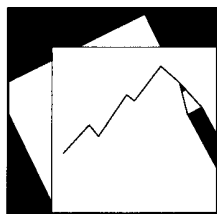


# Working Paper

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INTERNATIONAL MONETARY FUND



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## Do Loan-to-Value and Debt-to-Income Limits Work? Evidence from Korea

*Deniz Igan and Heedon Kang*

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## **IMF Working Paper**

Research Department and Monetary and Capital Markets Department

### **Do Loan-to-Value and Debt-to-Income Limits Work? Evidence from Korea**

**Prepared by Deniz Igan and Heedon Kang<sup>1</sup>**

Authorized for distribution by Stijn Claessens and Karl Habermeier

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### **Abstract**

With another real estate boom-bust bringing woes to the world economy, a quest for a better policy toolkit to deal with these boom-busts has begun. Macroprudential measures could be in such a toolkit. Yet, we know very little about their impact. This paper takes a step to fill this gap by analyzing the Korean experience with these measures. We find that loan-to-value and debt-to-income limits are associated with a decline in house price appreciation and transaction activity. Furthermore, the limits alter expectations, which play a key role in bubble dynamics.

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## I. INTRODUCTION

The financial crisis of 2007-08 brought real estate boom-bust cycles to the fore of policy discussions and academic circles. What triggered the illiquidity and, ultimately, solvency problems in the financial sector that rocked the markets and brought the global economy to the brink was the downturn in the U.S. residential real estate. During the boom years, first-time buyers (and sometimes speculators) had taken advantage of the relaxation in lending standards to obtain loans with little down-payment requirements and back-loading features such as negative amortization schemes. Existing homeowners also utilized the easy credit conditions as refinancing activity, frequently with cash-out options, picked up. When house prices started to fall, an increasing number of homeowners, including not only speculators but also owner-occupiers, were quickly pushed to the negative-equity territory. Defaults increased as strategic default incentives kicked in and homeowners facing difficulty to afford their mortgage payments because of interest rate resets were unable to refinance. Losses reflected in loan portfolios carried over to the valuation of mortgage-backed securities. Unconventional policy measures were taken to provide liquidity and, soon after, to ensure survival of key financial institutions.

Prior to the crisis, when it came to dealing with asset price booms, the widely-accepted tenet was one of ‘benign neglect’, namely, to wait for the bust and pick up the pieces (Bernanke and Gertler, 2001). Yet, the crisis and its formidable costs shifted the balance to the opposite camp favoring pre-emptive policy actions that could stop bubbles or, at least, could contain the damage to the financial sector and the broader economy when the bust comes. In other words, many policymakers now think that it is better to act than wait on the sidelines because the cost of inaction may greatly exceed the potential negative side effects of policy intervention. But, many still agree that monetary policy is too blunt a tool to be the best response (Posen, 2009). Then, in the quest to better design the policy toolkit to deal with real estate booms and busts, macroprudential tools such as maximum limits on loan-to-value ratios (LTV) and debt-to-income ratios (DTI) are heavily advocated (see Crowe et al., 2011a, on pros and cons of various policy options). This has led several countries to recently adopt such limits or measures that would discourage high-LTV/DTI loans (Table 1; also see Crowe et al., 2011b, and IMF, 2011, for a summary of specific country cases on macroprudential measures).

But, especially from an empirical perspective, we know little about the impact of these measures that have become popular with many regulators after the crisis. Theoretically, limits on LTV and DTI can kill two birds with one stone: they can curb the feedback loop between mortgage credit availability and house price appreciation, and, by restraining household leverage, they can help reduce the incidence and loss given default of residential mortgage loan delinquencies. These mechanics are at work in many theoretical models such as the one in, for instance, Ambrose et al. (1997) and, more recently, in Allen and Carletti (2010). Econometric analyses analyzing their effects, however, have been relatively lacking. Lament and Stein (1999) and Almeida et al. (2006) provide evidence that economic activity is more sensitive to house price movements if LTV is higher. Duca et al. (2010) estimate that a 10-percentage-point decrease in LTV of mortgage loans for first-time buyers is associated with a 10 percentage point decline in house price appreciation rate. Crowe et al. (2011b) confirm the positive association between LTV at origination and subsequent price

appreciation using state-level data in the U.S. Wong et al. (2004) argue that, in Hong Kong SAR, losses in the financial sector in the wake of the Asian crisis were limited because of low LTVs, in line with the finding that LTV at origination is an important determinant of loan default (see, for instance, Avery et al., 1996). Wong et al. (2011) present some cross-country evidence, at the aggregate level, that low LTVs can reduce delinquencies in response to economic downturns and property price busts. One reason for the little empirical evidence on the effectiveness of LTV/DTI limits used as macroprudential tools is the fact that use of mandatory limits on these loan eligibility criteria especially in an actively-managed manner in response to cyclical movements in real estate markets has a short history and only a few countries, namely, Korea, Hong Kong SAR, Singapore, and Malaysia (at varying degrees of complexity), have adopted such frameworks.

This paper examines the impact of LTV and DTI limits on house price dynamics, residential real estate market activity, and household leverage in Korea. First, a regional dataset is used to exploit the variation across regions with different LTV/DTI limits in effect at different points in time. Second, and more innovatively, we use a unique dataset gathered from annual surveys conducted by Kookmin Bank and complemented with information from the Bank of Korea. This unique dataset covers information on the housing tenure and mortgage decisions of roughly 2000 households each year and runs from 2001 to 2009. We ask two questions. First, what happens when LTV/DTI limits are adjusted in response to developments perceived to be risky? Second, can we quantify the impact of LTV and DTI limits on housing and mortgage activity?

We find that transaction activity drops significantly in the three-month period following the tightening of LTV/DTI regulations. Price appreciation slows down a bit later, in a six-month window rather than the three-month window. Moreover, price dynamics appear to be reined in more after LTV tightening rather than DTI tightening. Survey data analysis using a matching estimator framework offers some insight into what the channel for the *impact* of the policy actions may be: expected house price increases in the future become lower after policy intervention and this is more prevalent among older households while plans to purchase of a home are more likely to be postponed by those who already own a property, i.e., potential speculators, but not by those who do not own a property, i.e., potential first-time home buyers. These findings suggest that tighter limits on loan eligibility criteria, especially on LTV, curb expectations and speculative incentives.

In terms of magnitude, our analysis point to sizeable impact on transaction activity and house price appreciation. More specifically, average drop in transaction activity in the three-month period following a tightening of macroprudential regulations on loan eligibility criteria is 16 percent for LTV and 21 percent for DTI. Appreciation rates decrease by a monthly rate of 0.5 percent against a historical monthly change of 0.4 percent in the six-month window following a tightening of LTV. The larger impact on transaction activity may indicate that most of the effect of these actively-managed macroprudential tools falls on the quantity in the market rather than the prices, raising concern that the price discovery process is hurt by the measures because some of the buyers and sellers decide to (temporarily) exit the market, but it may also be just an artifact of the adjustment mechanism in real estate markets where transactions respond first and prices adjust at a slower pace. We do not find as strong an

effect on growth rates of mortgage loan originations and household debt levels, perhaps reflecting the slow-moving nature of these variables.

Our contribution to the literature comes not only from the study of a timely and interesting topic that has not yet been studied in depth but also the use of disaggregated data in the empirical analysis. Wong et al. (2011) look at the responses in aggregates, as we do in the first part of our analysis, but it is hard to infer causal links from such cross-country analysis. To the best of our knowledge, ours is the first paper to look into the effects of actively-managed macroprudential regulation on loan eligibility using information at the household level. By exploiting variation across households, we can go beyond the correlation between macroprudential tools and housing market developments and assess the *causal* impact of LTV and DTI limits.

Policy implications of our analysis are encouraging but should be taken with a grain of salt. In housing markets, expectations are key as they often facilitate the settling in of bubble dynamics (Allen and Carletti, 2010). If, as suggested by the evidence presented here, limits on LTV and DTI curb expectations and discourage potential speculators, they can be effective tools to tame real estate booms and contain the associated risks. Having said that, the analysis provides only a *partial* assessment of the LTV and DTI regulations. The broader housing policy has implications for the mismatches between housing supply and demand, as well as for maintaining expectations of slow but steady house price appreciation. Hence, macroprudential regulations may be treating the symptoms of distortions caused by these other policies. The lack of evidence on any impact on the growth rate of mortgage debt may suggest that LTV and DTI regulations indeed are not fully effective in reining in the buildup of excess leverage, which remains attractive because of the other policies in place. In addition, the individual welfare costs of excluding some households from the housing market would be outweighed by an aggregate welfare gain if the tightening of LTV/DTI prevents or curbs a bubble, the detection of which remains a difficult task.

The rest of the paper is organized as follows. Section II provides brief background information on Korean housing and mortgage markets. Section III gives the details of the dataset, describes the empirical approach, and presents the findings. Section IV concludes.

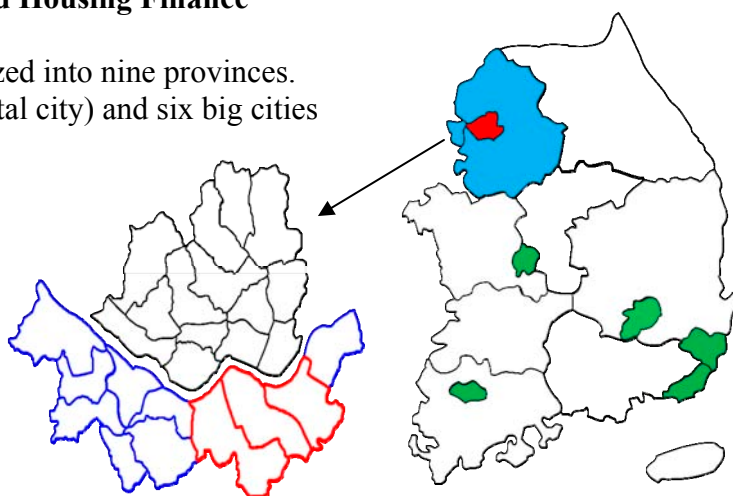
## II. BACKGROUND: KOREAN HOUSING AND MORTGAGE MARKETS

### A. Basic Facts

#### Residential Real Estate Sector and Housing Finance

Administratively, Korea is categorized into nine provinces. Urban areas include Seoul (the capital city) and six big cities known as “Gwangyeok cities”. Economically, however, the country is better characterized by three areas (Text Figure): Seoul (shown in red), Metropolitan Area excluding Seoul, composed of

Text Figure. Map of Republic of Korea and Seoul



Incheon, one of the six Gwangyeok cities, and the remainder of the Gyeonggi province (shown in blue), and Non-Metropolitan Area which includes the remaining five Gwangyeok cities (shown in green) as well as the rural areas scattered in the remaining eight provinces (white). Seoul can be further divided into two areas (geographically marked by the Han River): the northern part (Gangbuk, traced by black lines) and the southern part (Gangnam, traced by blue lines). In the latter, “Gangnam Three” (traced by red lines), which includes the three major boroughs (Seocho-gu, Gangnam-gu, Songpa-gu), stands out as the most desirable area to reside in as it is host to high-quality urban structures including schools. As a result, this area has higher median home prices and has experienced the largest increases and fluctuations in house prices over the last couple of decades, making it to top of the watch list of the supervisors.

The residential real estate market in Korea has gone through significant change in the past two decades. A government-led drive to build two million new dwellings between 1988 and 1992 helped alleviate the housing shortage and make homes more affordable. Beginning in 1995, price controls on new apartments and regulations on the conversion of agricultural land were gradually reduced, propelling urbanization. The ratio between the number of housing units and the number of households has increased nationwide from 72 percent in 1990 to 109.9 percent in 2008 while consumption of housing space per capita rose from 13.8 square meters in 1990 to 22.8 in 2005 (Kim and Cho, 2010). Still, mismatches between supply and demand remain in some regions, most notably, southern Seoul. The majority of housing stock consists of apartments, rather than single-family homes, reflecting the high urbanization rate (68 percent of households live in urban areas with almost 70 percent of these living the metropolitan area). Homeownership rate, standing at around 55.6 percent as of 2005, is in the lowest quartile among OECD countries. Given the somewhat stagnant population growth, gross value added by the construction industry (as a percent of the total value added) has been declining since the late 1990s but remains higher than many advanced countries at about 6.6 percent. Affordability, as measured by price-to-income ratio, has improved in comparison to the 1980s and 1990s.

The housing finance system in Korea was deregulated in second half of the 1990s. Particularly, commercial banks entered the mortgage business in 1996 followed by the privatization of the Korean Housing Bank (KHB), the monopolistic provider of low-interest, long-term housing loans, in 1997.<sup>2</sup> Before the deregulation of the housing finance system, more than 80 percent of mortgage loans was held by the publicly-owned National Housing Fund (NHF) (Chang, 2010).<sup>3</sup>

As a consequence of the deregulation, outstanding mortgage debt grew considerably from a roughly 12 percent in 1996 and now amounts to slightly more than 30 percent of GDP. The

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<sup>2</sup> KHB’s name was changed to Housing and Commercial Bank (H&CB) in 1996 and the entity was privatized in 1997. H&CB merged with Kookmin Bank in 2001.

<sup>3</sup> The NHF continues to offer services to lower-income households by securing money through bond issuance and housing subscription savings for building rental homes, helping people take out housing loans, and improving the residential environment.



prevalent loan type carries an adjustable rate and 56 percent LTV at origination. While maturities up to 20 years are common, the majority of mortgages are “bullet loans”, which require full payment or refinancing after a 3-year period. Banks dominate the mortgage market with a market share exceeding 80 percent. Deposit-based financing remains the norm, although mortgage-backed-security issuance has grown to 5.8 percent of total mortgage debt outstanding in 2010 since the establishment of the Korean Housing Finance Corporation (KHFC) in 2004.<sup>4</sup>

## Regulatory Approach

One of the lessons policymakers in Korea, and a few other Asian economies, took away from the crisis in 1997-98 was that asset price and credit booms, and the ensuing busts, can be devastating. Moreover, the credit card bubble, which had emerged partly owing to the expansionary policy measures aiming to stimulate the economy in the aftermath of the financial crisis, burst in 2003. Delinquencies rose sharply and economic growth took a hit as consumer spending shrunk. This demonstrated, once again, the need to monitor systemic risks and contain distress that can emerge from common exposures and feedback loops between the financial and real sectors, i.e., macroprudential supervision, since micro-prudential supervision focusing only on the soundness of individual financial institutions proved to be insufficient in satisfying this need.

Accordingly, as one of the first cases to tackle from a macroprudential perspective, the Financial Supervisory Service (FSS) took on the real estate markets starting in late 2002. LTV limits were introduced first, followed by DTI limits in 2005. The same year, in an effort to further improve macroprudential supervision, the FSS created the Macroprudential Supervision Department, with the mandate to assess systemic risk factors using early warning systems and stress tests to guide prudential policies.

As a result of these developments, housing and mortgage markets in Korea have been heavily influenced by policy interventions. In general, stable house prices, defined as annual house price appreciation rates within the zero and nominal GDP growth rate band, have been an overarching policy objective along with the goals of assisting urbanization and providing affordable housing options to low-income households. Strict regulations on land use and redevelopment also affect the real estate market dynamics by holding back prompt supply response. The battery of policy tools to accomplish the objective of stable house prices include adjustments in LTV and DTI limits as well as moral suasion on lenders, subsidies to housing finance, changes in taxes, direct support for the private construction sector, and government supply of new housing units or purchase of existing units. In our empirical analysis, we keep the focus on LTV and DTI limits but also check the robustness of the

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<sup>4</sup> KHFC purchases long-term mortgages from commercial banks in order to provide liquidity and increase the duration of loans available on the market. By the end of March 2010, KHFC's total mortgage-backed security issuances amounted to 5.8% of Korea's total mortgage debt outstanding (Chung, 2010). There has also been discussions of adding covered bonds to the instruments used to access capital market funding (Kim and Cho, 2010).

findings by considering major changes in other policies as control variables in the regressions, including monetary policy stance.<sup>5</sup>

## **B. Recent Market Developments and Policy Responses**

Between 2001 and 2010 (our sample period), Korea experienced two major housing cycles split by the trough in March 2005 (Figure 1).<sup>6</sup> House prices (together with transaction activity) and mortgage loan growth tend to move in the same direction, demonstrating the two-way feedback loop documented in the literature (see Crowe et al., 2011b, and references therein).

Price and credit dynamics have been driven, in addition to supply and demand conditions, by often policy-induced restraints on lending standards.<sup>7</sup> These dynamics vary across geographical regions, and so has the policy response.<sup>8</sup> Since their launch in September 2002 and August 2005, respectively, the LTV and DTI limits have been changed several times not only in terms of the levels themselves but also in terms of the areas and the financial institutions to which they are applicable. Tables 2a and 2b give detailed information, including the timeline, on the LTV and DTI regulations, respectively.

In the first cycle, real estate emerged as a preferred asset class in the wake of the IT bubble burst. As monetary policy eased to give a boost to the economy and financial institutions, burnt by corporate bankruptcies, rebalanced their loan portfolios by extending credit to households aggressively, returns to housing in comparison to bank deposits and corporate bonds surged. Policymakers took action starting in September 2002 with the introduction of the 60 percent LTV limit (maximum allowed). House price appreciation decelerated significantly from more than 20 percent on a year-on-year basis to 9 percent in six months, but accelerated again eliciting tightening of LTV limits twice (Figure 2).<sup>9</sup> The second

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<sup>5</sup> See, for instance, De Nicolo et al. (2010) and references therein on how monetary policy can affect incentives for risk taking in financial institutions. Such effects may have the potential to undo the impact of more strict financial regulation.

<sup>6</sup> Since the last trough in April 2009, prices bounced back rather quickly but started declining again in July 2010, at least in part due to the tightening of LTV/DTI limits and moral suasion on banks to keep mortgage loan growth rates in check. The policy response has been reversed in August 2010 and mortgage lending and house prices resumed their ascent in late 2010.

<sup>7</sup> One concern often voiced by opponents of frequent adjustments to loan eligibility criteria by policymakers is the increased volatility in prices.

<sup>8</sup> See Appendix for a detailed description of geographical regions and their main socio-economic characteristics as well as the variation in policy response applicable to loans of different characteristics and in different regions.

<sup>9</sup> We use the official apartment prices index from the Korea National Statistical Office throughout our analysis. Measuring house prices is a notoriously hard task and discrepancy in quantification of house price changes is unavoidable when series from different sources are used (Igan and Loungani, 2011). See Appendix for a comparison of different price series in Korea.

tightening was accompanied by tax measures, which included changing the basis for capital gains tax calculations to real transaction price and increasing the capital gains taxes for owners of multiple properties, marked the beginning of the downturn phase. The decline in prices gained pace with the restitution of development gains on housing construction projects in June 2004.

The second cycle set in as monetary policy took an accommodative stance again, this time in response to the financial distress due to the credit card debacle. Other factors pushing prices up were increasing competition among lenders and release of large land compensation funds under various urban development initiatives. With higher capital gains taxes discouraging potential sellers, a shortage of homes for sale followed. Policy response came quickly in various forms reining in part of the exuberance in early 2007. Prices slid further as the global financial crisis hit but recovered as early as the second half of 2009. The authorities intervened again in October 2009 and markets remained cooled down through the third quarter of 2010. As bubble concerns turned into “excessive cooling”, some of the measures were loosened in August 2010.

### III. EMPIRICAL ANALYSIS

In order to analyze how the introduction of the LTV and DTI regulations, designed to set limits on the leverage taken by homebuyers and in turn reduce housing demand and stabilize prices, we gather data both at the macro and micro levels. We first describe the analysis and present the findings for the macro-level data (subsection III.A) and then the micro-level data (subsection III.B). This allows us utilize both the cross-sectional and the time-series variation in our datasets in an effort to tease out a relationship that goes beyond simple correlations in our analysis of the impact the policy interventions in Tables 2a and 2b.

#### A. Effects of LTV and DTI Limits on Regional Housing and Mortgage Market Activity

At the macro level, aggregate series for house prices, transaction volumes, and mortgage loans are obtained from the Bank of Korea and the Korea National Statistical Office. Time coverage is restricted to the 2002-10 period, when macroprudential policy interventions were actively used. Additionally, we get information from the Realtors Association on the “dominance of selling”, that is, the proportion of realtors reporting that the number of sellers exceeds the number of buyers. All macro-level data are available at monthly frequency.

At the regional level, the regulatory limits are set separately for “speculative zones” and non-speculative zones”. An area is designated as a speculative zone if the following criteria are satisfied:

- monthly nominal house price index (HPI) rose more than 1.3 times nationwide inflation rate (CPI) during the previous month, and
- either (i) the average of the HPI appreciation rates in the previous two months was higher than 1.3 times the average of the national HPI appreciation rates in the previous two months, or (ii) the average of the month-on-month HPI appreciation

rates over the previous year was higher than the average of the month-on-month national HPI appreciation rates over the previous three years.

We look at the differences in the responses of housing market activity and mortgage loan originations across these regional divides before and after a change in the LTV and DTI regulations take effect. The baseline regression is

$$V_{rt} = \alpha + \beta'X_{rt} + \gamma D_{rt} + \varepsilon_{rt}$$

where  $V_{rt}$  is the variable of interest in housing and mortgage markets, i.e., the house price appreciation rate, number of transactions, mortgage loan growth rate, and dominance of selling in region  $r$  at time  $t$ .  $X_{rt}$  is a matrix of control variables including indicators of the level of general economic activity, monetary policy stance, and measures of tightness and expectations in housing markets. This equation is estimated using ordinary least squares (OLS) for each variable of interest separately.  $D_{rt}$  is a dummy variable that takes on the value of 1 in the six months following the announcement of a rule change. We also construct this dummy for one or three months after the rule change and one, three, or six months before a rule change. Looking at the responses of markets at these various windows helps us assess the horizon over which a policy intervention has an effect as well as find out whether the *anticipation* of a policy intervention, rather than the specifics of a rule change per se, triggers a response in the markets.

We split the analysis into two parts and examine interventions that tighten the existing regulations and those that loosen them separately. There were 13 interventions in total, 6 of which were related to LTV and 7 related to DTI, in the period we are examining. Of these 13 interventions, 3 (one LTV-related and two DTI-related) loosened the existing regulations. Hence, we are left with 10 *tightening* interventions, five on LTV and five on DTI regulations, in the first part of the analysis and 3 *loosening* interventions in the second part.

There are two issues that deserve further investigation by modifying the baseline specification. First, notice that the estimated difference in housing market activity before and after the policy intervention in this specification is compared to the sample average. In other words, we identify the impact of the policy interventions as the change in housing market activity relative to its average over the whole sample period. Therefore, it is likely that the impact is underestimated. In order to examine the response in housing market activity after each intervention more accurately, we run the specification with a separate dummy for each intervention.

Second, note that this specification combines all interventions and, hence, treats them as identical without distinguishing the interventions in terms of their scope (e.g., only applicable to banks versus applicable to all financial institutions) and strength (e.g., a change of 10 percentage points in the level of LTV/DTI limit versus a change of 5 percentage points). In order to take into account the fact that each intervention is different because of e.g. the number of lenders and borrowers it affects and in the degree it changes the existing rules, we

construct an index,  $I_{rt}$ , based on the regions and types of lender, borrower, property, and loan to which the rule change is applicable.<sup>10</sup> In this case, the empirical specification is

$$V_{rt} = \alpha + \beta'X_{rt} + \varphi I_{rt} + \varepsilon_{rt}$$

Admittedly, the decision to tighten a particular regulation in an area or to change the designation of an area to a speculative zone is not an exogenous one: areas showing signs of overheating are more likely to be subject to a tightening. Moreover, as shown by numerous studies, there generally is a two-way relationship between house prices and mortgage credit as well as between house prices and business cycle movements. Hence, note that it is difficult to tease out the causal effect of LTV and DTI limit adjustments in this setup. We analyze such a causal effect in the next subsection using household level information.

At a first glance, average appreciation rate in house prices and growth rate of transactions and household debt levels, calculated on a month-on-month basis, drop considerably following a tightening in the rules governing LTV and/or DTI limits (Figure 3). Decline in the growth of number of transactions is particularly striking compared to the other variables of interest. Also interesting is to note that the experience in metropolitan areas is starkly different from the experience in the non-metropolitan areas. Hence, when we look into the changes in these variables of interest one by one, we distinguish between these two areas.

## House Prices

Price appreciation rates are significantly lower following the implementation of an LTV rule tightening (Table 3a, first column). Moreover, this effect is only observable in the metropolitan areas, where tighter rules are more likely be applicable. Hence, while still plausible, it is less likely that the negative and significant coefficients on the LTV tightening dummy are driven by nationwide developments over time. The evidence for DTI tightening is not as strong: while the coefficients for all windows (one, three, or six months) are negative, they are not statistically significant.

There appears to be some positive association between price appreciation prior to an LTV rule tightening and the implementation of the rule change. While this may be an indication of anticipation of the rule changes by market participants, it is hard to rule out reverse causality: the tightening decision is based on recent price changes in the market.

On the flip side, the response in house price appreciation rates is less visible when rules are loosened (Table 3b, first column). Actually, it looks like there is a negative association between house price changes and more lax rules: LTV dummy at rule change announcement and DTI dummy for the month following the rule change have negative and significant coefficients. While counterintuitive at first, this association can be explained by the policy intervention decision being based on what has been happening in the housing market and inertia in prices. The coefficient for the LTV reverses at the one-month window, but the

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<sup>10</sup> See Appendix for a detailed description of how the index is constructed.

coefficient is small in magnitude compared to tightening of the rules in Table 3a. Taken together, these seem to suggest that bringing a (temporary) halt to exuberance in housing and mortgage markets may be easier than giving a boost to slowing markets.

### **Transaction Activity**

Growth in the number of transactions shoots up with the announcement of a tightening in loan eligibility criteria and plunges in the following months (Table 3a, third column).<sup>11</sup> Especially with a DTI tightening, the hit from the tightening appears to be borne mostly by transactions rather than prices. This may have important implications depending on the mechanism behind. More specifically, if the stronger response in transaction activity is just an artifact of the workings of housing markets, where quantity adjustment comes before price adjustment, macroprudential rules, especially LTV, appear to be effective tools to curb excessive house price appreciation. But, if this is a reflection of potential buyers and sellers exiting the market, the price discovery process, which already is slow in real estate markets, may become impaired. Further implications related to welfare concerns may follow in this case: it may be the potential first-time home buyers being forced out of the market by lower limits on LTV and DTI, and reduced access to finance by these often younger and less wealthy groups may create social and political frictions. In our analysis of survey data, we examine the characteristics of the households that are more affected by the policy interventions to shed more light into this issue.

### **Mortgage Loans**

Since we do not have mortgage loan data broken down by regions, we examine the changes in household debt levels instead. To the extent that financial decisions are determined together, mortgage loans and other loans to households will tend to move together.

Perhaps reflecting the slow-moving nature of balance sheet measures, we do not find much evidence of the expected negative association between the growth of household leverage and tightening of macroprudential rules. Contrary to the findings on prices and transactions, DTI appears to be more closely linked to the evolution of household debt levels. Furthermore, the symmetric effect seem to exist with loosening of DTI rules but, again, not with LTV. This is somewhat surprising given that LTV appeals more to leverage and strategic default incentives whereas DTI is considered to appeal more to affordability. One explanation could be that, since payments on loans other than mortgages are included in the calculation of DTI, households are forced to consolidate their debt in order to get approved for a mortgage loan. This process may end up reducing the overall household debt levels although outstanding mortgage loans increase.

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<sup>11</sup> In regressions not reported here, we find that this effect disappears at the twelve-month window.

## Dominance of Selling

There is some evidence that the residential real estate market becomes more seller-dominated following the changes, both tightening and loosening, in loan eligibility criteria (Tables 3a and 3b, seventh columns). DTI appears to be more effective in turning the marketplace from being buyer-dominated to seller-dominated when it is a tightening while LTV seems to have stronger support for such an effect in the loosening case. This may be indicating that potential buyers that are at the margin in terms of their affordability constraints get out of the market when DTI limit is lowered but they are not as easily persuaded back into the market with the loosening whereas the developers flood the market when LTV limit is raised.

In sum, the empirical analysis of macro data shows that macroprudential rules are followed by a large drop in transaction activity and they may be effective in taming rapid house price appreciation rates. These seem to apply more closely to LTV regulations. When we repeat the regressions by introducing a separate dummy variable for each policy intervention, the broad picture is not altered, yet it is clear that not all interventions work the same way or to the same extent (Tables 4a and 4b). As explained earlier, to incorporate the differences among these interventions and reflect their varying strength, we construct an index with higher values corresponding to tighter regulation. The results, however, are not significant.<sup>12</sup> This insignificance, aside from issues related to the construction of such an index, may be indicative of macroprudential tools working through expectations rather than by creating a one-to-one impact commensurate with their strength.

### B. Effects of LTV and DTI Limits on Household Choices

At the micro level, we utilize information on individual households using the *Survey on Mortgages and Housing Demand* conducted annually by Kookmin Bank. This dataset covers the period from 2001 to 2009 and around 3000 households each year across the nation. Disproportional stratified sampling is the method used in conducting the survey. To put it more precisely, households are first divided by region using regional population as weights and then the survey participants are selected randomly within each region. The dataset includes information on the households' socio-economic and demographic background (e.g., age, education level, income level, balance sheet position) as well as their plans on housing tenure and expectations on house prices.

In order to estimate the average effect on property buying decisions and perceptions on the direction of house prices, we distinguish between two types of households: those who are subject to a particular rule change, i.e., those that are given treatment, and those that are not. Let  $C_i^1$  and  $C_i^0$  denote the outcome variable for household  $i$  with treatment and without, respectively. Note that for each household we only observe the outcome in one state or the other. Further, let the conditional expectations of these variables, given a vector of observable characteristics  $X_i$ , be given by  $X_i\delta^1$  and  $X_i\delta^0$ , where  $\delta^1$  and  $\delta^0$  are unknown

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<sup>12</sup> These regressions results are omitted here for sake of brevity but are available from the authors upon request.

parameters. Defining  $T_i = 1$  if household  $i$  received treatment and  $T_i = 0$  if not, the observed outcome can be written as

$$C_i = T_i C_i^1 + (1 - T_i) C_i^0.$$

Although whether a household receives treatment or not is not random and potentially endogenous to the outcome variable, it is possible to estimate the effect of getting the treatment while accounting for its endogeneity is possible using the techniques described in Heckman, Ichimura, and Todd (1997) and Abadie and Imbens (2006). Specifically, the problem is one of missing data. For each household  $i$ , we do not observe the counterfactual so we cannot compare the outcome with and without treatment. But we can find another household whose characteristics are similar but who were not exposed to the LTV/DTI rule changes and associate the missing outcome to the outcome for that household. In other words, we first match the treated households to untreated households based on their observable characteristics and then compare the outcomes for the matched pairs to estimate the sample average treatment effect.

We match the households that were subject to the tightening of loan eligibility criteria to those that were not using their income level, financial assets, debt, and the price of the property they live in.<sup>13</sup> Table 5 shows the summary statistics for the treated and untreated groups before and after the matching procedure. Observably, the treated and the untreated have stark differences. The matching procedures eliminates these differences and the two subsamples are no longer statistically different. So, when we compare the outcomes for the treated and the untreated only using the matched pairs, the difference in the outcomes can be attributed to the treatment rather than to differences in observable characteristics, taking us a step further in interpreting this effect in a causal way rather than a simple correlation.

## Expectations and Demand for Housing

Results from the matching estimator framework are presented in Table 6. On an experimental treatment effect basis, both LTV and DTI tightening are effective in delaying property purchase decisions. Such a policy intervention also pushes down price expectations but only in the case of LTV. These findings offer an interesting interpretation for the results on the aggregate data: the drop in transaction activity and the slowdown in house price appreciation rates following a tightening may work through the expectations channel. To put it more precisely, lowering LTV limits curbs agents' expectations about future house price gains and alters their housing tenure and investment choices. Demand for homes drop as households believe they face lower returns to housing in the future, alleviating the pressure on prices. Interestingly, we find the opposite effect on expectations for DTI limits. One reason for this could be the fact that DTI works more closely through the affordability channel and a tightening of this measure may lead agents to believe that those who can now qualify for a mortgage loan are actually richer households and they would be able to pay more for the same house.

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<sup>13</sup> We run robustness tests using several sets of observable characteristics to do the matching. The results remain virtually the same.



This finding is promising because the inertia in house prices and the difficulty of breaking bubble dynamics once they set in real estate markets have been pointed out to highlight what makes real estate cycles potentially dangerous. In particular, agents tend to revise their expectations of future house price changes in an adaptive manner and higher *realized* increases translate into higher *expected* increases. Expectations of better returns to housing push more households to buy today rather than tomorrow and, at the same time, attract speculators into the market. Hence, a self-fulfilling loop emerges until the house price levels breach affordability constraints and loop reverses. If macroprudential tools can affect expectations, they offer a viable option to put a backstop to this loop and, hence, to deal with real estate booms.

## Response to Policies and Characteristics of Households

Although the negative impact on expectations and prospective demand is an intended consequence, one issue is *whose* expectations these macroprudential tools affect. A commonly-raised concern regarding LTV and DTI limits is that they may inadvertently target young couples or first-time home buyers. This is because both LTV and DTI impose direct financial constraints on the households' ability to borrow and they tend to become binding for those with little savings to use as a downpayment or those with little income as they are at the beginning of their life cycle of earnings. The fact that the constrained households are easy to identify and the social goals associated with housing may pose important political challenges in implementing LTV and DTI limits.

We split our sample to see if this is indeed an issue. First split is based on the age of the head of the household: we label those below 35 as “young” and others as “old”. The second split compares those who already own a property (“speculators”) to those that currently do not (“first-time home buyers”)<sup>14</sup>. Looking at the results in Table 7, it is not obvious that this is a problem in Korea's experience. On the contrary, it is the older households and speculators (i.e., those who already own a property) that are influenced more by the policy interventions. This is again promising for efficacy of LTV as a macroprudential tool as they indicate that social issues associated with denying homeownership to young, first-time home buyers does not find support, at least, in the Korean case.<sup>15</sup> Once again, we find the opposite effects for DTI when expectations are the variable of interest, but a similar results holds when we look at the demand for properties: limits on DTI lead to a delay of property purchase plans by the older households and speculators but not the young households or the (potential) first-time home buyers.

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<sup>14</sup> It is possible that the latter had owned property before.

<sup>15</sup> It could well be the case that these findings are specific to Korea and/or to a specific time period. But, an advantage of using LTV and DTI limits is that they can be tailored to protect certain households based on, e.g., income levels, allowing for them to achieve the goal of curbing a real estate boom and preserve financial system health while keeping up with broader social housing goals.

#### IV. CONCLUSION

We examine the impact of LTV and DTI limits on house price dynamics, residential real estate market activity, and household leverage in Korea. We find that transaction activity drops significantly in the three-month period following the tightening of LTV/DTI regulations. Price appreciation slows down a bit later, in a six-month window rather than the three-month window. Moreover, price dynamics appear to be reined in more after LTV tightening rather than DTI tightening. Survey data analysis using a matching estimator framework offers some insight into what the channel for the *impact* of the policy actions may be: expected house price increases in the future become lower after policy intervention and this is more prevalent among older households while plans to purchase of a home are more likely to be postponed by those who already own a property, i.e., potential speculators, but not by those who do not own a property, i.e., potential first-time home buyers. These findings suggest that tighter limits on loan eligibility criteria, especially on LTV, curb expectations and speculative incentives.

Policy implications of our analysis are encouraging. In housing markets, expectations are key as they often facilitate the settling in of bubble dynamics. If, as suggested by the evidence presented here, limits on LTV curb expectations and discourage potential speculators, they can be effective tools to tame real estate booms and contain the associated risks.

### Regional Characteristics

Based on socio-economic characteristics, Korea is split into the two main areas: (1) Seoul Metropolitan Area (Seoul, Incheon Gwangyeok city, and Gyeonggi province), and (2) Non-Metropolitan Area (five Gwangyeok cities except Incheon and the remaining areas scattered through eight provinces). Seoul is further divided into two areas: Gangbuk and Gangnam. Socio-economic characteristics of these regions are shown in Appendix Table 1.

Appendix Table 1. Basic Characteristics by Regions in Korea

As of 2005	Korea	Seoul Metropolitan Area					Non-Metropolitan Area		
			Seoul	Gangbuk	Gangnam	Incheon Gyeonggi		Five Gwangyeok Cities	Rural Area
Size of Area (%)	100.0	11.8	0.6	-	-	11.2	88.2	3.8	84.4
Population (10 thousand)	4,704	2,262.1	976.3	487.2	489.0	1,285.9	2,442.0	986.6	1,455.5
- Population Ratio by Region (%)	100.0	48.1	20.8	10.4	10.4	27.3	51.9	21.0	30.9
Population Growth Rate (%)	0.2	0.7	-0.3	-	-	1.2	-0.1	-0.2	-0.0
Population Density (Person/Km2)	474.5	1,941.9	16,221.0	-	-	1,164.0	278.9	2,641.8	173.6
Number of Households (10 thousand)	1,588.7	746.2	331.0	165.0	166.0	415.2	842.5	327.9	514.6
- Household Ratio by Region (%)	100.0	56.4	25.0	12.5	12.6	31.4	63.7	24.8	38.9
Number of House Units	1,562.3	716.5	310.2	-	-	406.3	845.8	318.1	527.7
House Supply Rate (%)	98.3	96.0	93.7	-	-	98.3	100.2	97.0	102.1
House Ownership Rate (%)	55.6	50.2	44.6	45.8	43.4	54.6	60.3	55.1	63.7
Type of Housing (Apartments) (%)	52.7	58.2	54.2	48.9	59.6	60.8	48.4	61.6	41.2
Median Apartment Price (10 Thousand Won)	23,470.4	35,388.5	51,177.0	38,773.7	61,530.7	26,864.8	11,277.15	13,381.5	9,172.8
Value of Land Stock (billion won)	2,753,001	1,757,436	867,136	-	-	890,300	995,565	360,886	634,679
- Ratio by Region (%)	100.0	63.8	31.5	-	-	32.3	36.2	13.1	23.1
GDP (billion won)	869,304	418,612	208,899	-	-	209,713	450,691	157,448	293,243
- GDP Ratio by Region (%)	100.0	48.2	24.0	-	-	24.1	51.8	18.1	33.7
Median Household Income (Gross) (10 thousand won)	3,035.9	3,132.3	3,501.4	-	-	2,947.8	2,800.6	2,928.9	2,720.3
Ratio of College Graduates (%)	35.5	41.4	46.0	40.5	51.4	37.7	30.4	36.2	26.6
Median Age	34.8	33.9	34.1	-	-	33.8	35.7	33.9	36.8
Age of Household Head	47.9	46.2	46.6	47.2	46.0	45.9	49.4	47.6	50.6

Even though Seoul Metropolitan Area (SMA) occupies only 11.8 percent of the geographical area, 48.1 percent of the population and 56.4 percent of the households live in SMA. Most of the government offices, headquarters of private companies, prestigious universities, and cultural facilities are concentrated in this area. Almost half of the GDP (48.2 percent) and two-thirds of the housing wealth (63.8 percent) is accounted for by SMA. Compared to the Non-Metropolitan Area (NMA), unemployment rate and household gross incomes are higher by 1.3 percentage points and 11.8 percent, respectively. In the desirable Gangnam area, the median price for apartments, which is the most popular type of residence in the country, is 2.6 times the median price in the country and is 6.7 times higher than the median apartment price in rural provinces.

### *Chonseil System*

Chonseil is a unique housing rental system. It requires the renter to make a “key money deposit” of about 50 to 90 percent of the market value of the rental space instead of paying monthly rent. This deposit is returned in its entirety to the renter at the end of the contract, which usually lasts two or three years. Early termination of the contract requires another renter to replace the outgoing renter. This enables the owner to freely invest the deposit during the contract period. For the Chonseil system to work, interest rates need to remain high, renters have to have enough cash upfront, and owners need to return the money faithfully. High interest rates allow the owners to make a reasonable profit from the alternative investment. During the past decades, interest rates in Korea were relatively high, so the owners had strong incentives to run the Chonseil system. With house prices also starting to rise at high rates, some owners attained leverage to buy an additional property through the Chonseil system by using the Chonseil deposit to complement their downpayment.

In 2005, 22.4 percent of Korean households lived in Chonseil. The ratio of Chonseil contracts in the Gangnam area was the highest with 33.5 percent and that in rural provinces was the lowest with 13.2 percent (Appendix Table 2). This is in line with the higher median apartment prices pushing more households to choose the Chonseil option as they cannot afford to buy the property.

**Appendix Table 2. Housing Tenure Types in 2005**

Unit: # of Household, %

	Total	Owned		Chonseil		Rented		etc	
Korea	15,887,128	8,828,100	55.6	3,556,760	22.4	3,011,855	19.0	490,413	3.1
SMA	7,462,090	3,744,978	50.2	2,172,612	29.1	1,379,158	18.5	165,342	2.2
- Seoul	3,309,890	1,475,848	44.6	1,100,175	33.2	679,980	20.5	53,887	1.6
- Gangbuk	1,649,566	754,814	45.8	543,823	33.0	322,888	19.6	28,041	1.7
- Gangnam	1,660,324	721,034	43.4	556,352	33.5	357,092	21.5	25,846	1.6
- Incheon & Gyeonggi	4,152,200	2,269,130	54.6	1,072,437	25.8	699,178	16.8	111,455	2.7
NMA	8,425,038	5,083,122	60.3	1,384,148	16.4	1,632,697	19.4	325,071	3.9
- 5 Major Cities	3,279,013	1,806,645	55.1	702,559	21.4	686,506	20.9	83,303	2.5
- Rural Area	5,146,025	3,276,477	63.7	681,589	13.2	946,191	18.4	241,768	4.7

Appendix Table 3. Announcement Dates and Levels of LTV Limits across Loan Classes and Regions

Date	Classification (Maturity, Payment, & Appraised Value)		Speculative Zone		Speculation-Prone Zone		Other Areas	
			Single	Apartment	Single	Apartment	Single	Apartment
Before Sept.6, 2002	under 3 years		N/A	N/A	N/A	N/A	N/A	N/A
	3~10 years		N/A	N/A	N/A	N/A	N/A	N/A
	over 10 years		N/A	N/A	N/A	N/A	N/A	N/A
Sept. 6, 2002 – Oct. 14, 2002	under 3 years		N/A	N/A	60	60	N/A	N/A
	3~10 years		N/A	N/A	60	60	N/A	N/A
	over 10 years		N/A	N/A	60	60	N/A	N/A
Oct. 14, 2002 – May 23, 2003	under 3 years		60	60	60	60	60	60
	3~10 years		60	60	60	60	60	60
	over 10 years		60	60	60	60	60	60
May 23, 2003 – Oct. 29, 2003	under 3 years		50	50	50	50	60	60
	3~10 years		60	60	60	60	60	60
	over 10 years		60	60	60	60	60	60
Oct. 29, 2003 – Mar. 24, 2004	under 3 years		50	40	50	50	60	60
	3~10 years		60	40	60	60	60	60
	over 10 years		60	60	60	60	60	60
Mar. 24, 2004 – July 4, 2005	under 3 years		50	40	50	50	60	60
	3~10 years		60	40	60	60	60	60
	over 10 years	Balloon payment	60	60	60	60	60	60
		Amortized payment	70	70	70	70	70	70
July 4, 2005 – Present	under 3 years		50	40	50	50	60	60
	3~10 years		60	40	60	60	60	60
	over 10 years	Over 600mil won	60	40	60	60	60	60
		Under 600mil won	60	60	60	60	60	60
	Amortized payment over 10 years		70	70	70	70	70	70

Date	Classification (Maturity, Payment, & Appraised Value)		Seoul		Seoul Non- speculative zone and Gyeonggi Province		Other Areas	
			Speculative Zone					
			Single	Apartment	Single	Apartment	Single	Apartment
July 4, 2009 – Present	under 3 years		50	40	50	50	60	60
	3~10 years		60	40	60	50	60	60
	over 10 years	Over 600mil won	60	40	60	50	60	60
		Under 600mil won	60	60	60	60	60	60
	Amortized payment over 10 years		70	70	70	70	70	70

Appendix Table 4. List of Areas Designated Speculative Zone Status through Time

Period	Korea								Non-Metropolitan Area
		Seoul Metropolitan Area							
		Total	Seoul		Seoul Neighboring Area				
			Total	Gang nam	Gang buk	Total	Gyeonggi	Incheon	
2001.1~2003.5									
2003.6				O			O		
2003.7~10		O	O	O		O	O		
2003.11~2004.8	O	O	O	O		O	O		
2004.9~2006.1		O	O	O		O	O		
2006.2~6	O	O	O	O		O	O		
2006.7~12	O	O	O	O	O	O	O		
2007.1~2008.11	O	O	O	O	O	O	O	O	
2008.12~2010.12				X <sup>1</sup>					

1. Gangnam Three, which consists of three boroughs (Seocho-gu, Gangnam-gu, Songpa-gu) in Gangnam area, has been the only speculative zone since December 2008.

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Notes: A score of 1, 1.5, or 2 is assigned for a ratio limit of 60, 50, and 40 percent, respectively. The score is set at 0 for other levels. The index is calculated as the weighted average of these scores where the weights are the measures related to the coverage of the rule in terms of type of lender, loan, and property, and regions. These weights include the ratio of mortgage loans by banks, the ratio of the number of households in Seoul Metropolitan Area, ratio of number of households in the speculative zones in Seoul, the ratio of mortgage loans with a maturity less than three years, and the ratio of the number of households who own a house valued over 600 million won. When regulations are loosened, only Gangnam Three is kept as the area for which the rules are applicable and an adjustment factor of 0.1 is used to multiply the weighted average.

Table 1. After the Storm: Examples of LTV and DTI Limits as Macro-Prudential Tools after the Global Financial Crisis

Country	Measure
Canada	Increase in minimum down-payment requirements for insured loans from 0 to 5 percent, reduction in the maximum LTV to 85 percent when refinancing
Finland	Recommendations for LTV limit of 90 percent
Hong Kong SAR	Tightening of rules on LTV and DTI that have been in effect since the early 2000s
Hungary	Introduction of LTV limit of 75 percent on all mortgage loans, restriction of covered bonds funding to loans with an LTV of 70 percent or lower
India	Introduction of LTV limit of 80 percent for residential real estate loans
Israel	Guidelines requiring increased provisions for mortgages with LTV higher than 60 percent
Korea	Tightening of rules on LTV and DTI that have been in effect since the early 2000s
Malaysia	Limit LTV on third homes to 70 percent
Netherlands	Introduction of maximum LTV of 112 percent with the portion exceeding 100 percent being redeemed in 7 years
Norway	Guidelines to limit LTV to 90 percent
Singapore	Tightening of rules on LTV that have been in effect since the early 2000s
Sweden	Introduction of the maximum LTV of 85 percent

Sources: Crowe et al. (2011), IMF (2011), and references therein.



Table 2a. Timeline of LTV Regulations

Date	Specification	Range of Application	Direction
Sept. 2002	- Introduced the LTV ceiling as 60 percent	Banks & Insurance Companies	Inception
June 2003	- Reduced the LTV from 60 to 50 percent for loans of 3 years and less maturity to buy houses in the speculative zones	Banks & Insurance Companies	Tighten
Oct. 2003	- Reduced the LTV from 50 to 40 percent for loans of 10 years and less maturity to buy houses in the speculative zones	Banks & Insurance Companies	Tighten
March 2004	- Raised the LTV from 60 to 70 percent for loans of 10 years or more maturity and less than one year of interest-only payments	All Financial Institutions	Loosen
June 2005	- Reduced the LTV from 60 to 40 percent for loans of 10 years and less maturity to buy houses worth 600 million won and more in the speculative zones	Banks & Insurance Companies	Tighten
Nov. 2006	- Set the LTV ceiling as 50 percent for loans of 10 years and less maturity to buy houses worth 600 million won and more in the speculative zones and originated by nonbank financial institutions such as mutual credits, mutual savings banks, and credit-specialized financial institutions	Extended to Nonbank Financial Institutions	Tighten
Nov. 2008	- Removed all areas except the three Gangnam districts off the list of speculative zones	All Financial Institutions	Loosen
July 2009	- Reduced the LTV from 60 to 50 percent for loans to buy houses worth 600 million won and more in the metropolitan area	Banks	Tighten
Oct. 2009	- Expand the LTV regulations to all financial institutions for the metropolitan area	Nonbank Financial Institutions	Tighten

Table 2b. Timeline of DTI Regulations

Date	Specification	Range of Application	Direction
Aug. 2005	- Introduced the DTI ceiling as 40 percent for loans used to buy houses in the speculative zones only if the borrower is single and under the age of 30 or if the borrower is married and the spouse has debt	All Financial Institutions	Inception
Mar. 2006	- Set the DTI ceiling as 40 percent for loans to buy houses worth 600 million won and more in the speculative zones	All Financial Institutions	Tighten
Nov. 2006	- Extended the range of application of DTI regulation to the overheated speculation zones in the metropolitan area	All Financial Institutions	Tighten
Feb. 2007	- Set the DTI ceiling as 40~60 percent for loans to buy houses worth 600 million won and less	Banks	Tighten
Aug. 2007	- Set the DTI ceiling as 40~70 percent for loans originated by nonbank financial institutions such as insurance companies, mutual savings banks, and credit-specialized financial institutions	Extended to Nonbanking Institutions	Tighten
Nov. 2008	- Removed all areas except the three Gangnam districts off the list of speculative zones (so, the DTI regulation does not apply to the metropolitan areas)	All Financial Institutions	Loosen
Sept. 2009	- Extended the range of application of DTI regulation to the non- speculative zones in Seoul and the metropolitan area (Gangnam Three 40 percent, non-speculative zones in Seoul 50 percent, the other metropolitan areas 60 percent)	Banks	Tighten
Aug. 2010	- Exempted the loans to buy houses in the non-speculative zones of the metropolitan area if the debtor owns less than two houses (set to expire by end-March 2011)	All Financial Institutions	Loosen

Table 3a. Housing and Mortgage Market Activity Before and After Tightening

	House Prices		Transactions		Household Debt		Seller Dominance	
	Metro	Non-Metro	Metro	Non-Metro	Metro	Non-Metro	Metro	Non-Metro
LTV interventions								
Six months prior	-0.171 [0.260]	-0.151 [0.306]	2.108 [4.808]	5.081 [3.849]	0.008 [0.085]	0.014 [0.111]	-5.227 [7.760]	-6.513** [3.217]
Three months prior	0.526** [0.247]	0.218 [0.178]	6.464 [5.968]	-1.330 [5.024]	-0.094 [0.089]	-0.003 [0.081]	-21.636*** [8.070]	-3.724** [1.714]
One month prior	-0.117 [0.207]	-0.110 [0.268]	-1.581 [5.687]	1.780 [4.180]	0.022 [0.113]	0.409*** [0.127]	22.076*** [6.176]	-1.311 [2.402]
At announcement	0.903* [0.512]	0.057 [0.267]	8.826* [5.204]	4.411** [1.879]	0.226*** [0.062]	0.028 [0.168]	-8.235 [11.299]	1.428 [2.274]
One month later	-1.133** [0.463]	0.291 [0.300]	-15.019** [7.115]	-5.365* [2.836]	-0.078 [0.159]	-0.128 [0.158]	25.000 [19.942]	7.170 [6.412]
Three months later	-0.715** [0.319]	0.235 [0.266]	-15.697** [6.344]	-7.566** [3.208]	-0.067 [0.105]	-0.112 [0.124]	12.151 [8.102]	0.936 [3.283]
Six months later	-0.537** [0.248]	0.393 [0.289]	-6.201 [5.001]	-2.165 [3.205]	-0.001 [0.098]	-0.067 [0.092]	10.227* [6.013]	-0.761 [2.681]
DTI interventions								
Six months prior	0.451 [0.350]	0.283 [0.185]	-2.473 [6.600]	1.601 [2.585]	0.132 [0.117]	0.152 [0.094]	-8.365 [8.343]	0.094 [2.071]
Three months prior	0.557 [0.416]	0.104 [0.120]	3.264 [7.661]	0.951 [3.041]	0.220* [0.116]	0.155* [0.092]	-15.888* [9.471]	1.213 [1.672]
One month prior	-0.101 [0.146]	0.522 [0.397]	-2.693 [7.038]	1.448 [3.721]	0.351*** [0.075]	0.037 [0.140]	-12.155*** [3.844]	3.424 [5.154]
At announcement	0.774 [1.030]	0.240 [0.162]	15.889** [7.816]	-1.427 [4.394]	0.089 [0.154]	0.056 [0.122]	-19.957 [21.075]	4.124 [3.008]
One month later	-0.533 [0.492]	0.252 [0.237]	-25.757*** [5.769]	-9.923** [3.900]	0.022 [0.155]	0.123 [0.169]	20.175** [8.843]	-5.096 [3.281]
Three months later	-0.509 [0.368]	0.239 [0.244]	-21.163*** [4.860]	-7.307** [2.999]	-0.205* [0.114]	-0.059 [0.087]	20.507** [8.059]	3.213 [1.934]
Six months later	-0.420 [0.337]	0.281 [0.268]	-10.543* [5.440]	-5.398** [2.711]	-0.267*** [0.080]	-0.114 [0.090]	13.438 [8.312]	2.424 [1.987]

Notes: Data are at monthly frequency. Sample period covers from January 2000 to December 2010. The dependent variables are the log change in real house prices, number of transactions, and household debt level, in each respective column. LTV and DTI intervention variables are dummy variables that take on the value of 1 for the respective periods before/after the intervention. In each regression, only two dummies (one for LTV and one for DTI) are included. In all regressions, lagged house price change, mortgage loan rate, and log changes in the money supply (M2), in unsold inventory of properties, in the composite index of coincident indicators (a measure of the business cycle) and in the KOSPI are included as controls. 'Metro' refers to the Seoul Metropolitan Area. 'Non-Metro' are all remaining areas. Newey-West standard errors, with maximum lag of 2, are in square brackets. \*\*\*, \*\*, and \* denote significance at the 1, 5, and 10 percent level, respectively.

Table 3b. Housing and Mortgage Market Activity Before and After Loosening

	House Prices		Transactions		Household Debt		Seller Dominance	
	Metro	Non-Metro	Metro	Non-Metro	Metro	Non-Metro	Metro	Non-Metro
LTV interventions								
Six months prior	-0.314 [0.393]	-0.169 [0.217]	-5.321 [12.179]	-8.371* [4.480]	0.234* [0.165]	-0.229* [0.137]	11.526 [7.222]	-4.125 [7.755]
Three months prior	-0.468 [0.337]	-0.372* [0.200]	-20.348 [13.291]	-10.021* [5.346]	0.465*** [0.088]	-0.031 [0.078]	8.547 [5.217]	-12.855*** [3.486]
One month prior	0.315 [0.451]	-0.461** [0.181]	1.527 [8.924]	-6.677 [4.531]	0.270 [0.165]	-0.184 [0.130]	-14.976 [11.645]	-6.354 [7.316]
At announcement	-0.751*** [0.154]	0.267** [0.103]	33.220*** [3.314]	10.701*** [2.328]	0.535*** [0.117]	-0.062 [0.067]	5.198 [3.375]	-4.474 [2.920]
One month later	0.484*** [0.161]	0.177 [0.108]	-6.158 [3.958]	0.333 [2.261]	-0.017 [0.143]	0.054 [0.060]	8.037** [3.606]	-9.927*** [2.666]
Three months later	-0.095 [0.238]	-0.026 [0.157]	-9.624** [4.536]	6.264* [3.259]	-0.345*** [0.106]	0.016 [0.073]	10.441*** [3.811]	0.876 [4.244]
Six months later	-0.379 [0.288]	-0.162 [0.223]	-11.560** [4.893]	3.781 [3.298]	-0.271* [0.160]	-0.094 [0.100]	13.960*** [4.310]	-1.583 [3.829]
DTI interventions								
Six months prior	0.085 [0.213]	0.480** [0.229]	-5.281 [7.311]	-1.487 [3.548]	-0.006 [0.088]	-0.071 [0.152]	2.823 [5.320]	2.836 [2.524]
Three months prior	0.232 [0.204]	0.282 [0.182]	-11.123 [8.348]	-2.911 [3.301]	0.101 [0.091]	0.195* [0.103]	3.236 [6.824]	4.633* [2.430]
One month prior	-0.137 [0.236]	1.637 [1.165]	-15.269* [8.132]	-10.216*** [3.585]	-0.047 [0.096]	-0.255 [0.179]	1.999 [5.025]	12.970*** [3.940]
At announcement	-0.064 [0.239]	0.068 [0.224]	-9.424 [7.596]	-3.415 [4.027]	-0.066 [0.098]	-0.006 [0.171]	-4.325 [4.483]	-6.489 [4.819]
One month later	-0.788*** [0.165]	0.231 [0.463]	-2.598 [5.129]	3.070 [7.706]	0.034 [0.055]	0.079 [0.138]	2.054 [5.496]	-0.297 [2.647]
Three months later	-0.150 [0.403]	-1.188 [0.721]	10.520* [6.065]	5.908 [4.320]	0.216*** [0.076]	0.242** [0.122]	2.102 [5.016]	-6.358* [3.406]
Six months later	-0.224 [0.301]	-1.037 [0.668]	16.519*** [5.963]	4.726 [5.335]	0.197* [0.107]	0.263** [0.118]	-0.356 [6.067]	-4.075 [3.104]

Notes: Data are at monthly frequency. Sample period covers from January 2000 to December 2010. The dependent variables are the log change in real house prices, number of transactions, and household debt level, in each respective column. LTV and DTI intervention variables are dummy variables that take on the value of 1 for the respective periods before/after the intervention. In each regression, only two dummies (one for LTV and one for DTI) are included. In all regressions, lagged house price change, mortgage loan rate, and log changes in the money supply (M2), in unsold inventory of properties, in the composite index of coincident indicators (a measure of the business cycle) and in the KOSPI are included as controls. 'Metro' refers to the Seoul Metropolitan Area. 'Non-Metro' are all remaining areas. Newey-West standard errors, with maximum lag of 2, are in square brackets. \*\*\*, \*\*, and \* denote significance at the 1, 5, and 10 percent level, respectively.

Table 4a. Housing and Mortgage Market Activity Before and After Tightening: Separate Dummies

	House Prices		Transactions		Household Debt		Seller Dominance	
	Metro	Non-Metro	Metro	Non-Metro	Metro	Non-Metro	Metro	Non-Metro
LTV interventions								
LTV, September 2002	-1.917*** [0.505]		-8.351 [9.303]				39.067** [19.654]	
LTV, June 2003	-0.808** [0.358]	-0.076 [0.541]	-11.272 [10.915]	-9.460* [5.045]		-0.354*** [0.097]	13.413 [8.401]	21.898*** [4.491]
LTV, October 2003	-0.750** [0.0.300]	0.148 [0.295]	-4.960 [11.891]	-1.880 [5.077]	-0.200 [0.142]	-0.045 [0.079]	17.687*** [5.524]	-12.214*** [2.950]
LTV, June 2005	-0.688** [0.294]	0.441 [0.378]	-2.325 [13.240]	0.203 [7.996]	-0.234 [0.162]	0.134** [0.077]	6.289 [7.139]	4.596 [3.605]
LTV, July 2009	0.100 [0.250]	0.306 [0.224]	-13.794 [10.290]	-8.936*** [3.390]	-0.417* [0.235]	-0.033 [0.268]	-1.492 [5.098]	2.340 [1.922]
DTI interventions								
DTI, August 2005	-0.022 [0.291]	-0.394 [0.428]	-7.134 [9.121]	-5.740 [5.121]	-0.151 [0.154]	-0.178** [0.084]	14.166 [8.582]	0.032 [3.331]
DTI, March 2006	-0.292 [0.477]	0.400 [0.413]	-8.569 [10.763]	-7.348 [5.812]	0.209 [0.157]	0.060 [0.098]	7.173 [9.584]	2.917 [3.359]
DTI, November 2006	-1.297** [0.509]	0.042 [0.113]	-28.108*** [8.617]	-8.041 [5.539]	-0.408 [0.253]	0.114 [0.115]	31.607*** [11.968]	3.157** [1.289]
DTI, February 2007	-0.353 [0.449]	-0.168 [0.109]	1.578 [6.565]	-2.160 [3.871]	-0.489* [0.247]	-0.405** [0.177]	7.378 [11.615]	2.427 [1.568]
DTI, September 2009	-0.171 [0.216]	0.606 [0.400]	-0.924 [10.492]	3.969 [2.764]	-0.126 [0.093]	-0.232 [0.188]	6.439 [6.399]	-0.493 [2.398]

Notes: Data are at monthly frequency. Sample period covers from January 2000 to December 2010. The dependent variables are the log change in real house prices, number of transactions, and household debt level, in each respective column. LTV and DTI intervention variables are dummy variables that take on the value of 1 for the six periods following the intervention. In all regressions, lagged house price change, mortgage loan rate, and log changes in the money supply (M2), in unsold inventory of properties, in the composite index of coincident indicators (a measure of the business cycle) and in the KOSPI are included as controls. 'Metro' refers to the Seoul Metropolitan Area. 'Non-Metro' are all remaining areas. Newey-West standard errors, with maximum lag of 2, are in square brackets. \*\*\*, \*\*, and \* denote significance at the 1, 5, and 10 percent level, respectively.

Table 4b. Housing and Mortgage Market Activity Before and After Loosening: Separate Dummies

	House Prices		Transactions		Household Debt		Seller Dominance	
	Metro	Non-Metro	Metro	Non-Metro	Metro	Non-Metro	Metro	Non-Metro
LTV interventions								
LTV, March 2004	-0.335 [0.291]	-0.137 [0.204]	-11.254** [4.883]	3.565 [3.153]	-0.270* [0.161]	-0.099 [0.102]	13.301*** [4.425]	-1.476 [3.863]
DTI interventions								
DTI, November 2008	-0.835** [0.403]	-0.160 [0.249]	12.263 [10.197]	-2.808 [6.952]	0.232 [0.201]	0.060 [0.141]	8.434 [9.731]	-0.334 [4.066]
DTI, August 2010	0.147 [0.237]	-1.978 [1.351]	19.099*** [6.481]	12.816*** [3.970]	0.175** [0.086]	0.481*** [0.135]	-5.507 [5.151]	-8.092 [5.779]

Notes: Data are at monthly frequency. Sample period covers from January 2000 to December 2010. The dependent variables are the log change in real house prices, number of transactions, and household debt level, in each respective column. LTV and DTI intervention variables are dummy variables that take on the value of 1 for the six periods following the intervention. In all regressions, lagged house price change, mortgage loan rate, and log changes in the money supply (M2), in unsold inventory of properties, in the composite index of coincident indicators (a measure of the business cycle) and in the KOSPI are included as controls. 'Metro' refers to the Seoul Metropolitan Area. 'Non-Metro' are all remaining areas. Newey-West standard errors, with maximum lag of 2, are in square brackets. \*\*\*, \*\*, and \* denote significance at the 1, 5, and 10 percent level, respectively.

Table 5. Survey Data: Summary Statistics Before and After Matching

	Treated	Untreated	p-value	Treated	Untreated	p-value
Income	2.99	2.76	0.00	1.80	1.82	0.16
Financial assets	62.54	47.25	0.00	21.35	22.15	0.11
Debt	36.79	28.17	0.00	13.18	13.38	0.19
Property price	144.53	111.93	0.00	51.29	52.28	0.26

Notes: 'Treated' are the households for whom the tightening of LTV/DTI regulation is applicable. p-value shows the result from the equivalence of means test.

Table 6. Effect of Policy Tightening on Household Decisions

	LTV		DTI	
	SATE	SATT	SATE	SATT
Demand	-0.045*** [0.015]	-0.021 [0.0137]	-0.023** [0.012]	-0.005 [0.010]
Upward price expectation	-0.056** [0.024]	-0.065*** [0.021]	0.087*** [0.018]	0.132*** [0.016]
Expected price appreciation	-1.005** [0.459]	-1.613*** [0.430]	1.237*** [0.355]	1.943*** [0.327]

Notes: SATE stands for sample average treatment effect (aka experimental treatment average). SATT stands for sample average treatment effect for the treated. Treated are the households for whom the tightening of LTV/DTI regulation is applicable. 'Demand' is a dummy variable that takes on the value of 1 if the household is planning to purchase a property over the course of the coming year. 'Upward price expectation' is a dummy variable that takes on the value of 1 if the household is expecting house prices to go up over the course of the coming year. 'Expected price expectation', expressed in percent, is what the households expect the change in house prices to be over the course of the coming year. The estimates are corrected for the bias due to inexact matching in finite samples. Standard errors are in square brackets. \*\*\*, \*\*, and \* denote significance at the 1, 5, and 10 percent level, respectively.

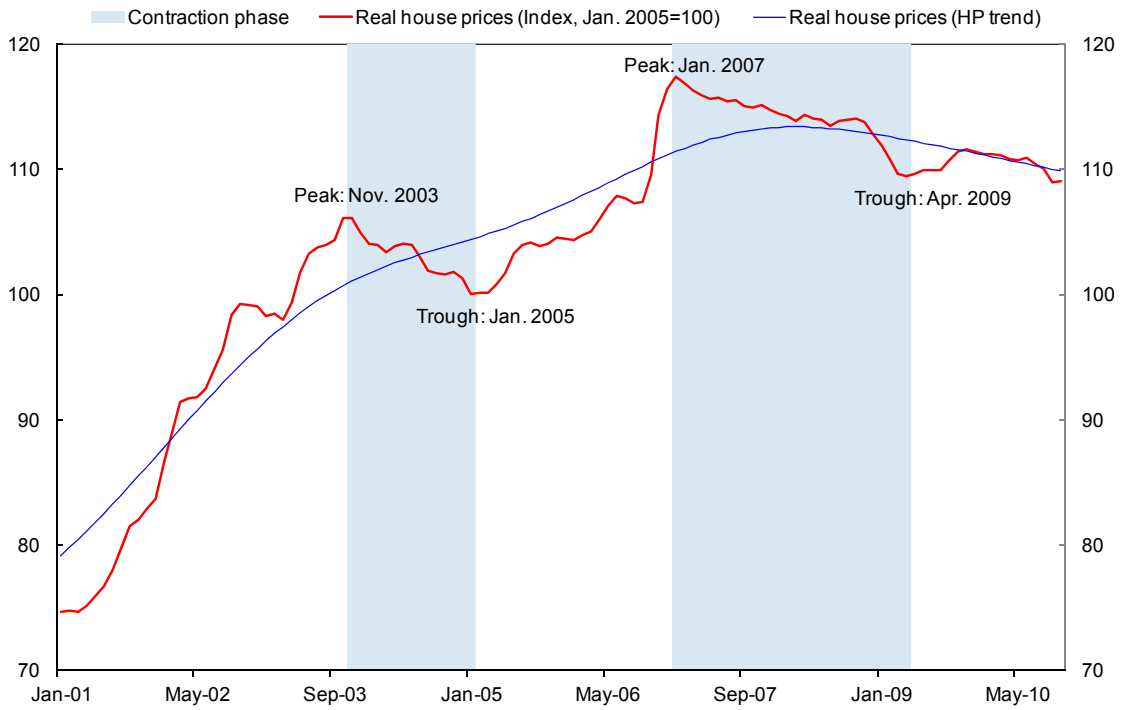


Table 7. Effect of Policy Tightening on Different Household Groups

	LTV		DTI		LTV		DTI	
	SATE	SATT	SATE	SATT	SATE	SATT	SATE	SATT
Young versus Old								
	Young				Old			
Demand	-0.040 [0.034]	-0.028 [0.034]	-0.023 [0.028]	0.013 [0.026]	-0.037** [0.016]	-0.027* [0.016]	-0.027** [0.012]	-0.016 [0.012]
Upward price expectation	-0.121** [0.050]	-0.083* [0.049]	0.048 [0.043]	0.143*** [0.037]	-0.060** [0.024]	-0.042* [0.024]	0.095*** [0.018]	0.134*** [0.017]
Expected price appreciation	-1.873* [1.035]	-1.409 [0.894]	1.548* [0.900]	2.382*** [0.746]	-0.955** [0.483]	-1.346*** [0.476]	1.450*** [0.351]	1.862*** [0.359]
First-time home buyers versus speculators								
	First-time home buyers				Speculators			
Demand	-0.038 [0.031]	-0.011 [0.020]	-0.014 [0.025]	0.007 [0.015]	-0.062*** [0.016]	-0.044*** [0.015]	-0.042*** [0.013]	-0.019 [0.012]
Upward price expectation	-0.021 [0.041]	-0.085*** [0.026]	0.118*** [0.034]	0.101*** [0.020]	-0.078** [0.035]	-0.046 [0.036]	0.080*** [0.027]	0.170*** [0.026]
Expected price appreciation	-0.420 [0.873]	-1.862*** [0.569]	2.172*** [0.734]	1.693*** [0.433]	-1.427** [0.620]	-1.148* [0.619]	0.879* [0.489]	2.155*** [0.476]

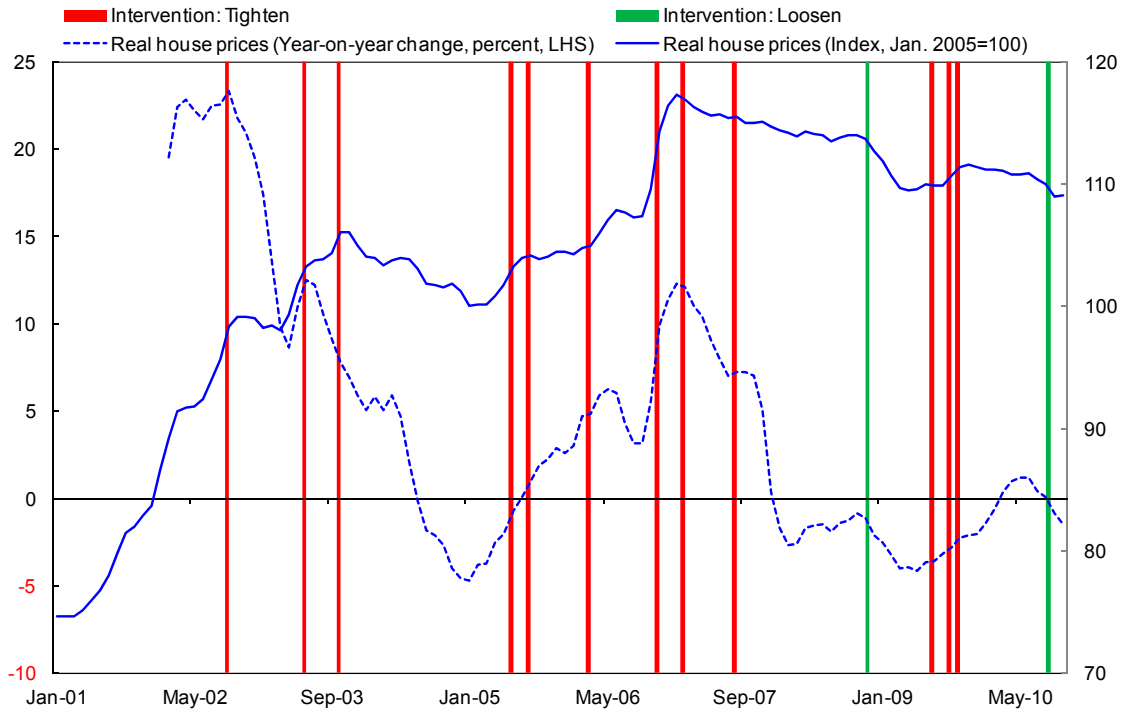
Notes: SATE stands for sample average treatment effect (aka experimental treatment average). SATT stands for sample average treatment effect for the treated. Treated are the households for whom the tightening of LTV/DTI regulation is applicable. 'Demand' is a dummy variable that takes on the value of 1 if the household is planning to purchase a property over the course of the coming year. 'Upward price expectation' is a dummy variable that takes on the value of 1 if the household is expecting house prices to go up over the course of the coming year. 'Expected price expectation', expressed in percent, is what the households expect the change in house prices to be over the course of the coming year. Young versus old distinction depends on a dummy that is one if the age of the head of household is less than or equal to 35. First-time buyers versus speculators are defined based on whether the household currently owns a property or not. The estimates are corrected for the bias due to inexact matching in finite samples. Standard errors are in square brackets. \*\*\*, \*\*, and \* denote significance at the 1, 5, and 10 percent level, respectively.

Figure 1. House Price Cycles in Korea: 2001-2010



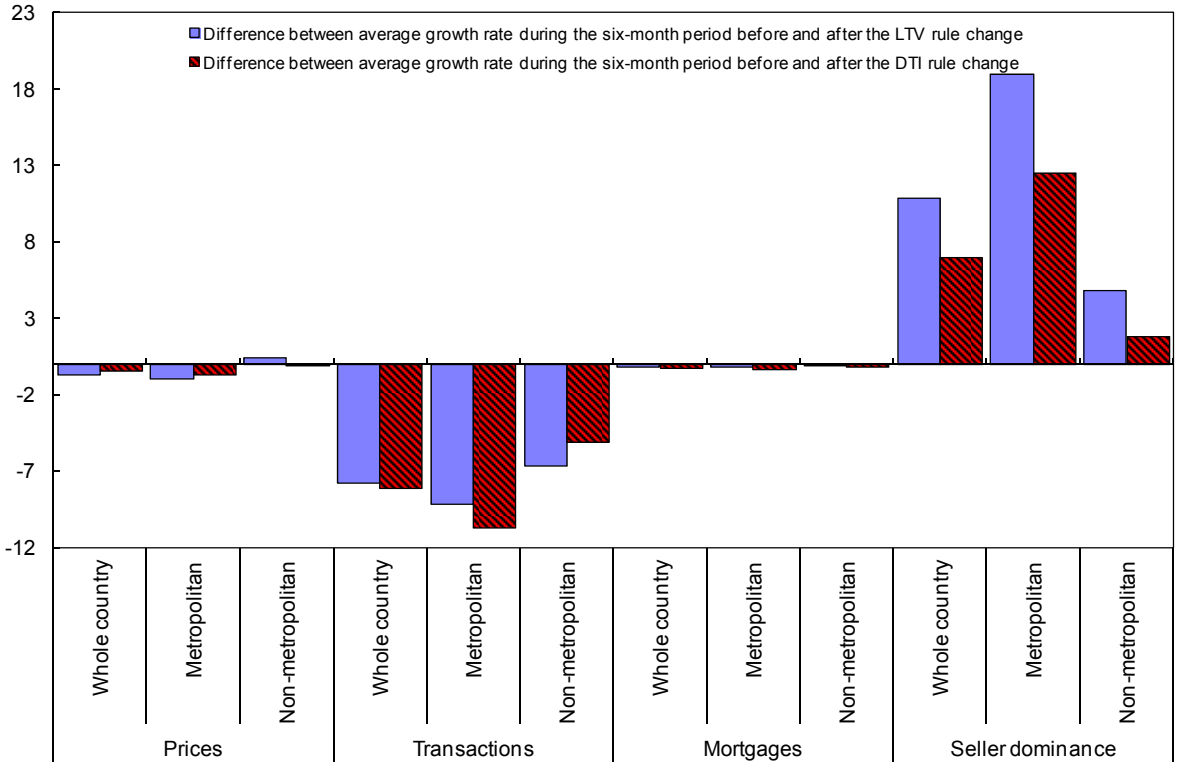
Source: Bank of Korea.

Figure 2. Policy Interventions: LTV and DTI Adjustments



Sources: Bank of Korea and Financial Supervisory Service.

Figure 3. Housing and Mortgage Market Activity following Policy Interventions



Sources: Bank of Korea, Financial Supervisory Service, Korea Realtors' Association, authors' calculations.

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