Cooling the Mortgage Loan Market:
The effect of Borrower-Based Limits on New Mortgage Lending

Martin Hodula, Milan Szabo, Lukáš Pfeifer, Martin Melecký

SUERF-Banca d'Italia-ECB-EIB conference

April 27, 2023

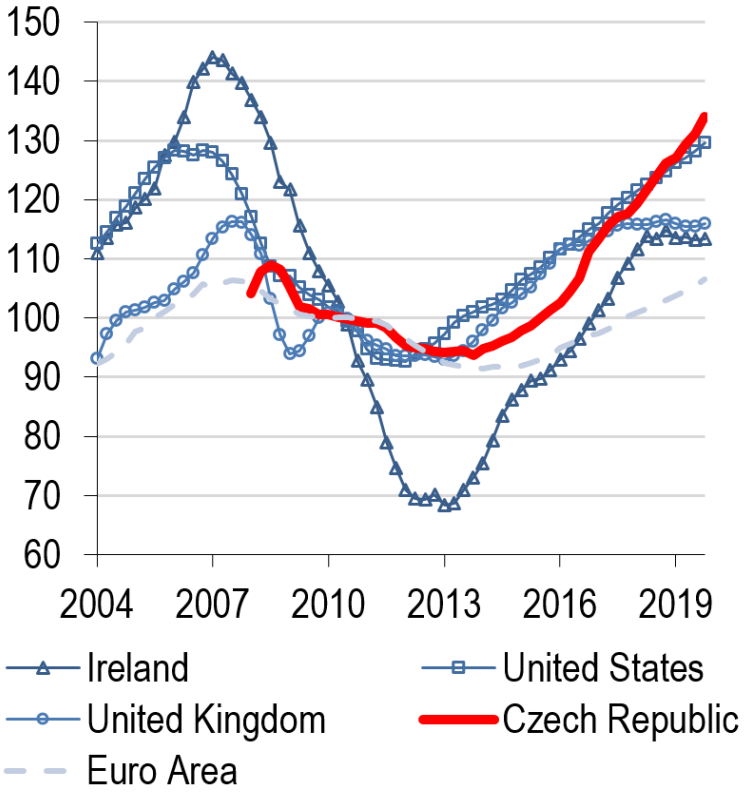
Disclaimer: The views expressed herein are those of the authors and should not be attributed to the Czech National Bank or the World Bank.

Introduction and motivation

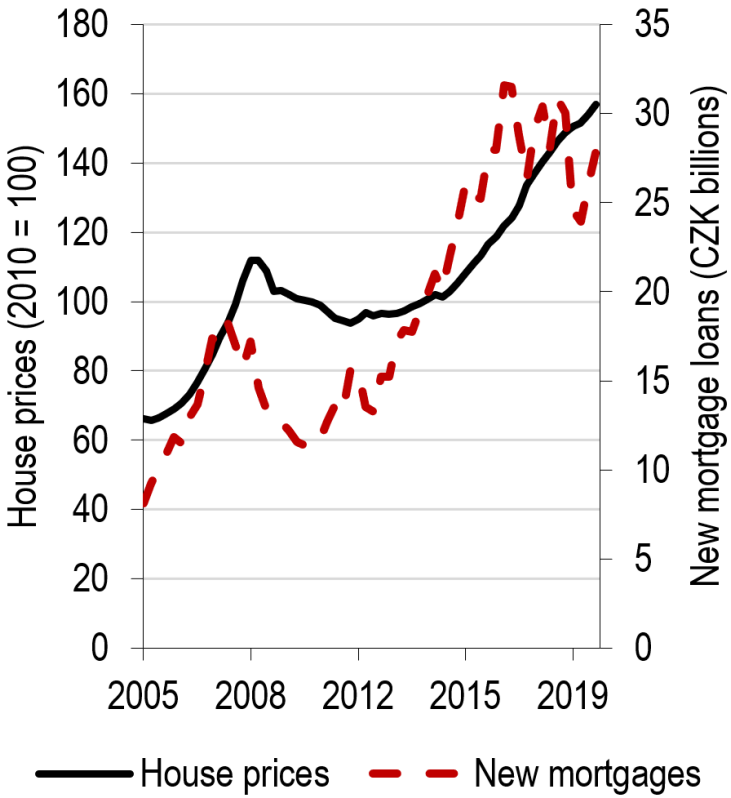
- Rapid growth of housing loans and house prices reinforce each other, leading to a build-up of systemic risk (Favara & Imbs, 2015; Justiniano *et al.*, 2019).
- Macroprudential policy is meant to weaken the feedback loop between credit and house prices and reduce the vulnerability of bank mortgage portfolios.
  - Borrower-based measures have been particularly favoured, having been adopted by more than 60 countries since 1990 (Alam *et al.*, 2019).
- We examine the effects of three borrower-based measures on mortgage lending in the Czech Republic, adopted in 2017 and 2018.
  - We combine loan-level data with borrower, bank and region-level information.
  - We use machine learning method of causal forest to estimate causal effect.
- Our contribution:
  - Comparison of the effects of using value-based (LTV) limit separately and jointly with income-based (DTI, DSTI) limits.
  - Exploration of heterogeneity in the transmission of the regulation.

The Property Cycle and House Prices

(A) House Prices: International Comparison



(B) The Property Cycle in the Czech Republic



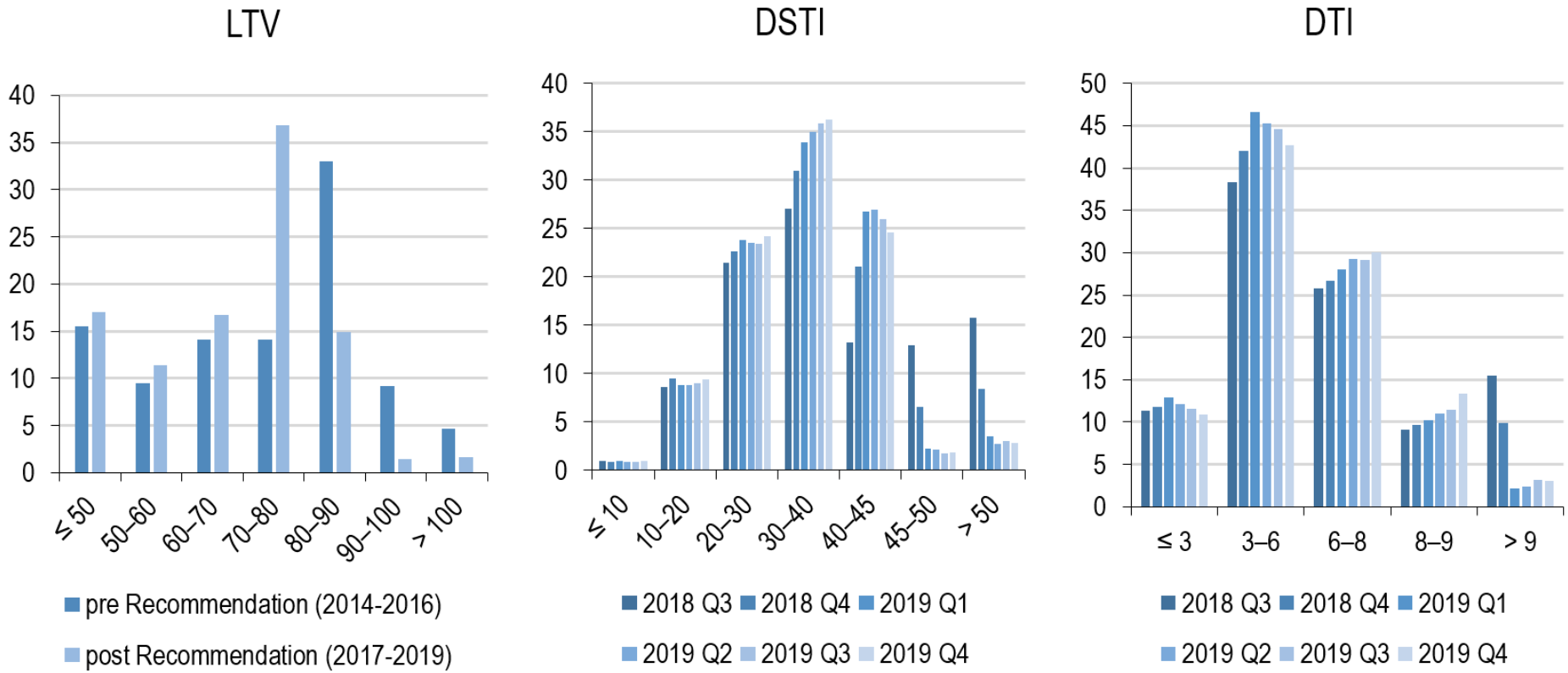
- Soft landing after the GFC, no major increases in non-performing mortgage loans or funding dry-ups.
- This allowed mortgage lending to grow and property prices to bounce back soon after the GFC and to grow rapidly between 2015 and 2017.

The Czech Residential Mortgage Market and Regulatory Measures During 2015–2018

Announced	Effective (A)	Hard caps (B)	Soft limits
16 June 2015	16 June 2015	LTV 100%	10% (LTV 90–100%)
14 June 2016	1 October 2016	LTV 95%	10% (LTV 85–95%)
14 June 2016	1 April 2017	LTV 90%	15% (LTV 80–90%)
12 June 2018	1 October 2018	LTV 90% DTI 9; DSTI 45%	5% (debt limits) 15% (LTV 80–90%)

- We focus on the effects of setting the 90% LTV limit and the introduction of income-based DTI and DSTI limits that followed.
- Interesting policy setup to evaluate – value-based vs. income-based limits.

Recommended Limits: Fulfilment and Loan Distribution



- Banks affected by the Recommendation were compliant with the limits.
- Following setting of the LTV limits, the share of loans with LTVs above 80% fell significantly.
  - Some regulatory arbitrage? 35% of loans had valued exactly equal to the LTV limit.

Data

- Main source: semi-annual loan-level survey: newly granted or refinanced mortgage loans from 2016 to the end of June 2019 (7 rounds of surveys).
  - Mandatory for all banks engaged in mortgage business
  - Anonymous individual data
- The survey contains following information:
  - Mortgage characteristics (e.g. size, collateral value, mortgage for rent or not, maturity, ZIP code, etc.).
  - Client characteristics (e.g. age, debt level, etc.).
  - Bank characteristics (e.g. regulatory distance from the limit, market share, etc.).
  - Loan characteristics are expanded with variables related to the regulatory recommendation (distance to the limit, days until Q-end).
- ZIP codes used to enrich the data with spatial characteristics (GDP, unempl., house prices).
- We work with 81,844 reported mortgage loans.
  - Substantial data cleaning, we start with 25 banks (91% of total assets of the sector).
  - After the mop-up, we cover 11 banks (83% of total assets).

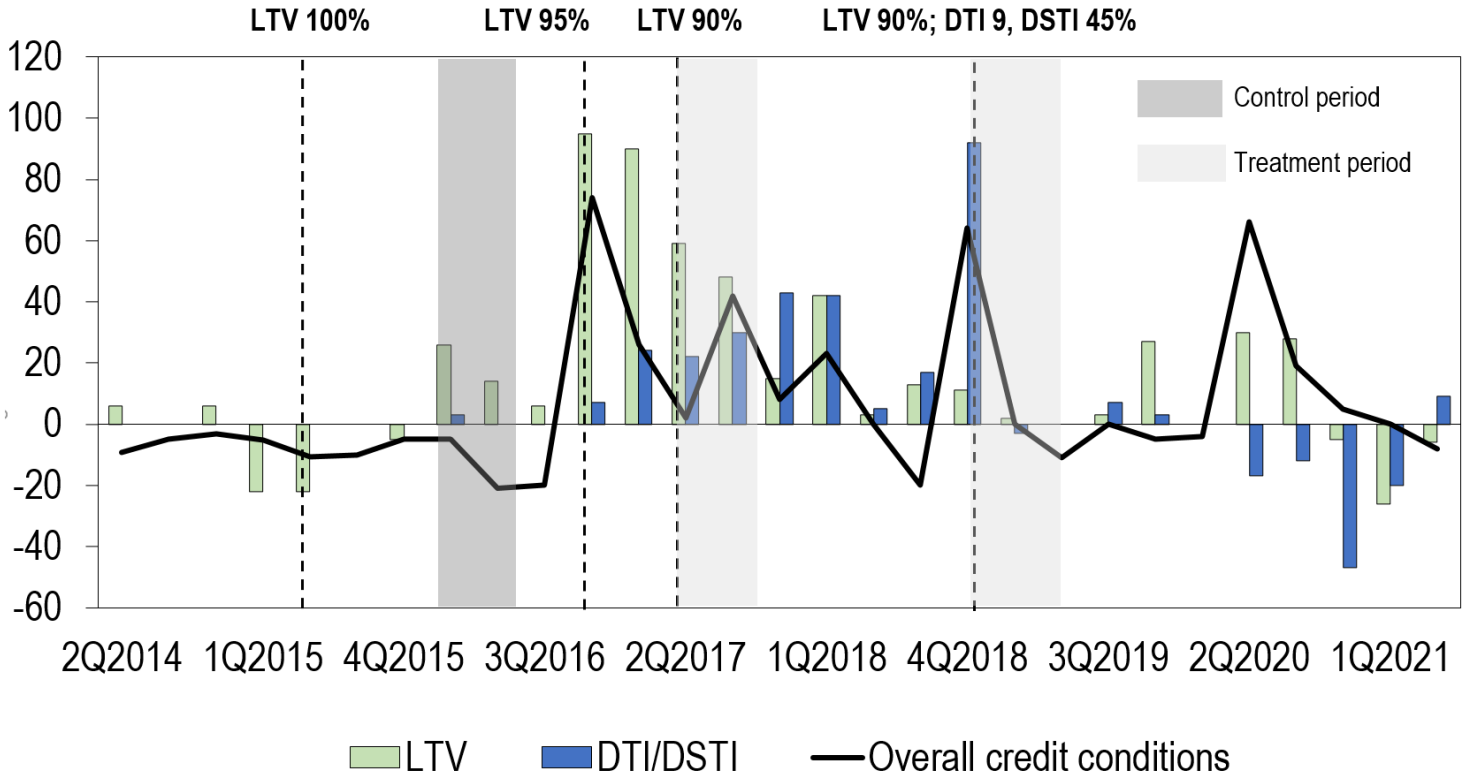
Identification Strategy (1/2)

- We assume the sequential changes in the loan distribution can be causally attributed to the introduction of recommended limits.
- The quasi-natural experiment that we evaluate has the following design:
  - Assign loans to the control group and two treatment groups.
  - The control group captures mortgages under the first Recommendation (no tightening of credit standards).
  - Two treatment groups (mortgages under LTV 90% and LTV-DTI-DSTI).
  - Loan-by-loan matching procedure.
- We estimate causal effect by comparing the differences between the control and treatment groups.
  - Matching method to reduce sampling bias.
  - Regression trees and random forest algorithm to search for treatment variation/heterogeneity over high-dimensional functions of covariates.

	Treatment			**Control**		
	minDate	maxDate	N	minDate	maxDate	N
LTV	1/6/2017	31/12/2017	37,019	1/1/2016	14/6/2016	28,104
LTV-DTI-DSTI	1/10/2018	14/6/2019	16,721	1/1/2016	14/6/2016	28,104

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

Insights from the BLS and the Time Assignment of Control and Treatment Periods



- Data prior 2015Q4 not included due to low quality (first rounds of the survey).
- The cutoff date of June 14, 2016 is chosen to account for the front-loading that probably happened after the intended 95% LTV limit was announced.

Estimation Methodology (Athey & Imbens, 2016)

- Each unit (in our case, a newly granted loan) has two potential outcomes based on a binary treatment:
  - $Y_i(W_i = 1)$ is the outcome if the unit had been treated
  - $Y_i(W_i = 0)$ is the the outcome had the unit not been treated
  - The causal (treatment) effect of a Recommendation on the *i*-th loan could be estimated as a simple difference between the potential outcomes
- We estimate the average treatment effect (ATE) as follows:

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

  we gradually consider size of mortgage loan, value of pledged real estate and distance to average interest rate as our left-hand side variables.
- Estimated ATEs show the change of the given variable due to the Recommendation.

Effects on Loans Size and Collateral Value

	LTV	LTV-DTI-DSTI
A) Size of mortgage loan		
Average Treatment Effect (ATE)	**-18,973**	**-342,290**
	(-33,104; -4,841)	(-378,988; -305,593)
Heterogeneous Treatment Effect (HTE)	7,278	**364,051**
	(-17,162; 31,718)	(295,636; 432,466)
No. of observations	65,123	44,825
B) Value of pledged property		
Average Treatment Effect (ATE)	**223,331**	43,024
	(127,309; 319,353)	(-881; 86,930)
Heterogeneous Treatment Effect (HTE)	**214,721**	**161,291**
	(63,781; 365,660)	(33,541; 289,041)
No. of observations	65,123	44,825

- After LTV limit, average loan size dropped by approximately 1.2%, while collateral value increased by 8.5%.
- After the DTI/DSTI limits, average loan size dropped by more than 20%.
  - Income-based limits may have provided for ”belt-and-braces” incentives that left little room for arbitrage by both borrowers and banks.

The Treatment Effects on Mortgage Loan Rates

	LTV	LTV-DTI-DSTI
Average Treatment Effect (ATE)	**0.179**	**0.339**
	(0.067; 0.291)	(0.220; 0.458)
Heterogeneous Treatment Effect (HTE)	-0.046	0.119
	(-0.264, 0.172)	(-0.065, 0.303)
No. of observations	65,123	44,825

- In general, one would expect a negative effect of BBMs on bank lending rates (rationing out riskier borrowers, improving the quality of the mortgage portfolio).
- The Czech case is special given the use of both, hard and soft limit
  - Banks have the option of providing a certain proportion of total loans with higher prudential ratios in the current quarter (15% in the case of LTV and 5% in the case of income-based limits).
- Estimates show that banks increased risk premiums on mortgage loans with high prudential ratios.

Exposing Heterogeneous Treatment Effects

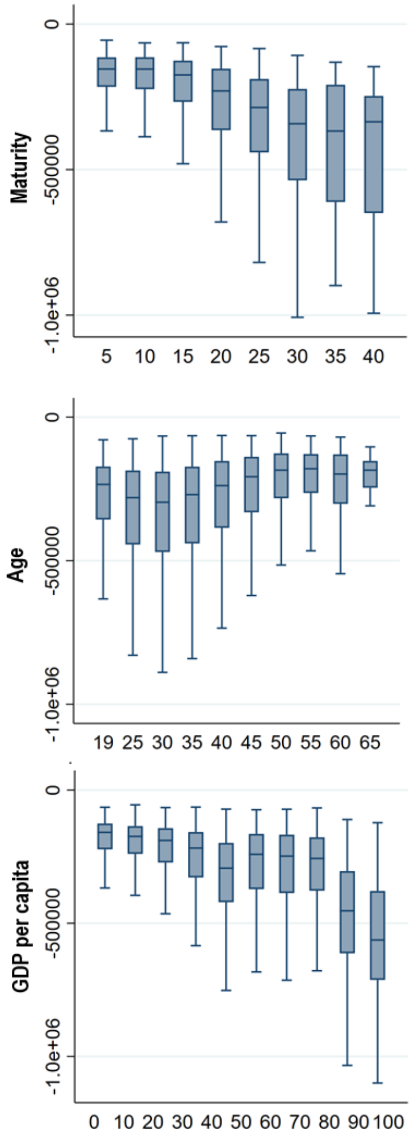
- We further estimate the conditional average treatment effect (CATE):

$$\tau(x) = E[Y_i(W_i = 1 - Y_i(W_i = 0)|X_i = x] \tag{2}$$

  which calculates the treatment effect for a sub-population with different characteristics, e.g. age, mortgage maturity, etc.
- We formally test for differences in average ATEs between the 30% of mortgages with the highest and lowers value of a given factor ("HTE test")
- The HTE test signals significant heterogeneous treatment effects of:
  1. DTI-DSTI on mortgage size,
  2. LTV and DTI-DSTI on collateral value.

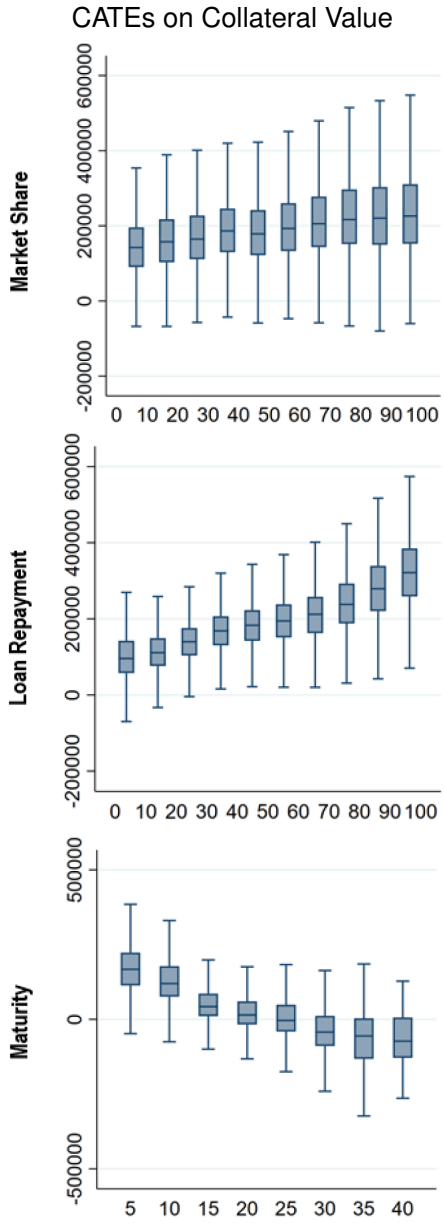
CATEs on Mortgage Size (DTI/DSTI Introduction)

- Higher treatment effect stemming from varying maturity of the new mortgages.
  - Longer maturity used to effectively lower the debt service.
  - Not possible for maturity exceeding 30y (hard limit).
- Higher treatment effect for mortgages with the youngest main borrower (up to 36y)
  - CNB now imposes weaker rules for younger borrowers (effective since 1 August 2021).
- ”Richer” regions saw higher reduction of loan volumes following the treatment
  - Improvement of equity in access to mortgages across regions with different levels of prosperity.



CATEs on the Value of Pledged Property

- After LTV limit:
  - Loans from banks with the greatest market share were issued with a significantly higher collateral value
  - The collateral value increased more for loans with the highest loan repayments
    - ★ Lending into a booming property market?
    - ★ Increased efforts by banks to assign a high value to pledged property at the higher end of the market?
- After DTI-DSTI limits:
  - The 30% of loans with the shortest maturity (roughly below 10 years) experienced positive treatment effect
    - ★ Could afford to buy property at a higher price (wealthier clients).
  - The collateral value decreased for the 30% of loans with higher maturity
    - ★ Poorer clients?, had to purchase (and pledge) a cheaper property.



Conclusions and Policy Implications

- We estimated that the recommended LTV limits reduced the average loan size and increased interest rate on new loans.
- LTV limits also caused collateral value to increase.
  - More pronounced for banks with higher market power.
- Additional DTI-DSTI limits provided for a belt-and-braces incentives for banks and borrowers that were harder to escape.
  - Income-based limits decreased loan volume much more than a standalone LTV limit (about 20 times larger treatment).
  - The mortgage rate increased substantially more than after the recommended LTV limits (0.34 versus 0.18 percentage points).
- Application of DTI-DSTI limits was rather heterogenenous in its impact.
- The combination of income-based and LTV limits has been much more effective in cooling the residential mortgage loan market than using LTV limit alone.

New Paper Coming Soon - Effects of Easing of Borrower-Based Measures

- We analyze the biggest easing of BBMs (worldwide) – in spite of the pandemic, the CNB has eased the LTV limit and abolished DTI and DSTI limits
- Notable difference in propagation of easing of value-based (LTV) and income-based (DTI, DSTI) limits
  - LTV-constrained borrowers act in line with a liquidity preference
  - DTI/DSTI-constrained borrowers act in line with a financial accelerator
- Significant heterogeneity of transmission
  - LTV more binding for first-time home buyers, younger borrowers, and borrowers from poorer counties
  - DTI/DSTI more binding for clients from richer counties and second+ mortgages

Thank you for your attention!

Comments are welcomed and much appreciated.

You can reach me at martin.hodula@cnb.cz

Back-up Slides

Robustness Check 1

- We separate the effect of treatment across constrained and unconstrained loan groups
  - We assess whether the loan was more likely to be treated based on LTV score (DSTI not available during control period, cannot be hand-crafted)
  - Constrained loans are those with LTV equal or higher than 80%
  - We split the baseline dataset into two separated subsets, one consists of the constrained loans and the other of the unconstrained loans.
  - We run the same models again separately for each of the subset and analyse differences in results.

ATEs of LTV Limit for Constrained and Unconstrained Mortgages

	Constrained	Unconstrained
ATE for size of mortgage loan	-13,441.8	-7,978.9
	(-39,270.9; 12,387.5)	(-19,736.6; 3,778.6)
No. Of observations	23,874	41,249
ATE for value of pledged real estate	**281,640.5**	-27,213.4
	(189,568.2; 373,712.8)	(-154,298.6; 99,871.8)
No. of observations	23,874	41,249
ATE for distance to average rate	**0.196**	0.109
	(0.083; 0.309)	(-0.043; 0.261)
No. of observations	23,874	41,249

Note: 95% confidence interval in parenthesis, significant estimates are highlighted in bold.

- The collateral increased following the implementation of LTV limit for constrained mortgages
- ...as well as interest rates

ATEs of Income-Based Limits for Constrained and Unconstrained Mortgages

	Constrained	Unconstrained
ATE for size of mortgage loan	**-231,118.2**	**-259,693.5**
	(-301,237.9; -160,998.5)	(-292,057.9; -227,329.2)
No. Of observations	17,076	27,749
ATE for value of pledged real estate	-54,786.4	**283,526.1**
	(-148,465.9; 38,893.3)	(115,779.5; 451,272.7)
No. of observations	17,076	27,749
ATE for distance to average rate	**0.360**	**0.281**
	(0.230; 0.490)	(0.117; 0.445)
No. of observations	17,076	27,749

Note: 95% confidence interval in parenthesis, significant estimates are highlighted in bold.

- The collateral channel is not longer operational in case of introducing LTV limits side-by-side with income-based limits
- Due to the existence of the soft limit, interest rates are found to increase more for constrained mortgages

Robustness Check 2

- To account for any time-specific endogeneity, we calculate distance to average loan size and collateral value (indicator value for given loan minus average at a given month in the given region)
- Estimates are largely compliant with our baseline

	LTV	TOTAL
A) Distance to average mortgage loan size		
Average Treatment Effect (ATE)	**-84,220.3**	**-326,697.2**
	(-108,223.5; -60,218.9)	(-361,484.6; -291,909.8)
No. of observations	65,123	44,825
B) Distance to average value of pledged real estate		
Average Treatment Effect (ATE)	**172,483.8**	131,652.464
	(63,209.7; 281,758.9)	(-15,274.1; 278,579.9)
No. of observations	65,123	44,825

Note: 95% confidence interval in parenthesis, significant estimates are highlighted in bold.

Bibliography I

Alam, Z, Alter, A, Eiseman, E, Gelos, G, Kang, H, Narita, M, Nier, E, & Wang, N. 2019. *Digging Deeper–Evidence on the Effects of Macroprudential Policies from a New Database*. IMF Working Paper No. 19/66. International Monetary Fund.

Athey, Susan, & Imbens, Guido. 2016. Recursive Partitioning for Heterogeneous Causal Effects. *Proceedings of the National Academy of Sciences*, **113**(27), 7353–7360.

Favara, Giovanni, & Imbs, Jean. 2015. Credit Supply and the Price of Housing. *American Economic Review*, **105**(3), 958–92.

Justiniano, Alejandro, Primiceri, Giorgio E, & Tambalotti, Andrea. 2019. Credit Supply and the Housing Boom. *Journal of Political Economy*, **127**(3), 1317–1350.