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Is Leverage a Determinant of Asset Price? Evidence from Real Estate Transaction Data

Daichi Kurashima
Ministry of Justice
Government of Japan

Masashi Mizunaga
Star Mica Corporation

Kazuhiko Odaki[*†]
College of Economics
Nihon University

Wako Watanabe
Faculty of Business and Commerce
Keio University

Abstract

By exploiting the correlation between the legal type of a property purchased as collateral and loan to value (LTV), particularly the positive correlation between use of the property as revolving collateral and LTV as a strong and valid instrumental variable for LTV, we isolate the positive effect of LTV on the property price from the observed negative reverse causality. We also find that the effect of LTV on the property price is far greater when unleveraged property transactions purchased with 100 percent equity financing are excluded than when they are included.

Key words: Bank lending; Asset price; Collateral; Loan to Value

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[†]Corresponding Author: Address: College of Economics, Nihon University, 1-3-2 Misaki-cho, Chiyoda-ku, Tokyo 102-8360 Japan. Phone: 81-3-3219-3301; E-mail: odaki.kazuhiko@nihon-u.ac.jp

1. Introduction

The rise and the fall of mortgage markets are well-documented facts that are widely observed during financial crises. In the United States, average home price as measured by the composite Case–Shiller index for ten major Metropolitan Statistical Areas monotonically increased until it reached its peak in April 2006, more than twice the index level at the beginning of 2000. This dramatic rise was followed by equally spectacular falls in home prices. The index monotonically decreased and lost about one-third of its peak value as of June 2009. The cyclical rise and fall in home prices coincided with the similarly cyclical credit expansion and its contraction, ultimately leading to the devastating global financial crisis of 2008 and 2009. As Mian and Sufi (2011) report, mortgage lenders accelerated lending in response to sharp home price appreciation, hoping that increased lending would be secured by the increased value of homes taken as collateral. Dell’Ariccia et al. (2012) show evidence that the expansion of mortgage demand and home price appreciation lead to rapidly deteriorating lending standards. Demyanyk and Van Hemert (2011) also present evidence that lending standards deteriorated year by year from 2001 through 2007. When home prices stopped rising and began to fall in 2007, lending standards tightened and the supply of mortgages decreased.

Indeed, as Reinhard and Rogoff (2009) summarize, it is not an overstatement that this boom-bust cycle of credit supply and asset price is a staple of financial crises. Most crises that took place in various parts of the world at various points in time exhibit similar cyclical patterns in credit and asset prices. One such instance of a crisis whose magnitude is comparable to the abovementioned global financial crisis is found in Japan.

In Japan, booming real estate prices during the bubble period of the second half of the 1980s reached their peak in 1991, and continued a roller coaster slide for more than a decade. As was well documented by Hoshi and Kashyap (2004), rapidly expanding mortgages, particularly those collateralized by commercial real estate, coincided with monotonically rising real estate prices in the 1980s, whereas these patterns were exactly reversed as real estate prices stopped rising and began to plummet in 1991. As empirical studies such as those by Woo (2003) and Watanabe (2007) document, banks incurred large capital losses when regulators urged them to clean non-performing loans off their books; they then responded to eroding capital by curtailing lending so as to prop up their regulatory capital ratio.

The macroeconomic literature incorporating the so-called collateral constraint into the dynamic general equilibrium model as pioneered by Kiyotaki and Moore (1997) assumes that firms can borrow up to the value of their assets (resources) available as collateral that are pledgeable to their lenders. Such a model advocates the positive effects of asset prices on the quantity of collateralized loans, while dismissing any causality that may run in the reverse direction. In these types of macroeconomic general equilibrium models, the price of asset determined in the equilibrium itself depends on the future productivity of assets that the firm employs as capital input to produce its output or on the future return on an endowment. Among these models, Kiyotaki and Moore (1997) specifically derive an expression for the equilibrium land price as the present value of the sum of discounted future marginal productivities of land. Put differently, in these mainstream macroeconomic models, the price of the asset is determined at its fundamental value.

As we will discuss shortly, changes in the price of an asset such as real estate have profound macroeconomic implications, both as a constraint on a firm's borrowing ability and as a result of a change in credit supply. This presumably is because the mainstream theoretical literature sheds light on the role of an asset as a constraint on borrowing. Empirical studies using micro data such as the study by Mian and Sufi (2011) test the causal effect of the price of an asset on a loan collateralized by the asset, while largely overlooking the reverse causality; that is, the causal effect of a loan collateralized by an asset on its price.

Regarding the relationship between the price of asset and a loan collateralized by the asset, however, views of practitioners engaged in asset trading and views of macroeconomists are starkly different. The consensus shared by practitioners is that this disrespected reverse causality is widely observed in asset markets. Their agreed view, indeed, is that a rapid increase in asset price during a bubble period and a sharp fall in the price after the bubble's burst are instigated by lenders' aggressive expansion of credit supply to asset buyers, followed by its rapid contraction. This is because asset buyers during a credit boom period who are able to borrow more can afford more assets at higher prices; they increase asset purchases if they expect assets to generate positive returns. Asset buyers during a period of credit contraction who are not able to borrow as much as during the boom are forced to buy fewer assets at lower prices.

Policymakers are well aware of the danger of credit expansion fueling the real estate. Bernanke (2010) mentions, "(t)he availability of these alternative mortgage products proved to be quite important and, as many have recognized, is likely a key explanation of the housing bubble", and refer such exotic mortgages as "evidence of a protracted deterioration in mortgage underwriting standards", suggesting that he suspects this danger. The Financial Stability Board (2012) states, “Jurisdictions should ensure that their regulatory and supervisory frameworks appropriately incentivise prudent approaches to the collateralisation of mortgage loans” on the ground that “high-LTV ratio loans consistently perform worse than those with a high proportion of initial equity.”

Most academic economists, however, have been skeptical about the effect of lending on asset prices. The theory that lies behind this skepticism is the efficient market hypothesis advocated by most financial economists. According to the hypothesis, stronger asset demand would not cause the equilibrium price of asset to rise above its fundamental value; neither would weaker demand cause it to fall below the fundamental value.

Traders who think the price of an asset is too high relative to its fundamental value or those who think it is too low have incentives to act as arbitragers. Under such circumstances, if arbitragers can short sell assets they think overpriced, they can quickly sell these overpriced assets until prices of assets revert (fall) to their fundamental values. Conversely, if they can make leveraged purchases of assets they think underpriced, again their prices immediately revert (rise) to their fundamental values. The efficient market hypothesis critically hinges on the assumption that asset traders are able to engage in unlimited arbitrage. As Shleifer and Vishny (1997) discuss, when this assumption is violated, the hypothesis does not hold true. It is well known that shorting certain assets, particularly real estate properties, is generally infeasible.

Geanakoplos (2010) departs from this “fundamental value” theory of asset pricing by assuming that beliefs about a future asset price held by asset traders are heterogeneous; that is, people are either optimistic or pessimistic about the future asset price. This causes optimistic traders to become leveraged asset buyers who borrow from pessimistic traders, enabling them to buy an asset at a price higher than its fundamental value. Because pessimistic traders are constrained to short selling, the arbitrage that would revert the price of the asset to its fundamental value does not take place, causing its price to remain higher.

To the best of our knowledge, this is the first study using transaction level data to identify directly the effect of an asset purchaser's leverage on the price of the asset by utilizing valid instrumental variables.

In this study, using a unique dataset of downtown Tokyo property transactions, where the run-up of real estate prices was sharper and the subsequent falls in these prices were more dramatic than anywhere else in Japan, we examine the effect of an asset buyer's leverage on the price of the purchased asset that is pledged as collateral to her lender. We believe that our approach to compiling the data used in our empirical analyses is itself a substantial contribution to the literature. The data are constructed by combining the data about property transactions, which are extracted from a privately available database to which we have special access through a private property trading firm, with the data about mortgages borrowed to purchase these properties as well as identities of each transaction's buyer and seller, which are extracted from a publicly available government database. We then run the regression of the property price adjusted for the regional trends on the loan to value ratio (LTV), which we use interchangeably with leverage.

We test the often-overlooked causal effect of asset price on leverage, while taking into account the possible reverse causality that has been the main focus of previous studies.

We construct instrumental variables for LTV by exploiting the fact that the level of LTV is associated with a loan's type of collateral. In practice, we employ two dummy variables to explain LTV. The first dummy variable indicates that the purchased property is used as a joint mortgage (collateral) along with other assets. The second dummy variable indicates that the purchased property is used as a revolving mortgage (collateral): that is, the asset is used not only to collateralize the current loan but also to secure loans borrowed in the past and in the future. We find that these dummy variables used to indicate type of collateral pledged to a creditor by an asset buyer are very strongly correlated with LTV, thereby ensuring their validity.

Our findings are threefold. First, we find that the estimated coefficient of LTV for the regression of the regional trend adjusted property price is positive and significant when LTV is instrumented by the abovementioned variables, but is insignificant when the regression is run using ordinary least squares (OLS). Second, the legal type of a purchased property as collateral, in particular whether it is used as revolving collateral, provides us with strong and valid instrumental variables that allow us to identify the effect of LTV on property price. Third, the effect of LTV on the adjusted property price is far greater when unleveraged property transactions purchased with 100 percent equity financing are excluded. On the basis of our regression results, the adjusted property price increases by 15 percentage points in response to an increase in LTV by 10 percentage points. Thus, the effect is not only statistically significant but also economically significant.

The remainder of this paper is organized as follows. Section 2 reviews relevant theoretical and empirical studies. Section 3 explains how we constructed the data and our empirical methodology. Section 4 reports and interprets empirical results. Section 5 concludes.

2. The Related Literature

Regarding the relationship between the price of an asset used as collateral and the loan borrowed by (credit available to) its purchaser, depending on the direction of causality, one is able to view the relationship between these two variables either as a causal relationship from asset price to credit or as a causal relationship in the reverse direction.

The literature employing the first view of the effect of credit (loans) on the asset price is represented by the strand of macroeconomic literature pioneered by Kiyotaki and Moore (1997). The principal contribution of Kiyotaki and Moore (1997) to the macroeconomic literature is to shape the general equilibrium model of the aggregate economy wherein firms (producers) produce using land (assets) as a capital input while pledging land as collateral to secure their loans borrowed from external creditors. They further assume the so-called collateral constraints faced by firms that take loans to purchase land so that the amount borrowed by a firm cannot exceed the value of assets a firm holds. The theoretical approach employed by Kiyotaki and Moore can be referred to as the “fundamental value” view, because in their models the equilibrium price of an asset is determined at its fundamental value, which prevents emergence of an asset price bubble. Kiyotaki and Moore show that the price of productive land indeed equals the present value of discounted future user costs or, equivalently, the present value of discounted future flows of productivity. This means that, for example, a negative (positive) exogenous shock to a firm’s future productivity depresses the price of land, which then tightens (relaxes) a firm's collateral constraint so that the firm is able to borrow less (more) from external creditors. Macroeconomic general equilibrium models in which agents face collateral constraints are also discussed by Caballero and Krishnamurthy (2001), Jeanne and Korinek (2010), and Bianchi (2011).

The "fundamental value" view not only ignores the reverse causality that runs from credit availability to asset price but also inevitably rules out the possible development of an asset price bubble; that is, the rise of the price of an asset above its fundamental value.[1] However, there is an evolving theoretical literature that models an asset buyer's leverage or her borrowing as a source of the asset bubble. Allen and Gale (2001) develop a model in which a loan borrowed by an asset buyer creates the asset bubble. In their model, the limited liability of a leveraged asset buyer, which allows her to default on a loan she borrows from external creditors when the realized return of the risky asset is low, makes the buyer bid up the risky asset above its fundamental value. On the other hand, in the model developed by Geanakoplos (2010), beliefs about the return on the risky asset are heterogeneous within the population; those who are optimistic about the return buy risky assets by borrowing from those who are pessimistic—who become sellers of these assets. He further discusses that the run-up of the risky assets occurs because optimistic investors with access to credit from pessimistic investors are able to bid up these assets, and that the crash of the asset price occurs because pessimists curtail credit to optimists. Because pessimists are constrained to short selling these assets, the

[1] The recent studies by Kocherlakota (2009) and Martin and Venture (2012) present the macroeconomic general equilibrium model in which entrepreneurs collateralize bubbly assets without any productive (fundamental) value such as (bubbles in) real estates when borrowing loans to finance their productive investment. The twist in their models is that the weak contract enforcement does not allow entrepreneurs to collateralize the (discounted value of) future flows of production. Rather they use bubbly assets to collateralize their loans, which makes intrinsically valueless bubbly assets scarce and valuable in an equilibrium.

arbitrage that would equalize the price of an asset with its fundamental value does not take place. Other studies that discuss investors' leverage by assuming investors' heterogeneous beliefs include those by Fostel and Geanakoplos (2008, 2012).

On the empirical front, several studies provide evidence that asset prices affect the quantity of (bank) credit. Using data of publicly traded Japanese firms, Gan (2007a) finds that aggregate (nationwide) land prices have a positive effect on credit availability to a firm as measured by the firm's long-term borrowing, empirically showing that Japanese firms face collateral constraints. Using individual-level data from the United States, Mian and Sufi (2011) find that the average homeowner borrows 25 cents for every dollar increase in house price. When running the regression of the leverage growth with house price growth as an independent variable, they instrument the independent variable by the elasticity of housing supply at the zip code level.

Using the aggregate flow of funds data, however, Adrian and Shin (2011), present the evidence inconsistent with the finding of Mian and Sufi (2011). They show that the effect of asset price appreciation (depreciation) on leverage varies depending on the type of asset buyers. They show that different sectors of the economy respond differently to a change in the price of an asset used as collateral when borrowing a loan. Non-financial firms, commercial banks, and investment banks employ an aggressive investment strategy in response to asset price appreciation that relaxes collateral constraints by accelerating leveraged asset purchases, which either raises their leverage or keeps it static. However, households take a passive approach and do not increase leveraged asset purchases. This reduces their leverage.

There is also recently evolving literature that draws implications about the effects of mortgages on real estate prices. The pioneering empirical work along this line is the study by Mora (2008). Using prefecture level data from Japan, she uses an increase in the local (prefecture level) share of *keiretsu* loans among total loans outstanding as an instrumental variable for an endogenous independent variable, the local share of real estate loans among total loans, as this independent variable and the employed instrument are negatively correlated. She finds that an increase in the share of real estate loans by one percentage point results in an increase in local land prices by 15% to 20%. Using county-level data of the United States, Favara and Imbs (2010) employ the index of inter-state branching deregulation as an instrumental variable for a key independent variable, a measure of mortgages borrowed by home buyers in the regression, for home price on the ground that banks are more active in supplying mortgages in a county where branching regulation is not tight. They find that an increase in the supply of mortgages leads to increases in home prices.

Mian and Sufi (2009) use U.S. zip code level data of home prices over the period from 1996 through 2007. They find that, within the same county, the average home price growth is faster in zip code areas where the fraction of subprime mortgage borrowers is initially greater than in zip code areas where the fraction of subprime borrowers is smaller. Using county-level data of the United States during the farm price boom and the following bust before the Great Depression, Ramcharan and Rajan (2011) find that greater credit availability in a county is associated with higher farm land prices in the same county. Using Metropolitan Statistical Area (MSA) level data over the period from 1998 through 2008, Glaeser et al. (2012) run OLS regressions to find that an increase in the local aggregate LTV by 10% raises the local home price by 3.6%.[2]

[2] Several recent studies discuss the effect of mortgage availability on the real estate price by showing the correlation between measures for the former and the latter using relatively aggregate data. These include Duca et al. (2011) who use the time series data of the United States and Crowe et al. (2013) who use the cross-country data of 21 mostly developed countries.

Using the region level data from South Korea, Igan and Kang (2011) find that the house price appreciation becomes slower after the government imposed limit to the LTV of a mortgage is raised.

Using the data of property transactions in the United States for the period from 1998 through 2008, Adelino et al. (2012) find that the price of the property is cheaper when the price is substantially greater than the conforming loan limit (CLL); a buyer is more borrowing constrained, that is, the loan size substantially exceeds the limit up to which government-sponsored enterprises including Fannie Mae and Freddy Mac can purchase and securitize, than when the price is closer to CLL, when the buyer is less borrowing constrained.

It is noteworthy that the empirical papers exploring the effects of mortgages on real estate prices mentioned above either do not use micro data of property transactions or do not successfully identify the effects of an exogenous change in mortgages (LTV), both of which we successfully do in our empirical exercise.

3. Data and Empirical Methodology

3.1. Empirical Model

In practice, we run the following cross sectional regression:

$$RP_i = \alpha_0 + \alpha_1 LTV_i + \alpha_2 BIND_i + \varepsilon_i \qquad (1)$$

where RP_i is defined as the transaction price per square meter of property *i*, P_i divided by the average price of residential land in ward *j* in year *t*, P_{jt}. LTV_i is a loan to value ratio of property *i*, and $BIND_i$ is a dummy variable to indicate that a property's buyer is an individual rather than a company.

Regarding the regression equation, several issues are worth mentioning. First, we construct the dependent variable by dividing the price of a property (per square meter) by the average land price (per square meter) in the year and in the ward of Tokyo in which the property transaction took place. This allows us to control for the local trend of the property price when running the regression. Second, our key independent variable, *LTV,* is defined as the amount of the mortgage borrowed to purchase a property divided by the price of the property at the time of its purchase (the transaction price). A dummy variable, *BIND*, is meant to control for possible inherent differences between an asset buyer's behavior when she is an individual and when it is a company.

3.2. Mortgage Types and Instrumental Variables

In Japan, when financing property (real estate) purchases, so called joint mortgages and revolving mortgages are widely utilized. The Japanese Civil Code stipulates three legally distinct types of mortgages, ordinary mortgages, joint mortgages and revolving mortgages. By law, an ordinary mortgage has to be pledged on a single loan. That is, neither can any ordinary mortgage collateralize a single claim jointly with other mortgages nor it can collateralize multiple claims. This is known as the "no claim, no (ordinary) mortgage" principle of an ordinary mortgage. When a bank and a property purchaser agree to break this principle, they set up either a joint mortgage or a revolving mortgage.

A joint mortgage is a type of mortgage that the purchaser creates over separate properties that she already owns in addition to the purchased property. A revolving mortgage covers not only the loan borrowed to purchase that property itself but also covers the loans the purchaser borrows from that bank.

In order to identify the effect of LTV on the property price, we construct instrumental variables for LTV by exploiting the relationship between the legal type of a mortgage and LTV (the credit that finances the property purchase). More precisely, we employ the dummy variable to indicate that the purchased property is used as a joint mortgage along with other assets (JMORT), and to indicate that the purchased property is used as a revolving mortgage (RMORT).

The two dummy variables are the variables to indicate that a mortgage a purchaser creates on the property is more favorable to a bank than an ordinary mortgage. When other assets are pledged in addition to the purchased property as collateral, the loan borrowed by the property purchaser is more secure to the originating bank. When a purchased property is designated as revolving collateral, the bank is able to utilize the home equity created by the purchaser's repayments as collateral for further loans, suggesting that the bank will be able to exploit future profitable opportunities that the borrower will present to it. Put differently, home equity loans that became very popular among lenders in the United States before the financial crisis are made possible in Japan only when a revolving mortgage is pledged. According to practitioners, a revolving mortgage is usually requested to a borrower by a bank that has a prior lending relationship. Thus, the relationship alleviates the asymmetric information about a borrower's credit quality so that the bank can grant a larger leverage (higher LTV) to the borrower.[3]

[3] Petersen and Rajan (1994) and Cole (1998) find that the bank's longer relationship with a

On the other hand, in practice, whether a buyer creates a joint mortgage, a revolving mortgage, or only an ordinal mortgage should not influence the transaction price except through the size of a loan the buyer can borrow from the bank. A bank is indifferent to the quality grade of a property when choosing to request a property buyer a type of a mortgage she creates on the purchased property. The bank requests her a joint mortgage because she has other collateralizable properties rather than because the purchased property is more luxurious. Similarly, the bank requests her a revolving mortgage because she has other loans outstanding borrowed from the bank.[4] [5]

One possibility, however, is that properties purchased by companies tend to be more expensive than those purchased by individuals. This is because i) companies are more likely to make speculative property investment for higher gains (returns) and ii) properties purchased by companies tend to be used as shops or offices while properties purchased by individuals tend to be used for residential purposes. On the other hand, companies are more likely to have other collateralizable assets such as shops and offices that they can create a mortgage jointly with the property to purchase than individuals are. Companies are also more likely to create a revolving mortgage than individuals do because companies tend to have needs to borrow more loans such as loans for working

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borrower firm is associated with larger credit availability in the United States.

[4] According to the Japanese language practical guides for bankers to deal with loans to finance real estate purchases, a bank designates a purchased property as an ordinary mortgage when the bank and a purchaser of the property engage in the loan contract for the purchase of that property only, whereas the bank designates the purchased property as a revolving mortgage covering many of loans between it and the property purchaser when the two are engaged in continuing transactions such as bills discounting. See pages 181 and 182 of Ishii et al. (1992) and pages 10 and 11 of Ishii and Sakuma (2006) for further details.

[5] According to the Survey concerning Managerial Realities of Financial Institutions that was conducted by the group of economists lead by Hiro Uchida including Watanabe who are funded by Grant-in-aid for Scientific Research (C 22530331) and is responded by 121 banks, shinkin banks and credit associations, majority of responding financial institutions answer that they designate a revolving mortgage for a borrower when they have already had such transactions as loans and bills discounting with the borrower.

capital. Thus, unless controlling for types of property buyers, our instrumental variables may be correlated with an error term in the regression equation for the property price so that they could be endogenous. This is essentially why we include BIND as an additional independent variable.

After controlling for the difference between individual and company, therefore, we have no rationale to consider that the type of the mortgage has any spurious correlation with the quality of the purchased property. The unit price of a property and the LTV of the loan financed by a bank may correlate through the causality as discussed later, but we can identify the effect of the LTV on the unit price by the instrumental variable method if it is clear that the instrumental variable, or the type of the mortgage, has no effect on the quality of the property. The choice of the type of mortgage is determined by the past events. A joint mortgage is designated when a firm has other properties. A revolving mortgage is chosen when the purchaser and the bank have close transaction relations. These past events have no causal or spurious correlation with the quality of the property now purchased. So the quality of the property, or the omitted variables which are included in the error term, is independent from the type of the mortgage, the instrumental variable.

3.3 The Cross-Sectional Effect of the LTV on the Property Price

Ideally, we would capture the dynamic effect of a change in LTV on a change in the property price using the panel data where multiple transactions were recorded for the same property. Use of the panel data, however, is unrealistic for our sake because real estate properties are traded very infrequently; ownership changes do not occur often more than decades. Thus, even though multiple transactions of a certain property are recorded, timings between transactions is so long that prices of the same property may be incomparable, that is, the property changes its attributes over a long period of time so that a change in its price may not reflect the change in the property of the same attributes but changes in its attributes, which may not be available in our data.

We believe that the effects of LTV on the property price estimated using the cross sectional data likely underestimate the true effects. Since our dependent variable is standardized by the time variant aggregate local property price, the positively estimated effect of LTV on the property price would capture the positive association between the cross-sectional variation in the property price and the variation in LTV; that is, it would capture the fact that at a given time a highly leveraged property purchase would bring about a higher property price than a moderately leveraged property purchase would. Suppose one investor is able to borrow a more highly leveraged mortgage loan than other investors. Since it is only this highly leveraged investor who can afford to bid up her target property while others are no match with this investor in their bids, she ends up acquiring the property with a higher but relatively modest bid.

In reality, during the period of lending boom, the LTV rises across the board of mortgage loans. Since competing bidders financed by highly leveraged mortgages are also very aggressive, an investor can acquire the target property only when her aggressive bid beats everyone else's. This suggests, when all the investors borrow mortgage loans with a higher LTV, their bids keep rising. Therefore, we suspect that the dynamic relationship between LTV and the property price may be stronger than the cross-sectional relationship, suggesting that the panel estimation of the effect of LTV on the property price would be stronger.

3.4. Data

In our empirical analyses, we use the data of land transactions in the Tokyo 23 wards area. The data are constructed from two sources: the transaction data and the registry data. The transaction data are provided by Star Mica Co., which collected the data of land transactions recorded on the Real Estate Information Network System. The REINS record all real estate transactions advertised to the public, suggesting that property buyers are predominantly individuals and small businesses. Among 27,845 transactions from 1991 to 2010 extracted from the REINS, we selected 1,622 of those accompanying a parcel number because in the registry data each parcel of land is identified by its parcel number rather than its mailing address. The information available in the transaction data includes date of transaction, price, area, mailing address, parcel number, and other characteristics of the traded land. Neither the information concerning attributes of a buyer of the traded land nor the mortgage loan financing the purchase of the land is contained in the transaction data, which is why we need to link the transaction data with the registry data.

The registry data are collected from the real estate registry information kept by local recorders of deeds and can be publicly accessible via the Internet.[6] The registry information about each parcel of land is divided into three parts. The first part records a parcel number along with area, use and location of the land. The second part records the history of ownership changes of the parcel, including dates of ownership changes and names of past and present owners. The third part records the history of mortgages associated with the parcel, including mortgage types, the loan mounts and names of

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[6] The real estate registry information is available at http://www1.touki.or.jp. The service and the data are in the Japanese language only.

mortgagers and mortgagees.

We match a property recorded in the transaction data with the registry information of the same property primarily using its parcel numbers.[7] We additionally use the area and the date of transaction of the property to confirm the correctness of the match. We believe that choosing only transactions of properties recorded on the REINS whose parcel number is available does not create a sample selection bias because whether or not a parcel number is available for a traded property is likely independent of the amount of loans borrowed to purchase it.

Regarding the denominator of our dependent variable, RP, in equation (1), we collect the annual data about the average land price (per square meter) in all 23 wards of Tokyo over our sample period from the Ministry of Land, Infrastructure, Transport and Tourism's "Land Market Value Publication".

We drop one observation whose information on mortgages is inconsistent: for this observations a mortgage is recorded to be purchased without a mortgage loan and the property is recorded to be designated as a joint mortgage. We also drop observations where either the property price (per square meter) or LTV is not less than the 99 percentile of the respective variable, thereby ensuring that the results are not distorted by outliers. This reduced sample size from 1620 to 1585. Table 1 presents descriptive statistics of the sample of properties we used in regression analyses. The property price per square meter is on average around 500,000 yen. The average LTV is 0.58.[8]

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[7] In practice, multiple parcels of land may be traded in a single transaction. In that case, we consolidate these multiple parcels as a single property and match with corresponding multiple parcels recorded in the registry data.

[8] We need to bear in mind that the average LTV reported on Table 1 is calculated on the basis of a sample that includes a large number of properties that are purchased without a mortgage (LTV = 0). Properties purchased without a mortgage constitute 36 percent of our sample. Thus, the average LTV conditional on a mortgage borrowed is 0.91.

Thirty-seven percent of the properties in our sample are used as a joint mortgage along with other assets. Likewise, 24 percent of sample properties are used as a revolving mortgage.

4. Results

4.1. Main Results

Table 2 reports OLS and two-stage least squares (2SLS) regression results of equation (1). The coefficients of LTV estimated using OLS (columns 1 and 2) are negative and statistically insignificant. However, the same coefficients estimated using 2SLS (columns 3 and 4), are positive and statistically significant at the one percent significance level. This implies that when the coefficient of LTV is estimated using OLS, the negative effect of the property price on LTV as reported by Adrian and Shin (2011) and the positive effect of LTV on the property price offset each other. The estimated 2SLS coefficient is greater when BIND is included as an independent variable (column 4) than when it is not (column 3), but the results are qualitatively similar regardless of inclusion of this variable. The point estimate of 0.199 when BIND is included also is economically significant. This means that a ten percentage point increase in LTV raises the property price by two percentage points.

4.2. Validity of Instrumental Variables

As Table 3 shows, we also find the strong positive correlations between these dummy variables and LTV. The average LTV of properties pledged as a joint mortgage

(JMORT = 1) is higher than that of those not (JMORT = 0). Similarly, the average LTV of properties pledged as a revolving mortgage (RMORT = 1) is higher than that of those note (RMORT = 0).

The first stage results of the 2SLS regressions reported in Tables 2 and 4 indicate that employed instrumental variables, JMORT and RMORT, are valid. The extremely large F statistics of excluded instrumental variables reported in Table 2 and the results of the OLS regressions of LTV on these dummy variables reported in Table 4 show that they are strongly correlated with LTV. The coefficients of JMORT and RMORT are both positive and statistically significant at the 1 percent significance level. The small J statistics reported in Table 2 further supports the validity of our instrumental variable regression results.[9]

4.3. The Results for the Sample of Properties by Leveraged Buyers Only

One characteristics of our sample is the presence of a large number of properties purchased without a mortgage loan, while other properties purchases are highly leveraged.[10] This disparity may be partly due to the fact that a buyer who is not liquidity constrained tends to purchase a property without borrowing a loan and partly due to the fact that a mortgage, be it even an ordinary mortgage, provides a mortgagee with strong legal rights, encouraging a lender to allow a higher LTV for a buyer if she wishes.

[9] As we discussed in Section 3.2., including the dummy variable that a buyer is an individual aimed at controlling for endogeneity due to a company's tendency to purchase an expensive property. We also divided the sample into subsamples of individuals and firms, and run the 2SLS regressions for two groups separately and found the results unchanged (not reported).

[10] Please see footnote 7 for a detail.

Thus, we run the regression using the sample of only properties purchased with a mortgage loan (the sample of only properties purchased by leveraged buyers). The results are reported in Table 3. The results are even sharper than the full sample results. First, the OLS coefficients of LTV are negative and statistically significant, suggesting that the relationship between LTV and property price is negative for leveraged property buyers. Second, the coefficient for the sample of only leveraged purchases is estimated to be more than 1.53, seven times as large as the corresponding coefficient for the full sample. This implies that 10 percentage point increase in LTV raises the property price by whopping 15.3 percentage points.[11]

The large disparity between the coefficients for the full sample and for the sample of leveraged transactions deepens our understanding of interplays between means to finance real estate purchases and real estate prices. Our finding implies that if the real estate markets were populated by more leveraged buyers, banks' more (less) aggressive lending would fuel (calm) real estate prices. The presence of unleveraged buyers makes property prices less susceptible to changes caused by banks' lending attitudes.

5. Conclusion

Many countries that saw financial crises experienced boom-bust cycles of collateralized loans and asset prices, particularly real estate prices. Recently developed economic theories try to explain this cycle, and suggest that credit supply will cause asset prices to rise above fundamental values. Using micro data of real estate property

[11] Another change from the results reported in Table 2 to those reported in Table 5 is that, in the first stage, the coefficient of the dummy variable to indicate that a property is pledged as joint collateral along with other assets is now statistically insignificant (not reported).

transactions, this study is the first attempt to identify the direct effect of the asset purchaser's leverage on the price of the asset by utilizing legal types of collateral when constructing valid instrumental variables. We also find that the effect of LTV on the property price is far greater when unleveraged property transactions are excluded than when they are included.

Policy implications are fourfold. First, monetary and prudential authorities should pay much greater attention to trends of prices and LTV in the real estate markets. Second, our results suggest that the regulatory requirement to keep LTV sufficiently low, an oft-employed policy during the boom in real estate prices, can effectively contain the boom.[12] Third, our finding that the presence of unleveraged buyers weakens the effect of LTV on the property price suggests that policy measures to encourage unleveraged or little leveraged real estate purchases during the boom time likely decelerate real estate price hikes that would be otherwise further fueled by influx of abundantly available credit.

[12] Igan and Kang (2011) find that the limit to LTV slows real estate appreciations in Korea.

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Table 1. Descriptive Statistics of Variables Used in Regressions

Variable	Definition	N	Mean	Median	Std. error	Min.	Max.
P	Property price per square meter (ten thousand yen)	1585	50.20	45.35	27.33	3.75	201.01
RP	P divided by the average price of residential land in the ward the property is located and in the year the transaction took place.	1585	1.10	1.03	0.51	0.14	4.71
LTV	Loan to value Ratio	1585	0.58	0.62	0.53	0.00	2.45
MORT	The amount of mortgage borrowed (ten thousand yen)	1585	28.11	22.31	32.79	0.00	314.22
BIND	The dummy variable that takes a value of one if the property is purchased by an individual and zero otherwise.	1585	0.62				
JMORT	The dummy variable that takes a value of one if the property is used as joint collateral with other assets.	1585	0.37				
RMORT	The dummy variable that takes a value of one if the property is used as revolving collateral.	1585	0.24				

Table 2. Results of the Regressions for the Adjusted Property Price Trend

Variable	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS
LTV	–0.037	−0.016	0.127 ***	0.199 ***
	(0.025)	(−0.26)	(0.042)	(0.045)
BIND		0.137 ***		0.176 ***
		(0.028)		(0.029)
Constant	1.118 ***	1.021 ***	1.023 ***	0.871 ***
	(0.019)	(0.029)	(0.025)	(0.038)
N	1585	1585	1585	1585
R-squared	0.0015	0.0183		
J statistics			0.374	2.388
			(0.541)	(0.122)
F statistics for excluded instruments			450.18	403.65
t statistic for endogeniety of LTV			−5.30	−6.66

A dependent variable, RP, is the property price per square meter, P divided by the average price of residential land in the ward the property is located and in the year the transaction took place. Variable definitions are described in Table 1. ***, **, and * show that the coefficient is statistically significant at the 1 percent level, the 5 percent level and the 10 percent level, respectively. The Huber–White heteroskedasticity robust standard error is in parenthesis below the corresponding estimated coefficient. Excluded instrumental variables employed for the 2SLS regressions whose results are reported in columns 3 and 4 are JMORT and RMORT. The number below the J statistic is the corresponding p value. The t statistic for endogeneity of COLLATERAL is computed in the following two steps. First, LTV is regressed on all the exogenous variables including instrumental variables using OLS. The predicted residual from the LTV regression is added as an independent variable to a set of independent variables in the OLS regression for RP. The t statistic is that of the coefficient of the predicted residual

Table 3. The Correlation Coefficients between LTV and Instrumental Variables

Panel A

	Joint collateral		
	Yes	No	Total
LTV = 0	0.000	0.000	0.000
LTV>0	0.918	0.910	0.914
Total	0.918	0.386	0.583

Panel B

	Revolving collateral		
	Yes	No	Total
LTV = 0	-	0.000	0.000
LTV>0	1.048	0.835	0.914
Total	1.048	0.438	0.583

Table 4. Results of the First Stages for Regressions for the Adjusted Property Price Trend

Variable	(1)	(2)
JMORT	0.427 ***	0.427 ***
	(0.022)	(0.022)
RMORT	0.494 ***	0.496 ***
	(0.026)	(0.029)
BIND		0.004
		(0.024)
Constant	0.307 ***	0.305 ***
	(0.014)	(0.022)
N	1585	1585
R-squared	0.3787	0.3787

A dependent variable is LTV. Variable definitions are described in Table 1. ***, **, and * show that the coefficient is statistically significant at the 1 percent level, the 5 percent level and the 10 percent level, respectively. The Huber–White heteroskedasticity robust standard error is in parenthesis below the corresponding estimated coefficient.

Table 5. Results of the Regressions for the Adjusted Property Price Trend: the Sample of Properties That Are Purchased with a Mortgage

Variable	(1) OLS	(2) OLS	(3) 2SLS	(4) 2SLS
LTV	−0.164 ***	−0.123 **	0.331 *	1.530 ***
	(0.051)	(0.055)	(0.177)	(0.439)
BIND		0.119 ***		0.454 ***
		(0.036)		(0.100)
Constant	1.254 ***	1.146 **	0.801 ***	−0.565 ***
	(0.049)	(0.065)	(0.158)	(0.449)
N	1011	1011	1011	1011
R-squared	0.0143	0.0261		
J statistics			7.904	1.953
			(0.005)	(0.162)
F statistics for excluded instruments			40.702	13.351
t statistic for endogeniety of LTV			−3.14	−5.78

A dependent variable, RP, is the property price per square meter, P divided by the average price of residential land in the ward the property is located and in the year the transaction took place. Variable definitions are described in Table 1. ***, ** and * show that the coefficient is statistically significant at the 1 percent level, the 5 percent level and the 10 percent level, respectively. The Huber–White heteroskedasticity robust standard error is in parenthesis below the corresponding estimated coefficient. Excluded instrumental variables employed for the 2SLS regressions whose results are reported in columns 3 and 4 are JMORT and RMORT. The number below the J statistic is the corresponding p value. The t statistic for endogeneity of COLLATERAL is computed in the following two steps. First, LTV is regressed on all the exogenous variables including instrumental variables using OLS. The predicted residual from the LTV regression is added as an independent variable to a set of independent variables in the OLS regression for RP. The t statistic is that of the coefficient of the predicted residual