Stress Testing and Calibration of Macroprudential Policy Tools

LUCY GORNICKA AND LAURA VALDERRAMA

2021 RiskLab/BoF/ESRB Conference on Systemic Risk Analytics
1-2 July 2021

Outline

- Model of Mortgage Risk
- Application I: Stress Testing and Adequacy of Tools in Switzerland
- Application II: Calibration of Borrower-Based Limits in Austria

3

Model of Mortgage Risk

Key features of the analysis

- Contribution: The paper investigates major loan loss events and informs the calibration of macroprudential policy to enhance banking system resilience
- Forward-looking: The approach applies stress testing techniques to provide a measure of credit risk by *risk bucket* and *vintage* under adverse conditions
- Scenario design: The model is applied to scenarios whose severity is linked to the level of risk (DSGE with exogenous shocks), or to assessments on near term likelihood (GDP 'at risk')
- Calibration: The model informs the adequacy and calibration of macroprudential instruments for real estate risk:
  - Amortization requirements and sectoral CCyB
  - LTV and DSTI caps
- The paper presents two applications: Mortgage markets in Switzerland and Austria

Modeling approach

It builds on RBNZ’s TUI model of mortgage lending risk, adds modeling enhancements

Main behavioral assumption: “Double trigger” theory of default:

- **Financial distress (liquidity constraint)**: the borrower is unable to service the loan due to financial difficulties (e.g. unemployment, lower income, higher rates)
  - The borrower cannot repay the debt on time
- **Economic default (negative equity)**: the net value of the collateral is less than the outstanding value of the loan
  - The borrower cannot pre-pay the loan

Semi-structural approach

- Structural process
- Estimation/calibration of parameters
- Simulation using current regulatory environment/counterfactual analysis

Financial distress (FD)

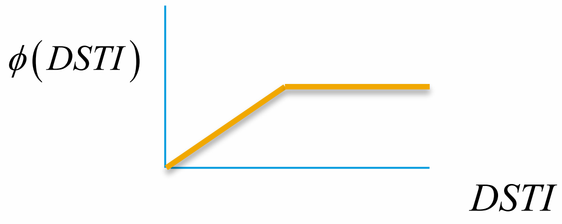
$$\Pr(FD_{i,t}) = \phi(DSTI_{i,t-1}) \times D_i + \beta_1 \times \Delta DSTI_{i,t}{}^{\gamma} + \phi(DSTI_{i,t-1}) \times (\beta_2 U_{t-1} + \beta_3 \Delta U_t{}^{\alpha})$$

Underlying risk drivers

- Macroeconomic conditions: aggregate shocks (interest rates, income, RE prices)
- Loan characteristics: type, tenor, rollover rate, degree of overcollateralization
- Borrower characteristics: idiosyncratic factors (unemployment/demographic)
- Regulatory environment: amortization requirements, borrower-based measures
- ❖ The impact on bank resilience depends on the availability of capital buffers

Predictors of illiquidity

- Changes in debt-servicing capacity $DSTI_t$ (income shocks, interest rate shocks, house price shocks)
- Changes in the unemployment rate U_t
- ❖ The impact of idiosyncratic factors (D, U_t) is a non-linear function of affordability risk (DSTI)



Economic default (ED)

The house price decline is sufficiently large, so that the loan becomes undercollateralized and early mortgage termination is not feasible:

$$\tilde{P}_{i,t} - C < NPV\left(L_{i,t}, r_t^{type,M}, r_t^f, T_s\right)$$

$$NPV\left(L_{i,t}, r_t^{type,M}, r_t^f, T_s\right) = L_{i,t} + \sum_{j=0}^{T-1} \frac{r_t^{type,M} L_{i,t}\left(1 - \frac{j}{T_s}\right)}{\left(1 + r_t^f\right)^j}$$

The NPV reflects:

- the outstanding principal
- penalty for early pre-payment: the amount of foregone interest payments which rise with the interest rate spread

The probability of default of borrower *i* is defined by:

$$PD_{i,t} = \Pr(FD_{i,t}) \times \Pr(ED_{i,t})$$

Loss Given Default (LGD)

The conditional LGD is driven by the discounted sale price of the repossessed collateral.

The sale occurs at *t+n* and proceeds net of transaction costs are discounted at a rate reflecting the risk premium of the foreclosed asset.

$$LGD_{i,t} = NPV(L_{i,t}, r_t^{type,M}, r_t^f, T_s) - (1-\delta) \times \frac{\tilde{P}_{i,t+n}}{\left(1 + r_t^f + spread\right)^n}$$

We use Monte Carlo simulations to simulate PDs and LGDs for vintages of mortgages (by LTV bucket):

- Each bucket is assumed to have 10,000 mortgages
- Within a bucket we draw a house price for each mortgage from a normal distribution of prices (idiosyncratic risk)
- We simulate each bucket 2,000 times to decrease simulation noise

Granular projections

The model generates 2-year bank-specific or aggregate banking system forecasts for PDs, LGDs, and loss rates (which are annualized):

- *By LTV bucket*. This allows identifying high risk buckets to inform the calibration of macroprudential instruments.
- *By vintage s.* This allows detecting high risk issuances to assess the effectiveness of macroprudential policy implementation (new issuances; outstanding stock)
- *By portfolio*. This allows forecasting credit losses by weighting the distribution of outstanding mortgages across risk buckets and vintages and assess the level of macroprudential buffers to build resilience

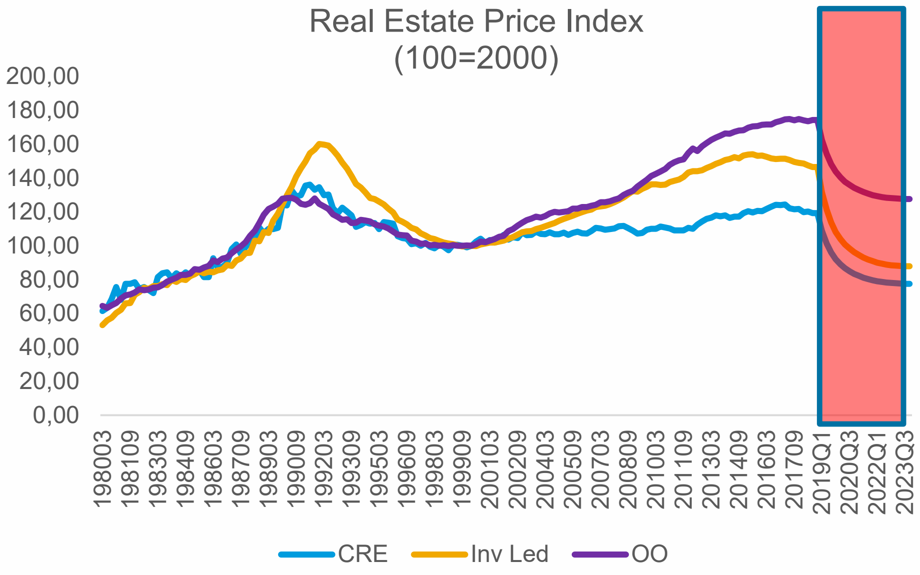
Characteristics of mortgage markets in CH and AT

	Switzerland	Austria
Data by risk bucket (LTV, LTI)	✓	✓
Vintage disclosure		✓
Real estate crisis	✓	
Typical mortgage	fixed	floating
Typical maturity	Rollover 1-10y	25y
Interest only	✓	
Margin call	✓	
Structural changes	✓	
Binding sectoral CCyB	✓	
Binding amortization requirement	✓	
Non-binding guidance		✓
Toolkit (LTV, DTI, DSTI, tenor)		✓

11

Application I: Stress Testing and Adequacy of Tools in Switzerland

Scenario for Switzerland



Peak-to-trough	Owner occupied	Investment	CRE
Historical	-17%	-31%	-23%
5-year adverse scenario	-27%	-40%	-35%

Variable	Cum change over two years (baseline)	Cum change over two years (adverse)
Real disposable income	3.6%	-4.4%
Real estate price	0%	-25.4%
Unemployment rate	-0.11%	1.4%
Mortgage rate	1.25 pp	3.75 pp

Regulatory Framework

Residents are allowed to draw on their second- and third- pillar pension assets to fund mortgage loan down payment	1995

Legal directives	Date
Sectoral CCyB activated at 1%	Feb 2013
Sectoral CCyB raised to 2%	Jan 2014
Increase of capital requirements to high LTV loans	Jan 2013

Self-Regulation approved by FINMA	
Borrowers required to provide at least 10% in equity	July 2012
The mortgage must be amortized to an LTV of 2/3 in 20 years	July 2012
The mortgage must be amortized to an LTV of 2/3 in 15 years	Sep 2014

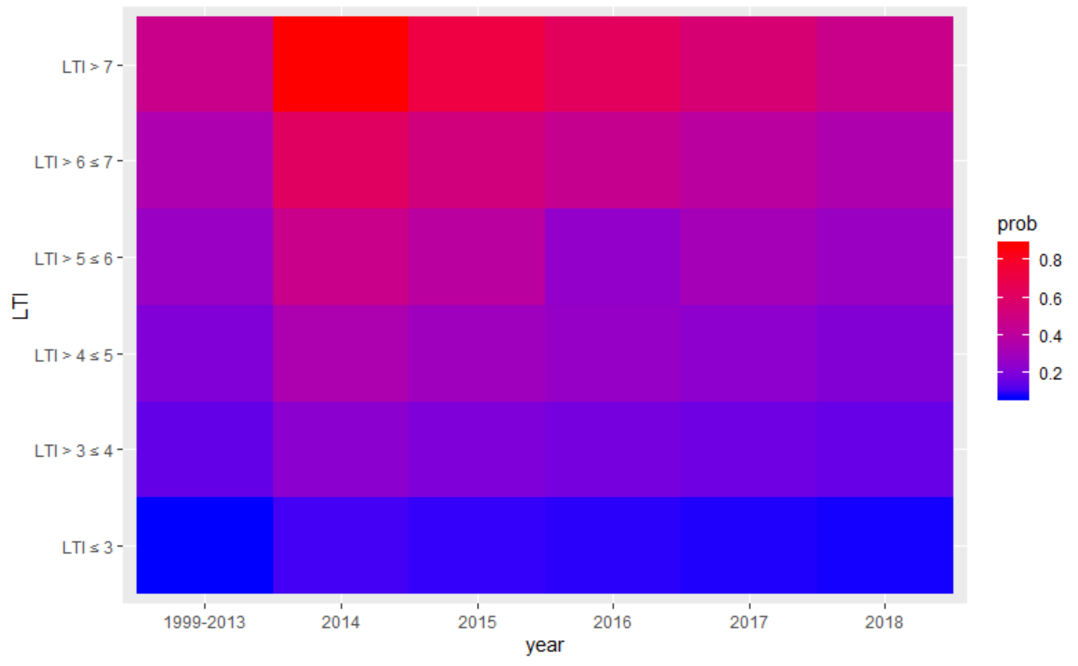
Common internal bank policies
LTV lower than 80%
DSTI (amortization rate, stressed 5% rate, and maintenance) lower than 1/3

Calibration

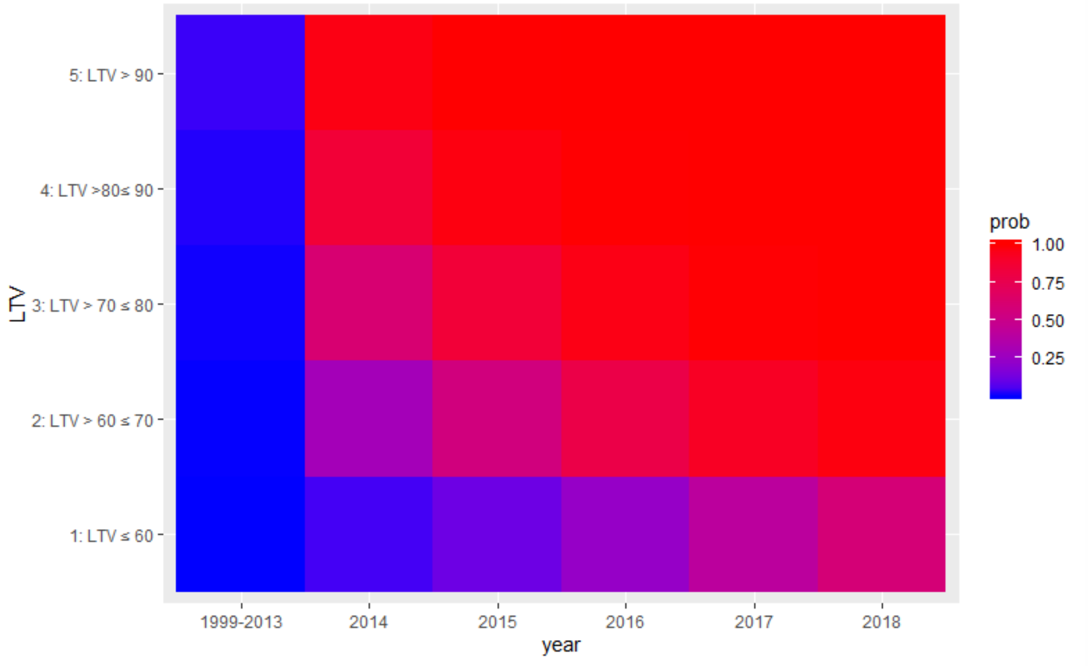
Procedure	Calibration
Estimate PD over 1989-92, assuming LGD=35%	$PD = 2.6\%$
Estimate the share of borrowers in distress, given defaults and negative equity	$\Pr(FD) = 13.2\%$
Allocate financial distress to interest rate and unemployment shocks	$from\ R\ shock = 0.8$ $from\ U\ shock = 0.2$
Compute aggregate sensitivity of Pr(FD) to changes in average DSTI (estimated DSTI over 50% in 1989 against 17% in 2018)	$\beta_1 = 4.1$
Calibrate $\phi(DSTI)$ to match Swiss banks' internal policies and UK distribution of impairment risk	$\phi(DSTI) = \begin{cases} 1.3 \cdot \left(\frac{DSTI - DSTI_{\min}}{1/3 - DSTI_{\min}} \right) & DSTI < 1/3 \\ 1.3 & otherwise \end{cases}$
Calibrate γ to the sensitivity of stressed sales to the interest shock in CH over 1989-1992 for DSTI tranches using the UK crisis experience	$\gamma = 2$
Calculate the aggregate sensitivity of $\Pr(FD)_i$ to ΔU in 1989-92	$\beta_3 = 2.7$
Calibrate D to match current mortgage loan loss rates	$D = 0.2$

Non-Linear Effects

Probability of Financial Distress



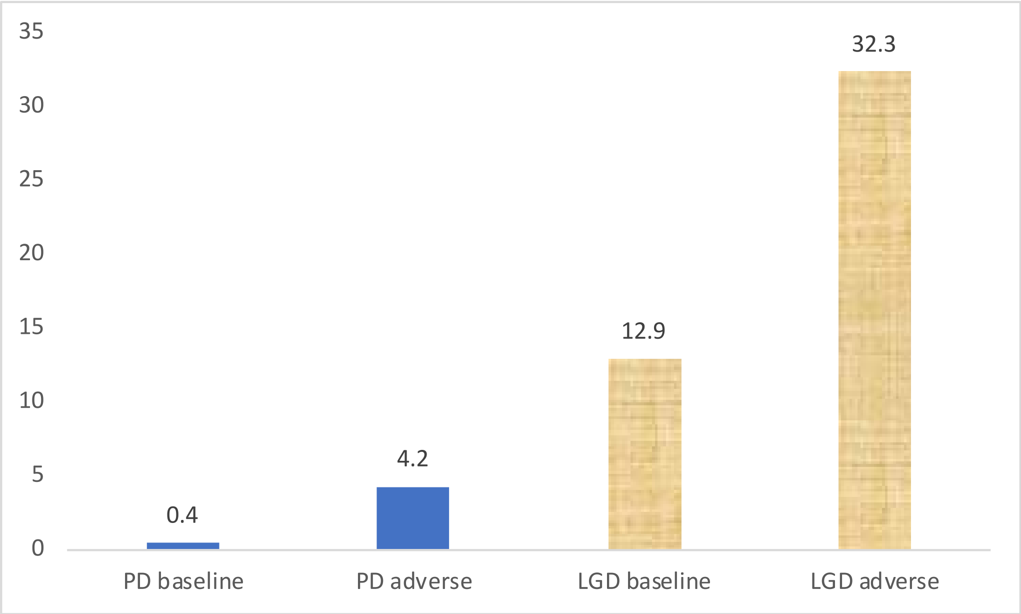
Probability of Negative Equity



Stress test results

- The average annualized default rate reaches 4.2% in 2019-20 with the average LGD at 32.3%.
- The loss rate of mortgage claims rises to 1.77% leading to a 135-bps decline of the banking system CET1 ratio.
- Default rates are concentrated in recent vintages with high LTV ratios
    - Loss rates range between 0.01% and 0.14% for old vintages, and between 2.7% and 8.8% for recent vintages.

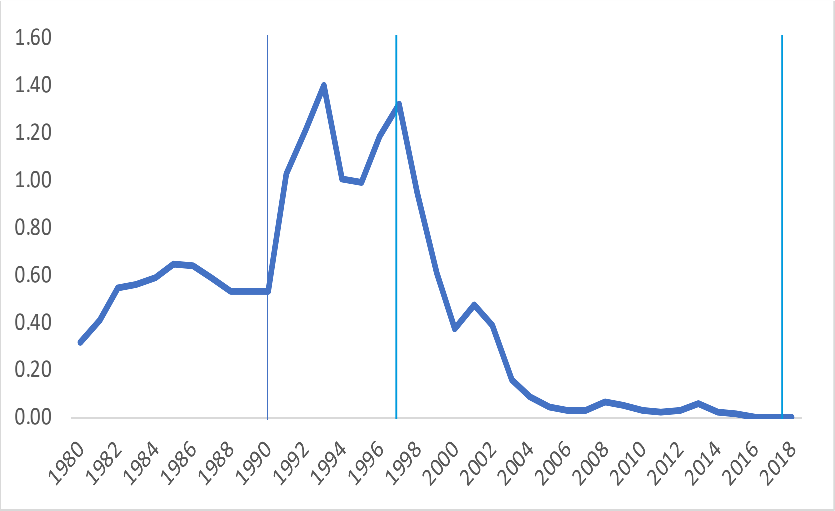
PD and LGD under baseline and adverse scenario (Percent)



Backtesting

The model is validated against ‘bad times’, ‘good times’, and current ‘benign conditions’

Mortgage loss rate
(Percent)



1989-1991	Loss Rate
Predicted	1.05
Observed	1.03

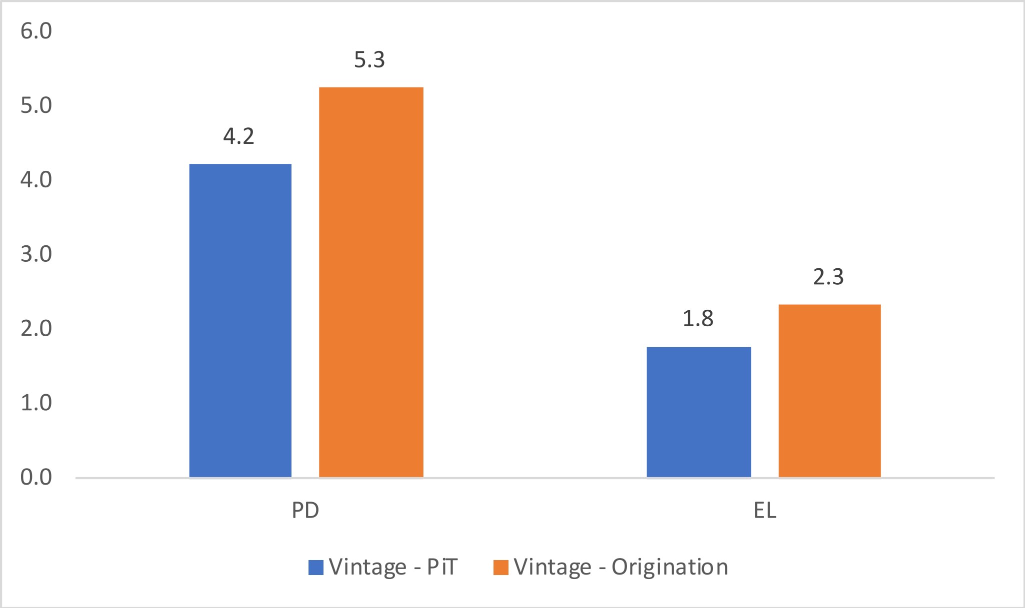
1997-1999	Loss Rate
Predicted	0.53
Observed	0.61

2019-20 baseline	Loss Rate
Predicted	0.06
IRB average estimate	0.10

Robustness checks

- Assumptions on vintage distribution
  - LTV PiT vs LTV at origination
  - EL increases from 1.77% to 2.33%
  - CET1 ratio decreases by 43 bps
- Margin call (switched off):
  - EL declines from 1.77% to 1.10%
  - CET1 ratio increases by 50 bps

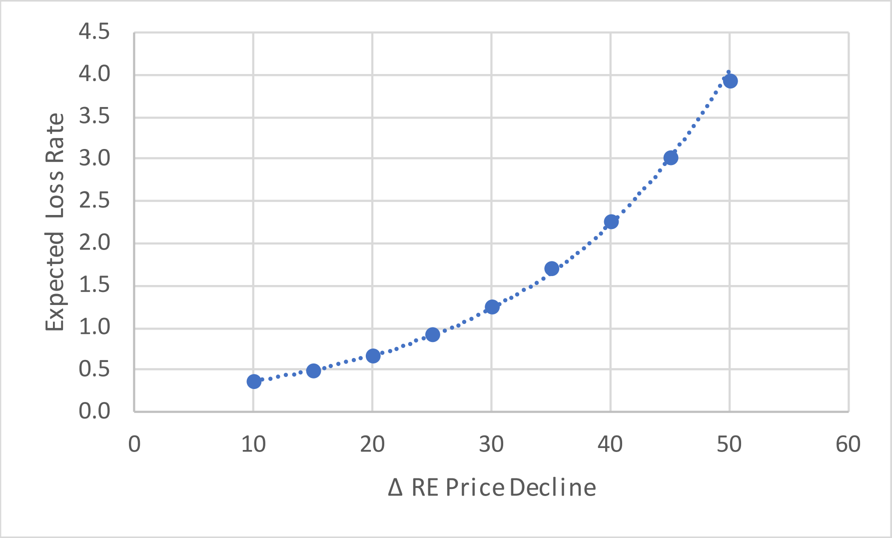
PD and Expected Loss rate under different vintage distributions (Percent)



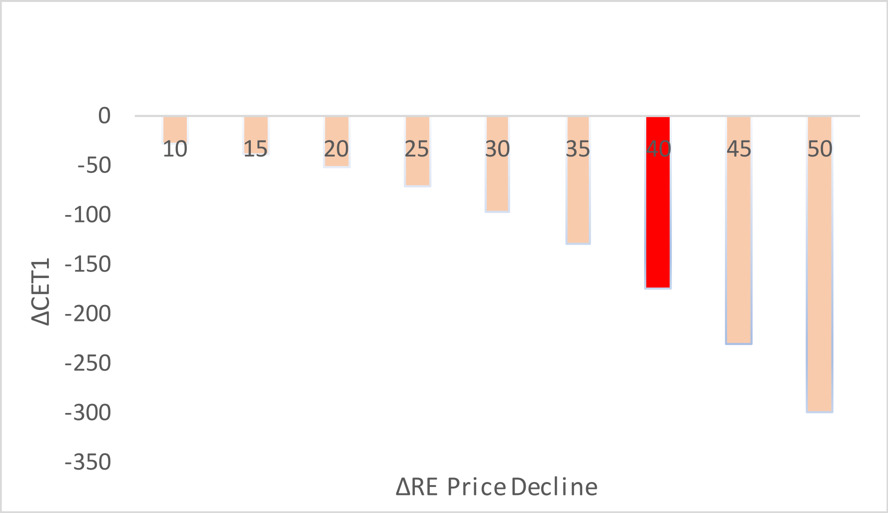
Sensitivity test – Real Estate Prices

Exponential effect on loss rates and CET1 depletion from larger real estate price corrections. Assume adverse conditions and IR=3%

Expected loss rate (Percent)



CET1 depletion (Percent)



ΔRE=-40% triggers EL=2.3%, and ΔCET1=-173 bps

Macroprudential Policy Assessment

Adequacy of buffers

- CET1 depletion by 135 bps represents **4.2 times the size of the CCyB**, with risk weight density of 26.4% or 3.8 times netting out provisions, **or 53% of the combined CCyB+CCB buffer**
- Increasing the risk weight density for IRB mortgages by 5pps, CET1 depletion would reach 3.4 times the CCyB buffer

Note: sectoral CCyB=2% of risk-weighted positions secured by “residential” property situated in Switzerland

Counterfactual policy analysis

- Decrease in the maximum amortization requirement for second mortgage from 20 to 10 years in 2014
- Offsetting effects on the risk of the portfolio
  - Financial distress (-)
  - Negative home equity (+)
  - Margin call (+/-, lower probability, higher impact)
- Result: The loss rate would increase from 1.77% to 2.45% percent.

21

Application II:
Calibration of Borrower-Based Limits in Austria

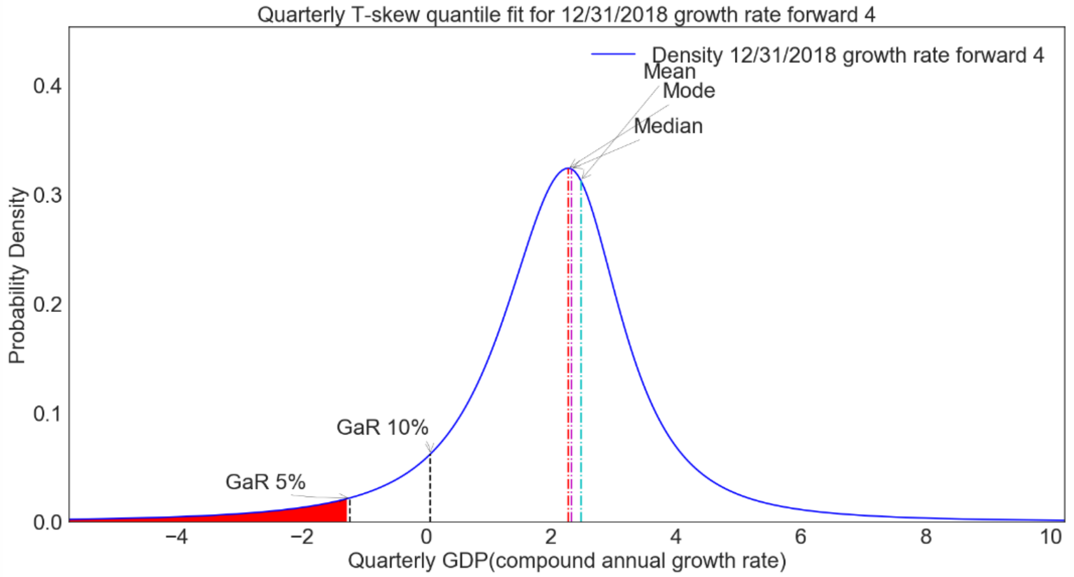
The desirable level of a macroprudential tool depends on the level of risk at a given point of time.

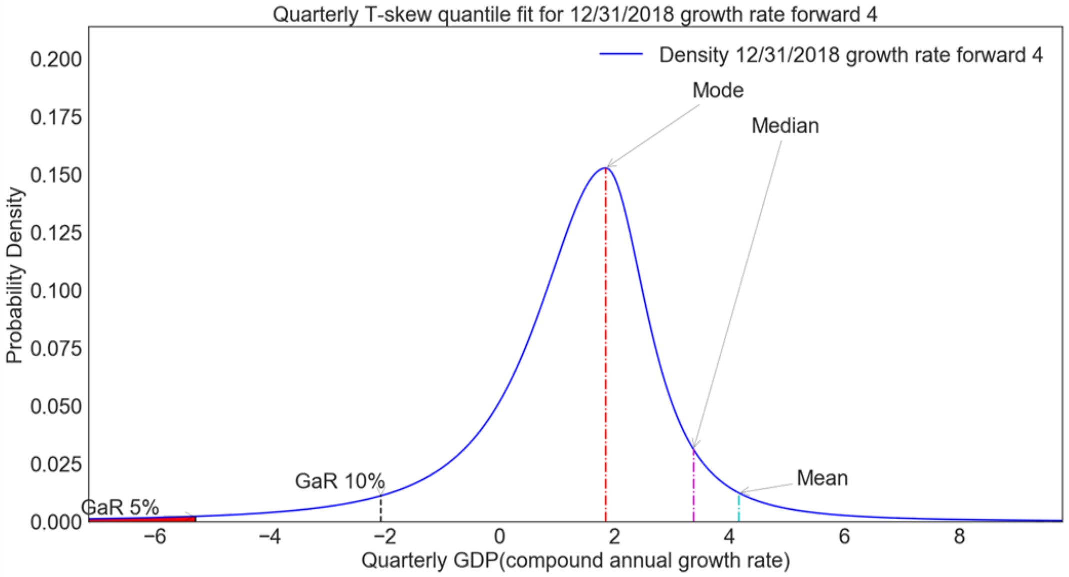
The approach combines information on tail risks from Growth-at-Risk (GaR) and House Price-at-Risk (HaR) analysis with the granular information on mortgage flows' characteristics from the supervisory data:

Direct link to current cyclical position and the systemic risk level. Inputs from GaR and HaR inform income, unemployment and house price shocks which are applied to the mortgage portfolio.

Granular approach to calibration of borrower-specific tools. Impact of shocks on housing loan portfolios is assessed for different levels of LTV and DSTI limits.

Tail-risk: Growth at Risk (GaR) and House Price at Risk (HaR)





Scenario for Austria

Variable	Cumulative percentage change over 2 years
Real disposable income	-2.5%
Real house price level	-11%
Unemployment rate	1.9%
Real rate on housing loans	1.4%

- The change in unemployment rate is estimated based on the past relationship with GDP growth.
- The change in the interest rate on housing loans is calibrated based on evidence from past recessions.

Introduction of borrower-based limits

We assume macroprudential limits are introduced *n* quarters before the tail risk materializes

- During the *n* quarters the new borrower-based measures are binding and affect the LTV, DSTI, and DTI distributions of new flows of mortgages, while some of outstanding loans mature.
- We assume “bunching” of new loans just below the regulatory limits.

During the *n* quarters, HH income and RE prices grow at the median values from the GaR and HaR models (no change in u or lending rate)

In the absence of macroprudential measures, new mortgage flows are similar to average flows (in terms of volume, LTV, DSTI and DTI distributions) observed in Q1-Q4 2018

Policy simulations

We set $n=8$ and consider the following regulatory interventions:

- LTV limits,
- DSTI limits,
- combined LTV and DSTI limits,

DSTI limits affect the debt service ratio in the “distress” formula, and the LTV distribution (joint distributions from the dataset).

For each of interventions we consider two alternatives:

- Hard limits
- Hard limits with speed limits

Results: No macroprudential limits

Without macroprudential policy actions annualized credit losses reach 1.6% on new mortgage flows over 2 years.

	Whole mortgage portfolio			New mortgage vintages		
	PD	LGD	EL	PD	LGD	EL
Tail risk event	1.9	26.6	0.8	3.9	34.0	1.6
Sensitivity analysis						
With fin wealth	1.6	28.5	0.7	3.4	33.7	1.5
dR=2%	3.4	32.0	1.5	6.9	40.0	3.1
dHP=-20%	2.3	29.2	0.9	4.5	37.7	2.0

Results: Impact of macroprudential limits

New mortgage vintages

		hard limits					speed limit of 20%				
LTV	none	80.0	none	80	80	90	80.0	none	80	80	90
DSTI	none	none	40	30	40	40	none	40	30	40	40
PD	3.9	2.7	3.2	1.3	2.2	2.7	3.3	4.0	2.3	3.3	3.7
LGD	34.0	31.9	31.8	31.8	31.8	32.1	32.9	34.1	32.9	32.9	33.4
EL	1.6	1.0	1.3	0.5	0.8	1.0	1.3	1.6	0.9	1.3	1.5

- DSTI limits of above 30% are not very effective (the average DSTI is below 30% *across* vintages and LTV buckets)
- Joint LTV-DSTI caps with a "speed limit" of 20 percent, or a tighter joint LTV-DSTI "hard limit" match expected losses with the "old" part of the portfolio.

Conclusion

- We propose a semi-structural approach for mortgage risk analysis to account for structural shifts in the mortgage market.
- It provides a vintage analysis to account for changes in regulatory policy, the life cycle of the mortgage, and real estate/credit cycle dynamics.
- The approach relies on regulatory data based on the risk bucket segmentation used by prudential authorities to set macroprudential policy.
- The model helps assess the effectiveness of different policy instruments to decrease systemic risk.

Thank you