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EMPIRICAL LINKS BETWEEN HOUSING MARKETS AND ECONOMIC RESILIENCE

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The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

On 25 May 2018, the OECD Council invited Colombia to become a Member. At the time of preparation the deposit of Colombia's instrument of accession to the OECD Convention was pending and therefore Colombia does not appear in the list of OECD Members and is not included in the OECD zone aggregates.

ABSTRACT/RÉSUME

Empirical Links Between Housing Markets and Economic Resilience

Housing markets, which are large and subject to sharp swings, shape to a great extent countries' exposure to economic crises and their capacity to recover from them. This paper analyses the transmission of housing-related shocks to the real economy: it investigates the role that policy plays in (a) mitigating or amplifying shocks and (b) facilitating or hampering a recovery. It considers macroprudential measures, rental regulation, taxation and land use restrictions. The aim is to investigate, which housing policy-related reforms can foster greater economic resilience. Among other results, it finds that a tighter macroprudential stance is generally linked to a lower likelihood of economic crisis and that higher effective rates of housing taxation are associated with smoother housing cycles.

JEL Classification codes: E37, E5, R31

Keywords: Housing, resilience, macroprudential policy, rent regulation, taxation, land use policy

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Relations empiriques entre marché du logement et résilience de l'économie

De taille importante et sujets à de brusques retournements de cycle, les marchés du logement sont, dans une large mesure, un déterminant de l'exposition d'un pays aux crises économiques et de sa capacité à s'en redresser. On analyse dans cette étude la transmission des chocs liés au secteur du logement dans l'économie réelle et l'on s'interroge sur le rôle des politiques publiques et comment elles (a) atténuent ou amplifient les chocs, et (b) facilitent ou entravent le redressement de l'économie. Sont examinées les mesures macroprudentielles, la réglementation locative, la fiscalité et les restrictions à l'occupation des sols. L'objectif est d'examiner, parmi les réformes de la politique du logement, celles qui sont susceptibles d'accroître la résilience de l'économie. Entre autres résultats, on observe qu'une orientation macroprudentielle plus restrictive va généralement de pair avec une plus faible probabilité de crise économique, et qu'une augmentation des taux d'imposition effectifs de l'immobilier résidentiel s'accompagne d'un lissage des cycles sur le marché du logement.

Classification JEL : E37, E5, R31

Mots-clés : Logement, resilience, politiques macroprudentielles, regulation du marché locatif, taxation, réglementation foncière

Table of contents

Tables

Figures

Empirical Links between Housing Markets and Economic Resilience

By Boris Cournède, Sahra Sakha, Volker Ziemann[1]

1. Introduction and main findings

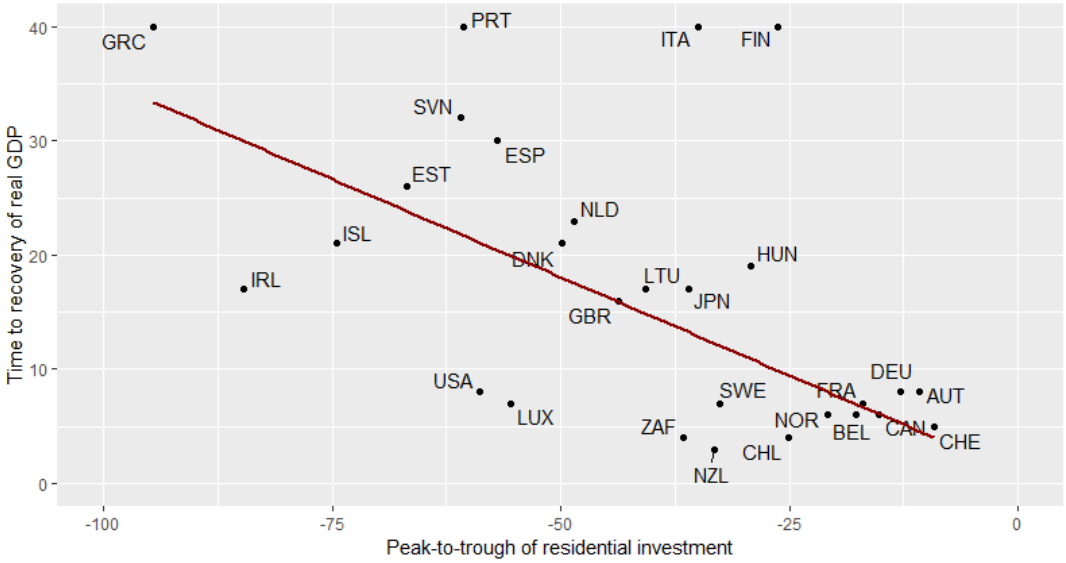
1. Housing market developments influence the business cycle and macroeconomic trends. Changes in house prices, rents and mortgage interest rates prompt variations in household wealth, income and expenditure that often have a sizeable impact on aggregate demand and inflation. Furthermore, house price fluctuations affect residential investment, and thereby GDP, as well as living standards depending on the adequacy of the construction response. Countries with sharper declines in residential investment in the aftermath of the global financial crisis generally needed more time to recover from the crisis and regain the pre-crisis level of real GDP (Figure 1).

2. This paper provides empirical analyses of the transmission of housing-related shocks to the real economy and the roles that policy plays in (a) mitigating or amplifying shocks and (b) facilitating or hampering a recovery. The empirical investigations in the present paper provide the analytical underpinning for the policy section of a companion report, which takes stock of current trends in housing markets, presents estimates of associated macroeconomic risks and discusses policy implications (Cavalleri, Cournède and Ziemann, 2019[1]).

3. Housing has other important social and well-being aspects. It fulfils a basic human right for shelter, and contributes to the well-being of families and entire communities. Future OECD analysis is planned to explore these dimensions.

1. This report contributes to the OECD Housing Project. The authors are members of the OECD Economics Department. The Working Party No. 1 on Macroeconomic and Structural Policy Analysis discussed an earlier version of this paper. The authors thank members of the Working Party and in particular its Chair, Mr. Arent Skjæveland (Norwegian Ministry of Finance), for their feedback. The authors are indebted to Laurence Boone, Peter Hoeller, Åsa Johansson, Luiz de Mello and Alain de Serres (OECD Economics Department) for their guidance and to Aida Caldera Sanchez (OECD Economics Department) for her review. They express their gratitude to Sonya Lu (Georgetown University) for her work on the database of macro-prudential measures. They would like to thank Christophe André, Andrew Barker, Sebastian Barnes, Isabelle Joumard, Tomasz Kozluk, Douglas Sutherland (OECD Economics Department) and Walid Oueslati (OECD Environment Directorate) for their comments. The authors are grateful to Aman Johal and Celia Rutkoski (OECD Economics Department) for editorial support. They can be reached at boris.cournede@oecd.org, sahra.sakha@oecd.org and volker.ziemann@oecd.org.

Figure 1. Recovery from the global financial crisis



Note: Time to recovery in quarters (equals 40 if not recovered by 2018). Peak-to-trough in % of pre-crisis peak.
Source: OECD Economic Outlook database.

4. To do so, this study provides new empirical evidence on the links between macroprudential and other housing policies, vulnerability to crises (ex-ante resilience) and recoveries from them (ex-post resilience). This paper complements past OECD work on housing and resilience (Andrews, Caldera Sánchez and Johansson, 2011; Caldera Sánchez and Roehn, 2016; Hermansen and Roehn, 2016), by drawing new policy lessons for the design of housing and macroprudential policies. It also lays the foundation for future work on housing and economic performance. A companion paper provides additional material on the empirical analysis (Sakha, 2019, forthcoming[2]).

5. The main findings are:

- Tighter loan-to-value (LTV) caps are associated with a reduced likelihood of severe downturns but also slower recoveries and less strong growth. Their effects on the tail risk of real output are inconclusive. Overall, the evidence confirms earlier results that LTVs seem to entail a trade-off between growth and crisis risk.
- More demanding capital requirements also appear to involve the same trade-off, as they are linked with a reduced incidence of downturns but lower median growth. Risk weights that penalise risky mortgages more are tentatively linked with stronger episodes of positive growth, which would be consistent with the hypothesis that they encourage a more efficient allocation of credit.
- More stringent rental market regulations are associated with severe downturns that are more likely and more protracted, which may be related to bottlenecks in housing supply and lower labour mobility. On the other hand, rental regulations seem to achieve their objective of protecting tenants against adverse economic shocks, as extreme output losses seem to be reduced by more stringent tenure security.
- Higher effective taxation of housing is associated with less severe downturns. Moreover, countries with higher taxation experience more moderate house price fluctuations and smoother residential construction cycles. The findings are based

on a cross-section of marginal effective tax rates on owner-occupied and rental investment property. Time series data would be highly valuable to confirm these cross-sectional findings.

- Policy indicators for land use regulations are not readily available. The paper draws on outcome measures of urban sprawl and develops composite indicators for urban sprawl, densification and zoning restrictiveness. Tentative results suggest that zoning restrictions hinder booms but also recoveries of housing investment.

Table 1. Main effects of tightening housing-related policies on resilience

	GDP-at-risk	Crisis risk	Severity of downturn	Strength of recovery
LTV caps		↘		↘
Capital requirements for mortgage loans		↘		↗
Rental regulation	↗	↗	↗	
Property taxation			↘	

Note: The table summarises the results of empirical exercises performed throughout the study. Only significant results are displayed. GDP-at-risk refers to the bottom 5% quantile of the distribution of quarterly real GDP growth. Tightening means increases in policy indicators, except for LTV caps where a decrease of the policy value signifies a tightening. Green arrows show good outcomes, red ones bad outcomes. Table 7 provides summary indications about the results relating to the housing transmission channels of policy effects.

6. The rest of the paper is organised as follows. The next section lays out the co-movement between housing and economic cycles before setting out a general framework for the analysis. The following section describes what kind of housing policies countries have been using and expected effects based on the literature. Section 4 assesses the link between housing policies and vulnerability to shocks (ex-ante resilience). Section 5 provides an empirical analysis of the relationship between policies and countries' capacity to recover from shocks (ex-post resilience).

2. Housing markets and resilience: A framework for the analysis

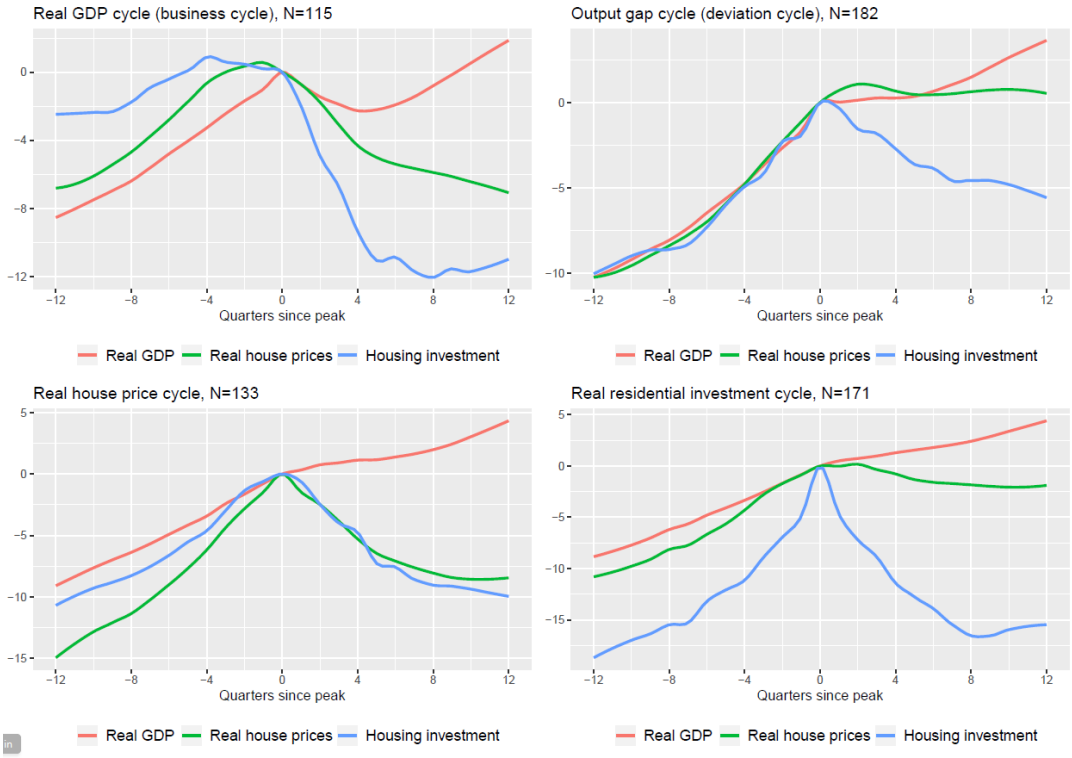
2.1. Housing and business cycles are synchronised

7. Links between the housing market and the business cycle can affect the level of economic activity and the economy's ability to recover quickly to long-term growth after a shock (Andrews, Caldera Sánchez and Johansson, 2011[3]). To shed light on the synchronisation of housing markets and business cycles, Figure 2 depicts local regressions of real GDP, the output gap, real house prices and residential investment around business cycles peaks (Panel A), deviation cycle peaks (Panel B), peaks in real house prices (Panel C) and peaks in residential investment (Panel D). Prior to business cycle recessions, residential investment is flat or falling (Figure 2, Panel A). In contrast, residential investment and real house prices move together with real output prior to turning points of the output gap, which is when growth falls below potential without necessarily trigging a recession (Panel B). In both cases, residential investment falls after the peak but, in line with real output, the fall is more substantial after business cycle peaks. Real house prices tend to lead real output when recessions occur but lag real output when the output gap peaks. This is partly due to the lag between peaks in output gaps and real GDP since growth falls below potential before becoming negative. In a nutshell, for the average recession,

first the growth rate falls below potential then real house prices peak and then the recession kicks in.

8. Similar to real output, one can define turning points in the housing market using real house prices or residential investment. The results suggest that declines in real house prices trigger similar declines in residential investment (Panel C) but that declines in residential investment affect real house prices and output much less (Panel D).

Figure 2. Cyclical behaviour of output, house prices and residential investment

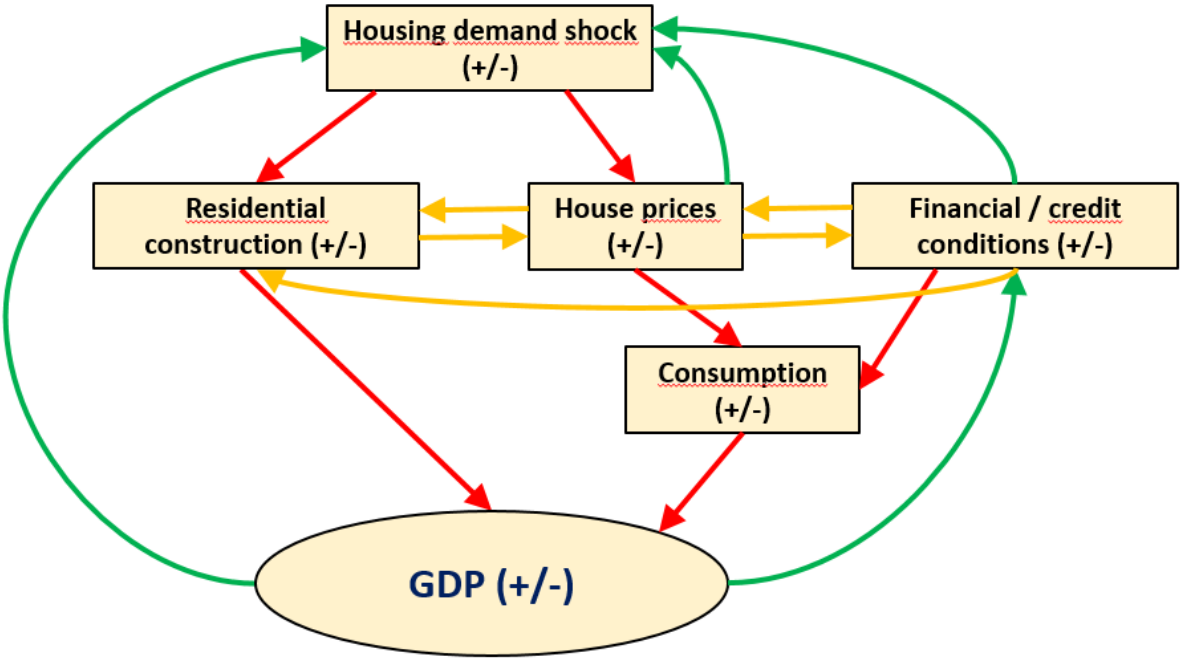


Note: Peaks are obtained using the Harding-Pagan (quarterly Bry-Boschan) business cycle dating procedure (Harding and Pagan, 2002[4]).
Source: OECD Economic Outlook database and OECD Analytical House Price database.

2.2. General framework for the analysis

9. Figure 3 depicts a simple framework for the transmission of housing demand shocks. Such shocks can come from demography, especially migration, changes in disposable income, house prices, interest rates or credit conditions. Shocks can stem from domestic factors, but also international ones such as shifts in global capital flows (Miles, 2019[5]). When a housing demand shock occurs, housing supply rigidities lead to either an increase in vacancies (negative demand shock) or scarcity (positive demand shock), which results in housing investment and house price adjustments to clear housing markets. The extent to which the housing demand shock affects prices depends on the financial cycle (e.g. initial over or under-valuation of house prices, credit conditions) but also on policies (inelastic supply due to zoning regulations, rent control, etc.) and cyclical or structural variables (e.g. construction costs, infrastructure).

Figure 3. Transmission channels of housing shocks

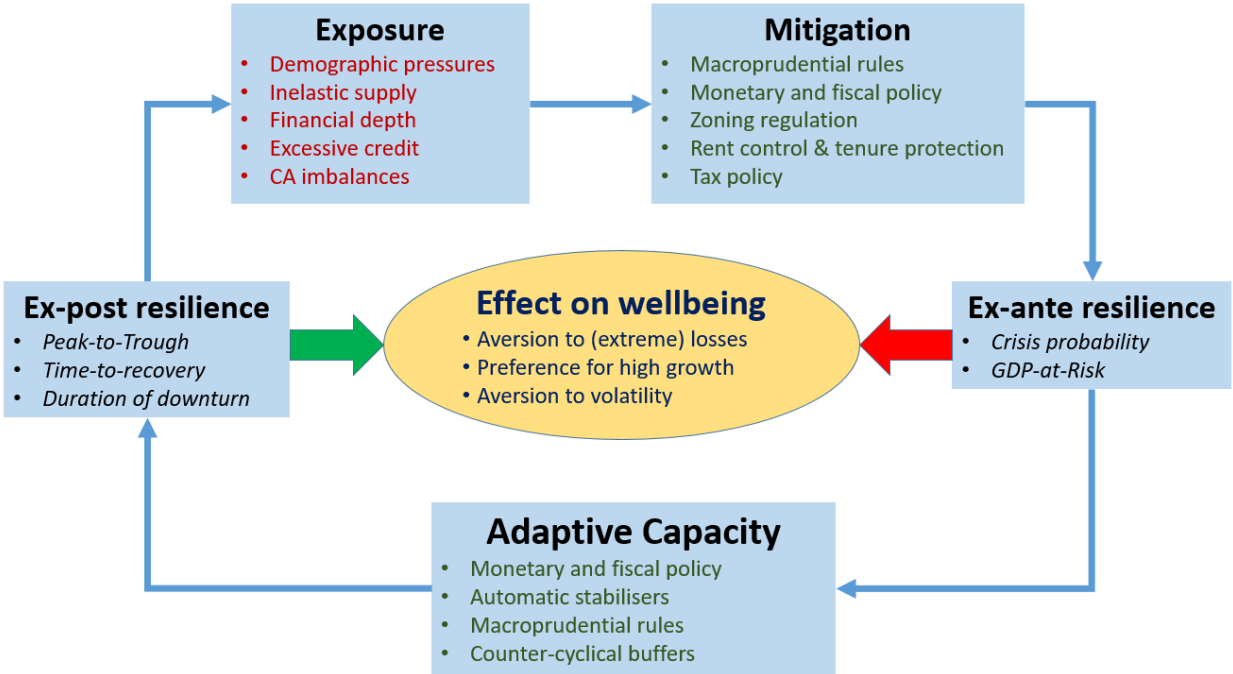


10. Changes in house prices obviously directly influence housing demand, but they also have indirect effects through the financial system. Movements in house prices indeed have a strong impact on household balance sheets. Financial and credit conditions react to changes in household balance sheets (Fissel, Hanweck and Sanders, 2018[6]), affecting, for instance, non-performing loans and loan-to-value ratios with opposite effects for incumbents and potential new homeowners.

11. Changes in house prices also affect consumption depending on the size and institutional set-up of mortgage markets. For instance, amortisation requirements and the choice between fixed and variable interest rate loans determine, ceteris paribus, whether the effect on consumption is pro or counter-cyclical. The pass-through also depends on the rate of homeownership. Current homeowners benefit (suffer) from the wealth and collateral (i.e. home-equity withdrawal) effect, while future homeowners face increasing (decreasing) saving needs to finance future down-payments. The experience of OECD countries shows that there is considerable co-movement between housing and business cycles.

12. This study assesses how housing-related policies can affect the transmission channels depicted in Figure 3 with the aim to find out, which policies affect the build-up of vulnerabilities, reduce the severity of crises and foster an economy's capacity to recover from them. Figure 4 lays out a simple conceptual framework for the analysis by disentangling ex-ante (vulnerability to shocks) and ex-post resilience. The functioning and characteristics of housing markets differ considerably across countries and so do related policies. The global financial crisis has triggered a wave of policy innovations many of which target the housing market directly. In particular, macroprudential policies have emerged as a means of leaning against credit bubbles and enhancing financial stability. Other housing-related policies considered in this study include property taxation, rent control and tenure protection, social housing, housing subsidies and zoning regulations.

Figure 4. A resilience framework for housing-related shocks



13. Ex-ante resilience will be assessed by i) the probability that a large shock occurs, and ii) GDP-at-risk, which measures the maximum loss in output with a certain likelihood (e.g. 95%). Ex-post resilience, on the other hand, will be assessed through measures for the i) severity of downturns (peak-to-trough), ii) the duration of downturns and iii) the time needed to recover, that is, regain the pre-crisis level of output. Table 2 depicts these indicators for deviation cycles (de-trended quarterly growth rates of real GDP) for 45 countries using for illustrative purposes the period from 1990 to 2017. Resilience indicators for business cycles (real GDP), real house price and housing investment cycles are shown in Annex B.

Table 2. Resilience indicators

	Ex-ante resilience		Ex-post resilience			
	Crisis prob-ability	Q5	Duration (bust)	Peak-to-trough	Strength of recovery	Number of peaks
ARG	22.7	-4.3	7.2	-11.2	6.3	6
AUS	2.7	-0.9	5.1	-1.3	0.8	10
AUT	2.7	-0.8	5.9	-2.5	1.4	8
BEL	3.6	-0.9	4.0	-1.7	1.1	9
BRA	11.6	-1.9	8.7	-6.4	1.5	6
CAN	4.5	-1.1	5.0	-2.4	1.1	8
CHE	3.7	-1.0	5.3	-2.3	1.6	8
CHL	7.1	-1.7	7.2	-4.5	2.6	6
CHN	2.7	-0.8	12.2	-2.8	1.6	5
COL	7.4	-1.4	5.0	-3.1	1.3	5
CRI	3.8	-1.2	4.2	-2.5	0.8	7
CZE	5.9	-1.1	7.5	-4.0	3.4	5
DEU	6.3	-1.3	4.8	-2.8	0.9	9
DNK	5.4	-1.5	4.9	-2.9	1.7	10
ESP	7.1	-1.4	15.7	-6.2	2.6	3
EST	6.9	-3.7	7.5	-14.2	6.6	2
FIN	11.6	-1.7	6.0	-4.3	1.7	6
FRA	2.7	-0.7	6.7	-2.1	1.3	6
GBR	4.5	-0.9	4.0	-1.5	1.3	10
GRC	10.7	-1.7	11.2	-7.9	2.3	5
HUN	5.6	-0.9	4.2	-3.4	0.4	5
IDN	4.6	-1.8	4.0	-8.3	3.3	5
IND	8.6	-1.5	5.7	-3.5	2.5	6
IRL	11.6	-3.6	5.3	-7.2	5.0	7
ISL	15.2	-3.6	4.3	-5.1	4.6	10
ISR	8.7	-1.5	5.0	-4.2	2.3	6
ITA	3.6	-1.1	4.3	-2.9	1.3	7
JPN	7.1	-1.4	4.7	-3.6	1.8	9
KOR	8.0	-1.7	4.4	-4.2	2.2	9
LTU	4.7	-1.4	3.8	-4.9	1.9	5
LUX	14.6	-2.4	5.2	-5.7	1.9	6
LVA	11.4	-3.5	5.0	-6.8	2.2	6
MEX	4.3	-1.4	4.0	-2.7	1.3	9
NLD	2.7	-1.0	6.3	-3.1	1.3	7
NOR	3.6	-1.4	7.3	-3.1	2.2	7
NZL	6.3	-1.7	4.0	-2.8	0.6	11
POL	6.7	-1.4	6.3	-3.9	3.0	6
PRT	9.8	-1.3	8.8	-5.8	2.3	5
RUS	11.8	-2.2	7.3	-8.4	2.5	3
SVK	5.7	-1.7	6.6	-4.8	1.3	5
SVN	6.6	-1.5	6.0	-5.6	1.0	4
SWE	6.3	-1.2	7.2	-4.0	3.5	5
TUR	13.0	-4.2	6.7	-9.0	-0.1	6
USA	4.5	-1.1	6.0	-2.3	1.4	7
ZAF	4.4	-1.0	6.6	-2.7	1.3	5

Note: Based on de-trended growth rate of real GDP from 1990 to 2017. Darker shading indicates more extreme values for the respective indicator. *Crisis probability* denotes the probability of experiencing a cumulative two percentage point decline over two consecutive quarters. *Q5* denotes the 5th percentile of the distribution. Busts refer to periods leading from a peak to a trough. Peaks are obtained using the Harding-Pagan (quarterly Bry-Boschan) business cycle dating procedure (Harding and Pagan, 2002[4]). Strength of recovery denotes growth over *n* quarters, *n* being the duration of the preceding bust period. Duration is in quarters, all other indicators are in percentage points. For ex-post resilience indicators, the table shows averages over observed cycles.
Source: OECD Economic Outlook Database and own calculations.

2.3. Policies covered in the analysis

This subsection goes over the indicators used in the empirical analysis and summarises their expected effects based on the literature. The companion paper provides a more extensive discussion of the extent to which countries are using these policies and what existing literature suggests about the impact of these policies on economic resilience (Cavalleri, Cournède and Ziemann, 2019[1]).

2.3.1. Macroprudential regulation

Macroprudential policy aims to prevent financial threats to economic stability by restraining the build-up of systemic risk. Macroprudential instruments can work on the side of borrowers or lenders. On the borrower side, the most frequently used tools include:[2]

- Loan-to-value ratios (LTVs) cap housing loans to a certain proportion of the house value. A shortcoming of LTVs is that the denominator, housing valuation, moves with housing cycles, which reduces the constraint imposed by LTVs. LTVs nonetheless appear to be capable of moderating boom-bust cycles in general-equilibrium as well as agent-based models (Baptista et al., 2016[7]; Laliotis and Población, 2016[8]; Kelly, McCann and O'Toole, 2018[9]; Funke and Paetz, 2016[10]; Balfoussia, Dellas and Papageorgiou, 2018[11]). Furthermore, a number of empirical studies have found that LTVs moderate housing cycles (Kuncl, 2016[12]; Ferrero, Harrison and Nelson, 2018[13]; BIS, 2018[14]; Armstrong, Skilling and Yao, 2019[15]).
- Debt-service-to-income ratios (DSTIs) require households to not pay more than a certain proportion of their income to service their housing loans. In some countries, DSTIs are based on total rather than only housing debt servicing costs. Debt-service-to-income ratios are promising, especially as they could avoid the problem intrinsic to LTV caps that their denominator, house valuations, gets inflated during a housing bubble (Greenwald, 2018[16]). The empirical literature looking at DSTIs and LTVs taken together has generally found that they contain credit growth (Cerutti, Claessens and Laeven, 2017[17]; Claessens, Ghosh and Mihet, 2013[18]; Alam et al., 2019[19]; Poghosyan, 2019[20]).

14. Typically used macroprudential policy tools working on the side of lenders include:

- A key policy lever is the minimum capital ratio with which banks must fund housing loans. The strength of this requirement is determined by the combination of minimum capital ratios and risk weights:
  - Minimum capital ratios set floors for the ratios of different measures of capital (core equity, equity, core Tier I, Tier I, total capital) over risk-weighted assets.
  - Risk weights (RW) for housing loans held on bank balance sheets can vary based on loan-to-value ratios. Higher risk weights make it more costly for banks to provide housing loans, which can be expected to contain housing booms. A case study for Israel indeed found that a hike in risk weights contained house prices (Laufer et al., 2018[21]). The empirical literature on the implications of

2. Other potential tools are restrictions on the use of variable-rate or foreign currency mortgages. Lack of data availability prevented their inclusion in the analysis.

risk weight changes on restricting credit growth found ambiguous results. Aiyar, Calomiris and Wieladek (2014[22]) using bank-level UK data showed that lenders unaffected by tighter capital requirements (foreign bank branches) offset one third of the impact of the tightening.

- Other lender-side policy levers with relevance to housing are minimum liquidity requirements (mostly the liquidity coverage ratio and net stable funding ratio), which aim to reduce liquidity mismatches between bank assets (including housing loans) and financing. Active use of these tools, which spread with the implementation of the Basel III framework, is, however, too recent to have produced sufficient experience for their inclusion in the econometric analysis below.

15. The literature is still split regarding the effect of macroprudential measures on average growth. Some cross-country contributions point to a trade-off between stability and long-term economic growth. For instance, Kim and Mehrotra (2018[23]), using a VAR model, find a negative effect of changes in macroprudential policies on output and inflation in the Asia-Pacific region. Similarly, Caldera Sánchez and Roehn (2016[24]), using quantile regression estimation, show that LTV caps reduce the median and upper part of the distribution of output growth. By contrast, Boar et al. (2017[25]) find that countries using macroprudential tools experience somewhat stronger and less volatile growth.

16. Measuring the cross-country intensity of macroprudential policy settings is challenging. Most existing databases usually rely on dummy or indicator variables for loosening (-1), tightening (+1), or no changes (0) in LTV limits. However, using a dummy variable implies that changes of different magnitudes are treated equally. To provide a more precise measurement, this study uses the ECB Macroprudential Policies Evaluation Database (MaPPED) which offers a detailed overview of the evolution of macro- and microprudential policy instruments for 28 EU member states with 1700 policy actions (e.g. implementation, recalibration or termination of an instrument) between 1995-2015 (Budnik and Kleibl, 2018[26]). The ECB collected qualitative data by sending out open-text questionnaires to regulatory authorities of EU member states asking for the existence of macroprudential policy instruments and changes from 1995-2015. In order to allow the quantification of changes in levels of macroprudential policies across a large set of euro area countries, this paper translated qualitative responses of policy changes from the survey into quantitative measures. This study complements this information with data collected by the Secretariat. The use of official publications and policy notes of national central banks and supervisory authorities has allowed to increase the coverage of the dataset and to include non-European OECD member countries and key non-member economies (Brazil, Russia, India, Indonesia, China and South Africa).

17. This study also uses information on capital requirements. To do so, it relies on the MaPPED database, which provides detailed information of tightening or loosening of capital requirements and minimum Tier 1 ratios for the euro area, which is important when jointly examining the impact of risk weights and capital requirements. Information on capital requirements is complemented using the Bank Regulation and Supervision (BRSS) database of the World Bank. Cross-country coverage on minimum capital requirement in the dataset is extensive including non-euro area OECD countries. However, these data are

only available for 2008, 2009 and 2010.[3] Information on Tier 1 capital is not available in the BRSS and is complemented whenever possible with official regulatory data sources provided by the OECD country desks. For the purpose of the study, mortgage loan capital requirements are defined as the product of average risk weights for mortgage loans and the minimum Tier 1 ratio.

2.3.2. Rental market regulation

18. Rent controls, which have been introduced for a variety of social reasons, can also have implications for resilience (as well as important side effects on efficiency). Past OECD research has shown that excessively tight rent regulations can affect the supply of new dwellings and maintenance of the existing rental housing stock and hamper the development of the rental market (Caldera and Johansson, 2013[27]). This in turn, can lead to shortages of housing supply, exacerbating speculative housing bubbles and increases in household debt posing significant vulnerabilities for macroeconomic stability and economic growth (Hermansen and Röhn, 2016[28]).

19. This study uses a new international longitudinal database of housing policies (i.e. rent control, tenure security and housing rationing) based on legislation and legal texts of 48 countries between 1910 and 2018 (Kholodilin, 2018[29]) to quantify the degree of stringency of each of these policies. Legal acts are mapped into numeric values using variables that range from 1, if regulation is stringent, to zero (if regulation is not stringent). Moreover, a summary index is constructed (called restrictive rental policy index) which simultaneously accounts for both rent control and protection from eviction. Using this database has important advantages: first, it covers a very long period of time, which is important, given long-lasting effects of housing regulations upon markets. Second, it uses a large panel of OECD countries.[4] Using panel data allows accounting for unobservable country-specific effects.

2.3.3. Property taxation

20. Stamp duties should slow down house price booms by reducing the expected return on speculative house purchases. Higher stamp duties could thus reduce housing transaction volumes (Davidoff and Leigh, 2013[30]).

21. By contrast, recurring property taxes can be expected to have some stabilising effect on house prices, as long as they move in line with prices (van den Noord, 2005[31]). There is indeed some empirical evidence that higher recurring property taxes reduce house price volatility (Blöchliger, 2015[32]).

22. New OECD measures allow gauging the combined weight of all tax instruments with relevance for housing, including personal income taxation, through marginal effective tax rates (METR) on owner-occupied and rental housing (OECD, 2018[33]). The METRs are derived as the difference between the pre and post-tax rates of return of a marginal investment divided by the pre-tax rate of return of that investment where the post-tax real rate is the minimum rate of return necessary to make the investment worthwhile. METRs are calculated for several saving vehicles including owner-occupied and rental property.

3. Information for 2010 is extended until the introduction of Basel III in 2014 as there were few regulatory changes in between.

4. The database focuses mainly on national level regulations and not on the state or municipal level.

Taxation of owner-occupied properties is typically lower as imputed rents are often not taxed and interest payments deductible. For the supply of housing, both types of investment matter.

2.3.4. Public support for housing

23. The public provision of social housing should in principle contribute to economic and especially social resilience (Salvi del Pero et al., 2016[34]). One channel with implications for resilience is that the availability of social housing reduces the need for more vulnerable and low-income workers to take risky housing loans in order to buy a home. Past OECD work has highlighted that low-income workers are more exposed than others to job-loss risk (Garda, 2016[35]).

24. The OECD Affordable Housing Database provides several indicators to measure the extent of public support for housing-related expenses. Two indicators are used for the purpose of this study: i) government support for social rental housing and ii) public spending on housing allowances.

2.3.5. Land use policies

25. Land use restrictions, which limit the freedom to build dwellings on new land or to densify existing built areas, have implications for housing cycles and economic resilience. Tight policies, which make building less responsive to demand, imply larger price swings but smaller construction swings (Glaeser and Gyourko, 2018[36]). Both price and construction booms can contribute to the business and financial cycle and to the risk of damaging crises. The effect of land-use restrictions on economic resilience therefore remains an open question. Land use regulations are complex and quantitative indicators not readily available. Recent OECD work has produced several indicators for urban sprawl for most OECD countries (OECD, 2018[37]). These indicators can be used to derive composite indicators for urban sprawl (Annex D).

3. Housing policies and ex-ante resilience

26. This section extends previous OECD work by estimating the impact of more and new housing-related and macroprudential policies on two measures of ex ante resilience, that is to say vulnerability (i.e. GDP-at-risk and severe downturns). This is the first study that analyses the long-term impact of rent regulation and tenure security separately in a macroeconomic framework.

3.1. How do housing policies affect GDP-at-risk?

27. Macroprudential and housing policies can affect the expected growth distribution. However, macroeconomic estimates predominantly focus on the expected mean growth, and usually do not model higher moments of the growth distribution. This focus on average growth can be too narrow when volatility and vulnerability increase as growth weakens, and may lead to the systematic underestimation of downside tail risks.

28. In the first part of this exercise, this study estimates the distribution of quarter-on-quarter changes of output using a panel quantile regression model. The advantage of the method is that it allows the analysis of higher moments of the distribution and is robust to outliers. This exercise focuses on the median, the upper 95th and the lower 5th percentile of the distribution of quarter-on-quarter demeaned GDP growth, called GDP-at-risk and how macroprudential and housing market policies affects these outcomes. GDP-at-risk is the

conditional growth of the (lower) 5th percentile of the growth distribution and, thus captures expected growth at a low realisation of the GDP growth distribution. This study expands previous OECD work by Caldera Sánchez and Roehn (2016[24]) who use quantile regression estimations to investigate and quantify the impact of various policies (i.e. financial, labour market and external) on the distribution of quarter-on-quarter demeaned GDP growth.

29. The empirical analysis covers 34 advanced economies as well as 15 emerging market economies over the time period 1960-2016. The categorisation of emerging economies follows the classification by the IMF.[5]

3.2. Estimation using quantile regressions and empirical results

30. The quantile regression estimator was originally designed by Koenker and Bassett (1978) for the analysis of cross-sectional datasets. In a mean regression, panel data allow for the inclusion of fixed effects to control for unobserved country heterogeneity. Conditioning on individual fixed effects in quantile regressions is not straightforward. Quantile regression techniques suitable for panel data is still an active field of research and no preferred method has yet emerged from the literature as discussed in Caldera Sánchez and Roehn (2016[24]). Similar to Caldera Sánchez and Roehn (2016[24]), this study uses the two-step approach by Canay (2011[38]) in order to estimate quantile regressions with fixed effects. The panel quantile regression estimation takes the following form:

$$Y_{it} = X'_{it}\beta_\theta + v_i + \mu_{it} \;\; with \;\; Quant\,(Y_{it} \mid X_{it}) = x_{it}\beta_\theta \qquad [1]$$

where Y_{it} is the quarter-on-quarter demeaned GDP growth rate for country i at time t. X'_{it} is a vector of regressors including housing and macroprudential policies for country i at time t and a set of control variables[6] that affect growth, β is the vector of parameters to be estimated, and μ_{it} is a vector of residuals. $Quant_\theta(Y_{it} / X_{it})$ identifies the θth conditional quantile of Y given X. Canay's panel quantile regression estimator deals with the problem of estimating the fixed effects v_i by assuming that they are 'pure location shift parameters' that take the same values at all values along the quantiles of the growth rate distribution.

31. Equation [1] estimates the impact of macroprudential and housing policies on vulnerability by looking at the quarter-to-quarter country demeaned growth distributions for all OECD and BRIICS countries and for advanced economies only. Timing and size of the detailed episodes of demeaned 5th percentile growth rate are listed in Sakha (2019, forthcoming[2]). Time periods include the 1970s, 1980s, 1990s and 2000s. Summary statistics of the main policy variables can be found in Annex D. The regressions do not include time fixed effects as it is of interest to capture common shocks (e.g. financial crisis) on countries and their impact on the growth distribution.[7] This approach is in line with the study of Caldera Sánchez and Roehn (2016[24]) as well Adrian et al. (2018[39]).

32. A challenge for empirical analysis of macroprudential tools is that their use was limited before the recent crisis, which limits the amount of data available for identification:

5. https://www.imf.org/external/pubs/ft/weo/2018/02/weodata/groups.htm.

6. The control variables include initial GDP per capita, trade openness, which is measured as exports plus imports as a share of GDP, government revenues as share of GDP, the real short-term interest rate and a financial openness index (defined as the ratio of private credit to GDP or stock market capitalization to GDP).

7. A disadvantage of this second approach, like in the standard within transformation, is that time invariant or slow moving policy variables cannot be investigated.

this suggests that effects at this stage are estimated with a certain degree of tentativeness, before future evaluation exercises can provide firmer conclusions with the benefit of greater hindsight. Limited experience so far also precludes the empirical analysis of a potentially important question related to the effectiveness of actively moving LTV ceilings and capital requirements over the cycle.

33. Another factor complicating the analysis of their effects is that macroprudential measures have typically been taken not in isolation, but in combination with other policies, especially monetary policy. All regressions therefore include interest rates as a way (albeit imperfect) of capturing effects of monetary policy.

34. Table 3 provides the main results of the quantile regression analysis.[8] The LTV cap variable is included separately in the regression while risk weights and minimum capital Tier 1 ratio are included jointly to determine the effect of risk weights and minimum capital requirement on economic growth. A loosening of LTV caps over time[9] is positively correlated at the 50th and 95th percentile of the conditional GDP growth distribution suggesting that higher LTV caps are linked with stronger median and top growth.

35. Another set of regressions explore the links between risk weights and capital requirements (measured by the minimum Tier I ratio) and growth outcomes. They investigate the link by controlling for the two variables simultaneously which allows distinguishing between their respective impacts. Increases in risk weights for residential mortgages turn out to be positively associated with growth at the 95th percentile of the conditional GDP growth distribution. This result could reflect that tighter risk weights on more risky mortgages (which is what the risk-weight variable entering the regression measures) encourage banks to shift their lending portfolios away from high-risk mortgages funding purchases of houses (an asset with comparatively low-economic returns) towards more productive activities, leading to positive growth spurts. By contrast, the Tier 1 capital ratio is negatively associated with median growth. However, the minimum capital Tier 1 capital ratio became binding after the financial crisis, so that its effects are identified only during a fairly specific crisis and end-of-recovery period. In order to investigate long-term implications of changes in minimum capital Tier 1 capital ratio, a longer time interval would be needed.

8. Identifying causal effects from policies to growth is difficult given reverse causality and the lack of suitable instruments. Hence, results should not be interpreted in a causal way. However, interesting correlations may be discovered that should stimulate further research into causal relationships.

9. Formal lag selection procedures (AIC, BIC, and likelihood ratio tests) suggest to take three lags of LTV caps, risk weights and Tier 1 capital.

Table 3. Macroprudential policies and GDP growth quantile regression

Panel A: All countries					
	Demeaned growth rate				
	Q5	Q50	Q95	OLS	N
LTV caps	-0.005	0.018***	0.023***	0.013	948
	(0.049)	(0.004)	(0.006)	(0.012)	
Risk weights	-0.009	0.0002	0.011*	-0.016	1309
	(0.009)	(0.002)	(0.007)	(0.010)	
Minimum Tier 1 capital ratios	0.009	-0.055*	-0.029	0.072	1309
	(0.152)	(0.028)	(0.127)	(0.131)	
Panel B: Advanced countries[10]					
LTV caps	-0.002	0.019***	0.023***	0.011	836
	(0.036)	(0.004)	(0.006)	(0.013)	
Risk weights	-0.022	-0.001	0.016*	0.011	1197
	(0.014)	(0.002)	(0.008)	(0.013)	
Minimum Tier 1 capital ratios	-0.203	-0.051	-0.0003	-0.019	1197
	(0.169)	(0.042)	(0.155)	(0.015)	
Controls	Yes	Yes	Yes	Yes	
Country fixed effects	Yes	Yes	Yes	Yes	
Time fixed effects	No	No	No	Yes	

Note: Bootstrapped standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Control variables include initial log GDP per capita, trade openness measured as exports plus imports as a ratio of GDP, government revenues as a ratio of GDP, the real short-term interest rate and financial openness (defined as the ratio of private credit to GDP or stock market capitalization to GDP). Risk weights denotes the unweighted average of risk weights for LTVs ranging from 50 to 125. Risk weights are lagged by three quarters. LTV caps refer to caps on mortgage loans for the purchase of the primary residence. LTV caps are lagged by three quarters. Minimum Tier 1 capital is the bank's core capital that includes equity capital and disclosed reserves.
Source: ECB Macroprudential Policies Evaluation Database (Budnik and Kleibl, 2018[26]), OECD, own calculations.

36. The results reported in Table 5 suggest that restrictive rental regulation makes the conditional growth distribution narrower with thinner tails on the lower and upper quantile. This points to a trade-off between GDP-at-risk at the lowest and highest quantiles indicating that regulation is there to strike a balance between various objectives. Looking at the restrictive regulation index, the coefficients at the lowest quantile are positively significant while negatively significant for the upper quantile. The positive effect holds for the tenure security index. One interpretation is that in countries with more restrictive housing market regulations, low-income households are better able to smooth income and consumption thanks to the stability provided by rent control and the reduced risk of eviction and homelessness through stronger tenure security. This narrowing of growth outcomes by restrictive rental market regulations does, however, not provide a protective form of stability, as it does not reduce the likelihood of long lasting severe downturns.

10. Excludes Russia, Lithuania and Poland. There is limited or no information available on macroprudential policies for other emerging economies such as Argentina, Brazil, Colombia, Chile, Mexico, India, Indonesia and South Africa (following the IMF classification of emerging economies.

Table 4. Housing market policies and GDP growth quantile regression

Panel A: All countries					
	Demeaned growth rate				
	(1)	(2)	(3)	(4)	
	Q5	**Q50**	**Q95**	**OLS**	**N**
Rental regulation index	1.062**	0.199*	-1.502***	0.529	1583
	(0.515)	(0.111)	(0.357)	(0.77)	
Tenure security index	0.753**	0.046	-0.975***	0.451	1583
	(0.329)	(0.069)	(0.247)	(0.60)	
Rent control index	0.750	0.224*	-0.685*	0.240	1583
	(0.499)	(0.125)	(0.382)	(0.59)	
Panel B: Advanced countries					
Rental regulation index	1.164**	0.124	-1.992***	0.994	1445
	(0.515)	(0.137)	(0.305)	(0.765)	
Tenure security index	0.734**	0.053	-1.157***	-0.060	1445
	(0.338)	(0.086)	(0.227)	(0.742)	
Rent control index	0.770	0.155	-1.479***	0.632	1445
	(0.595)	(0.142)	(0.331)	(0.424)	
Control variables	Yes	Yes	Yes	Yes	
Country fixed effects	Yes	Yes	Yes	Yes	
Time fixed effects	No	No	No	Yes	

Note: Bootstrapped standard errors are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1. Control variables include initial log GDP per capita, trade openness measured as exports plus imports as a ratio of GDP, government revenues as a ratio of GDP, the real short-term interest rate and financial openness (defined as the ratio of private credit to GDP or stock market capitalization to GDP). The rental regulation index is the simple average of the variables rent control and tenure security. The tenure security index is a variable that goes from 0 to 1, the higher the value the more stringent the regulation based on four tenure security categories (i.e. eviction protection during term or period, eviction protection at the end of term or period, minimum duration variable, short-term tenancies). The rent control index is a variable that goes from 0 to 1, the higher the value the more stringent the regulation based on six binary variables (i.e. real rent freeze, nominal rent freeze, rent level control, intertenancy control, other specific rent control). All housing policy variables are lagged by eight quarters.
Source: OECD Economic Outlook database and OECD calculations and DIW (Kholodilin, 2018[29]).

37. By contrast the coefficients on the top quantiles are all negative and significant suggesting that tighter housing regulation is associated with fewer and weaker strong growth episodes. The results would be consistent with the empirical evidence that tight regulation affects the efficient reallocation of labour by hampering the migration of low-skilled workers towards high-income places and thereby productivity growth especially after an economic crisis (Andrews, Caldera Sánchez and Johansson, 2011[3]). Empirical evidence by Charles, Notowidigdo and Hurst (2018[40]), and Gopinath (2017[41]) suggests that debt booms caused by house price fluctuations may reduce human capital accumulation and distort resource allocation in such a manner that it reduces longer-run output. The results are robust to changes in the lag structure and the specification of the quantile regressions.

3.3. Estimation using a probabilistic model of a severe downturn and empirical results

38. The analysis in this section investigates whether macroprudential and housing policies can mitigate or amplify severe downturns. It relies on the definition of severe downturns proposed by Turner, Chalaux and Morgavi (2018[42]). A downturn is defined as a cumulative decline in real GDP per capita by at least 2 percentage points, the start being the first quarter where the real GDP per capita quarter-on-quarter growth is negative. The end of the episode is defined either when the quarter-on-quarter real GDP per capita returns back to at least to its previous level or when there are three consecutive positive quarter-on-quarter growth rates. In the latter case, the downturn would stop at the first quarter of positive growth rates (see Turner, Chalaux and Morgavi, 2018).

39. The specification uses a probabilistic model of a severe downturn event in country *i,* in year *t*, as a function of lagged macroprudential and housing policies *POL* at year *t*:

$$\text{Probit}\ (p_{it}) = \beta_1\ (\text{L})\ POL_{it} + \gamma X_{it} + \delta_i + \varepsilon_{it}$$

40. The dependent variable in the probit estimation is a dummy equal to one when there is a severe downturn episode and otherwise zero. The estimation includes the same control variables as used in the GDP-at-risk regressions.

41. Table 5 presents the results from the probit estimation. All specifications include country fixed effects. The main variable of interest is the sum of all lags of the policy variable. It is not possible to implement a probit model with year time effects due to the incidental parameters problem with small T and large N leading to inconsistent fixed effects estimators. Moreover, conditional fixed effects can only be estimated using years in the panel where there is variation in the outcome variable. Moreover, including time fixed effects removes time-varying common shocks which are captured in the severe downturn indicator. Accordingly, the probit model includes country but not time effects.

42. The key finding is that all estimates show that higher LTV caps, over the previous three quarters, are associated with a heightened risk of a severe downturn. The sum of the lag coefficients is statistically significant at the 5% confidence level. The diagnostic tests show that the three lags are jointly statistically significant at the 1% level.

43. No effect for the risk weights controlling for the level of minimum regulatory capital Tier 1 ratio was found. Looking at the minimum regulatory tier 1 ratio, this study finds that it is negatively associated with the risk of a downturn at the 10 and 5% significance level.

Table 5. Macroprudential policies and severe downturns

	(1)	(2)
	Downturn	**Downturn**
		Advanced
Sum of lagged coefficients, LTV caps	0.026**	0.025**
S.E of sum of lagged coefficients	(0.013)	(0.013)
Sum of lagged coefficients, risk weights	0.014	0.011
S.E of sum of lagged coefficients	(0.018)	(0.020)
Sum of lagged coefficients, Tier 1	-0.305*	-0.284**
S.E of sum of lagged coefficients	(0.144)	(0.143)
Control variables	Yes	Yes
Country fixed effects	Yes	Yes
Observations	1167	1101

Note: Clustered standard errors are in parentheses; *** p<0.01, ** p<0.05, * p<0.1. The dependent variable takes the value of 1 if the real GDP per capita of a country falls cumulatively by at least 2 percentage points until quarter-on-quarter real GDP per capita goes back to at least its previous level or when there are three consecutive positive quarter-on-quarter growth episodes. In that case, the downturn would stop at the first quarter of positive growth. Control variables include initial log GDP per capita, trade openness measured as exports plus imports as a share of GDP, government revenues as share of GDP, the real short-term interest rate and financial openness (defined as the ratio of private credit to GDP or stock market capitalization to GDP).

Source: ECB Macroprudential Policies Evaluation Database (Budnik and Kleibl, 2018[26]), OECD, own calculations

44. The regression of rental regulation on the likelihood of severe downturns (Table 6) shows that the risk of a severe downturn is significantly exacerbated when rental regulation is tighter. This effect seems to be driven mostly by tenure security.[11]

Table 6. Rental regulation policies and severe downturns

	(1)	(2)
	Downturn	**Downturn**
		Advanced
Sum of lagged coefficients, rental regulation index	2.687**	4.032***
S.E of sum of lagged coefficients	(1.378)	(1.291)
Sum of lagged coefficients, rent control	-0.075	-0.126
S.E of sum of lagged coefficients	(0.846)	(1.857)
Sum of lagged coefficients, tenure security	2.472***	2.705***
S.E of sum of lagged coefficients	(0.701)	(0.779)
Control variables	Yes	Yes
Country fixed effects	Yes	Yes
Observations	1466	1374

Note: Clustered standard errors are in parentheses; *** p<0.01, ** p<0.05, * p<0.1. The dependent variable takes the value of 1 if the real GDP per capita of a country falls cumulatively by at least 2 percentage points until quarter-on-quarter real GDP per capita goes back to at least to its previous level or when there are three

11. Regression estimates were also run using a "shock" as the dependent variable that takes the value of one if real per capita growth falls by 1 percentage point below potential in one quarter. The results are qualitatively similar.

consecutive positive quarter-on-quarter growth rates. In that case, the downturn would stop at the first quarter of positive growth episodes. Control variables include initial log GDP per capita, trade openness measured as exports plus imports as a share of GDP, government revenues as share of GDP, the real short-term interest rate and financial openness (defined as the ratio of private credit to GDP or stock market capitalization to GDP).
Source: Kholodilin (2018[29]), OECD calculations.

3.4. Robustness checks

45. In the first robustness exercise, this paper takes a broader look at crisis episodes and looks at the lower 10th percentile of quarter-on-quarter demeaned GDP growth rate. The results remain qualitatively the same. The results do not show any significant relationship between macroprudential policies such as LTV caps and risk weights controlling for minimum capital Tier 1 ratios at the lower quarter-on-quarter demeaned GDP growth distribution. For the rental regulation variables, the robustness exercise shows that more restrictive policies, especially tenure security, is associated with GDP-at-risk at the 10th percentile of quarter-on-quarter demeaned GDP growth rate.

46. In the next exercise, this paper investigates whether previous findings hold using different lag structures. For macroprudential policies, this paper uses 5 lags (from previously used 3 lags). For the rental regulation index, it uses 6 lags (from previously used 8 lags). Positive coefficients on the maximum LTV ratios on the medium and upper tail growth distribution remain robust to different lag structures. This study also finds that results for the rental regulation policies remain robust to different lags structure.

47. Finally, further robustness tests include the employment of logistic regressions instead of probit for the analysis on severe downturns. The results remain significant. Detailed results of the robustness exercises are available in Sakha (2019, forthcoming[2]).

4. Housing policies and ex-post resilience

4.1. How do housing policies affect the severity of downturns?

48. To empirically assess the link between housing-related policies and resilience, resilience indicators are computed over all cycles (see Table 2 and Annex B). 4.3. Annex G reports standardised coefficients (t-stats) of the corresponding pooled univariate regressions. The results suggest that tighter LTV caps are associated with lower amplitudes of real output cycles. But tighter LTV caps also significantly weaken the strength of the recovery of business cycles and, to a lesser extent, of deviation cycles.

49. More stringent tenure security is associated with shorter and less pronounced output booms and also less severe downturns hinting at more stable financial conditions for households which allows for smoother consumptions paths. Similarly, more generous housing allowances tend to shorten and smoothen output cycles. As a result, pre-crisis levels of output are reached significantly faster.

50. Marginal effective tax rates on housing property are only available for the most recent period. As they generally do not change much over time, cross-country differences are assumed to be stable over time. Extrapolation of tax rates allows to assess their impact

on the cross-section. Tentative results suggest that property tax rates are associated with a lower amplitude of real cycles, in particular in the case of rental income.

51. Proxies for building restrictions suggest a link between tighter restrictions and more moderate housing price busts as well as faster recoveries of residential investment. This association is likely to reflect that building restrictions limit the scope for overbuilding, even if they may have other adverse implications.

4.2. How do policies affect the transmission of housing shocks?

52. To shed light on the transmission of housing shocks, turning points of real house price cycles are identified. The subsequent correction of house prices is used as a proxy for adverse housing shocks. The stance of various housing-related policies is observed at the peak of the house price cycles and compared to the growth of real house prices, housing investment, household credit and private consumption following the peak in house prices during the subsequent two years. Table 7 summarises the results.

53. Stricter capital requirements limit the correction of both house prices and housing investment which seems to support private consumption. Tighter LTV caps slow down household credit and hold back its recovery, but do not seem to have significant effects on housing outcomes or consumption following a correction of house prices. More stringent rent control seems to exacerbate house price corrections. It is also associated with stronger growth in household credit which may be related to lower counter-party risk for banks resulting in more stable bank lending to households.

Table 7. How do housing policies affect the transmission of house price corrections?

	Real house prices	Housing investment	Household credit	Private consumption
Capital requirements	0.098** (0.041)	0.224** (0.091)	-0.039 (0.032)	0.037* (0.021)
LTV caps	-0.002 (0.004)	-0.002 (0.008)	0.005*** (0.001)	0.001 (0.002)
Rent control	-0.092* (0.052)	-0.063 (0.113)	0.213*** (0.069)	0.005 (0.026)
Tenure security	-0.023 (0.074)	0.032 (0.100)	-0.067 (0.055)	-0.017 (0.023)

Note: Turning points of real house prices are obtained using the Harding-Pagan (quarterly Bry-Boschan) business cycle dating procedure (Harding and Pagan, 2002[4]). The subsequent 2-year growth of outcome variables (columns) are pooled and regressed on time-varying policy variables (rows). The table displays regression coefficients. Standard deviations are in parentheses and stars denote statistical confidence levels: *p<0.1; **p<0.05; ***p<0.01.

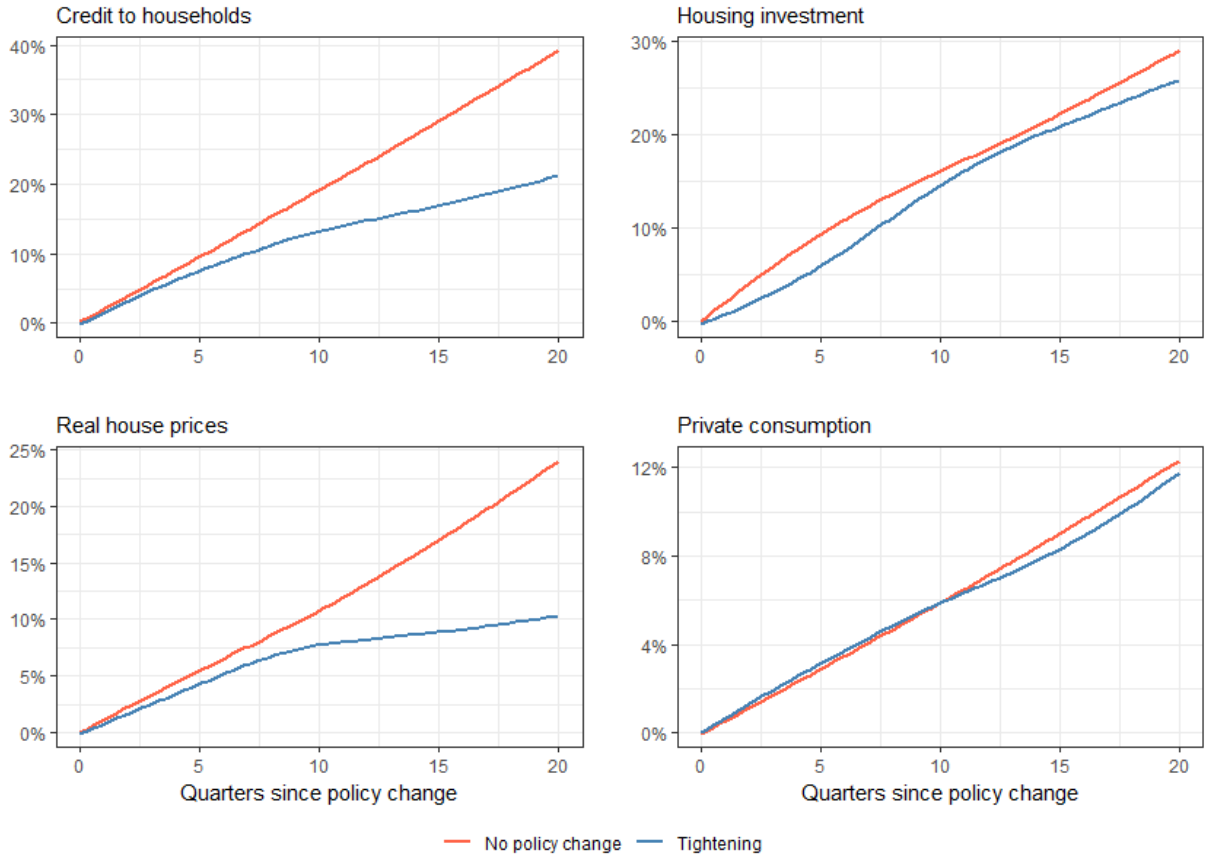
4.3. Gauging causality: Measuring the impact of policy changes on real, financial and housing variables

54. In an attempt to alleviate concerns about endogeneity and reverse causality, this section assesses the impact of a policy change on real, financial and housing variables using matching techniques. The idea is to simulate a natural experiment by comparing two episodes that are as similar as possible, one with a policy change (treatment) and one without (control). The policy change can then by assumed to be exogenous and observed outcome differences between the treatment and the control group are likely to be caused by the policy change.

55. One matching technique is propensity matching. First, a treatment group consisting of countries with policy change events is identified. Second, a probit model with 1-year and 3-year changes of real, financial and housing-related variables as predictors of policy changes is built using stepwise selection. Based on the obtained functional relationship a control group is constructed by finding country-period pairings without a policy change but with similar statistical properties than the treatment country-period pairings. Local smoothing is then used to obtain an estimate of the average path of i) credit to households, ii) real house prices, iii) housing investment and iv) private consumption around the time of policy changes (in the case of the treatment group).

56. The results suggests that a tightening of LTV caps curbs credit to households, slows real house prices and construction while there is no sizeable impact on private consumption or aggregate output (Figure 5).

Figure 5. Effect of tightening LTV caps

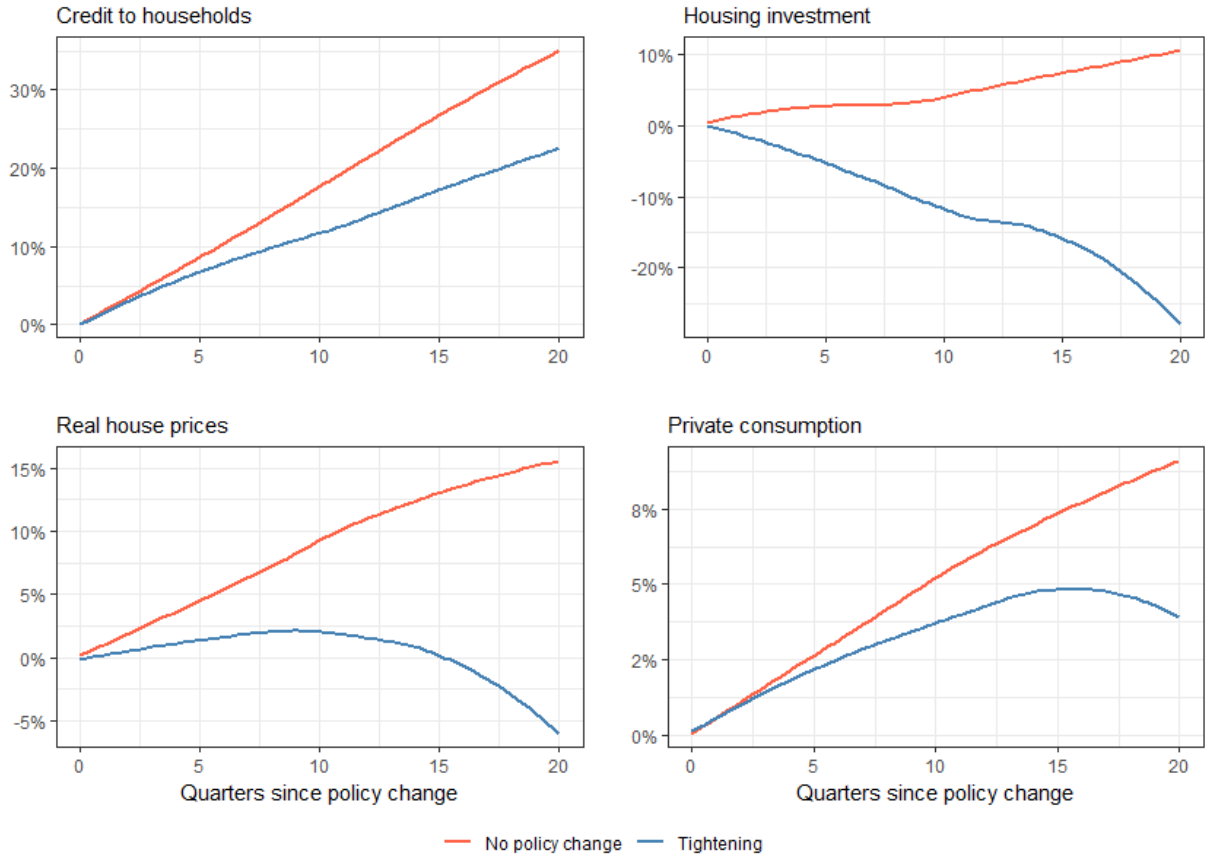


Note: The treatment group consists of country-episodes with a tightening of LTV caps at time=0. The control group, comprising country-episode pairings without such a policy change, has been determined by propensity matching techniques using a probit model with real and financial variables as covariates.
Source: OECD calculations.

57. Increasing risk weights imposed on banks for their mortgage portfolio has similar effects on credit and house prices as tightening LTV caps (Figure 6).[12] The effects are larger, primarily because many of the tightening actions fall in the period of the global financial crisis. The dampening effect on real house prices is more persistent than in the case of LTV caps and residential construction declines more strongly, which slows down both GDP and consumption compared with the control group.

12. Capital requirements are not introduced in this part of the analysis to avoid excessively shrinking the sample.

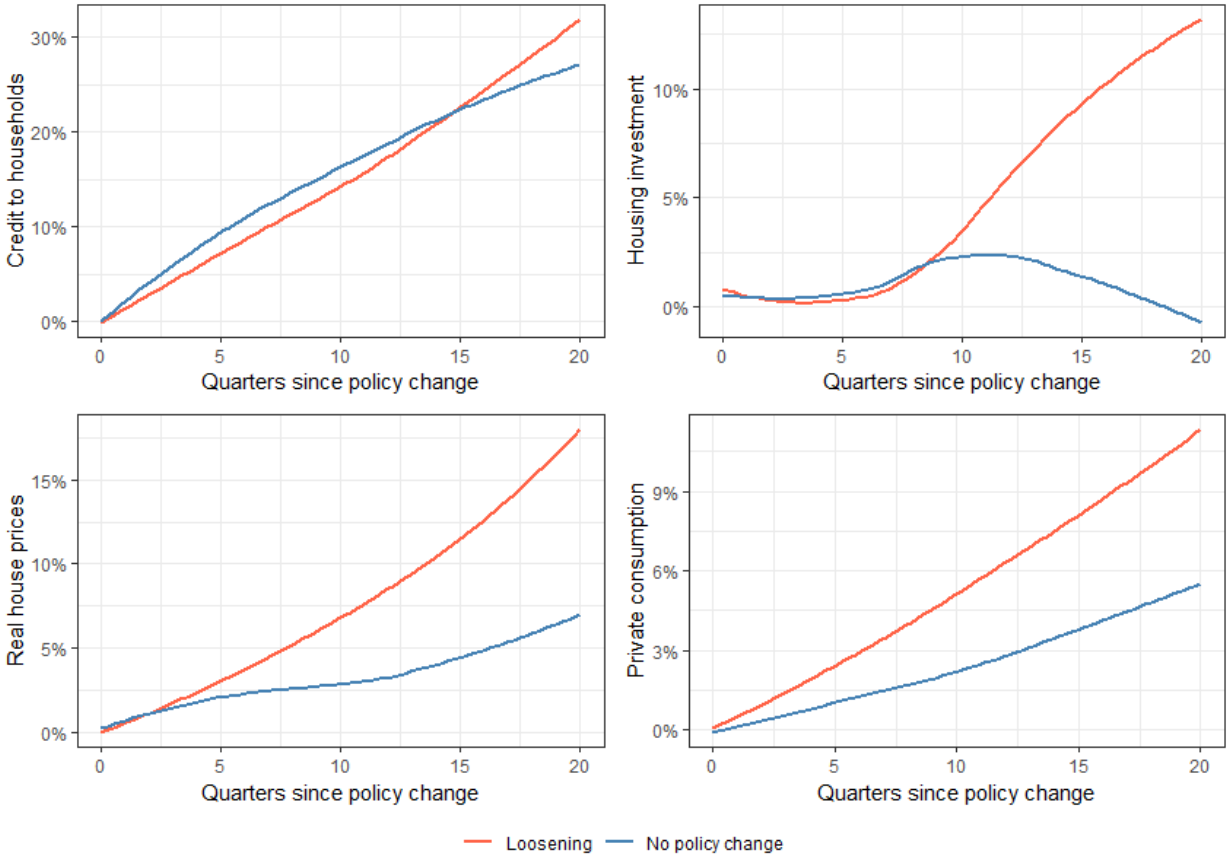
Figure 6. Effect of tightening of risk weights



Note: The treatment group consists of country-episodes with an increase of risk weights at time=0. The control group, comprising country-episode pairings without such a policy change, has been determined by propensity matching techniques using a probit model with real and financial variables as covariates.
Source: OECD calculations.

58. Propensity matching suggests that reducing rent control boosts both residential construction and house prices (Figure 7). Effects on aggregate output and private consumption are tiny suggesting that deregulation merely alters investment opportunities leading to a shift towards real estate away from other forms of investment. Deregulating rental markets increases expected returns from housing investment let out for rental. The resulting increase in housing supply boosts both residential investment and real house prices.

Figure 7. Effect of loosening rent control



Note: The treatment group consists of country-episodes with a loosening of rental regulation at time=0. The control group, comprising country-episode pairings without such a policy change, has been determined by propensity matching techniques using a probit model with real and financial variables as covariates.
Source: OECD calculations

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Annex A. Coverage of outcome variables

	Real GDP	House prices	Housing investment
ARG	1993-2017		
AUS	1969-2017	1970-2017	1969-2017
AUT	1976-2017	2000-2017	1976-2017
BEL	1969-2017	1970-2017	1969-2017
BRA	1980-2017	2008-2017	
CAN	1969-2017	1970-2017	1969-2017
CHE	1991-2017	1991-2017	1991-2016
CHL	1996-2017	2002-2017	1996-2014
CHN	1990-2017	2010-2017	
COL	2001-2017	2001-2017	2001-2017
CRI	1998-2017		
CZE	1996-2017	2008-2017	1996-2017
DEU	1970-2017	1970-2017	1970-2017
DNK	1972-2017	1972-2017	1972-2017
ESP	1978-2017	1978-2017	1978-2017
EST	2000-2017	2005-2017	2000-2017
FIN	1970-2017	1970-2017	1970-2017
FRA	1979-2017	1979-2017	1980-2017
GBR	1971-2017	1971-2017	1971-2017
GRC	1984-2017	1997-2017	1984-2017
HUN	1995-2017	2007-2017	1995-2017
IDN	1990-2017	2002-2017	
IND	1997-2017	2010-2017	
IRL	1977-2017	1977-2017	1977-2017
ISL	1970-2017	2005-2017	1970-2017
ISR	1995-2017	1995-2017	1995-2017
ITA	1969-2017	1970-2017	1969-2017
JPN	1972-2017	1972-2017	1972-2017
KOR	1975-2017	1986-2017	1975-2017
LTU	2002-2017	2006-2017	2002-2017
LUX	1995-2017	2007-2017	1995-2017
LVA	1996-2017	2006-2017	1996-2017
MEX	1995-2017	2005-2017	1995-2017
NLD	1969-2017	1970-2017	1969-2017
NOR	1978-2017	1978-2017	1978-2017
NZL	1989-2017	1989-2017	1989-2017
POL	1995-2017	2010-2017	1995-2017
PRT	1980-2017	1988-2017	1980-2017
RUS	1999-2017	2001-2017	
SVK	1996-2017	2005-2017	1996-2017
SVN	1999-2017	2007-2017	1999-2017
SWE	1969-2017	1970-2017	1970-2017
TUR	1995-2017	2010-2017	
USA	1969-2017	1970-2017	1969-2017
ZAF	2001-2017	2001-2017	2001-2017

Source: OECD Economic Outlook database and OECD Analytical House Price database.

Annex B. Resilience indicators

Table B.1. Business cycles

	Downturn probability	Q5	Volatility (boom)	Volatility (bust)	Duration (bust)	Peak-to-trough	Strength of recovery	Time to recovery	Peaks
ARG	15.0	-3.6	1.0	1.3	4.1	-6.9	2.5	6.4	1994Q4 1998Q2 2001Q1 2008Q3 2011Q4 2013Q3 2015Q2
AUS									
AUT	2.7	-0.4	0.5	0.3	3.7	-2.2	1.6	4.3	2000Q4 2008Q1 2012Q1
BEL	1.8	-0.4	0.4	0.4	4.0	-1.8	2.6	3.3	1992Q1 2000Q4 2008Q2 2012Q1
BRA	4.5	-1.4	0.8	0.6	4.2	-3.1	3.6	2.0	1991Q1 1995Q4 2000Q4 2002Q4 2008Q3 2014Q1
CAN	2.7	-0.6	0.4	0.4	2.5	-2.4	1.7	3.5	2008Q3 2014Q4
CHE	0.9	-0.5	0.3	0.3	2.3	-1.3	1.2	3.2	1992Q1 1996Q1 1998Q2 2001Q2 2002Q3 2008Q3
CHL	2.7	-0.5	0.8	1.0	3.5	-3.6	5.5	3.5	1998Q2 2008Q2
CHN									
COL	3.6	-0.7	1.1	0.4	3.7	-2.7	3.5	4.7	1995Q4 1998Q2 2015Q4
CRI	0.9	-0.3	0.9	0.8	3.0	-2.0	3.1	2.5	1995Q1 2008Q3
CZE	8.0	-2.7	0.7	1.6	4.2	-7.8	2.8	16.8	1990Q4 1992Q4 1996Q4 2008Q3 2011Q4
DEU	1.8	-0.6	0.5	0.7	2.8	-2.1	1.7	4.2	1992Q1 1995Q3 2002Q3 2004Q2 2008Q1 2012Q3
DNK	3.6	-1.1	0.6	0.6	4.0	-2.6	2.7	6.5	1992Q1 1997Q2 2006Q2 2007Q4
ESP	1.8	-1.0	0.2	0.5	7.7	-4.4	3.9	14.7	1992Q1 2008Q2 2010Q3
EST	6.5	-2.8	1.6	2.3	5.5	-11.7	9.1	14.5	1998Q1 2007Q4
FIN	8.0	-1.5	0.6	1.2	5.7	-4.8	3.0	9.0	2007Q4 2011Q4 2013Q3
FRA	0.9	-0.2	0.3	0.3	3.3	-1.6	1.2	4.0	1992Q2 2008Q1 2012Q3
GBR	2.7	-0.3	0.4	0.8	5.0	-6.3	2.4	16.0	2008Q1
GRC	10.7	-2.2	0.9	0.8	9.0	-8.5	1.5	5.7	1992Q1 2004Q3 2007Q2 2014Q3
HUN	3.7	-0.8	0.3	1.0	4.0	-3.0	2.1	7.3	1995Q1 2006Q4 2008Q2 2011Q4
IDN	3.6	-0.6	1.7	1.8	3.5	-9.2	8.1	9.0	1994Q2 1997Q3
IND	0.9	0.0		0.0	2.0	-0.2	6.9	1.0	2008Q3
IRL	4.5	-1.8	1.1	1.3	5.5	-6.9	5.2	9.0	2007Q4 2012Q2
ISL	10.7	-2.6	1.7	1.1	4.0	-4.1	3.2	5.3	1991Q1 1994Q3 2007Q4 2011Q4 2014Q3 2016Q4
ISR	0.0	-0.5	0.8	0.2	3.5	-1.8	1.9	5.0	2000Q3 2011Q4
ITA	3.6	-0.9	0.4	0.3	4.4	-2.4	1.9	2.2	1992Q1 1997Q4 2001Q1 2002Q4 2008Q1 2011Q2 2013Q3
JPN	3.6	-1.2	0.7	0.7	3.7	-3.0	2.8	5.7	1993Q1 1997Q1 2001Q1 2008Q1 2010Q3 2012Q1
KOR	2.7	-0.4		3.9	3.0	-8.1	6.8	4.0	1997Q3
LTU	3.3	-1.1	1.1	3.4	5.0	-9.8	6.7	10.0	1998Q3 2008Q2
LUX	2.7	-1.6	1.4	0.7	3.4	-2.9	4.8	3.0	1994Q4 2002Q2 2007Q4 2011Q1 2015Q1
LVA	6.5	-2.7	1.9	1.3	6.5	-11.7	6.9	15.5	1998Q2 2007Q3
MEX	3.6	-0.7	0.7	1.0	3.7	-6.9	4.0	5.7	1994Q4 2000Q3 2008Q3
NLD	1.8	-0.6	0.4	1.0	5.5	-3.2	1.7	15.0	2008Q2 2011Q1
NOR	1.8	-1.4	1.1	0.6	3.2	-1.9	3.0	3.6	1992Q3 2002Q2 2007Q4 2010Q1 2016Q1
NZL	1.8	-1.1	0.7	0.8	3.2	-2.5	3.5	3.2	1990Q4 1997Q3 2000Q1 2007Q4 2010Q2
POL	3.6	-1.4	1.3	0.0	2.0	-0.2	2.2	1.0	2001Q3
PRT	4.5	-1.0	0.5	0.5	6.3	-4.4	3.4	9.3	1992Q1 2002Q1 2008Q1 2010Q3
RUS	9.8	-2.0	0.9	1.2	4.3	-7.4	4.7	9.0	1995Q3 1997Q4 2008Q2 2014Q2
SVK	2.9	-0.7	1.4	1.3	4.0	-6.2	3.4	8.0	1998Q4
SVN	9.8	-2.1	0.5	1.3	5.5	-7.1	3.0	20.0	2008Q2 2011Q2
SWE	2.7	-0.7	0.8	1.3	5.0	-4.3	4.1	5.0	2007Q4 2011Q3
TUR	8.0	-3.9	1.6	2.4	3.0	-8.8	7.5	4.6	1993Q4 1998Q3 2000Q3 2007Q1 2008Q1
USA	1.8	-0.4	0.5	0.6	4.0	-2.7	2.6	5.5	1990Q3 2007Q4
ZAF	1.8	-0.6	0.4	0.5	3.5	-1.5	1.6	2.5	2008Q3 2015Q1

Note: Based on quarterly growth rate of real GDP from 1990 to 2017. See Table 2 for definitions.

Table B.2. Real house price cycles

	Downturn probability	Q5	Volatility (boom)	Volatility (bust)	Duration (bust)	Peak-to-trough	Strength of recovery	Time to recovery	Peaks
ARG									
AUS	10.7	-1.9	1.1	0.8	5.8	-4.8	7.6	5.2	1991Q3 1994Q3 2004Q1 2008Q1 2010Q2
AUT	6.9	-2.8	0.9	2.6	4.0	-5.6	4.5	12.3	2001Q1 2002Q3 2007Q3
BEL	0.9	-1.0	0.9	0.3	2.3	-1.2	2.0	1.7	1990Q4 1992Q2 2000Q1 2008Q4 2010Q4 2013Q1 2015Q4
BRA									
CAN	5.4	-2.0	1.3	0.9	6.8	-4.8	3.8	10.3	1991Q2 1997Q2 2008Q2 2010Q2
CHE	17.9	-2.9	1.0	0.5	9.3	-5.7	6.5	9.8	1994Q3 2001Q4 2007Q1 2008Q4
CHL	14.1	-2.6	1.2	0.9	6.0	-5.4	6.7	5.5	2004Q4 2011Q1 2013Q4 2015Q3
CHN	16.7	-1.8	0.8	0.8	4.5	-5.0	8.3	4.5	2011Q2 2014Q1
COL	19.6	-4.2	0.9	2.1	8.0	-14.9	0.0	31.3	1996Q2 1998Q1 2001Q4
CRI									
CZE	12.5	-1.8		1.0	21.0	-13.8		12.0	2008Q3
DEU	6.3	-1.5	0.6	0.8	9.2	-4.6	-0.5	13.8	1991Q1 1995Q1 1999Q4 2006Q4 2009Q4 2013Q2
DNK	15.2	-2.7	0.7	1.2	6.0	-10.4	2.7	5.3	1991Q4 1994Q1 2007Q1 2010Q4
ESP	24.1	-3.7	1.5	1.5	14.7	-21.3	11.9	11.5	1991Q4 1997Q2 2007Q3
EST	19.2	-8.5	2.2	3.3	6.0	-27.4	8.9	2.0	2007Q2 2016Q4
FIN	17.0	-4.6	1.3	0.8	7.8	-5.4	9.3	4.3	1994Q2 2000Q2 2008Q1 2010Q3
FRA	11.6	-1.6	0.8	0.6	15.0	-11.8	20.8	12.5	1991Q1 2007Q4 2011Q3
GBR	19.6	-3.0	1.0	1.4	8.0	-10.7	10.4	4.5	1994Q4 2007Q4 2010Q1
GRC	27.4	-3.6	1.1	1.1	21.5	-24.0	9.5	3.0	2003Q1 2007Q3
HUN	34.1	-4.5		1.8	24.0	-34.6			2007Q4
IDN	39.1	-3.3	1.3	0.1	2.0	-0.9	0.4		2016Q2
IND									
IRL	20.5	-5.2	1.9	1.4	11.3	-19.7	5.2	2.5	1991Q4 2001Q1 2007Q1
ISL	15.4	-7.0	0.7	1.5	4.7	-13.3	4.6	10.7	2006Q1 2007Q4 2012Q3
ISR	17.7	-2.5	1.3	1.0	6.6	-7.6	3.5	17.6	1997Q3 2002Q1 2004Q2 2005Q4 2011Q3
ITA	31.3	-2.2	0.6	0.9	15.5	-17.9	11.5	27.0	1991Q4 2008Q1
JPN	25.0	-1.7	0.6	0.6	27.0	-16.0	2.2	3.5	1991Q1 2010Q4 2013Q4
KOR	30.4	-3.7	0.8	0.8	8.7	-10.6	8.1	6.0	1990Q4 1999Q3 2003Q4 2008Q3 2009Q4 2011Q4 2016Q1
LTU	20.8	-5.5	0.9	3.5	5.7	-16.2	1.5	4.5	2008Q1 2011Q1 2013Q1
LUX	0.0	-1.0		1.1	8.0	-3.9	5.7	2.0	2007Q3
LVA	20.8	-12.4	0.0	3.9	6.5	-26.2	5.1	4.0	2008Q1 2011Q1
MEX	1.9	-1.0	0.6	0.5	4.2	-2.0	1.4	5.8	2006Q1 2007Q2 2009Q4 2011Q4 2013Q2 2016Q1
NLD	12.5	-1.9	1.5	1.2	25.0	-25.0			2007Q4
NOR	13.4	-2.8	1.3	1.1	3.3	-4.8	6.1	3.3	1998Q2 2002Q2 2007Q3 2013Q2
NZL	12.5	-1.7	0.9	0.9	5.0	-7.3	2.8	12.0	1997Q2 1999Q3 2007Q3 2009Q4
POL									
PRT	19.6	-2.5	0.7	0.7	9.7	-9.8	0.1	13.5	1992Q2 1994Q4 2001Q2 2005Q3 2009Q4 2014Q2
RUS	36.8	-5.1	6.5	8.5	4.0	-22.7	-11.4		2008Q3 2010Q2
SVK	25.0	-4.8		2.6	18.0	-30.4	19.4		2008Q2
SVN	31.8	-4.6	0.6	1.3	13.5	-16.2	3.2	1.0	2008Q1 2015Q2
SWE	12.5	-3.3	1.0	0.7	4.7	-5.1	5.6	5.0	1994Q3 2007Q3 2010Q4
TUR	3.1	-2.0		1.1	4.0	-4.8	4.6	5.0	2010Q4
USA	13.4	-1.9	0.4	0.9	14.0	-14.3	1.6	4.0	1992Q1 2006Q1
ZAF	14.3	-2.8	1.2	1.1	6.7	-7.4	3.4	9.8	1991Q4 1994Q3 1998Q1 2001Q4 2007Q3 2010Q1 2016Q1

Note: Based on quarterly growth rates of real house prices from 1990 to 2017. See Table 2 for definitions.

Table B.3. Real housing investment cycles

	Downturn probability	Q5	Volatility (boom)	Volatility (bust)	Duration (bust)	Peak-to-trough	Strength of recovery	Time to recovery	Peaks
ARG									
AUS	22.3	-4.3	2.5	2.6	4.7	-14.1	9.9	10.7	1994Q2 2000Q2 2004Q1 2007Q1 2008Q2 2011Q2
AUT	18.8	-3.3	1.9	1.7	6.7	-7.7	2.6	8.0	1996Q3 1998Q4 2005Q3 2008Q1 2011Q2 2012Q3 2013Q4
BEL	25.0	-2.9	1.1	1.1	5.2	-8.1	6.4	13.4	1990Q3 1992Q4 1995Q1 1997Q2 1999Q2 2007Q4 2010Q3 2012Q2 2014Q4
BRA									
CAN	18.8	-5.9	1.7	1.4	4.0	-7.1	7.9	5.5	1992Q3 1994Q2 1997Q4 2002Q4 2006Q1 2007Q4 2010Q1 2012Q1
CHE	20.4	-2.7	1.7	1.3	12.3	-14.5	11.2	32.3	1995Q1 1998Q1 2005Q1
CHL	23.7	-4.0	1.4	1.1	6.3	-12.8	6.0	8.0	1998Q1 2006Q1 2008Q1 2011Q4
CHN									
COL	20.8	-10.7	5.3	6.2	4.5	-14.9	17.2	4.3	2004Q4 2006Q3 2008Q3 2014Q3
CRI									
CZE	15.9	-5.7	4.5	2.5	4.0	-7.9	7.2	6.7	1996Q3 1999Q2 2000Q4 2002Q1 2007Q1 2012Q2
DEU	20.5	-3.5	2.2	1.4	4.4	-7.0	6.0	6.0	1992Q4 1995Q2 1998Q1 1999Q3 2003Q3 2006Q4 2008Q1 2010Q2 2012Q3 2014Q1
DNK	25.0	-9.2	3.3	3.1	4.7	-16.1	8.0	6.2	1992Q3 2000Q1 2001Q4 2004Q2 2006Q3 2011Q1 2012Q3
ESP	27.7	-4.5	2.2	1.4	14.7	-23.5	10.9	4.0	1990Q3 1996Q1 2006Q4
EST	19.6	-15.4	9.8	8.6	6.6	-28.4	35.6	2.8	1997Q4 2004Q1 2006Q4 2014Q1 2016Q2
FIN	32.1	-5.5	3.1	1.9	8.5	-16.8	17.3	7.0	1995Q1 2000Q3 2006Q4 2011Q1
FRA	15.2	-2.2	0.4	0.6	7.3	-6.6	2.2	9.0	1995Q1 2007Q2 2010Q4 2013Q2
GBR	26.8	-6.9	2.9	3.4	6.4	-13.1	7.4	8.8	1993Q4 1996Q4 2005Q2 2007Q1 2010Q3 2011Q4 2014Q3
GRC	40.2	-24.1	13.3	10.1	8.8	-44.3	-5.2	13.3	1991Q1 2000Q2 2004Q3 2006Q1 2007Q3 2011Q3
HUN	34.8	-7.8	1.5	2.5	12.0	-36.7	30.6	7.0	1996Q4 2004Q3 2009Q1
IDN									
IND									
IRL	22.3	-12.6	2.7	3.9	9.3	-27.1	14.9	2.0	1992Q2 1997Q3 2001Q2 2005Q4
ISL	27.7	-10.9	2.9	3.9	4.9	-18.4	11.2	10.5	1991Q4 1994Q2 1996Q3 2001Q2 2007Q4 2012Q2 2014Q2
ISR	19.6	-6.1	3.3	2.6	6.4	-14.9	10.3	21.2	1992Q1 1997Q1 2000Q1 2001Q3 2014Q3
ITA	18.8	-3.3	1.5	2.0	9.0	-9.9	-1.2	6.3	1991Q4 1995Q4 1997Q4 2001Q2 2006Q4 2010Q2
JPN	29.5	-8.2	2.2	2.2	6.2	-16.1	2.8	3.5	1990Q3 1994Q3 1996Q4 1999Q3 2004Q3 2005Q4 2008Q4 2011Q3 2014Q1
KOR	23.2	-8.5	4.2	2.9	4.3	-15.5	6.6	10.4	1991Q4 1996Q3 1997Q4 2002Q1 2004Q1 2007Q1 2009Q3 2011Q4
LTU	27.2	-20.4	7.2	12.1	4.0	-25.8	26.6	6.8	1999Q1 2000Q3 2004Q4 2008Q2 2015Q3
LUX	30.4	-21.4	11.7	8.4	4.6	-27.2	17.6	10.4	1995Q3 1998Q1 1999Q3 2004Q1 2008Q1 2012Q1 2014Q1
LVA	27.2	-37.2	17.6	24.6	8.2	-52.8	43.8	13.7	1996Q4 2000Q4 2007Q4 2012Q3 2015Q2
MEX	23.0	-5.1	3.2	2.3	3.3	-7.6	6.1	3.3	1994Q4 1996Q1 1999Q1 2000Q2 2004Q1 2006Q3 2008Q2 2010Q1 2011Q4
NLD	25.9	-7.8	3.3	2.7	7.8	-13.5	8.7	2.8	1992Q4 1994Q4 2000Q1 2001Q2 2007Q1 2008Q2
NOR	20.5	-5.3	3.1	1.4	4.8	-7.3	10.0	4.0	1994Q4 1998Q1 1999Q4 2002Q1 2007Q2 2013Q1
NZL	17.9	-10.2	4.1	4.2	4.9	-16.6	9.6	10.1	1992Q1 1997Q3 2000Q1 2004Q2 2007Q3 2010Q2 2016Q2
POL	17.4	-3.8	1.6	1.5	5.8	-9.3	7.8	7.0	2000Q1 2002Q2 2008Q2 2012Q2 2014Q1
PRT	33.0	-5.7	1.9	2.0	11.0	-20.5	7.5	2.0	1992Q4 1995Q2 2000Q1 2002Q1 2005Q1
RUS									
SVK	23.9	-12.1	5.5	8.4	6.4	-23.1	14.3	7.0	2000Q3 2005Q1 2009Q3 2013Q4 2016Q4
SVN	38.0	-5.6	1.8	1.9	11.0	-21.6	7.9	7.3	1997Q4 1999Q3 2001Q3 2008Q2
SWE	26.8	-9.7	2.6	3.5	7.0	-21.8	19.3	11.0	1996Q1 2007Q2 2011Q3
TUR									
USA	20.5	-6.5	1.5	1.0	4.5	-12.1	7.5	2.6	1994Q2 1996Q2 2000Q1 2005Q3 2013Q3 2016Q1
ZAF	23.2	-5.0	2.4	1.9	6.6	-13.0	10.0	13.5	1992Q2 1995Q1 1996Q3 2001Q1 2005Q4 2007Q2 2015Q3

Note: Based on quarterly growth rates of real housing investment from 1990 to 2017. See Table 2 for definitions.

Annex C. Description of policy variables

Variable	Description	Source
LTV caps	Maximum loan-to-value ratios applied to mortgage loans.	ECB's Macroprudential Policies Evaluation Database (MaPPED) complemented by own research
Capital requirements	Minimum regulatory Tier 1 ratio multiplied with unweighted average of risk weights for mortgage loans with an LTV ranging from 50 to 130.	ECB's Macroprudential Policies Evaluation Database (MaPPED) complemented by own research
Rent control	Index reflecting on the number of regulations that restrict rent increases including real rent freezes, nominal rent freezes, rent level control, limits of decontrolling (e.g. change of tenant, new or vacant dwelling) as well as restrictions on subletting	DIW (Kholodilin, 2018[29])
Tenure security	Index capturing the intensity of regulation protecting tenants from eviction including the prohibition of short-term tenancies.	DIW (Kholodilin, 2018[29])
Social rental market	Number of social rental dwellings as a share of the total number of dwellings, 2015 or latest year available.	OECD Affordable Housing Database
Housing allowances	Public spending on housing allowances as % of GDP, 2015.	OECD Affordable Housing Database
Property tax rate (owner-occupied)	Marginal effective tax rates (METR) on owner-occupied are derived as the differences between the pre- and post-tax rates of return of a marginal investment divided by the pre-tax rate of return of that investment where post-tax real rate is the minimum rate of return necessary to make the investment worthwhile.	OECD Tax Policy Studies paper (OECD, 2018[33])
Property tax rate (rental)	Marginal effective tax rates (METR) on rental dwellings are derived as the differences between the pre- and post-tax rates of return of a marginal investment divided by the pre-tax rate of return of that investment where post-tax real rate is the minimum rate of return necessary to make the investment worthwhile.	OECD Tax Policy Studies paper (OECD, 2018[33])
Urban sprawl (restrictiveness)	Composite indicator derived from the first principal component of changes in 8 urban sprawl indicators from 2000 to 2014. The indicator is associated with an increasing share of low populated areas and decentralisation. "Urban sprawl restrictiveness" is defined as the negative of the urban sprawl composite indicator.	Own calculations based on OECD's Urban Sprawl indicators (OECD, 2018[37])
Densification (restrictiveness)	Composite indicator derived from the second principal component of changes in 8 urban sprawl indicators from 2000 to 2014. "Densification restrictiveness" is defined as the negative of the densification composite indicator.	Own calculations based on OECD's Urban Sprawl indicators (OECD, 2018[37])
Zoning (restrictiveness)	Composite indicator derived from the third principal component of changes in 8 urban sprawl indicators from 2000 to 2014. The indicator is associated with urban expansion and declines in fragmentation. "Zoning restrictiveness" is defined as the negative of the zoning composite indicator.	Own calculations based on OECD's Urban Sprawl indicators (OECD, 2018[37])

Annex D. Gauging land use policies from urban sprawl data

In the absence of harmonised quantitative indicators for land use regulation, outcome variables of urban sprawl could serve as a proxy for impediments to housing supply. Recent work at the OECD has produced a range of useful metrics in this regard (OECD, 2018[37]). To summarise the information contained in 8 urban sprawl indicators, more precisely their change between 2000 and 2014, principal component analysis can be used (Table D1). The resulting first principal component reflects urban sprawl in the narrow sense and is associated with an increasing share of people living in low-density areas. The second principal component reflects densification of areas outside the urban core leading to polycentric structures with more but smaller urban centres. The third principal component reflects the extension of urban footprint and is associated with an increase of developed land and a reduction of fragmentation.

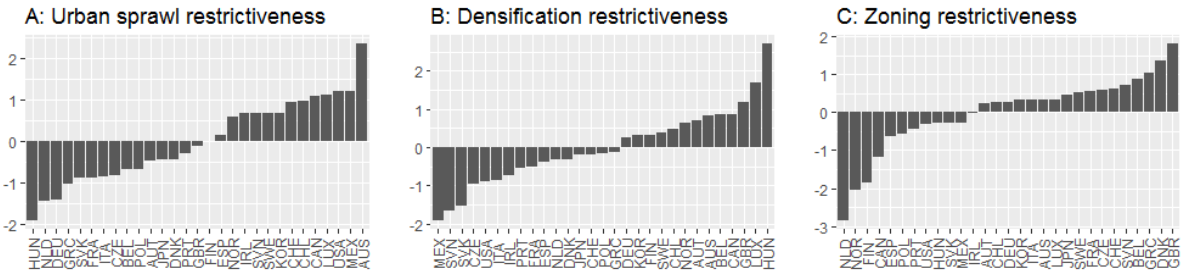
Table D.1. Urban sprawl indicators – principal component analysis

Variable	Description	PC1	PC2	PC3
Population density	Average functional urban area population density: number of inhabitants/km^2	**-0.90**		
Fragmentation	Fragmentation index: number of urban fabric fragments per km^2			**-0.55**
Polycentricity	Number of urban centres		**0.75**	
Coefficient of variation	Coefficient of variation of population density		**0.60**	
Decentralisation	Share of functional urban area population living outside of urban centres		**-0.69**	
Land to density allocation	Percentage of urban footprint occupying areas of density below 2500 inhabitants/km^2	**0.90**		
Population to density allocation	Percentage of population living in areas with a density below 2500 inhabitants/km^2	**0.92**		
Artificial area	Sum of functional urban area's artificial area in km^2			**0.89**

Note: Principal component analysis on the change between 2000 and 2014 of eight urban sprawl indicators is performed. The table shows loadings with a contribution of more than 15% per principal component (PC) for the first three PCs that explain more than 75% of the overall variation in the data.
Source: Rethinking Urban Sprawl, Moving towards Sustainable Cities (OECD, 2018[37]).

Non-policy drivers of urban sprawl include population growth, the rise in household income, the decline of commuting costs and individual preferences for living in low-density areas. Assuming common trends for individual preferences and commuting costs across countries, controlling for increases in household income allows to derive unexplained changes to urban sprawl, densification and the extension of the urban footprint. The inverse of these indicators are then used as proxies for the respective restrictiveness across countries (Figure D1).

Figure D1. Land use restrictiveness indicators



Note: Based on composite indicators for urban sprawl, densification and newly developed urban land drawn from principal component analysis of changes to urban sprawl indicators between 2000 and 2014 (Table). Restrictiveness indicators are obtained as the inverse of the principal components after controlling for the increase in disposable household income.
Source: Own calculations.

Annex E. Summary statistics of policy variables

	Macroprudential regulation		Rental regulation		Public support		Property taxation		Land use restrictiveness		
	LTV caps	Capital require-ment	Rent control	Tenure security	Social rental market	Housing allowances	Property tax rate (owner-occupied)	Property tax rate (rental)	Urban sprawl	Densifi-cation	Zoning
ARG			0.27	0.75			0.28	0.57			
AUS		8.00	0.17	0.00	4.90	0.27	0.15	0.88	2.33	0.85	0.34
AUT		8.00	0.17	0.75	26.20	0.16	0.15	0.59	-0.48	0.70	0.23
BEL		8.00	0.17	0.25			0.49	0.51	-0.69	0.86	0.89
BRA			0.00	0.50							
CAN	94.87	8.00	0.33	0.25	4.10		0.39	0.75	1.08	0.86	-1.17
CHE	93.33	8.00	0.33	0.50			0.23	0.28	0.94	-0.17	0.62
CHL			0.17	0.25		0.01	0.21	0.21	0.96	0.47	0.27
CHN	75.26	8.00									
COL			0.50	0.25			0.17	0.17			
CRI											
CZE	97.13	8.00	0.02	0.50	0.50	0.27	0.11	0.22	-0.82	-0.96	0.59
DEU		8.00	0.40	0.50	3.90	0.59	0.19	0.66	-1.40	0.26	0.27
DNK	82.37	8.00	0.77	0.40	22.20	0.48	0.21	0.49	-0.44	-0.30	1.36
ESP		8.84	0.33	1.00		0.01	0.37	0.48	0.16	-0.37	-0.64
EST		8.84	0.50	0.50	1.40	0.04	0.00	0.22			
FIN	99.74	8.00	0.17	0.25	12.80	0.82	0.12	0.50	0.01	0.32	-1.85
FRA		8.00	0.32	1.00	18.70	0.83	0.23	0.47	-0.88	-0.50	0.57
GBR		8.00	0.17	0.25	17.60	1.41	0.28	0.55	-0.11	1.17	1.80
GRC		8.00	0.00	0.00			0.27	0.26	-1.02	-0.12	1.04
HUN	80.00	8.00			4.00		0.15	0.30	-1.89	2.70	-0.29
IDN	83.96	8.00									
IND	83.75	9.00									
IRL		8.00	0.33	0.25	8.70	0.21	0.07	0.58	0.66	-0.74	-0.03
ISL			0.00	0.25			0.16	0.36			
ISR							0.10	0.28			
ITA		8.00	0.17	1.00			0.02	0.47	-0.84	-0.86	0.34

JPN		12.00			3.80	0.12	0.21	0.37	-0.44	-0.20	0.47
KOR	67.37	14.55			6.40	0.06	0.06	0.09	0.68	0.31	0.33
LTU	85.00	8.00	0.17	0.25		0.06	0.03	0.19			
LUX		8.00	0.67	0.50	1.60		0.00	0.47	1.11	1.70	0.35
LVA	92.11	8.84	0.17	0.50	0.20	0.08	0.22	0.33			
MEX			0.00	0.25			0.11	0.46	1.21	-1.90	-0.27
NLD	104.11	8.00			34.10	0.45	0.10	0.50	-1.44	-0.31	-2.84
NOR	85.00	10.00	0.17	0.75	4.60	0.09	0.17	0.67	0.59	0.63	-2.04
NZL	85.83	8.00	0.17	0.25	5.80	0.47	0.20	0.46			
POL	86.05	9.68	0.33	0.50	8.30	0.09	0.06	0.15	-0.66	-0.15	-0.56
PRT		8.53	0.20	0.50	2.00	0.05	0.15	0.44	-0.30	-0.54	-0.45
RUS			0.17	0.25							
SVK	78.17	8.00	0.17	0.50			0.00	0.21	-0.89	-1.53	-0.28
SVN		8.00			6.40		0.08	0.34	0.67	-1.66	0.73
SWE	85.00	8.00	0.50	0.50		0.45	0.06	0.24	0.68	0.40	0.52
TUR	76.04		0.31	0.25			0.07	0.36			
USA		8.00	0.17	0.25	4.30	0.10	0.40	0.58	1.20	-0.89	-0.31
ZAF							0.23	0.59			

Note: Averages over 2012-2017 are shown. See Annex C for data description.

Annex F. Identified episodes of severe downturns

Countries	1960s	1970s	1980s	1990s	2000s
ARG					2000q2-2002q2
					2008q4-2009q3
					2011q4-2017q1
AUS	1960q3-1961q4	1971q1-1971q2	1981q4-1983q2	1991q1-1991q2	
		1974q1-1974q2			
		1975q3-1975q4			
AUT					2008q2-2010q1
BEL		1974q2-1975q1		1992q2-1993q1	2008q2-2009q2
BRA	1962q2-1963q2		1980q2-1981q4	1998q1-1999q4	2003q1-2003q2
			1987q2-1988q1		2008q4-2009q1
			1989q2-1990q3		2015q1-2016q4
CAN		1974q3-1975q1	1981q3-1982q4	1989q2-1992q2	2008q4-2009q2
CHE	1969q1-1969q2	1974q2-1976q2	1981q4-1982q4	1992q4-1993q1	2008q3-2009q2
CHL				1998q3-1999q2	2000q3-2009q2
CHN		1875q4-1976q4		1997q1	2006q2
COL				1998q2-1999q2	2015q1-2015q2
CZE				1990q3	2008q4-2009q2
				1991q1-1992q1	
DEU		1974q2-1975q2	1980q2-1982q4	1992q2-1993q4	2008q2-2009q1
DNK		1974q2-1975q1	1980q2-1981q1	1992q2-1993q1	2008q1-2009q2
ESP				1992q2-1993q2	2008q1-2013q2
FIN		1973q2	1980q4-1981q1	1990q2-1993q2	2008q1-2010q1
		1975q2-1975q4			2011q4-2013q1
FRA		1974q4-1975q3		1992q2-1993q1	2008q2-2009q2
GBR		1973q3-1976q2	1979q3-1981q1	1990q3-1992q2	2008q2-2009q3
GRC		1973q2-1974q1	1980q2-1983q1	1992q2-1992q4	2008q2-2014q3
			1986q2-1987q1		
HUN				1991q2-1993q1	2008q3-2010q1
IND				1996q1	
IRE					2007q2-2013q1
ICE	1967q1-1968q4		1982q2-1983q3	1999q2-1999q3	2002q1
			1987q4-1989q2		2003q2
					2004q2
					2005q1
					2005q4-2006q1
					2008q1-2011q1
ISR		1975q2-1977q2	1988q2-1989q2		2000q4-2003q3
ITA		1974q4-1975q2		1992q2-1993q3	2008q2-2009q2
		1977q1-1977q3			2011q2-2014q2

Note: Table continues on the next page. All growth rate are demeaned, i.e. country specific growth rates are substracted from the observed growth rate.
Source: OECD calculations

Annex F. Identified episodes of severe downturns *(cont.)*

Countries	1960s	1970s	1980s	1990s	2000s
JPN		1973q4			2001q2-2002q1
					2008q2-2009q1
KOR	1961q3-1962q2	1970q1	1988q2	1997q4-1998q2	2008q4-2009q2
	1963q2-1963q4	1979q3-1980q4			2017q4
	1964q2				
	1966q3-1966q4				
LTU					2008q3-2009q2
LUX		1974q2-1975q2		1996q1-1997q1	2001q2-2001q3
					2002q3-2003q1
					2007q4-2009q2
					2013q4
					2015q2-2016q2
LAT					2007q4-2009q3
MEX			1982q1-1983q2	1995q1-1995q2	2000q4-2002q2
					2008q3-2009q2
NLD	1962q4-1963q1	1974q4-1975q1	1980q1-1982q2		2008q3-2009q2
	1966q1-1966q2	1979q1			
NOR			1980q2-1980q4		2008q1-2009q1
			1987q3-1988q2		
NZL	1961q4-1962q1	1970q2-1970q4	1982q4-1983q1	1997q4-1998q2	2008q1-2009q2
	1962q4-1964q1	1971q4-1972q1	1989q3		2010q3-2011q1
		1972q3-1972q4			
		1973q2-1973q3			
		1974q4-1975q2			
		1977q1-1978q1			
POL				1990q2-1991q2	
				1996q4	
POR		1974q1-1975q3	1983q1-1984q2	1992q2-1993q1	2002q2-2003q3
					2008q1-2009q1
RUS				1995q4-1997q2	2008q3-2009q2
					2014q3-2015q1
SLK				1999q1-1999q4	2008q1-2008q3
					2009q1-2009q4
SLV				1990q1-1992q4	2008q3-2010q1
SWE		1976q2-1977q3		1990q2-1991q4	2008q1-2009q3
TUR	1960q2-1961q2	1979q2-1980q1	1988q1-1989q2	1990q3	2000q4-2001q4
	1965q1-1965q2			1991q1	2006q3
				1994q1	2007q2-2007q3
				1998q4-1999q4	2008q2-2009q1
					2016q3
USA		1973q3-1975q1	1979q4-1980q3	1990q3-1991q1	2008q1-2009q2
			1981q2-1982q4		
ZAF	1967q4-1968q3	1974q4-1975q1	1981q4-1983q2	1989q3-1992q3	2008q3-2009q3
	1969q4-1970q1	1976q2-1978q2	1984q3-1985q3		2015q2-2016q1

Note: All growth rate are demeaned, i.e. country specific growth rates are substracted from the observed growth rate
Source: OECD calculations

Annex G. Housing policies and resilience indicators

Business cycles (real GDP)	Duration (boom)	Duration (bust)	Trough-to-peak	Peak-to-trough	Strength of recovery	Time to recovery
LTV caps	1.0	1.2	**1.8**	-1.3	**2.0**	0.1
Capital requirements	-0.8	-0.6	-0.3	-1.5	**1.6**	0.7
Rent control	0.9	-0.4	0.1	1.0	-0.1	0.7
Tenure security	**-1.7**	-0.7	**-2.8**	**1.6**	-0.7	0.7
Social rental market	-0.2	-0.2	-0.9	0.7	-1.4	-0.4
Housing allowances	-0.5	-1.2	-1.3	1.4	**-2.3**	**-1.8**
Property taxe rate (owner)	**1.9**	0.8	0.2	0.9	-0.4	-0.3
Property taxe rate (rental)	-0.1	-0.8	**-1.7**	**1.9**	-0.2	**-1.9**
Urban sprawl restrictiveness	1.3	-0.7	**2.1**	0.4	**2.3**	-0.5
Densification restrictiveness	0.0	-0.4	0.1	0.6	0.5	-1.2
Zoning restrictiveness	-1.2	-0.6	-1.3	-0.3	**-1.9**	0.4
Deviation cycles (output gap)	**Duration (boom)**	**Duration (bust)**	**Trough-to-peak**	**Peak-to-trough**	**Strength of recovery**	**Time to recovery**
LTV caps	**1.6**	1.5	0.0	**-1.6**	1.3	-
Capital requirements	0.2	-0.5	1.5	-0.6	-0.9	-
Rent control	**-1.6**	1.0	-1.2	1.1	-0.8	-
Tenure security	0.1	1.0	0.1	0.1	0.0	-
Social rental market	0.3	0.7	-1.0	1.3	-0.8	-
Housing allowances	1.0	**-1.9**	-1.2	**2.1**	-1.4	-
Property taxe rate (owner)	0.1	0.3	**-2.2**	1.5	-1.4	-
Property taxe rate (rental)	1.0	1.2	-0.6	1.1	-0.5	-
Urban sprawl restrictiveness	-0.5	-0.9	0.0	0.1	1.3	-
Densification restrictiveness	0.7	0.3	-0.9	1.0	-1.5	-
Zoning restrictiveness	-1.1	**-2.8**	-1.5	0.9	-0.2	-
Housing investment cycles	**Duration (boom)**	**Duration (bust)**	**Trough-to-peak**	**Peak-to-trough**	**Strength of recovery**	**Time to recovery**
LTV caps	1.2	0.2	0.2	0.5	**-1.8**	1.1
Capital requirements	-1.0	-1.4	1.3	0.2	0.7	-1.0
Rent control	0.3	-0.2	1.3	-0.7	**1.7**	0.5
Tenure security	0.9	1.2	-0.2	**1.9**	0.1	0.3
Social rental market	0.4	1.0	**-1.7**	1.0	-1.3	0.3
Housing allowances	0.1	0.2	**-1.6**	1.1	-0.7	1.0
Property taxe rate (owner)	0.0	0.3	**-2.2**	1.4	**-2.1**	0.4
Property taxe rate (rental)	-0.1	-0.2	**-2.2**	**2.7**	-0.9	-0.9
Urban sprawl restrictiveness	0.7	-1.3	1.5	0.7	**2.1**	0.8
Densification restrictiveness	-0.6	-0.9	0.3	0.1	1.5	0.2
Zoning restrictiveness	**-1.9**	-0.1	-0.5	-0.9	-1.2	1.5
Real house price cycles	**Duration (boom)**	**Duration (bust)**	**Trough-to-peak**	**Peak-to-trough**	**Strength of recovery**	**Time to recovery**
LTV caps	1.2	-0.1	0.8	-0.2	1.5	-0.8
Capital requirements	-1.2	-1.1	-1.2	1.2	-0.4	-0.2
Rent control	0.6	0.1	1.4	-1.0	-0.8	**1.6**
Tenure security	1.1	0.3	**1.8**	-0.5	-0.9	0.9
Social rental market	1.4	0.4	1.6	-0.8	0.2	-0.3
Housing allowances	**1.8**	1.0	1.0	0.4	0.2	**1.8**
Property taxe rate (owner)	1.3	-0.4	0.2	0.0	-0.7	0.1
Property taxe rate (rental)	1.1	-0.7	0.8	0.5	-0.6	-0.2
Urban sprawl restrictiveness	0.0	**-1.7**	0.4	0.9	**2.8**	-1.2
Densification restrictiveness	-0.3	**-2.1**	-0.9	**2.4**	1.5	-0.3
Zoning restrictiveness	0.3	0.9	0.1	-0.5	-1.0	0.3

Note: Cycles are obtained by searching for turning point using the Harding-Pagan (quarterly Bry-Boschan) business cycle dating procedure (Harding and Pagan, 2002[4]). Each of the characteristics of the cycle (column) is regressed one-by-one on the policy variable (row) as observed at the peak. Pooled OLS regressions are used and t-statistics reported. Bold numbers indicate significance at the 10% level.