mortgagors. We also document an increase in borrower's income (0.8 percent for the affected group) but this is much smaller in magnitude compared to the increase in debt and monthly debt service. Again, we record comparatively smaller responses in the group of unconstrained borrowers.

4.1 Distinguishing Between LTV-, DTI-, and DSTI- Constrained Borrowers

We now examine the adjustments in the balance sheets of borrowers who are constrained by one of the limits. We label these sub-groups of affected borrowers as LTV-, DTI-, and DSTI-constrained borrowers.[17] The estimated ATEs for these different borrower sub-groups are summarized in Table 6.

In panel A, we check how borrowers responded to the regulatory easing with respect to changes in the average mortgage size, property price and down payment. In response to an increase in the LTV limit, a borrower has two options: 1) purchase more expensive property and post a similar down payment or 2) purchase a similar property and post a smaller down payment. Option 1 would be in line with classic accelerator behavior, as described by traditional macroeconomic models with financial frictions (Kiyotaki and Moore, 1997; Bernanke et al., 1999). Option 2 would be typical of liquidity preference behavior where the borrower prefers to retain cash for either savings or consumption. We find that LTV-constrained borrowers respond to the macroprudential loosening in line with the liquidity preference behavior. They post a significantly smaller down payment (a decrease of about 19.7 percent relative to the average pre-easing mortgage) while the average property price increased only slightly (by about 1.7 percent). From a financial stability perspective, the liquidity preference behavior is favored as borrowers increase housing leverage but, at the same time, have improved their liquidity positions. In contrast to LTV-constrained borrowers, we find that DTI- and DSTI-constrained borrowers act more in line with the classic accelerator mechanism. Following the abolition of DTI and DSTI limits, DTI- and DSTI-constrained borrowers purchased significantly more expensive properties (10.7% increase for DTI-constrained borrowers and 6.3% for DSTI-constrained borrowers) and posted somewhat higher down payments (7% increase in case of DTI-constrained borrowers) or similar to the pre-easing levels in case of DSTI-constrained borrowers. We record only a small increase in the average mortgage loan size for unconstrained borrowers (2.3 percent increase) and no change in their choice of property or down payment.

[17] Note that the constrained categories can overlap, e.g. a mortgage can be simultaneously constrained by the LTV and the DSTI limit. The overlap is minimal in case of the LTV limit and income-based limits, under 10% of the sample. However, the overlap is substantial (as expected) in case of the two income-based limits. While we identify more than 7,000 mortgages that are constrained either by the DTI or the DSTI limit, over 2,000 mortgages are constrained by both limits.

Table 6: Average Treatment Effects of LTV-, DTI- and DSTI-Constrained Borrowers

	LTV	**DTI**	**DSTI**	**All**
		Constrained		Unconstrained
	(1)	(2)	(3)	(4)
Panel A) Liquidity preference or classic accelerator behaviour				
Mortgage size	197,173***	481,907***	393,187***	53,679***
	(9,822)	*(38,540)*	*(30,880)*	(7,776)
Property price	55,297***	338,417***	200,144***	28,362
	(19,846)	*(82,190)*	*(57,272)*	*(26,587)*
Down payment	-147,055***	55,284***	-37,410	22,216
	(12,566)	*(6,166)*	*(39,051)*	*(19,933)*
Panel B) Changes to borrower characteristics				
Total borrower debt	-51,521***	223,169***	174,852***	39,300***
	(10,824)	*(39,968)*	*(23,546)*	*(7,620)*
Borrower's income	-914	94,447***	23,481***	38,055***
	(3,133)	*(10,940)*	*(6,757)*	*(2,767)*
First mortgage	0.050***	-0.217***	-0.095***	-0.002
	(0.005)	*(0.012)*	*(0.012)*	*(0.004)*
No. of co-applicants	-0.044***	-0.124***	-0.052***	0.018***
	(0.005)	*(0.014)*	*(0.014)*	*(0.004)*
Panel C) Changes to banks' perception of risk				
Mortgage rate	0.023***	-0.049***	0.022***	-0.008***
	(0.003)	*(0.007)*	*(0.008)*	*(0.002)*
PD	-0.066***	-0.077***	0.055	-0.200***
	(0.013)	*(0.024)*	*(0.036)*	*(0.009)*
Panel D) Reallocation effect				
City (district-level)	-0.007	0.061***	0.013	-0.001
	(0.006)	*(0.016)*	*(0.015)*	*(0.004)*
N	62,185	50,057	51,687	74,063
Treated	14,822	2,694	4,324	26,700
Control	47,363	47,363	47,363	47,363

Note: This table shows the shift in borrower and mortgage characteristics among homebuyers that were granted a mortgage before and after the relaxation of borrower-based limits. The unit of observation in each regression is a mortgage. The sample includes mortgages granted from April to December 2019 and April to December 2020. LTV-, DTI- or DSTI-constrained mortgages are those with an LTV of 80% and above, a DTI of 9 and above and DSTI of 45% and above in the period following the regulatory easing (i.e. from April to December 2020). Each constrained mortgage is matched to a mortgage granted before the policy easing (from April to December 2019). The mortgages are matched using the characteristics described in Section 3. Column 4 serves as a robustness check as it shows the difference between the matched control group and "unconstrained" mortgages (e.g. those granted in the after period with limit characteristics below the previously set limits). We use Robust Abadie-Imbens standard errors. The statistical significance is denoted as *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

In panel B, we check for changes to borrowers' characteristics or borrower composition that can be attributed to the regulatory easing. We start by analyzing changes to household debt which includes all debt in addition to newly obtained mortgages. We confirm our previous findings that –

following the regulatory easing – more leveraged borrowers are entering the market but we add that these borrowers are the ones constrained by the DTI or DSTI limits. Simultaneously, we observe that these clients availed to a greater extent themselves of second and additional mortgage loans after the regulatory easing. While the creditworthiness of these clients improved in terms of their income, the increase was only minor and the observed growth in debt could imply a rise in the vulnerability of the new loans portfolio in the event of an income shortfall for these clients. Next, we examine changes to borrower composition. For one, our evidence implies that raising the LTV limit increased the share of first-time borrowers on the market. This would suggest that the LTV limit was binding mostly for first-time borrowers. On the other hand, abolishing the DTI and DSTI limits has increased the share of second-time borrowers. Second-time borrowers could have been more bound by the income-based limits as they effectively affect the ability of highly leveraged borrowers to obtain a mortgage. Last, we find, somewhat unsurprisingly, that the regulatory easing has led to a decrease in the share of applications with co-applicants. This is primarily attributed to the removal of the DTI limit, as clients were no longer required to demonstrate sufficient income during the mortgage loan application process.

In panel C, we check for the response of banks following the regulatory easing. Specifically, we evaluate changes in the pricing of mortgages and in the estimated probability of default (PD). We find that the average loan rate increased for LTV- and DSTI-constrained borrowers, while it decreased for DTI-constrained borrowers. This suggests that banks acted prudently following the regulatory easing and did not allow the credit risk premiums to decline significantly. At first glance, the increase in loan rates may appear to contradict the decline in PDs among clients constrained by LTV, DTI, and DSTI limits. However, as mentioned in the discussion of the panel B estimates, the incomes of these borrowers has increased after the regulatory easing. Therefore, the improvement in clients' creditworthiness may have contributed to the decrease in PD across all client groups. The most significant decrease in PD is observed among unconstrained clients, indicating that banks likely considered the previous limits when assessing PD after regulatory easing.

Finally, in panel D, we test whether we can pick up on any changes in borrowers' preference in terms of house location. For instance, Acharya et al. (2022) document that following an LTV tightening in Ireland, mortgage lending reallocated from hot housing markets (urban areas) to cool markets (rural areas). Assuming that regulatory tightening and easing work in a symmetric way, we may expect to see the opposite, e.g. a move towards cities. We thus estimate changes to the city (district-level) variable which is a dummy variable taking the value of 1 if the property is located in a city (based on district-level classification) and zero if it lies outside an urban area. We document the presence of a reallocation effect in case of DTI-constrained borrowers only. Following the abolition of the DTI limit in 2020, borrowers constrained by the limit begin to purchase more properties located in the urban areas which are more desirable for buy-to-let investments. Note that this estimation can also be perceived as our first robustness check of the effects of the pandemic on the housing market. For instance, in spite of the pandemic, borrowers may have started to favor properties outside of the city (due to lockdowns) and move to the periphery (rural areas). However, we do not record this type of reallocation towards rural areas.

5. Robustness Checks

Before we turn to studying heterogeneity in the transmission of macroprudential easing, we conduct several robustness checks to verify our main findings. The first set of robustness checks is aimed at testing for the relative impact of the Covid-19 pandemic on the real estate market. The second set of robustness checks uses a difference-in-difference framework of Van Bekkum et al. (2019) that accounts for time effects.

5.1 Testing for the Immediate Effects of the Covid-19 Pandemic on the Real Estate Market

The fact that the macroprudential loosening took place shortly after the outbreak of the Covid-19 pandemic may complicate the interpretation of the estimated ATEs as a result of the purely regulatory shock. The pandemic may impact the mortgage market in two ways. For one, it could change the composition of borrowers and possibly scare off more risk-averse households who would postpone their mortgage decision until less uncertain times. Two, the pandemic may change borrower behavior. For instance, instead of buying a flat in a city, a household may prefer to buy a house or a holiday home on the periphery. However, we have already ruled out this reallocation effect in the previous section (see Table 6, panel D).

We conduct several robustness checks to alleviate concerns related to the impact of the Covid-19 pandemic on the mortgage loan market. First, we check the evolution of the number of new mortgage contracts in 2019–2021 for any structural shifts. Reassuringly, the number of new (or refinanced) mortgages remains steady over our sample period. Second, to formally account for the potential effects that the pandemic might have had on the mortgage loan market (and real estate market in general), we collect information on the number of Covid-19 cases per 100,000 inhabitants in the individual districts. We then use the information from our mortgage survey on the zip code of the purchased property to sort mortgages into two sub-samples: those granted to borrowers located in the more Covid-19-affected districts and those granted to borrowers in the less Covid-19-affected districts. Finally, we re-estimate our baseline model as it appears in Table 5 for these two sub-samples and we evaluate the difference in the estimated ATEs. These new estimates are stored in Table 7. We do not pick up any significant differences between the estimated ATEs in the more or less Covid-19-affected districts. The estimated ATEs are, in terms of magnitude and significance, largely in line with our baseline ATEs.

Our third robustness check concerning the pandemic features a reduced sample period estimation. Specifically, we sharpen our focus on mortgages granted during the first three months following the relaxation of borrower-based measures. Hence, our treatment group in this exercise contains affected mortgages granted between April and June 2020 and our mirrored control group covers mortgages granted in April–June 2019. This effectively reduces the number of observations from over 66,000 in the baseline to approximately 14,500. The motivation behind this robustness check is clear. We hope to filter out the potential influence of other policy measures taken during the course of the pandemic which are summarized in Section 2[18]. Table C1 shows that estimates are quantitatively and qualitatively similar to those reported in the baseline. For instance, the baseline model estimates that the average LTV for constrained borrowers increased by 10.4 pp (Table 5, column 2), while the reduced sample period model signals an increase of 10.8 pp. This suggest that the effects of other policy measures taken to alleviate the negative effects of the Covid-19 pandemic did not materially affect the real estate market in the analyzed period.

[18] For instance, we do not record any fiscal policy measures aimed at the mortgage (credit) market during our reduced sample period. While key interest rates were cut twice in early 2020, the monetary policy pass-through to mortgage interest rates in the Czech Republic is estimated to be (at least) four months (Gregor et al., 2022).

Table 7: Average Treatment Effects of Borrower-Based Measures Easing: Districts with the Most Covid Cases per 100,000 Inhabitants

	Least affected districtsdistricts			**Most affected districtsdistricts**		
	Constrained		Unconstrained	Constrained		Unconstrained
		FTB			FTB	
	(1)	(2)	(3)	(4)	(5)	(6)
LTV	0.124***	0.131***	-0.040***	0.118***	0.130***	-0.027***
	(0.003)	*(0.003)*	*(0.004)*	*(0.002)*	*(0.003)*	*(0.003)*
DTI	0.012***	0.011***	-0.002***	0.010***	0.009***	-0.004***
	(0.000)	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*	*(0.000)*
DSTI	0.042***	0.040***	-0.014***	0.036***	0.024***	-0.019***
	(0.002)	*(0.003)*	*(0.003)*	*(0.002)*	*(0.002)*	*(0.002)*
Matching covariates						
Borrower	Y	Y	Y	Y	Y	Y
Loan	Y	Y	Y	Y	Y	Y
Spatial	Y	Y	Y	Y	Y	Y
Regulatory distance	Y	Y	Y	Y	Y	Y
N	49,641	30,266	30,653	51,435	31,506	32,541
Treated	2,287	1,391	1,778	4,081	2,631	3,666
Control	47,354	28,875	28,875	47,354	28,875	28,875

Note: This table shows the shift in LTV, DTI, and DSTI choices among homebuyers that were granted a mortgage before and after the relaxation of the borrower-based limits. The unit of observation in each regression is a mortgage. The sample includes mortgages granted from April to December 2019 and April to December 2020. Constrained mortgages are those with an LTV of 80% and above, a DTI of 9 and above and a DSTI of 45% and above in the period following the regulatory easing (i.e. from April to December 2020). Each constrained mortgage is matched to a mortgage granted before the policy easing (from April to December 2019). Mortgages are matched on the characteristics described in Section 3. Unconstrained mortgages are those granted in the after period with limit characteristics below the previously set limits). Least/Most affected districts denotes a sub-group of mortgages granted for a property located in a district with a low (first quartile of the distribution) or high (third quartile of the distribution) number of Covid-19 cases per 100,000 inhabitants. We use Robust Abadie-Imbens standard errors. The statistical significance is denoted as *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Our fourth robustness check is a standard placebo test where we select a fake treatment period with no policy changes and test for differences against the control period. Specifically, we estimate the differences between mortgages granted in Feb–Mar 2019 (control period) and mortgages granted two months before the regulatory easing (Feb–Mar 2020). The matching procedure mimics the one used in the main estimation framework as we track changes to the distribution of LTV, DTI and DSTI ratios. Table 8 shows that there were no measurable differences between mortgage characteristics granted in the control period and those granted in the fake treatment period.

Table 8: Placebo Test

	Nearest neighbor matching	
	First-time buyers	Second+-time buyers
	(1)	(2)
LTV	0.005	0.000
	(0.004)	*(0.006)*
DTI	0.004	0.000
	(0.003)	*(0.001)*
DSTI	0.000	-0.007**
	(0.002)	*(0.003)*
Matching covariates		
Borrower	Yes	Yes
Bank	Yes	Yes
Spatial	Yes	Yes
N	13,319	7,807
Treated	7,931	4,301
Control	5,388	3,506

Note: This table shows the shift in LTV, DTI, and DSTI choices among homebuyers that were granted a mortgage before and after a fake treatment. The unit of observation in each regression is a mortgage. The sample includes mortgages granted from February to March 2019 and February to March 2020. Each mortgage is matched to a mortgage granted before the fake treatment (from February to March 2019). Mortgages are matched using the characteristics described in Section 3. We use Robust Abadie-Imbens standard errors. The statistical significance is denoted as *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

5.2 Accounting for Time Effects

As an alternative to using a nearest-neighbor matching estimator to measure the impact of the policy shock, we implement LTV, DTI, and DSTI prediction models to classify households into affected and control groups in the spirit of Van Bekkum et al. (2019) and use a difference-in-difference estimation framework to estimate the effect of the 2020 regulatory easing on the mortgage loan market. Note that in addition to bank and postal code fixed effects, the model features month fixed effects which should account for changes to system-wide features, such as changes to monetary policy.

Estimates are summarized in Tables C2 and C3. In Table C2, columns 1 and 2 track changes to the LTV ratio while considering a model without any controls and just fixed effects side-by-side with a fully saturated model. The DiD framework estimates that the policy easing induced an increase in LTV of 1.6 pp. In columns 3 to 5, we repeat the estimation using the (log) mortgage size, collateral value, and property price as the dependent variable. The DiD estimates show that affected homebuyers increase borrowing by 11.5 percent relative to the control group (as compared with the baseline estimation using the matching framework of 11.2 percent). The households affected also require slightly higher collateral value (2.4 percent higher) but purchase properties that are, on average, 7.1 percent more expensive. In Table C3, we continue by conducting a DiD analysis focused on changes to the DTI and DSTI limits and the underlying mechanisms. Using the richest set of controls, the analysis confirms that affected homebuyers went for mortgages with an almost 0.6 pp higher DTI than the control group (1.1 pp in the baseline) and a 1.7 pp higher DSTI (4.2 pp in the baseline). The underlying transmission mechanisms hold when compared to the baseline. We notice a substantial increase in household debt in the affected group which is not mirrored in

an increase in their income. Thus, more leveraged borrowers entered the market as a result of the regulatory easing in 2020.

6. Heterogeneity in the Transmission of Macroprudential Easing

In this chapter, we harness the richness of our cross-sectional database and test for the heterogeneous treatment effects of the 2020-easing. Exploring possible treatment heterogeneity can provide valuable information about how to improve the targeting of the borrower-based measures and uncover what mechanisms/conditionality drive the results. To this end, we estimate the conditional average treatment effect (CATE) – e.g. treatment conditional on covariates X – defined as:

$$\tau(x) = E[Y_i(D_i = 1 - Y_i(D_i = 0)|X_i = x] \tag{4}$$

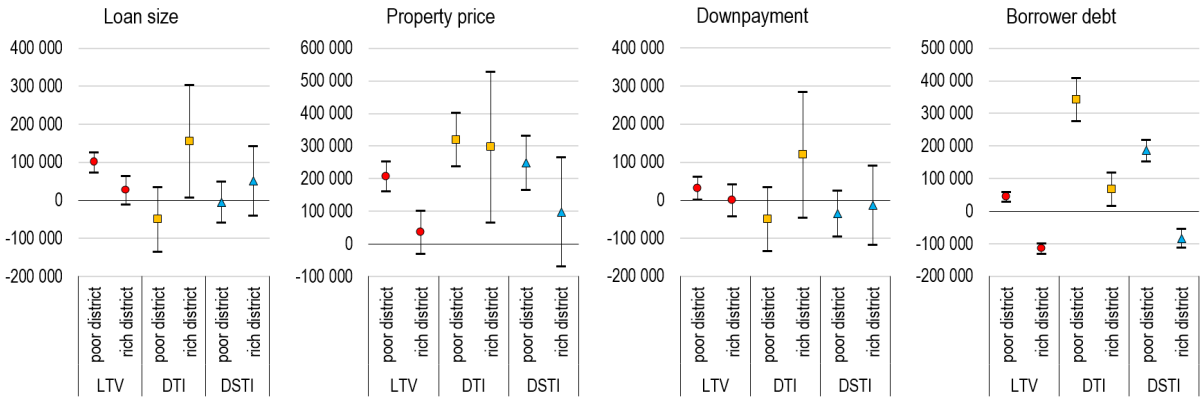
We gradually check for the heterogeneous treatment effect on three outcome variables – loan size, property price and borrower debt – with respect to borrowers' location (e.g. poor vs rich district), age and whether this is the borrower's first mortgage or not. These broad characteristics could potentially impact the transmission of the 2020-easing, both in terms of the strength and direction of the effect. We continue to distinguish between LTV-, DTI- and DSTI-constrained borrowers who are assessed against matched controls.

To check for the spatial heterogeneity of the transmission, we first identify poor and rich districts based on their GDP per capita. The poor/rich districts are those with GDP per capita in the first/last quartile of the distribution. The spatial effect is important due to the contrasting trends in house prices and income levels between poorer and wealthier districts. Borrowers' age influences the duration of their economic activity and consequently affects the loan maturity and debt repayment. Additionally, the distinction between first and subsequent mortgages is relevant to the purpose of the loan (residential or buy-to-let) and influences the client's debt level. In policy practice, the variables we use for splitting the sample are often used to differentiate the calibration approach of borrower-based regulation to individual borrowers. For example, stricter restrictions in the investment or property purchase segment are applied in Ireland, Latvia, and Switzerland. Less strict LTV and DSTI limits for young borrowers have been applied in the Czech Republic since 2022 and there are exemptions from DTI limits for young borrowers in Slovakia (ESRB, 2022). The estimates are summarized in Figures 4 to 6.

Figure 4 plots the estimated CATEs based on mortgage property location. We distinguish between poor and rich districts based on their GDP per capita. We find that in response to the easing of borrower-based measures, LTV-constrained borrowers located in poor districts were able to obtain higher mortgages and purchased more expensive property (relative to the matched control group). This is due to the fact that collateral values in poorer districts are lower compared to richer districts. This heterogeneous treatment effect thus improves equity in access to mortgages across districts with different levels of prosperity. Intuitively, "poorer" districts experienced lower growth in property prices before the easing (also due to lower mortgages), with resident borrowers more likely to take out mortgage loans of a size that made them breach the previously applied LTV limit. The figure further shows that DTI-constrained borrowers located in poor districts that received a mortgage after the regulatory easing increased their debt about 3 times more compared to those in rich districts. This would signal that the DTI limit was more binding for borrowers located in poorer regions who typically have lower income levels compared to richer regions. In terms of the

borrower adjustment mechanism, we find that LTV-constrained borrowers located in poorer districts and DTI- and DSTI-constrained borrowers (regardless of location) acted more in line with the classic accelerator behavior. Following the regulatory easing, they post similar or even lower down payments but purchase much more expensive properties.

Figure 4: Is the Transmission Different Between Poor and Rich Districts?

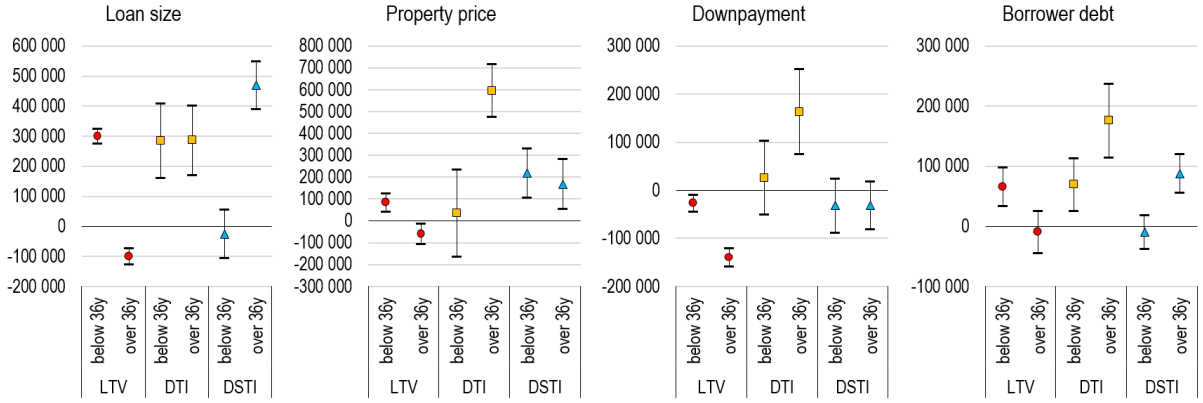


Note: This figure shows the shift in borrower and mortgage characteristics among homebuyers that were granted a mortgage before and after the relaxation of the borrower-based limits. The unit of observation in each regression is a mortgage. The sample includes mortgages granted from April to December 2019 and April to December 2020. LTV-, DTI- or DSTI-constrained mortgages are those with an LTV of 80% and above, a DTI of 9 and above and a DSTI of 45% and above in the period following the regulatory easing (i.e. from April to December 2020). Each constrained mortgage is matched to a mortgage granted before the policy easing (from April to December 2019). Mortgages are matched based on the characteristics described in Section 3. Poor/rich district sorts mortgages into two sub-groups based on property location: first/third quartile of the distribution based on the district's GDP per capita. We use Robust Abadie-Imbens standard errors. The statistical significance is denoted as *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 5 checks for heterogeneity in response to the 2020-easing with respect to borrowers' age. We distinguish between young (under 36) and old (aged 36 and over) borrowers.[19] There is a clear distinction between younger and older borrowers, both in terms of the statistical and economic significance of their responses. For instance, younger LTV-constrained borrowers recorded a substantial increase in their average loan size (by about CZK 300k) relative to a matched control group. At the same time, however, they have allowed their down payment to decrease and have not purchased significantly more expensive property since the easing – in line with a liquidity preference motive. On the contrary, older borrowers, especially those identified as DSTI-constrained, went for significantly higher mortgages and also purchased more expensive properties. This is quite logical given that older borrowers cannot decrease their debt service by choosing longer maturity. At the same time, younger borrowers are logically more constrained by the LTV limit due to lower collateral at their disposal.

[19] The threshold of 36 years is set manually given that, as of 2021, the CNB imposes more lenient conditions on mortgage loan applicants under 36 years.

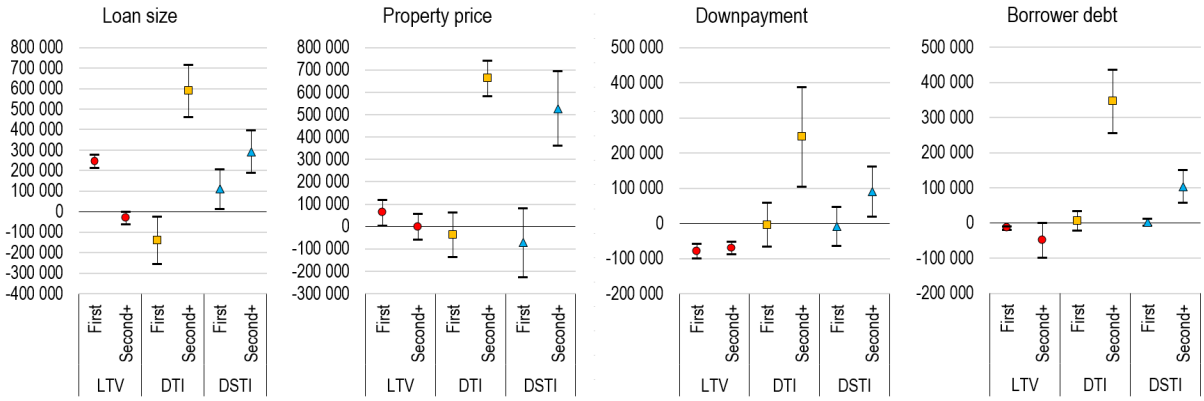
Figure 5: Are Younger Borrowers More Exposed to the Regulatory Easing?



Note: This figure shows the shift in borrower and mortgage characteristics among homebuyers that were granted a mortgage before and after the relaxation of the borrower-based limits. The unit of observation in each regression is a mortgage. The sample includes mortgages granted from April to December 2019 and April to December 2020. LTV-, DTI- or DSTI-constrained mortgages are those with an LTV of 80% and above, a DTI of 9 and above and a DSTI of 45% and above in the period following the regulatory easing (i.e. from April to December 2020). Each constrained mortgage is matched to a mortgage granted before the policy easing (from April to December 2019). Mortgages are matched based on the characteristics described in Section 3. Under/over 36y sorts mortgages into two sub-groups based on the borrower's age. We use Robust Abadie-Imbens standard errors. The statistical significance is denoted as *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Figure 6 focuses on differences in the treatment of first-time borrowers and those with a second+ mortgage. Relative to the matched control group which includes all pre-easing mortgages, we find that second-time borrowers are mostly driving the previously identified increases in borrower debt and property prices. This evidence shows that abolishing the income-based limits has helped mostly second-time borrowers who were able to obtain a higher mortgage and purchase more expensive property (classic financial accelerator). On the contrary, increasing the LTV limit helped mostly first-time borrowers to obtain higher mortgages. However, first-time borrowers do not necessarily purchase more expensive properties and post significantly smaller down payments, thus forming a liquidity buffer.

Figure 6: Checking for Differences Between First-Time Mortgages and the Rest



Note: This figure shows the shift in borrower and mortgage characteristics among homebuyers that were granted a mortgage before and after the relaxation of the borrower-based limits. The unit of observation in each regression is a mortgage. The sample includes mortgages granted from April to December 2019 and April to December 2020. LTV-, DTI- or DSTI-constrained mortgages are those with an LTV of 80% and above, a DTI of 9 and above and a DSTI of 45% and above in the period following the regulatory easing (i.e. from April to December 2020). Each constrained mortgage is matched to a mortgage granted before the policy easing (from April to December 2019). Mortgages are matched based on the characteristics described in Section 3. First/Second+ sorts mortgages into two sub-groups based on information whether the borrower is a first-time mortgagor or not. We use Robust Abadie-Imbens standard errors. The statistical significance is denoted as *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

7. Conclusions

In the paper, we provide a comprehensive micro-level analysis of the transmission of the easing of different borrower-based macroprudential measures. We explore detailed loan-level data on residential mortgages in the Czech Republic to examine the effects of the 2020 easing of the LTV limit and abolition of the DTI and DSTI limits.

We show that while households tend to borrow more after credit conditions are eased, they also increase their liquidity buffers by posting lower down payments. However, cash-retention behavior is mainly characteristic of borrowers who were constrained by the previously set LTV limit. The DTI- and DSTI-constrained borrowers are found to act in line with the financial accelerator, increasing their mortgage size and purchasing more expensive properties. Further, as household indebtedness is found to rise substantially in spite of the regulatory easing, so does borrower income level which lowers financial stability concerns. Our findings have direct implications for regulators and policymakers. They contribute to the ongoing discussion on the practical use of LTV, DTI and DSTI limits by providing still rather unique evidence from a case of substantial regulatory easing.

Apart from estimating the overall impact on the market, we also show that the application of different borrower-based limits posits heterogeneous effects on different groups of borrowers. In this exploration, we made several key findings. First, we observe that the relaxation of LTV limits had a more pronounced effect in economically poorer districts. Conversely, the abolition of DTI and DSTI limits predominantly affected borrowers located in wealthier districts. Furthermore, we discovered that younger borrowers are more susceptible to the effects of easing LTV and DTI limits, whereas DSTI limits tend to have a stronger impact on older borrowers. Lastly, our analysis

revealed that relaxing the LTV limit primarily affected first-time borrowers. On the other hand, the removal of DTI and DSTI limits proved beneficial for second-time borrowers.

Our results contribute to policy decision-making discussions regarding the structural or cyclical approach to the calibration of borrower-based measures. We offer comprehensive empirical evidence from a case where a country cyclically released borrower-based limits during the Covid-19 pandemic. In this respect, more research is required to assess the potential costs and benefits of both approaches. In fact, the macroprudential authority may also adopt a structural approach with cyclical elements. In such cases, certain constraints could remain stable over time, while others would flexibly adjust to current market conditions. This combination represents a simple and transparent approach while providing sufficient flexibility within the borrower-based macroprudential framework. In this respect, we hope to contribute to the debate by providing empirical estimates of the transmission of regulatory easing of individual limits (value-based and income-based).

Our analysis of macroprudential policy easing opens up new avenues for future research. In particular, the policy being studied took place during a period of record low interest rates. The documented relationships and the effects of the individual policy tools may shift once interest rates begin to normalize. For example, in a scenario marked by restrictive monetary policies and stagnant property prices, the dynamics of the mortgage market would likely be characterized by reduced activity despite the easing of mortgage limits. The rise in borrowing costs would likely deter a section of potential homebuyers and lead to a potential decline in the demand for mortgages. Furthermore, with property prices remaining static or experiencing minimal growth, the traditional incentive for property investment might diminish and prospective buyers could adopt a more cautious stance. Therefore, given the limited volume of newly originated mortgage loans, there would be no emergence of systemic risk, irrespective of the changes in characteristics of the new clients. The effect of easing mortgage limits would thus probably be fundamentally different from the point of view of financial stability.

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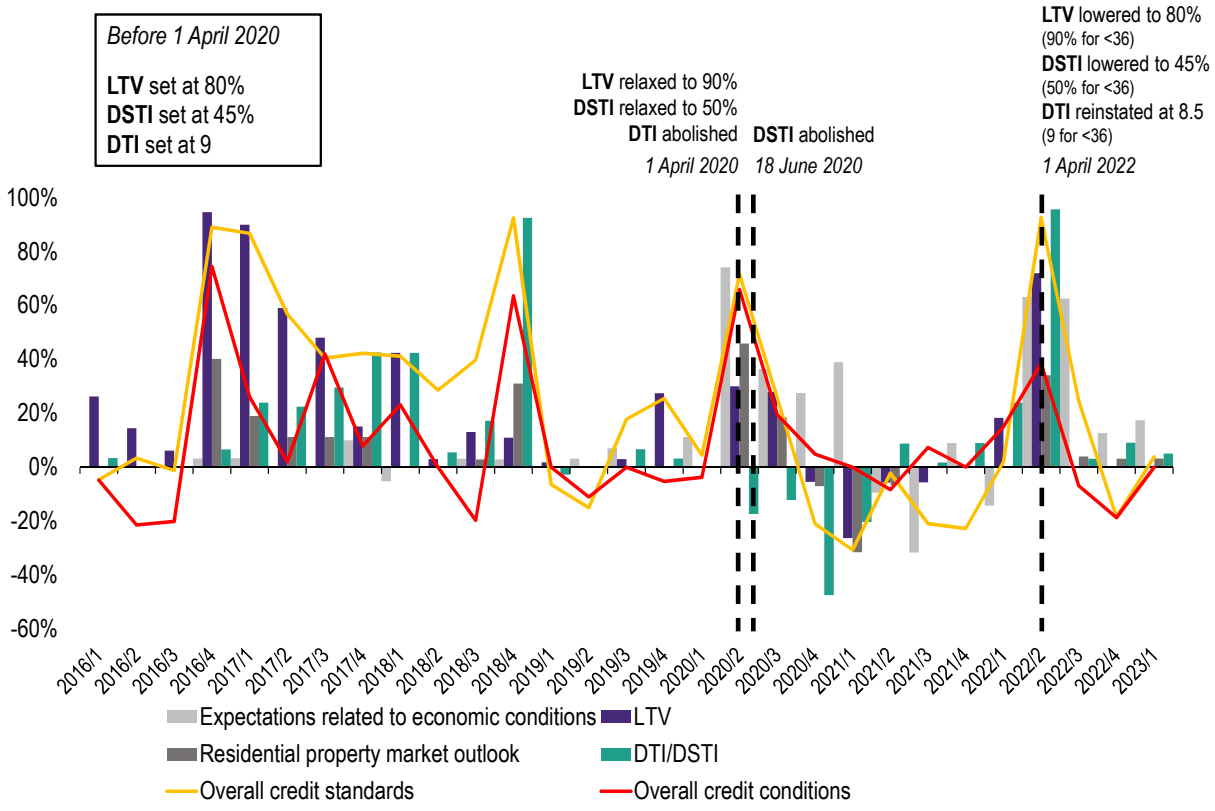
Appendix A: Sample Details

Table A1: Selected Macroeconomic Variables for the Czech Republic and the EU

A) Control period	2019-Q1	2019-Q2	2019-Q3	2019-Q4
Real GDP growth	3% (2.1%)	3.1% (1.8%)	3% (2%)	2.8% (1.4%)
Unemployment rate	2% (7.1%)	2% (6.8%)	2% (6.7%)	2.1% (6.7%)
B) Treatment period	2020-Q1	2020-Q2	2020-Q3	2020-Q4
Real GDP growth	-1.5% (-2.2%)	-10.8% (-13.4%)	-5.2% (-3.7%)	-4.6% (-3.8%)
Unemployment rate	2% (6.7%)	2.5% (7%)	2.8% (7.9%)	3.1% (7.5%)

Note: The EU average values are in parentheses. Real GDP growth is calculated on the same quarter of the previous year.
Source: OECD.

Figure A1: Bank Lending Survey: Factors Affecting Credit Conditions and Standards for Mortgage Loans



Note: The net percentage (y-axis) is calculated as the difference between the market share of banks reporting a tightening of credit standards/conditions or an increase in demand for loans, and the market share of respondents reporting an easing of credit standards/conditions, or a decline in demand for loans, for a given question. The black dashed vertical lines indicate the effective date of the relaxation of the limits described above the lines.
Source: Czech National Bank.

Table A2: Summary Statistics for Fitted and Observed Values

		Obs	Mean	Std. Dev.	Min	Max
A) Before period (control group, all mortgages)						
LTV	observed	51,188	62.47	23.17	8.00	90.00
	fitted	50,273	62.39	12.26	15.00	112.53
DTI	observed	52,048	5.05	2.16	0.96	11.18
	fitted	50,273	5.02	1.41	-2.08	9.83
DSTI	observed	52,064	31.77	10.24	8.00	57.91
	fitted	50,273	31.75	6.01	2.40	55.95
B) After period (all mortgages)						
LTV	observed	54,796	63.07	22.55	8.00	90.00
	fitted	45,502	59.84	12.37	10.54	119.19
DTI	observed	56,070	5.48	2.34	0.96	11.18
	fitted	45,502	5.14	1.46	-2.22	10.18
DSTI	observed	56,070	32.00	10.77	8.00	57.91
	fitted	45,502	32.85	6.16	2.69	54.80
C) After period (treatment group, constrained mortgages)						
LTV	observed	22,660	78.02	14.83	8.00	90.00
	fitted	18,721	62.63	12.53	11.28	119.19
DTI	observed	23,934	6.19	2.37	0.96	11.18
	fitted	18,721	5.05	1.44	-2.22	9.98
DSTI	observed	23,934	34.92	11.32	8.00	57.91
	fitted	18,721	32.01	6.19	2.69	54.16

Note: The table shows summary statistics for observed and fitted LTV, DTI, and DSTI values. Panel A considers the before period (i.e. mortgages granted from April to December 2019) while panels B and C contain the period after the relaxation of the policy (from April to December 2020). Panel B considers all mortgages granted in the after period while panel C is limited to constrained mortgages only.

Appendix B: Details on the Matching Procedure

The non-random assignment of mortgages into the control and treatment groups would make it difficult to correctly assign changes in outcome variables to the borrower-based measures easing. To take care of the selection bias, we rely on a nearest neighbor matching (NNM) estimator (Abadie and Imbens, 2006). The matching approach imputes the missing potential outcome for each subject by using the average of the outcomes of similar subjects that receive the other treatment level. It is based on a weighted function of the covariates for each observation.

More specifically, NNM pairs units based on the Mahalanobis distance, which is a distance measure similar to a scale-free Euclidean distance. Two units with identical covariate values have a Mahalanobis distance of 0, and the greater the differences in covariate values, the larger the Mahalanobis distance. The idea is to find control units with a small Mahalanobis distance to the treated units to establish matched pairs with similar covariate values and achieve a similar covariate distribution in both groups.

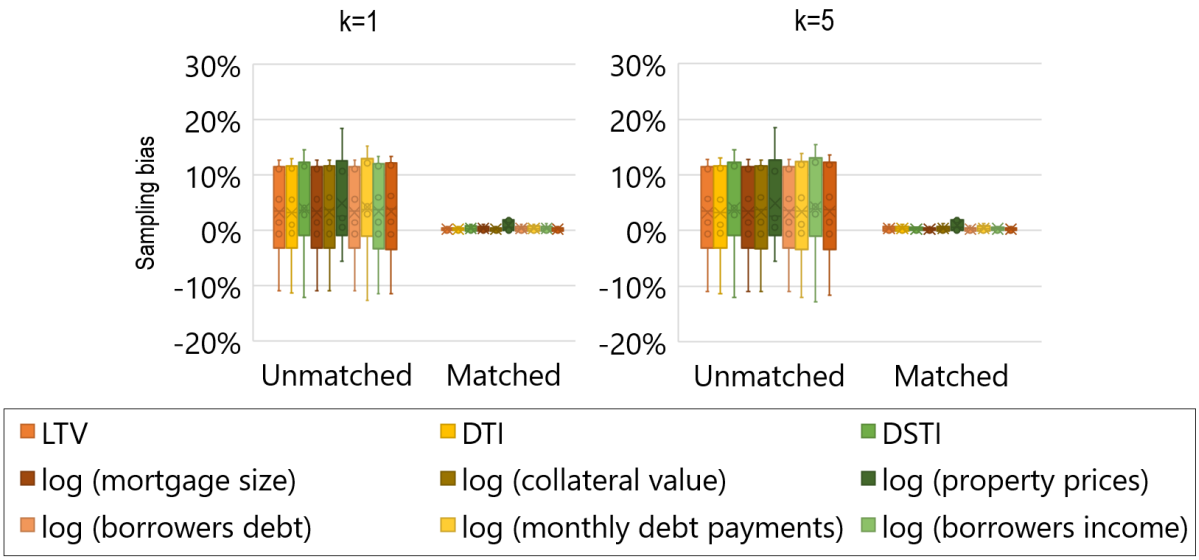
The vector of matching covariates X includes an indicator on whether the household is a first time borrower or not and the postal code of the property (district level) for which we use exact matching. Further, the vector contains several borrower characteristics for which we match using the computed Mahalanobis distance. These include the borrower's income, age, selected loan maturity and fixation, and regulatory exposure, all expressed as deciles. We request at least five matches to be identified for the treated observations. We have experimented with setting the caliper value, i.e. the maximum distance at which two observations are a potential match, but find that the differences are not significant to a case where we do not set a caliper value. This is mainly due to the use of exact matching for certain variables and then matching on deciles for the remaining variables.

Figure B1 plots the difference between the mean values or the treated group and the control group for the sample before and after the matching procedure. As is apparent, there are significant differences between the two groups before the matching which were reduced close to zero afterwards. Both algorithms, i.e. with one and multiple nearest neighbors, were able to remove the differences between groups. The results of this balancing test are similar for different outcome variables.

An important advantage of using the matching estimator (compared to multivariate regression) is that matching does not require imposing assumptions about a linear relationship (or any other functional form) between the outcome, treatments and covariates. This is particularly useful when one is not equipped with a clear underling model and needs to deal with simultaneity, endogeneity and an unclear lag length. Angrist and Kuersteiner (2011) expose these advantages in the context of the impact of monetary policy shocks.

An important difference between the matching estimators and multivariate regression is the weighting of the observations. In both cases, one needs to set up weights for the difference between treated and untreated values to be able to calculate the average effect for the whole sample. In regression analysis, the greatest weights are placed on observations with an equal likelihood of being treated or untreated whereas in matching, the greatest weights are put on the control observations most "similar" to the treated observations (i.e. observations representing the highest likelihood of being treated but were not).

Figure B1: Matching Evaluation



Note: The graph shows box plots summarizing the difference in means between the treated and control groups (based on selected covariates) before and after the matching using the nearest neighbor matching algorithm.

Appendix C: Additional Estimates

Table C1: Average Treatment Effects of Borrower-Based Measures Easing – Reduced Treatment

	Nearest neighbor matching		
	Constrained		Unconstrained
	First-time buyers only		
	(1)	(2)	(3)
LTV	0.085***	0.108***	-0.035***
	(0.003)	*(0.004)*	*(0.003)*
DTI	0.015***	0.015***	-0.003***
	(0.000)	*(0.000)*	*(0.000)*
DSTI	0.059***	0.057***	-0.011***
	(0.002)	*(0.003)*	*(0.002)*
Matching covariates			
Borrower	Y	Y	Y
Loan	Y	Y	Y
Spatial	Y	Y	Y
Regulatory distance	Y	Y	Y
N	14,536	8,888	9,423
Treated	2,900	1,810	2,345
Control	11,456	7,078	7,078

Note: This table shows the shift in LTV, DTI, and DSTI choices among homebuyers that were granted a mortgage before and after the relaxation of the borrower-based limits. The unit of observation in each regression is a mortgage. The sample includes mortgages granted from April to June 2019 and April to June 2020. Constrained mortgages are those with an LTV of 80% and above, a DTI of 9 and above and a DSTI of 45% and above in the period following the regulatory easing (i.e. from April to June 2020). Each constrained mortgage is matched to a mortgage granted before the policy easing (from April to June 2019). Mortgages are matched on the characteristics described in Section 3. Unconstrained mortgages are those granted in the after period with limit characteristics below the previously set limits). We use Robust Abadie-Imbens standard errors. The statistical significance is denoted as *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$.

Table C2: Average Treatment Effects of Borrower-Based Measures Easing – Accounting for Time Effects (1/2)

	Loan-to-value		log(size)	log(collateral)	log(price)
	(1)	(2)	(3)	(4)	(5)
Treatment	0.027***	-0.017***	-0.176***	-0.260***	-0.186***
	(0.003)	(0.003)	(0.009)	(0.010)	(0.015)
Post	-0.000	0.004	0.183***	-0.081***	-0.141***
	(0.012)	(0.012)	(0.037)	(0.029)	(0.049)
Treatment × *Post*	0.011***	0.016***	0.115***	0.024**	0.071***
	(0.004)	(0.004)	(0.011)	(0.011)	(0.018)
N	105,984	105,046	108,382	105,851	35,823
adj. R^2	0.041	0.132	0.141	0.320	0.354
Bank FE	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	Yes	Yes

Note: This table shows the shift in borrower and mortgage characteristics among homebuyers that were granted a mortgage before and after the relaxation of the borrower-based limits. The sample includes mortgages granted from April to December 2019 and April to December 2020. *Treatment* denotes a group of mortgages granted during the period being studied whose predicted $\widehat{LTV}$ is 80% or above, $\widehat{DTI}$ is 9 or above, and $\widehat{DSTI}$ is 45% or above. *Post* is an indicator equal to 1 from April to December 2020, and zero otherwise. The control variables include borrower income, age, interest rate, loan fixation, and an indication of whether the borrower is a first-time borrower or not. The robust standard errors are in parenthesis. The statistical significance is denoted as * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table C3: Average Treatment Effects of Borrower-Based Measures Easing – Accounting for Time Effects (2/2)

	Debt-to-income		log(debt)	Debt-service-to-income		log(payment)	log(income)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Treatment	-0.007***	-0.011***	0.038	-0.069***	-0.068***	-0.303***	0.025***
	(0.000)	(0.000)	(0.038)	(0.002)	(0.002)	(0.010)	(0.003)
Post	0.003**	0.001	0.301**	-0.005	0.013**	0.066*	-0.014*
	(0.001)	(0.001)	(0.118)	(0.006)	(0.006)	(0.035)	(0.008)
Treatment × *Post*	0.005***	0.006***	0.174***	0.013***	0.017***	0.171***	-0.004
	(0.000)	(0.000)	(0.052)	(0.002)	(0.002)	(0.012)	(0.004)
N	108,118	107,121	68,874	108,134	107,133	103,966	103,968
adj. R^2	0.068	0.198	0.349	0.079	0.115	0.235	0.881
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
District FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	Yes	No	Yes	Yes	Yes

Note: This table shows the shift in borrower and mortgage characteristics among homebuyers that were granted a mortgage before and after the relaxation of the borrower-based limits. The sample includes mortgages granted from April to December 2019 and April to December 2020. *Treatment* denotes the group of mortgages granted during the period being studied whose predicted $\widehat{LTV}$ is 80% or above, $\widehat{DTI}$ is 9 or above, and $\widehat{DSTI}$ is 45% or above. *Post* is an indicator equal to 1 from April to December 2020, and zero otherwise. The control variables include borrower income, age, interest rate, loan fixation, and an indication of whether the borrower is a first-time borrower or not. The robust standard errors are in parenthesis. The statistical significance is denoted as * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

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CZECH NATIONAL BANK
Na Příkopě 28
115 03 Praha 1
Czech Republic

ECONOMIC RESEARCH DIVISION
Tel.: +420 224 412 321
Fax: +420 224 412 329
http://www.cnb.cz
e-mail: research@cnb.cz

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