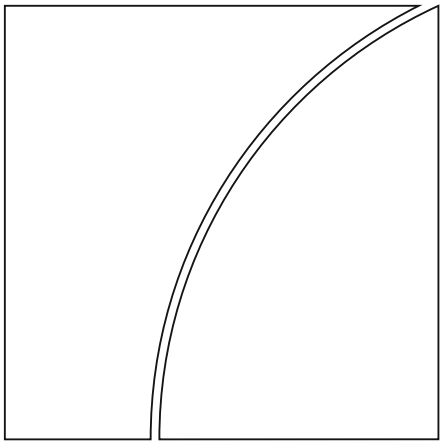


BANK FOR INTERNATIONAL SETTLEMENTS

BIS Working Papers

No 496

When is macroprudential policy effective?

by Chris McDonald

Monetary and Economic Department

March 2015

JEL classification: E58, G28

Keywords: loan-to-value limit, debt-to-income limit, housing credit, house-price-to-income ratio

BIS Working Papers are written by members of the Monetary and Economic Department of the Bank for International Settlements, and from time to time by other economists, and are published by the Bank. The papers are on subjects of topical interest and are technical in character. The views expressed in them are those of their authors and not necessarily the views of the BIS.

This publication is available on the BIS website (www.bis.org).

ISSN 1020-0959 (print)
ISSN 1682-7678 (online)

When is macroprudential policy effective?[1]

Chris McDonald[2]

Abstract

Previous studies have shown that limits on loan-to-value (LTV) and debt-to-income (DTI) ratios can stabilise the housing market, and that tightening these limits tends to be more effective than loosening them. This paper examines whether the relative effectiveness of tightening vs. loosening macroprudential measures depends on where in the housing cycle they are implemented. I find that tightening measures have greater effects when credit is expanding quickly and when house prices are high relative to income. Loosening measures seem to have smaller effects than tightening, but the difference is negligible in downturns. Loosening being found to have small effects is consistent with where it occurs in the cycle.

Keywords: loan-to-value limit, debt-to-income limit, housing credit, house-price-to-income ratio

JEL classification: E58, G28

[1] I would like to thank my colleagues at the BIS Hong Kong office, especially Frank Packer, Ilhyock Shim and James Yetman, for their helpful comments. I am also thankful to Paul Mizen and others at the University of Nottingham's Centre for Finance, Credit and Macroeconomics (CFCM) and the Money, Macro and Finance Research Group (MMF) conference in Nottingham in November 2014 for their comments. Steven Kong deserves a special mention for assisting me with collecting data.

[2] This paper was mostly completed while on Secondment at the Bank for International Settlements Representative Office for Asia and the Pacific in Hong Kong during 2014. Since then I have returned to the Reserve Bank of New Zealand. Email: chris.mcdonald@rbnz.govt.nz.

Introduction

Loan-to-value (LTV) and debt-to-income (DTI) limits have become increasingly popular tools for responding to house price volatility since the global financial crisis. Nonetheless, our understanding of the effects of these policies is uncertain. One aspect not well understood is how their effectiveness varies over the cycle. It is also not clear if the effects of tightening and loosening are symmetric. This paper seeks to address these issues by considering the effects of policy changes at different parts of the housing cycle. Then, controlling for this, I evaluate if the effects of tightening and loosening are symmetric or not.

There are at least two inter-related reasons for using macroprudential policies: (i) to create a buffer (or safety net) so that banks do not suffer overly heavy losses during downturns; and (ii) to restrict the build-up of financial imbalances and thereby reduce the risk of a large correction in house prices. Here I examine the relationship between changes in LTV and DTI limits and the build-up of financial imbalances. There is a growing group of economies that use macroprudential policies to target imbalances in their housing markets in this way. This analysis relies on the experience of these economies: many of which are from Asia, though the results are likely to be relevant to other economies as well.

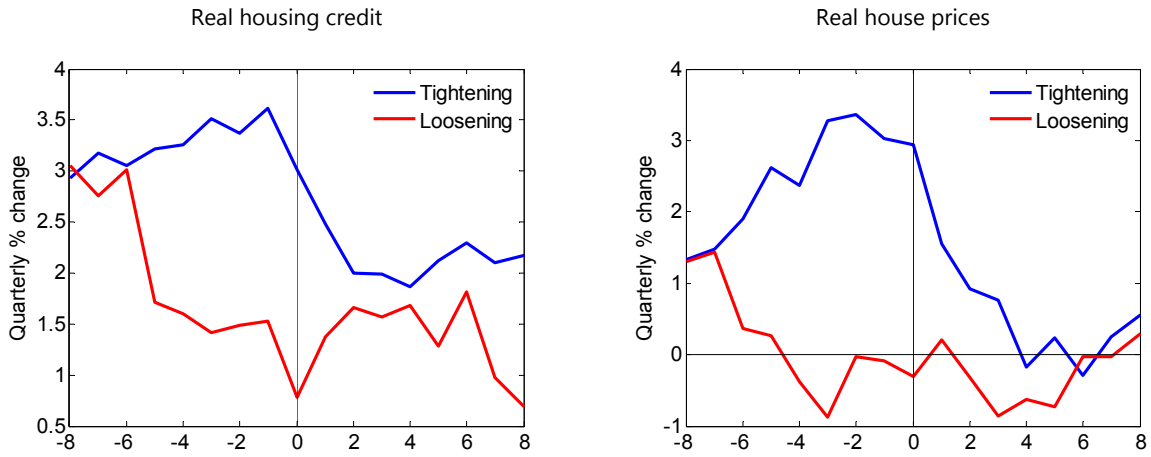
The literature on the effectiveness of macroprudential policies at taming real estate cycles has grown quickly since the 2008 financial crisis. For a wider discussion on the effectiveness of macroprudential policies, the background papers by the Committee on the Global Financial System (2012) and the International Monetary Fund (2013) provide a good overview. The consensus is that these measures can contain housing credit growth and house price acceleration during the upswing. Kuttner and Shim (2013) estimate the effects of a range of policy changes on housing credit growth and house price inflation across 57 economies. They find that tightening DTI limits reduces housing credit by 4 to 7 percent, while tightening LTV limits reduces housing credit by around 1 percent. Crowe et al (2011) also find evidence that LTV limits prevent the build-up of financial imbalances. They find that the maximum allowable LTV ratio between 2000 and 2007 was positively correlated with the rise in house prices across 21 economies.

Previous papers on the cyclical impacts of macroprudential policy look at the entire lifespan of policy, and not just around changes. Classaens et al (2013) use bank-level data from 2800 banks across 48 countries to consider if macroprudential policies can help reduce growth in bank vulnerabilities. They find that several macroprudential policies (including LTV and DTI limits) reduce growth in bank leverage, assets, and noncore-to-core liabilities during boom times, and that their effectiveness strengthens with the cycle. During downturns, the effects of LTV and DTI limits differ: LTV limits continue to reduce growth in bank assets and noncore-to-core liabilities, making the downturn worse, whereas DTI limits increase growth in these measures.[3] Research by the International Monetary Fund (2012) that uses country level data to examine the effectiveness of macroprudential policy finds that

[3] The authors suggest that LTV limits may have perverse effects during credit contractions because, as borrowers' net worth and income decline, strict LTV limits make it even harder for lenders to extend loans, possibly leading to further declines in house prices, and setting off a perverse cycle of even tighter LTV ratios.

LTV and DTI limits lower quarterly credit growth by between 0.6 and 1.0 percent in emerging market economies. They find little evidence that the effects are any different during recessions or credit busts.

Housing credit growth and house price inflation before and after policy changes Figure 1



Notes: This shows the mean quarterly growth of real housing credit and real house prices X-quarters before and after policy changes.

While the persistent (or long-run) effects of LTV and DTI limits are important, the shorter-term impact of changes to them may also be important for policymakers – ie to respond appropriately to current financial conditions. Loosening LTV or DTI limits may not simply reverse their long-run effects. Relaxing lending requirements may not lead to an expansion of credit if demand is weak. It would be useful to know if loosening measures are capable of stimulating mortgage lending, even in downturns, for example. Kuttner and Shim (2013) and Igan and Kang (2011) consider the effects of tightening and loosening LTV and DTI limits separately. Both papers find that loosening these policies does little to boost the housing market, whereas tightening them can reduce housing credit growth and house price inflation. The effects of tightening, and lack-of effects of loosening, can be seen by looking at mean real housing credit growth and mean real house price inflation before and after such changes – figure 1. When LTV and DTI limits have been tightened, quarterly credit growth has on average fallen by around 1.5 percent and quarterly house price inflation by around 3 percent. Loosening on the other hand seems to have had little or no effect on either housing credit or house prices.

One of the aims of this paper is to determine if loosening measures are ineffective because they are often implemented during downturns. In particular, I examine whether tightening and loosening measures have the same effect once you control for where in the cycle changes are made. The effects of changing LTV and DTI limits are estimated using the model outlined by Kuttner and Shim (2013) on data for 17 economies. This group of economies includes the most active users of macroprudential policy and, as a result, includes most of the changes to LTV and DTI limits that have occurred over the past two decades. The effects of policy changes are estimated on real housing credit growth and real house prices inflation. These estimates rely on a counterfactual: what would have happened without the policy change. This counterfactual is constructed using real interest rates, income

growth and assuming persistence in credit growth (or house price inflation). I estimate the effects of policy changes over the succeeding year, like Kuttner and Shim (2013), but I also compare before and after policy changes as an alternative measure. Accounting for what happens before policy changes seems to better account for endogeneity. For example, if surprisingly weak credit growth leads to a policy loosening it can seem as if the loosening contribute to the weakness, even though it was driven by something else. While allowing for persistence in the dependant variable partly accounts for this, any persistence in the residuals is not accounted for.

Another contribution of this paper is that I allow the effects of changes to LTV and DTI limits to vary across the cycle. I account for this by interacting the effects of policy changes with various cyclical measures, such as the house-price-to-income ratio. House-price-to-income ratios are common measures of housing affordability and are often used by regulators to measure financial imbalances. Intuitively, LTV and DTI limits should bind most when house prices are expensive relative to income. Higher house prices imply down payments take longer to accumulate, so fewer people can afford the deposit required to meet the LTV limit. Higher house prices also make the size of loans bigger so that DTI limits are more likely to be binding. Policy changes can also affect housing demand by changing expectations of future house prices, as shown by Igan and Kang (2011). Expectations might be more vulnerable to a negative shock when house prices are high. Other cyclical measures that I examine include annual housing credit growth and annual house price inflation. These measures may correlate with the effectiveness of LTV or DTI policies if, for example, lending standards are more stretched during booms.

The results suggest that tightening LTV and DTI limits tend to have bigger effects during booms. Several measures of the housing cycle correlate with the effects of changing LTV and DTI limits; annual housing credit growth and house-price-to-income ratios are some examples. Loosening LTV and DTI limits seems to stimulate lending by less than tightening constrains it. The difference between the effects of tightening and loosening is small in downturns though. This is consistent with loosening being found to have small effects because of where it occurs in the cycle.

Data

The starting point for this empirical analysis was collecting data for each economy. The data is categorised into two parts: LTV and DTI limits and other macro data.

LTV and DTI limits

The changes to LTV and DTI limits used in this analysis are from Shim et al (2013).[4] The full dataset covers 60 economies from 1990 to mid-2012. I have updated it to the end of 2013 for the 17 economies used in this analysis. This includes 11 economies from Asia-Pacific: Australia, China, Chinese Taipei, Hong Kong, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore, and Thailand. Six other active

[4] This macro-prudential policy database is available on the BIS website.

users of macroprudential policies are also included: Iceland, Denmark, Canada, Sweden, Latvia, and Norway. In the dataset, LTV limits have been tightened 54 times and loosened 21 times, and DTI limits have been tightened 20 times and loosened 5 times. Policy has been tightened three times as often as it has been loosened.

To estimate the effects of policy changes, I construct time series for LTV and DTI tightening and loosening measures for each country. Following the approach of Kuttner and Shim (2013), the time series are given values of 1 when policy is tightened (or loosened) and zero at other times. Four time series are constructed: a tightening and a loosening series for each of LTV and DTI policies. LTV policies include any changes to loan requirements relative to the value of the house on which the loan is issued. Loan prohibitions, such as loans to foreigners or for third homes, are thought of as zero LTV limits and therefore when they are implemented the LTV tightening series is given a value of 1 and when they are removed the LTV loosening series is given a value of 1. DTI requirements are those that limit the size, or the servicing cost, of a loan relative to the borrower's income. Not all tightening measures and loosening measures are equivalent. For example, LTV limits may only apply to second homes or in certain regions. Their effects may be quite different, reducing the statistical significance of key parameters in the regressions. However, the approach offers the advantage that it is simple and easily replicable.[5]

Other macro data

The effects of changes to LTV and DTI limits are estimated on real housing credit growth and real house price inflation. Housing credit data is sourced from CEIC, official statistics agencies, and central banks. House price indices are mainly sourced from CEIC and the BIS property price database. The control variables in the regression also come from a variety of sources. The short-term interest rates (which are mainly money market rates) and CPI data come from the International Financial Statistics (IFS) database produced by the International Monetary Fund. Household disposable income is proxied by real gross national income per capita from the World Bank (interpolated from annual to quarterly frequency).

Several cyclical measures are considered as possible indicators of the effectiveness of LTV and DTI policy changes: including, for example, annual housing credit growth and annual house price inflation. House-price-to-income ratios, both in absolute terms and relative to each economy's mean, are also considered.[6] House-price-to-income ratios are constructed in the following way. House prices are, where possible, in terms of median price per unit and are not necessarily the same as the house price indices used as the dependent variable. Measures based on housing transactions, such as the median house price, are more representative of what buyers are willing to pay and, therefore, may be more appropriate for considering the effects of LTV and DTI policies. For most Asian economies, the house price measures are for the capital city (or for a selection of major cities). These measures are more widely available and a large portion of housing credit

[5] By looking at the effects in the year after LTV and DTI changes, and not over their lifetime, the results focus on the ability of these policies to lean against the build-up of financial imbalances, rather than how they buffer the financial system in a downturn. There are some similarities between this and the use of monetary policy to lean against the business cycle.

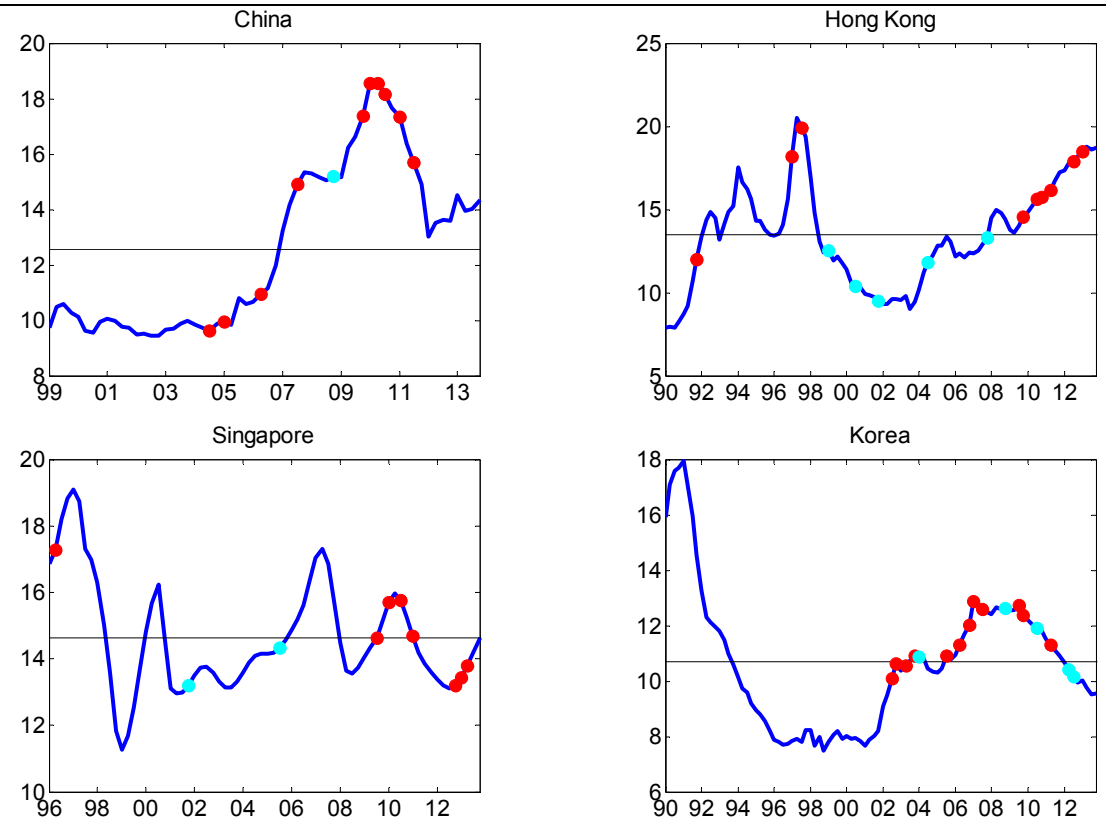
[6] When house-price-to-income ratios are relative to average they mainly capture cyclical movements within each economy, whereas in absolute terms they also capture differences between economies.

goes to borrowers in cities anyway. Gross household income, from household surveys undertaken by national statistics agencies, is the measure of income.[7]

House-price-to-income ratios for the four most active economies, in terms of LTV and DTI policy changes, are shown in figure 2. Red dots represent when LTV or DTI limits were tightened and light-blue dots show when LTV or DTI limits were loosened. The horizontal black line shows the average house-price-to-income ratio for the post-1990 sample. House-price-to-income ratios are currently high in many economies. The current ratio in Hong Kong SAR is the highest, at nearly 20 times the median income. The house-price-to-income ratio in China is also very high (at around 14) but is down from its peak of 18 in 2010.[8] The Asian financial crisis had a notable impact on these measures in Hong Kong and Singapore. House prices in Korea had already fallen by this stage, the result of a large correction in the early 1990s. House-price-to-income ratios in many developed economies are currently high relative to average: Australia, New Zealand, Sweden, Norway, and Canada are some examples – figure A1 in the appendix.

House-price-to-income ratios in economies actively setting LTV and DTI limits

Figure 2



Notes: Each red dot shows a tightening of LTV or DTI limits; each light-blue dot shows a loosening. House price measures are transaction based, either median or mean price per unit. Income measures are estimates of nominal household income.

[7] Where available, median house price and income measures are used and, if not, the mean is used. An alternative method would be to use official house prices indices and scale them to match the level of house prices.

[8] This house-price-to-income measure is the average for Beijing, Shanghai and Shenzhen.

Hong Kong SAR is probably the best example of an economy where macroprudential policy has been set in line with the house-price-to-income ratio. In the 1990s, rising house prices relative to incomes were met by tighter LTV limits. After the Asian financial crisis, these limits were eased on several occasions up until the 2008 financial crisis. Only since 2009, when house prices have once again become relatively expensive, has policy been tightened. Across the sample of 17 economies, house-price-to-income ratios have typically been above average when policy has been tightened and around average when policy has been loosened – table A1 in the appendix. Regulators look at many measures of financial imbalances though, so some policy changes appear to be at odds with the house-price-to-income ratio. For example, both Korea and China loosened lending requirements during the 2008 crisis, even though they had high house-price-to-income ratios at the time. Singapore has recently tightened policy even though house prices remain low relative to income.

Empirical specifications

This section outlines how the effects of changes to LTV and DTI limits are estimated over the cycle. The effects are estimated in a panel regression using data from 1990Q1 to 2014Q1, although for many economies the data starts later. The model is from Kuttner and Shim (2013). The dependent variables are real housing credit growth and real house price inflation.[9] The control variables, which account for other factors that influence the housing market, include real interest rates, real disposable income growth and the lagged dependent variable. Housing credit, house prices, and income are in terms of annualised quarterly percent changes. The following equation outlines the baseline regression for housing credit:

$$\Delta Credit_{j,t} = A_j + B(controls)_{j,t-i} + C(policy\ changes)_{j,t-i} + residual_{j,t} \qquad (1)$$

Economies are represented by subscript *j*, *t* represents time, and *i* represents lags on the control and policy variables.[10] Country-fixed effects allow for cross-country differences in average credit growth. The parameters in the model are estimated using generalised method of moments (GMM) as introduced by Arellano and Bover (1995) and Blundell and Bond (1998). The standard errors are robust.

Policy changes are lagged so that the correlation between credit growth and policy changes (C) is more likely to capture the effect of policy on credit and not policy responding to credit growth. If regulators set policy based on information not included in the model, and this information is relevant for future credit growth, the effects of policy changes could be under-estimated. For example, if regulators expect the housing market to weaken (as in the early stages of the global financial crisis) and loosened policy accordingly, it may look like the loosening contributed to the downturn. Including the lagged dependent variable in the regression helps control for past unexplained influences of credit growth.

[9] The range of housing credit data available for each country is in the appendix.

[10] One and two quarter lags of interest rates and income growth are included. Only the first lag of the dependent variable is included.

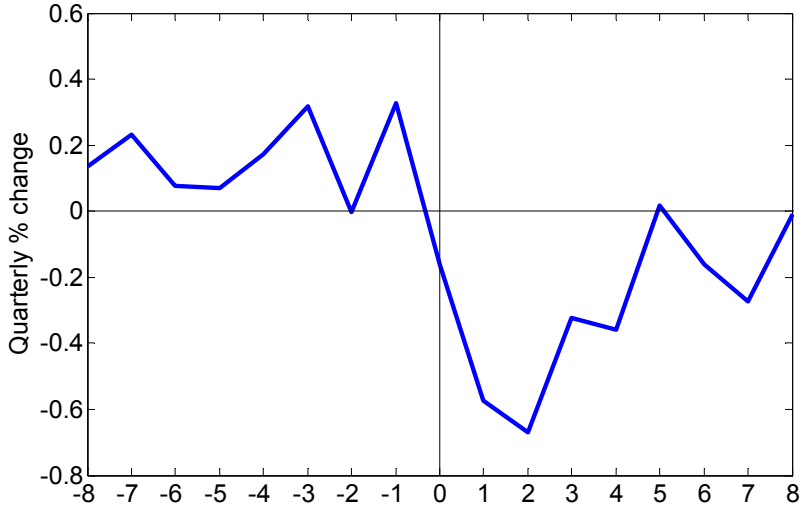
Kuttner and Shim (2013) came up a way to summarise the impacts of policy changes on credit, referred to as the four-quarter effect. This captures the effects of policy changes on the level of housing credit (or house prices) over the succeeding four quarters, accounting for the persistence in credit growth. This is defined as:

$$4Q\ effect = \frac{1}{4}[\gamma_{t+1}(1+\rho+\rho^2+\rho^3) + \gamma_{t+2}(1+\rho+\rho^2) + \gamma_{t+3}(1+\rho) + \gamma_{t+4}] \qquad (2)$$

where ρ is the coefficient on the lagged dependent variable and γ_i is the coefficient on the policy variable lagged i quarters.[11] A positive sign for the four-quarter effect implies a policy change increases the level of credit, whereas a negative sign implies a policy change reduces it.

I also estimate the difference between the four-quarter effects in years before and after policy changes as an alternative measure of their effects. Policy is usually tightened (or loosened) when credit has been surprisingly strong (weak). Figure 3 demonstrates this for tightening measures. It shows estimates for dummy variables placed 8 quarters before tightening measures through to 8 quarters after tightening measures. The estimated dummies are positive prior to tightening suggesting that credit growth is usually stronger than implied by the model. If lending requirements stayed the same, some of the preceding strength may be expected to continue and the effect of tightening may be larger than implied by Kuttner and Shim's four-quarter effect. The difference between the four-quarter effects in the years before and after policy changes – referred to as the before/after difference – assumes prior surprises will have continued and gives an upper bound for the effects of policy changes. The four-quarter effect from Kuttner and Shim (2013) provides the lower bound.

Dummy variable estimates before and after tightening measures — Figure 3



Notes: The regression includes the policy variable advanced up to 8 quarters, contemporaneously, and lagged up to 8 quarters.

[11] The delta method is used to calculate the standard errors.

I use two approaches to estimate the effects of policy changes over the cycle. First, I split policy changes into two groups for each cyclical indicator (a top half and a bottom half). The effects for the two groups are estimated using the following equation:

$$\Delta Credit_{j,t} = A_j + B(controls)_{j,t-i} + C(policy\ changes\ above\ X)_{j,t-i} + D(policy\ changes\ below\ X)_{j,t-i} + residual_{j,t} \quad (3)$$

The second way that policy changes are allowed to have different effects over the cycle is by interacting the policy change variable with the various cyclical measures, such as:

$$\Delta Credit_{j,t} = A_j + B(controls)_{j,t-i} + C(policy\ changes)_{j,t-i} + D(policy\ changes \times cycle)_{j,t-i} + residual_{j,t} \quad (4)$$

C is the effect of policy changes when the cyclical indicator is at zero, and D is how this effect changes with the cycle. The statistical significance of the interaction term determines if policy changes have different effects across the cycle. An assumption of this approach is that the effects of policy changes increase or decrease monotonically. Of these two approaches, splitting policy changes into two groups is simple and easy to understand, whereas including an interaction term is likely to be less sensitive to the small sample size.[12]

Results

The baseline regression shows the parameter estimates on the control variables. These control variables determine the underlying counterfactual from which the impacts of policy changes are calculated. The results from two regressions are shown in table 1: one on housing credit growth and the other on house price inflation. Housing credit growth and house price inflation both display persistence. Higher interest rates tend to reduce housing credit growth and house price inflation, while higher income growth increases them. The parameters are re-estimated in each regression in the remainder of the paper and, although they are not shown, their values are generally similar to those presented here.

The baseline regression also shows the average effects of LTV and DTI policy changes – as in Kuttner and Shim (2013). For each type of policy change, both the four-quarter effect and the before/after difference in four-quarter effects are displayed. The results suggest that tightening LTV limits has a bigger effect, reducing housing credit by 4 to 6 percent and reducing house prices by 5 to 9 percent. Tightening DTI limits seems to reduce housing credit by 2 to 3 percent and, while the point estimates are negative, they have an insignificant effect on house prices. These effects are different from Kuttner and Shim (2013); they find that tightening DTI limits has bigger effects than tightening LTV limits. The effects of

[12] One and two quarter lags of the cyclical indicators are added as additional control variables if they are not already included. Cyclical indicators are lagged one-quarter when they are interacted with policy changes or used to split the sample. This accounts for policy changes affecting the cyclical indicators immediately. For example, if tightening policy lowered annual credit growth immediately it might appear that bigger effects occur when annual credit growth is initially lower.

loosening LTV and DTI limits on both housing credit and house prices are not significantly positive.

Baseline regression — Table 1

Variables		Real housing credit growth	Real house price inflation
Real housing Credit growth {-1}		0.66*** (0.07)	
Real house price inflation {-1}			0.46*** (0.13)
Real interest rate {-1}		-0.33*** (0.06)	-0.39*** (0.09)
Real interest rate {-2}		-0.01 (0.10)	0.10* (0.08)
Real GNI per capita growth {-1}		0.36** (0.17)	0.96*** (0.32)
Real GNI per capita growth {-2}		-0.14 (0.16)	-0.51* (0.28)
Tightening measures			
LTV	4-quarter effect (after)	-3.88*** (1.23)	-4.67*** (1.17)
	Before/After difference	-6.32*** (1.83)	-9.80*** (1.95)
DTI	4-quarter effect (after)	-3.50** (1.25)	-0.10 (2.85)
	Before/After difference	-2.03 (1.93)	-3.70 (5.41)
Loosening measures			
LTV	4-quarter effect (after)	0.59 (2.20)	-3.93 (2.80)
	Before/After difference	-0.92 (1.87)	-2.38 (3.01)
DTI	4-quarter effect (after)	-5.25*** (1.84)	-3.08 (1.95)
	Before/After difference	-1.76 (2.02)	-3.63 (3.68)
Observations		1309	1450

Notes: Robust standard errors are in parenthesis. Standard errors for the four-quarter effects and the Before/After differences are constructed using the delta method. Lag length is shown in curly brackets. */**/*** represents statistical significance at the 10/5/1 percent levels. The effects of policy changes are jointly estimated, ie each column is a single regression.

Throughout the following analysis, LTV and DTI limits are grouped together in order to maximise the sample size, though as a robustness check their effects are separately estimated. Either grouped together or kept separate, the individual effects of changes to LTV or DTI limits at different times and in different countries will vary – some will be larger, others smaller and the magnitude may depend on many factors. Therefore, in the next section I consider if the timing of a policy change, ie where in the housing cycle the change occurs, is a determinant of its effectiveness.

Do the effects of LTV/DTI changes depend on the cycle?

In this section, I examine the effects of tightening measures and consider whether they are different depending on where they occur in the cycle. The comparison of tightening and loosening measures is left to the next section. These results show the

combined effects of tightening LTV and DTI limits on real housing credit; their individual effects are considered in a later section.

The first approach to examine if policy changes have different effects across the cycle is to split policy changes into two groups based on the preceding state of the cycle. For example, the threshold house-price-to-income ratio that splits the tightening observations into two similarly sized groups is 1.12 times each economy's average. Tightening measures above this threshold reduce the level of housing credit by between 3.4 and 5.5 percent over the following year. Tightening measures below this threshold reduce housing credit by 3 to 4 percent. This difference is small, but if we look at some of the other cyclical measures in table 2 the effects can be significantly different.

Effects of tightening measures on real housing credit over the cycle — Table 2

	4-qtr effect (after)			Before/After difference		
Cyclical variables	Bottom half	Top half	Difference	Bottom half	Top half	Difference
Housing						
HP-to-income relative to mean	-3.04*** (1.04)	-3.41*** (0.66)	-0.37 (1.26)	-4.06*** (1.16)	-5.49*** (1.56)	-1.43 (2.03)
Absolute HP-to-income ratio	-2.16* (1.23)	-4.15*** (0.55)	-1.99 (1.29)	-3.10** (1.54)	-6.30*** (1.51)	-3.20 (2.52)
Annual housing credit growth	-3.65*** (0.62)	-3.97*** (1.39)	-0.32 (1.45)	-2.79*** (0.61)	-8.04*** (1.55)	-5.25*** (1.53)
Annual house price inflation	-2.68** (1.10)	-2.80*** (0.60)	-0.12 (1.28)	-1.93** (0.80)	-6.33*** (1.41)	-4.40*** (1.34)
Housing credit gap	-2.56*** (0.94)	-2.80*** (0.95)	-0.24 (1.38)	-0.79 (1.39)	-6.49*** (1.39)	-5.70*** (1.86)
Other						
Annual CPI inflation	-3.32*** (0.82)	-4.06*** (0.99)	-0.74 (1.05)	-6.06*** (1.88)	-4.65*** (1.01)	1.40 (1.94)
Annual GNI growth	-2.87*** (1.01)	-4.84*** (0.72)	-1.97* (1.13)	-3.39*** (0.77)	-7.22*** (1.29)	-3.83*** (1.19)
GNI gap	-3.61*** (0.93)	-3.91*** (1.01)	-0.30 (0.89)	-3.50*** (0.79)	-6.52*** (1.86)	-3.01* (1.60)
Real interest rate	-4.43*** (1.05)	-2.99*** (1.07)	1.45 (1.50)	-6.59*** (1.56)	-3.06*** (1.28)	3.53* (2.09)

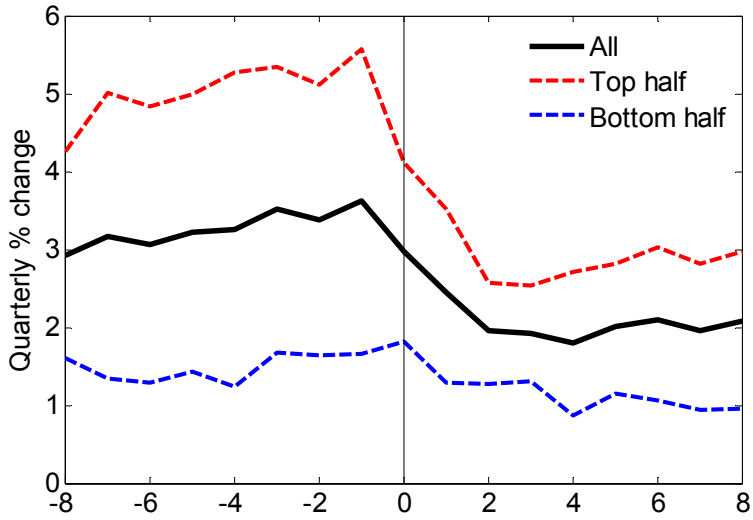
Notes: Standard errors in parenthesis. */**/*** represents statistical significance at the 10/5/1 percent levels. The gap measures are in terms of percent deviations from HP-filtered trends, where lambda is set to 1600. The cyclical variables are added as controls to the regression if they are not there already.

The first thing to note is that for most of the cyclical indicators the top half have bigger effects than the bottom half. The differences are bigger and more significant when looking at the before/after difference, but they are in the same direction for the four-quarter effects as well. The cyclical measures that seem to correlate with different effects are annual housing credit growth, annual house price inflation, the housing credit gap and annual GNI growth. Based on prior annual credit growth, the top half of tightening measures reduce the level of credit by 4 to

8 percent while the bottom half reduce it by around 3 percent. This suggests that when credit grows quickly it tends to be affected more by tightening measures.

Figure 4 illustrates this slightly differently. It shows mean housing credit growth before and after tightening measures and splits tightening measures into the top half and bottom half based on the preceding annual credit growth. By construction the top half have stronger credit growth before tightening than the bottom half. The black line shows that, on average, tightening measures are preceded by around 3.5 percent quarterly credit growth and followed by around 2 percent quarterly credit growth. The decline is biggest for tightening measures with the highest rates of preceding annual credit growth, with mean quarterly credit growth falling from nearly 5 percent to around 2.5 percent. Conversely, when preceding credit growth was lower, the mean growth rate started between 1 and 2 percent and barely fell at all.[13] Even with this simple approach, the effects of tightening seem to be bigger when preceding credit growth is stronger.

Mean real housing credit growth before and after policy tightening — Figure 4



Notes: Top half is when annual housing credit growth was above 10.8 percent at t-1.

Another approach is where the effects of tightening measures are interacted with various cyclical indicators. This can also tell us if tightening measures have bigger or smaller effects depending on the preceding state of the cycle. Table 3 displays the results for both the interactions with the four-quarter effects and with the Before/After difference. A negative sign on an interaction term implies the effects are bigger during booms.

[13] Credit growth seems to increase in the quarter immediately before tightening when credit growth is initially strong – perhaps reflecting buyers rushing in to get loans – something not seen when credit growth is initially slower.

Interactions between tightening effects on credit and cyclical measures Table 3

Cyclical variables	Interaction with 4-qtr effect	Interaction with Before/After difference
Housing		
HP-to-income relative to mean	-1.72 (3.81)	-9.59 (6.95)
Absolute HP-to-income ratio	-0.31** (0.14)	-0.49* (0.27)
Annual housing credit growth	-0.03 (0.03)	-0.37*** (0.05)
Annual house price inflation	-0.05 (0.06)	-0.34*** (0.06)
Housing credit gap	-0.02 (0.12)	-0.95*** (0.18)
Other		
Annual CPI inflation	-0.51 (0.43)	-0.57 (0.83)
Annual GNI growth	-0.30* (0.17)	-0.56*** (0.19)
GNI gap	-0.11 (0.30)	-0.72* (0.36)
Real interest rate	0.34 (0.41)	0.53 (0.51)

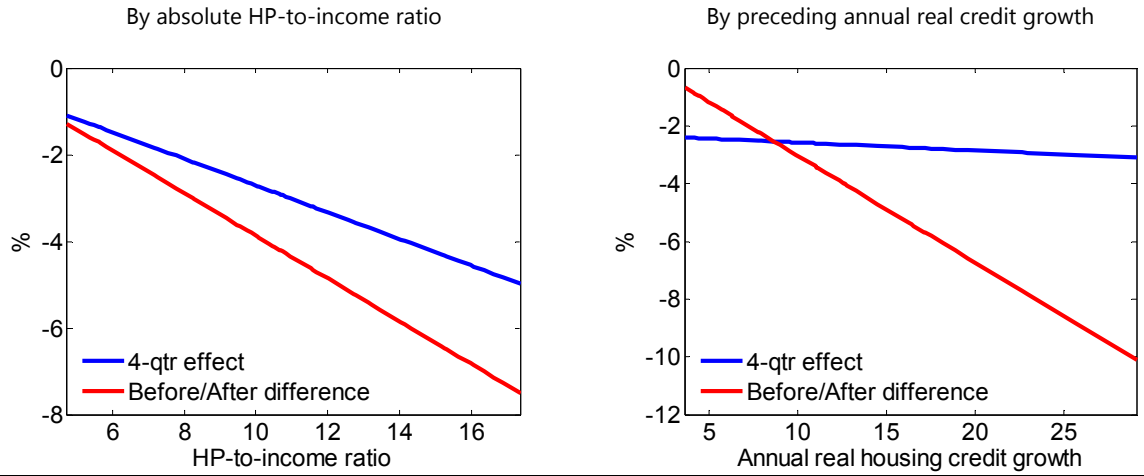
Notes: Standard errors in parenthesis. */**/*** represents statistical significance at the 10/5/1 percent levels. The gap measures are in terms of percent deviations from HP-filtered trends, where lambda is set to 1600.

Almost all of the interaction terms are negative implying tightening measures are more effective during expansionary phases. Further, the interaction terms between the before/after difference and the absolute house-price-to-income ratio, annual housing credit growth, annual house price inflation, the housing credit gap and annual GNI growth are significantly negative. The four-quarter effect from tightening when the absolute house-price-to-income ratio is 10 is 1.5 percentage points larger than when the ratio is 5. Similarly, the before/after difference is 2.5 percentage points bigger when the house-price-to-income ratio is 10 compared to 5. At high absolute house-price-to-income ratios tightening measures reduce credit by roughly 4 to 6 percent. At low absolute house-price-to-income ratios the effects of tightening are more like 2 percent. This suggests the effects of LTV and DTI limits in places like Singapore, Hong Kong and China may be larger than they are in most developed countries which have lower house-price-to-income ratios.

Figure 5 illustrate the different effects of tightening measures across the cycle – both in terms of the absolute house-price-to-income ratio and in terms of the preceding rate of annual housing credit growth. The effects of tightening are larger at higher house-price-to-income ratios and when preceding credit growth is faster, though there is some inconsistency with the different approaches for credit growth. The before/after difference assumes that the strength prior to tightening would have continued, whereas the four-quarter effect ignores it. If tightening had not occurred then some, but perhaps not all, of this strength would have continued.[14] The likely effect of tightening is, therefore, somewhere between the four-quarter effect and the before/after difference. This also suggests that tightening may have bigger effects when credit growth is initially stronger – consistent with what we saw in figure 4.

[14] The own lag captures the persistence of credit growth but not any persistence in the underlying residuals.

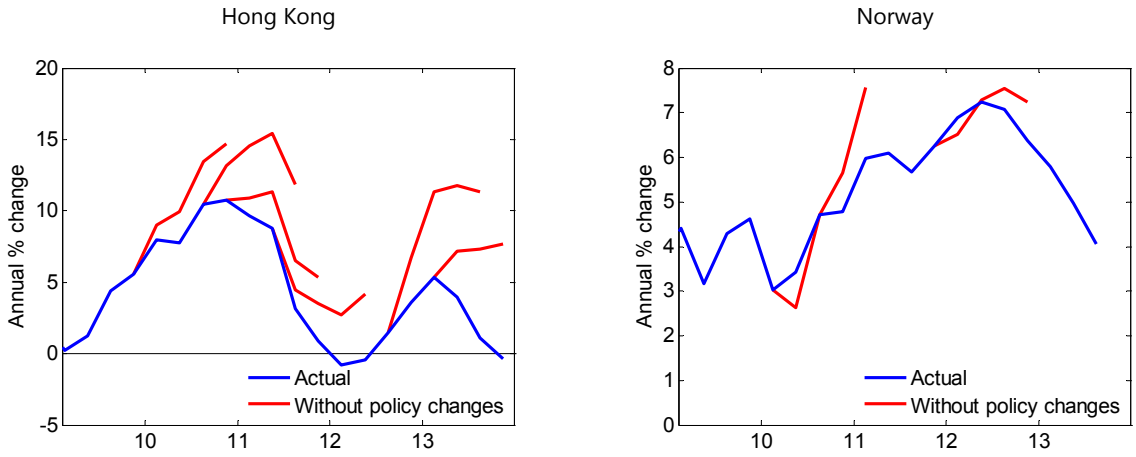
Effects of tightening measures on real housing credit over the cycle Figure 5



Notes: The range of the x-axis is set to include the middle 80 percent of tightening measures.

To address the economic significance of these results, I calculate what credit growth would have been if Hong Kong SAR and Norway had not tightened LTV and DTI lending requirements since 2008 (figure 6). I allow the effects of tightening measures to depend on the preceding house-price-to-income ratio using the interaction approach. The blue line shows observed housing credit growth and the red lines show what would have happened in the years following policy changes if tightening measures had not occurred. These plots are based on the estimated four-quarter effect in years following policy tightening, not the before/after difference. When the house-price-to-income ratio is high, as it has been in Hong Kong, changing LTV and DTI limits has substantial effects on housing credit according to the model estimates. Policies implemented in 2012Q3 and 2013Q1 each lowered credit growth by more than 5 percent in the year following their implementation. As a result, credit growth was nearly zero at the end of 2013. The effects in Norway are quite different. Tightening measures taken there did little to reduce credit growth because they occurred at low house-price-to-income ratios. This suggests the effects of tightening lending standards can be large and variable.

Effects of tightening on real housing credit in Hong Kong and Norway Figure 6



Notes: The red lines show implied credit growth if tightening had not occurred. The effects are estimated for only 1 year after each tightening measure. Tightening measures include changes to both LTV and DTI limits.

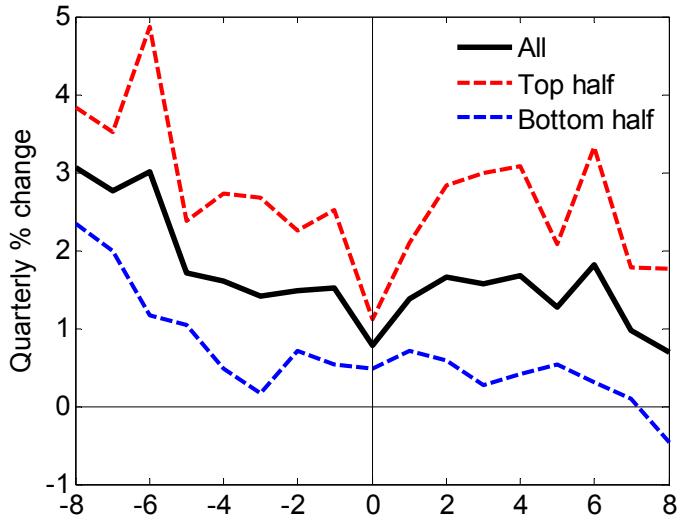
Are tightening and loosening measures symmetric?

The baseline regression showed that the effects of loosening LTV and DTI limits were insignificant – not an uncommon finding. As mentioned in the introduction, both Kuttner and Shim (2013) and Igan and Kang (2011) also find that loosening has insignificant effects. I examine in this section whether the effects of tightening and loosening measures are different because of where they occur in the cycle. The previous section showed that the effects of tightening during weaker parts of the cycle were smaller than during booms. We also know that loosening measures tend to occur more often during downturns; maybe this is why loosening measures have been found to have little effect.

Figure 7 shows mean quarterly credit growth before and after loosening measures, separating them by prior annual credit growth. The top half includes the 13 loosening measures preceded by annual credit growth above 7 percent and the bottom half are the 13 measures preceded by credit growth below 7 percent. By construction, the top half have higher quarterly credit before loosening than the bottom half (2.5 percent compared to 0.5 percent). In contrast to tightening, there is no clear change in credit growth after loosening. Credit growth tends to be stronger after loosening when it was stronger before loosening and weaker after loosening when it was weaker before. [15] Table 4 displays the estimated effects of loosening measures more formally. To compare their effects at different parts of the cycle I split them by the absolute house-price-to-income ratio, annual credit growth and annual GNI growth.

[15] One thing that might suggest loosening has a stimulatory effect is that average credit growth declines in the quarter that loosening occurs, particularly when credit growth had previously been strong (figure 7). This decline is not accounted for in table 4, as it only looks at before and after loosening.

Mean real housing credit growth before and after policy loosening Figure 7



Notes: "Top half" includes the 13 loosening measures when annual credit growth was above 7 percent in the quarter just before tightening (t-1). The "bottom half" are those preceded by annual credit growth below 7 percent.

Effects of loosening measures on real housing credit by cyclical measures Table 4

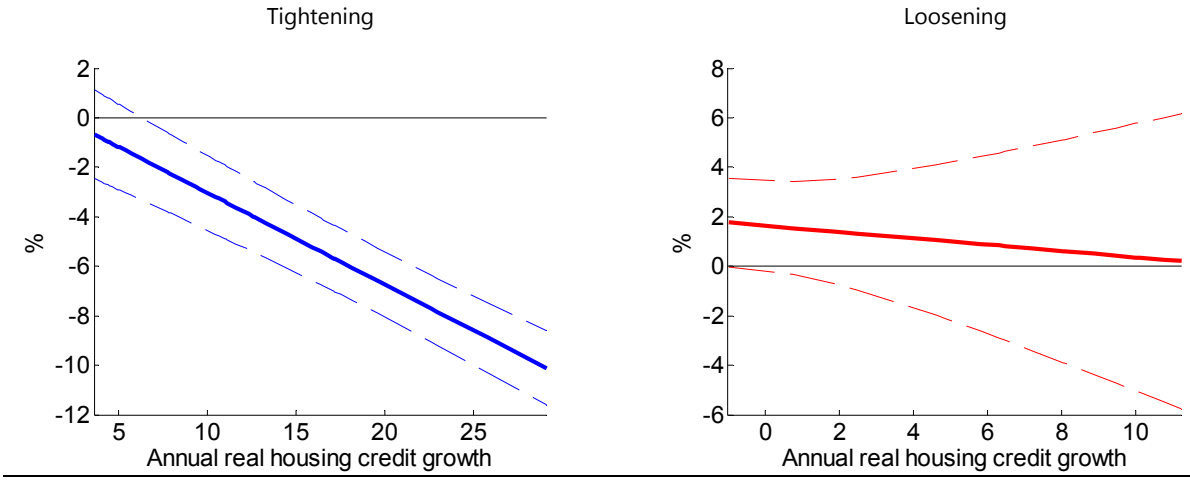
	4-qtr effect (after)			Before/After difference		
Cyclical variables	Bottom half	Top half	Difference	Bottom half	Top half	Difference
Absolute HP-to-income ratio	2.00 (2.31)	-0.15 (2.65)	-2.15 (3.77)	-0.06 (2.05)	1.38 (3.14)	1.44 (3.87)
Annual housing credit growth	-3.09*** (0.86)	5.12** (2.57)	8.21*** (2.84)	1.75 (1.17)	1.90 (3.48)	0.15 (3.45)
Annual GNI growth	2.04 (2.34)	-0.60 (2.41)	-2.65 (2.34)	2.78 (2.52)	0.81 (2.71)	-1.97 (3.50)

Notes: Standard errors in parenthesis. */**/*** represents statistical significance at the 10/5/1 percent levels.

This table highlights a flaw in the four-quarter effect measure and helps to demonstrate why I've included the before/after difference as an alternative. The four-quarter effects for the top half and bottom half of loosening measures by prior annual credit growth are very different. The four-quarter effect is significantly negative when credit growth was previously weak, whereas it is significantly positive when credit growth was previously strong. This reflects what is shown in figure 7, that weak credit growth prior to loosening is matched by weak credit growth after loosening. The four-quarter effect, therefore, suggests that when credit is weak loosening makes the downturn worse. This is almost certainly not the actual impact of loosening lending standards. By subtracting the four-quarter effect prior to loosening, the before/after difference may be a better measure of the effect of loosening policy. The before/after differences are almost all positive, though not significantly so, and are similar at different parts of the cycle. This measure suggests that loosening increases the level of housing credit by 0-3 percent. These effects are difficult to disentangle though and not that consistent.

With tightening and loosening measures, one way to compare like-with-like is to estimate their effect at equivalent parts of the cycle. Figure 8 shows the estimated effects of loosening compared with those of tightening, given various rates of preceding credit growth (by interacting annual credit growth with policy changes). These effects are based on the difference between the four-quarter effects in years before and after policy changes (the before/after difference). When preceding annual credit growth is low, say below 10 percent, the point estimates suggest loosening raises the level of credit by 1-2 percent while tightening has a negative effect of about the same size. There are few loosening measures available with strong credit growth so it is difficult to get a read of their effects. So are tightening and loosening measures symmetric? It seems that at least some of the difference between the estimated effects of tightening and loosening could be because of where they occur in the cycle. Loosening occurs during downturns when, in general, changes to lending standards have relatively small effects.

Tightening and loosening effects by prior annual real housing credit growth — Figure 8



Notes: Effects are calculated between the 10th and 90th percentiles of annual credit growth from quarters when policy was tightened or loosened. The dashed lines show the 90 percent confidence intervals, where standard errors are calculated using the delta method. The effects are based on the before/after difference, ie the four-quarter effect in the year after minus the four-quarter effect in the year before.

Robustness

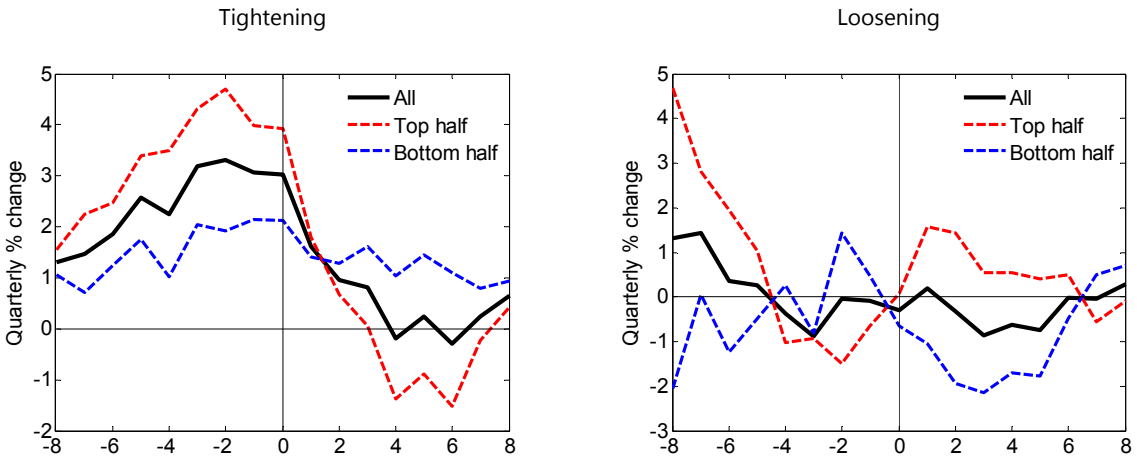
I test if the results are sensitive to two variations of the model: (i) replacing housing credit with house price inflation as the dependent variable and (ii) estimating the effects of LTV and DTI changes separately.

House prices

The effects of policy changes on house prices lead to similar conclusions to those found using housing credit. Figure 9 shows that mean house price inflation before and after policy changes, with changes split based by preceding annual credit growth. House price inflation tends to be around 3 percent before tightening and around zero before loosening. Quarterly house price inflation tends to fall following tightening measures and the decline is largest for those measures preceded by high

credit growth – similar to the effects on credit. Loosening measures cause little change in mean house price inflation, in line with loosening having little or no effect on house prices. When splitting loosening measures by prior credit growth the effects appear to diverge.

Mean house price inflation before and after policy changes by prior credit growth Figure 9



Notes: The top and bottom halves are split based on the preceding rate of annual credit growth.

Table 5 shows the estimated effects of policy changes on house prices, with policy changes split by house-price-to-income ratios and annual housing credit growth. Tightening measures have significant negative effects on house prices and these effects are larger at higher house-price-to-income ratios and when prior annual credit growth is stronger. The differences are largest given differences in preceding annual credit growth. Tightening reduces house prices by 6-12 percent when credit growth is strong and by 2-4 percent when credit growth is weak. The effects of loosening measures on house prices are varied but mostly insignificant. There are few loosening observations available and the standard errors are large.

Effects of policy changes on real house prices Table 5

	4-qtr effect (after)		Before/After difference	
Cyclical variables	Bottom half	Top half	Bottom half	Top half
Tightening				
Absolute HP-to-income ratio	-1.99* (1.10)	-2.67** (1.27)	-6.92*** (2.40)	-8.31*** (2.50)
Annual housing credit growth	-1.61** (0.70)	-5.77*** (1.92)	-4.02** (1.96)	-12.23*** (2.31)
Loosening				
Absolute HP-to-income ratio	-6.51 (4.52)	0.56 (1.73)	-3.51 (3.95)	1.96 (2.66)
Annual housing credit growth	-5.23** (2.35)	1.29 (2.24)	-6.54 (4.03)	9.84** (3.80)

Notes: Standard errors in parenthesis. */**/*** represents statistical significance at the 10/5/1 percent levels.

Individual effects of LTV and DTI limits

The individual effects of changing LTV and DTI limits on credit growth are summarised in table 6. Tightening LTV and DTI limits have similar effects. At higher house-price-to-income ratios and stronger prior credit growth the effects are greater, especially when looking at the before/after difference. During upturns tightening LTV limits seem to reduce the level of credit by 4 to 9 percent, whereas during downturns they reduce credit by around 2 to 5 percent. Tightening DTI limits also seems to have bigger effects given higher house prices and faster credit growth: 6 to 8 percent during upturns compared to 0 to 6 percent during downturns.

LTV loosening measures raise the level of credit by 0-2 percent, according to the before/after difference, suggesting loosening may have small positive effects. The effects of loosening though do not seem to be different at stronger or weaker parts of the cycle. The effects of loosening LTV limits seem, if anything, low compared to the tightening measures, even compared to tightening measures in downturns (ie the bottom half). The standard errors are large though, so their effects are quite uncertain.

Individual effects of policy changes on real housing credit — Table 6

	4-qtr effect (after)		Before/After difference	
	Bottom half	Top half	Bottom half	Top half
Tightening LTV				
Absolute HP-to-income ratio	-2.41 (1.80)	-4.73*** (0.76)	-4.83** (2.21)	-8.08*** (2.04)
Annual housing credit growth	-5.28*** (0.79)	-4.11** (1.79)	-4.80*** (1.25)	-9.09*** (2.13)
Tightening DTI				
Absolute HP-to-income ratio	-2.52*** (0.83)	-6.92*** (0.62)	-0.29 (1.45)	-8.58*** (1.37)
Annual housing credit growth	-6.61*** (1.63)	-5.97*** (1.47)	-4.54*** (1.00)	-7.10*** (2.36)
Loosening LTV				
Absolute HP-to-income ratio	2.68 (2.92)	1.60 (3.13)	0.95 (2.34)	0.31 (4.93)
Annual housing credit growth	-3.58*** (1.35)	5.67** (2.63)	2.13 (1.51)	0.28 (3.73)

Notes: Standard errors in parenthesis. */**/*** represents statistical significance at the 10/5/1 percent levels. Loosening DTI limits are not split into two groups because there are only five observations available – the results for these five are available in table 1.

Conclusion

By looking at 100 policy adjustments across 17 economies, I find that changes to LTV and DTI limits tend to have bigger effects when credit is expanding quickly and

when house prices are relatively expensive. Tightening measures (such as lowering the maximum LTV ratio) during upturns lower the level of housing credit over the following year by 4-8 percent and the level of house prices by 6-12 percent. Conversely, during downturns they reduce housing credit by 2-3 percent and house prices by 2-4 percent. This is consistent with the finding of Classeans et al (2013): that the persistent (or long-run) effects of LTV and DTI limits increase with the intensity of the cycle.

Several measures of the housing cycle correlate with the effects of changes to LTV and DTI limits. Stronger credit growth before tightening is associated with bigger effects. While there might be several reasons for this, one explanation is that lending is available to more marginal borrowers during booms. High house-price-to-income ratios are also correlated with bigger tightening effects. Limits on LTV and DTI ratios appear to become more constraining when houses are expensive. This may be an important element for explaining cross-country differences in the effectiveness of macroprudential policies, given that house-price-to-income ratios can differ substantially.

Tightening LTV and DTI limits appears to be more effective than loosening them, as found in past research. In downturns, ie when credit growth is weak and house prices are relatively cheap, tightening reduces the level of housing credit by around 2-3 percent and loosening raises it by 0-3 percent. Given the bounds of uncertainty, these are not that different – consistent with loosening having small effects because it usually occurs during downturns.

References

Arellano, M and O Bover (1995): "Another look at the instrumental-variable estimation of error-components models," *Journal of Econometrics* 68, pp 29-52.

Blundell, R and S Bond (1998): "Initial conditions and moment restrictions in dynamic panel data models," *Journal or Econometrics* 87, pp 115-143.

CGFS (2012): "Operationalising the selection and application of macroprudential instruments," *CGFS Papers,* 48, December.

Claessens, S, S Ghosh and R Mihet (2013): "Macro-prudential policies to mitigate financial system vulnerabilities," *Journal of International Money and Finance*.

Crowe, C, G Dell'Ariccia, D Igan and P Rabanal (2011): "How to Deal with Real Estate Booms: Lessons from Country Experiences," *IMF Working Paper* 11/91.

Igan, D and H Kang (2011): "Do Loan-to-Value and Debt-to-Income Limits Work? Evidence from Korea," *IMF Working Paper* 11/297.

IMF (2012): "The interaction of monetary and macroprudential policies – background paper," December 27.

IMF (2013): "Key aspects of macroprudential policy – background paper," June 10.

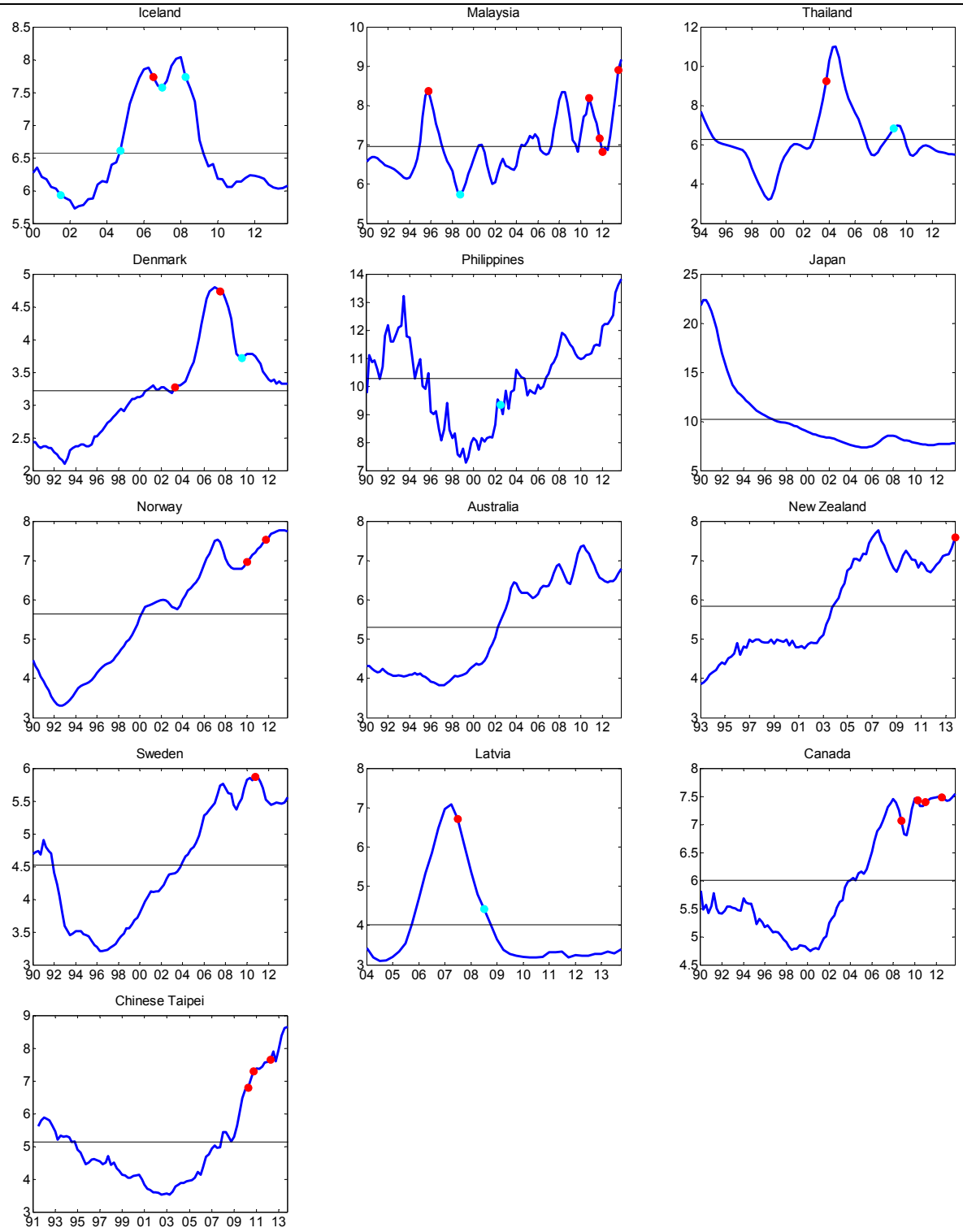
Kuttner, K and I Shim (2013): "Can non-interest rate policies stabilise housing markets? Evidence from a panel of 57 economies," *BIS Working Paper* 433.

Shim, I, B Bogdanova, J Shek and A Subelyte (2013): "Database for policy actions on housing markets," *BIS Quarterly Review,* September, pp 83-95.

Appendix

HP-to-income ratios and changes to LTV and DTI limits

Figure A1



Notes: Red dots are in quarters when LTV or DTI policies were tightened and light-blue dots when these policies were loosened. The black horizontal line shows the average house-price-to-income ratio over the sample.

Summary statistics: Policy changes relative to HP-to-income ratios

Table A1

Policy change		Observations	Median	10th percentile	90th percentile
Tightening	LTV	54	1.18	0.90	1.43
	DTI	20	1.16	0.91	1.35
Loosening	LTV	21	0.98	0.80	1.18
	DTI	5	1.04	0.95	1.18

Notes: This table shows the median, 10th percentile and 90th percentile for the house-price-to-income ratio (relative to mean in each country) from quarters when LTV and DTI limits were changed.

Summary statistics of regression variables

Table A2

Variable	Obs	Mean	SD	Max	Min
Real housing Credit growth	1425	9.0	11.8	77.4	-26.1
Real house price inflation	1469	2.4	13.5	72.5	77.8
Real short-term interest rate	1866	2.5	6.1	76.7	-70.5
Real GNI per capita growth	1898	2.8	4.8	23.8	-44.7
HP-to-income ratio (relative to average)	1525	1.0	0.2	2.2	0.5

Notes: Growth rates are annualised quarter-on-quarter changes. The real interest rate is deflated using the annualised quarterly percent change in the CPI.

Range of real housing credit growth data by country

Table A3

Country	Start	End	Country	Start	End
Australia	1990Q1	2013Q4	Thailand	1992Q1	2014Q1
China	2001Q2	2013Q4	Chinese Taipei	1992Q1	2014Q1
Hong Kong	1990Q1	2013Q4	Iceland	1992Q1	2014Q1
Japan	1990Q1	2013Q4	Denmark	2000Q4	2013Q3
Korea	1996Q1	2013Q4	Canada	1990Q1	2014Q1
Malaysia	1997Q1	2014Q1	Sweden	2002Q1	2014Q1
New Zealand	1991Q2	2014Q1	Latvia	2003Q4	2013Q4
Philippines	1997Q2	2013Q4	Norway	1990Q1	2013Q3
Singapore	1990Q1	2013Q4			

Notes: Housing credit data comes from a variety of places: CEIC, national statistics offices, and central banks. I have tried to use mortgage credit data but in a couple of economies, like Norway, I have had to use total household credit. Nominal series have been deflated using the consumer price index.