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Land Share, Mortgage Default, and Loan-to-Value Ratio as a Macro-Prudential Policy Tool

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Abstract

In assessing the riskiness of a mortgage loan, one of the primary underwriting criteria used by lenders and one of the macro-prudential measures used by policy makers is the LTV ratio at the time of origination. This ratio is critical because it determines the probability of a default and the magnitude of the loss the lender will face in the case of a default. In this paper, we address mortgage default from a new perspective: instead of focusing on the overall property value, we separate land value from building value, and focus on the role of land share of the overall property value as a determinant of default risk. Using new property level data for properties sold in Orange County, California, between 2005 and 2015, we show that when land share increases by 10 percentage points, the probability of default increases by 1.54 percentage points. The primary explanation is that land value is more volatile than the improvements value. Thus, when housing markets experience a negative demand shock, properties with a higher land share experience a higher default risk. The implication of this result for the players in the mortgage industry and for policy makers is that, in order to have the same default rate, a property with a higher land share needs to have a lower LTV. Our results also suggest that macro-prudential measures on LTV restrictions will be more effective if they focus more on the land component of the property value. Lenders and policy makers can improve performance of mortgage loans if they employ property-specific LTV ratios that are a function of that property's land share, rather than setting uniform LTV standards across properties.

Keywords: Macro-prudential Policy, Land Share, Loan-to-Value Ratio, Default Risk

JEL classification: E5, G28, R38

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1. Introduction

There have been significant movements in real estate values in many economies in the past two decades. In the United States, house prices increased by 55% during the period between 2000 and 2006. The following sharp decline in house prices has been widely viewed as a major factor contributing to the 2008 financial crisis. This financial crisis has drawn the attention of participants in mortgage markets and policy makers to the importance of more accurate methods of assessing mortgage default risk.

Previous literature has studied the impact of various risk factors on default risk, such as property attributes, loan terms, borrower's characteristics, and macro-economic variables. One of the critical mortgage default risk factors identified in the literature is the loan-to-value ratio (LTV). Not surprisingly, LTV is also one of the primary underwriting criteria used by lenders, and one of the macro-prudential measures used by policy makers. In this paper, we address the role of LTV in mortgage default risk from a new perspective: instead of focusing on the overall property value, we separate land value from building value, and focus on the role of land value as a share of total property value as a determinant of default risk.

Since the stock of housing can be used as collateral for borrowing, house price movements and dynamics are crucial for participants in the mortgage market. The value of a property contains values for land and the improvements on it. Land is non-transportable and in limited supply. Benefits associated with land can only be enjoyed at a fixed location. On the contrary, mobility of labor and materials makes it possible for structures to be reproduced. As a result, it is possible that the value of land evolves differently from the value of improvements on it. Indeed, previous studies (Bostic, Longhofer and Redfearn, 2007; Davis and Palumbo, 2008; Houghwout, Orr, and Bedoll, 2008; Nichols, Oliner, and Mulhull, 2013; Kok, Monkkonen, and Quigley, 2014; and Kurlat and Stroebel, 2015) have shown that most of the volatility in the price of a house is due to volatility in the value of the underlying land. This is not surprising, as the value of structures largely reflects the cost of construction (replacement cost less any accumulated depreciation), and, because of the mobility of labor and construction materials, cost of construction does not fluctuate nearly as much as property values do. Building on this, we show that partitioning of house value into land value and improvements value can help better explain default outcomes and mortgage decisions, beyond the explanation that the loan-to-value ratio provides. We argue that when a property has a higher share of land value, the resulting increase in property price volatility leads to a higher risk of default in a down market.

We estimate the impact of land share (Land Value / Total Property Value) on mortgage default outcomes by using a property-level dataset from 2005 to 2015 for about 70,000 residential properties in Orange County, California. We find that when land share increases by 10 percentage points, the probability of default increases by 1.54 percentage points. The implication of this result for the players in the mortgage industry and for policy makers is that, in order to have the same default rate, a property with a higher land share needs to have a lower LTV. According to our results, a 10 percentage point increase in land share needs be accompanied by a 3.62 percentage point decrease in LTV in order to maintain the same default rate. As an example, compared to a property with 40 percent land share and 90 percent LTV, a property with 80 percentage land share needs to have an LTV of approximately 75 percent in order to have the same default rate. This result stems from the fact that land value is more volatile than the value of improvements. Thus, when the housing market goes down, properties with a higher land share experience a higher default risk.

This paper offers the first attempt to focus on the critical significance of land value for mortgage default risk. The results of the paper have implications for lenders and policy makers as they show that incorporating land share of property value into mortgage default analysis would enhance our understanding of mortgage default, help lenders with better pricing of risk, and improve the effectiveness of LTV-based macro-prudential measures adapted by policy makers. Lenders and policy makers can improve performance of mortgage loans if they employ property-specific LTV ratios that are a function of that property's land share, rather than setting uniform LTV standards across properties. Such an adjustment to LTV would also eliminate the subsidy provided by low-land-share borrowers to high-land-share borrowers under the current LTV policies that overlook the importance of land share for default risk.

Given the significant damage that asset price bubbles can cause in the real economy, a crucial question faced by central banks is whether or not monetary policy should react to excessive changes in asset prices. On the one side of the question, some economists (e.g., Bernanke and Gertler, 2001, and Greenspan, 1999) argue that central banks should not respond to asset prices unless these prices impact inflation expectations. According to this argument, central banks should get involved only after the bubble bursts in order to reduce the resulting economic and financial damage. On the other side of the question, some economists (e.g., Cecchetti, et. al., 2000) argue that central banks can improve macroeconomic performance by responding to excessive asset price movements.[1] One obvious challenge for central banks is that asset price bubbles can be very difficult to identify, and central banks are likely to face strong criticism from politicians and the public for fighting "increasing" asset prices. However, it is important to emphasize that the problem is not with increasing asset prices per se. Rather, the problem is with the economic damage that excessive asset price movements inflict. The severity of the economic damage depends largely on the involvement of the lending industry in financing the purchase of these assets at inflated prices. Asset price booms and busts can and do occur without lending;[2] however, lending turns an asset price bubble into a financial crisis, and into a much bigger economic crisis.[3] The consensus among the economists before the financial crisis was that monetary policy should focus on price stability and should not pursue curbing financial excesses as an additional target. However, the consensus has shifted following the financial crisis. The financial crisis confirmed the need for macro-prudential policies to prevent the build-up of excess real estate financing (Blanchard et al. 2010). Macro-prudential tools specifically targeting mortgage financing have become very common (Mian and Sufi, 2009). Many countries have imposed restrictions on the Loan-to-Value (LTV) or Debt-to-Income (DTI) ratios of originated mortgages (IMF, 2013). The current paper contributes to this literature by establishing the critical importance of land share for mortgage default probability, and shows how the loan-to-value ratio needs to be adjusted to improve its effectiveness as a macro-prudential measure to curb excessive leverage in housing markets.

[1] There is a growing literature on this debate. Recent examples include Airaudo, Cardani and Lansing (2013), Chen, Cheng and Chu (2014). Kajuth (2010) and Nutahara (2015).

[2] Recent experimental studies have obtained boom and bust cycles for asset prices even in very simple trading environments where there is no borrowing and there is very little or no uncertainty about the future dividends (as examples, see Smith, Suchanek and Williams, 1988; Lei, Noussair and Plott, 2001; and Ikromov and Yavas, 2012).

[3] Consider the extreme case where all property purchases are done with 100% cash. An asset price bubble in such a property market will still cause misallocation of resources. However, there will be little, if any, impact on the banking sector and financial stability, and the degree and the duration of the impact on the rest of the economy will be much smaller than that of a similar asset price bubble in a highly leveraged property market. There is also ample evidence that leverage can be an important contributor to an asset price boom, and thus leverage and inflated house prices can feed into each other (Mian and Sufi, 2009 and 2011).

Ideally, LTV adjustment should be a function of the price volatility of each individual property. However, measuring the price volatility at property level is often very difficult or impossible. In this paper, we propose land share as a more practical alternative for two reasons: land share has already been shown to be a good proxy to capture price volatility, and land share is much easier to measure than price volatility.

The rest of the paper is organized as follows. The next section reviews the literature and explains our motivation to use land share to study mortgage market dynamics. Section 3 discusses the unique, property-level dataset for the Orange County, CA, area that we use for the analysis. Section 4 lays out the empirical test and results of our study. Section 5 concludes.

2. Literature Review

It is important to separate the bundle of housing goods into structures and land. Structures provide shelter and have a relatively elastic supply while land has inelastic supply and generates utility because of its particular location. The locational amenities are typically capitalized into the value of land but not the value of the physical structures on that parcel of land.[4] It is relatively easy to reproduce a structure, given the mobility of labor and materials while the land supply is fixed in most residential areas. The mobility of labor and materials results in similar construction costs within and across housing markets. Thus, when there is a positive demand shock for housing, the price of structures will not react, due to a relatively flat supply curve, while the price of land will increase, due to a steep supply curve. Similarly, the land value will be more responsive than the improvements value when there is a negative demand shock. Thus, asymmetric appreciation across properties must arise from the asymmetric reaction of land values. In other words, land value must be more volatile than improvements value in any given housing market.

The importance of decomposing property value into land and structures has already been highlighted by a number of papers in the literature. Bostic, Longhofer, and Redfearn (2007), using data from

[4] The classic models (Alonso, 1964; Mills, 1967, 1972; and Muth, 1969) all relate commuting costs and distance from the urban core to explain spatial distribution of land prices.

Wichita, Kansas, show that properties with a higher land share will have a stronger price reaction to the same economic shock. Using a nationwide data set, Davis and Heathcote (2007) show that both house price growth and house price volatility are primarily driven by changes in the price of residential land and not by changes in the price of structures. They also show that land's share of aggregate home value in the US has been trending upwards. According to their estimates, the average land share in the value of the aggregate housing stock was 36 percent between 1975 and 2006, increasing to 46 percent of aggregate home value by 2016. Nichols, Oliner, and Mulhall (2013) use a large dataset of land sales dating back to the mid-1990s and construct land price indexes for 23 MSAs in the United States. Their analysis also confirms that home prices and commercial property prices are more volatile in areas where land represents a larger share of real estate value. Using a large sample of data on vacant land transactions, Kurlat and Stroebel (2015) also report that houses with a larger land share in total value move more in the direction of the market, both when prices increase and when prices decrease. Sirmans and Slade (2012) compare land price volatility across land uses and find significant differences, with residential use exhibiting the most volatility.

Davis, Oliner, Pinto, and Bokka (2014) use property level data from Washington, DC, to show that land prices were more volatile than house prices everywhere, but especially so in the areas where land was initially inexpensive. In those areas, the land share of property value jumped during the boom, and this rise in the land share was a good predictor of the subsequent crash in house prices. However, they also find that house prices were most volatile in areas with low land shares. This is in contrast with the previous studies that reported a positive relationship between house price volatility and land share. They attribute the difference to the fact that previous research examined this question across cities while they examine it within a large metropolitan area.

Using panel data from Hong Kong's housing transactions over the period 1992 – 2008, Wong, Yiu, and Chau (2012) focus on liquidity in real estate markets and land share. They show that properties with a high land value relative to its building value are more liquid, and that the sensitivity of trading volume to real estate price depends on the relative share of land value.

The current paper is also related to a second line of research. There is a vast and growing literature on the determinants of mortgage default. As would be expected, LTV at origination and current LTV, measured as a ratio of current loan balance to current property value, show up as important determinants of default in these studies. Thus, it is not surprising that LTV is used as one of the critical measures of default risk by lenders in their underwriting and pricing decisions of mortgage products. Moreover, central banks and banking regulators in many countries do not feel comfortable with leaving underwriting decisions completely to lenders, and instead choose to impose macro-prudential policy measures, including maximum limits on LTV ratios and debt-to-income ratios. In fact, LTV caps on mortgage loans have become one of the most frequently used macro-prudential measures by central banks and banking regulators.[5] The purpose of these measures is to prevent the build-up of excess mortgage financing and to break the link between credit growth, house prices, and financial sector instability.

A related, but equally important, question is whether LTV restrictions are effective. There is a concern that the banking industry and shadow banking institutions often find a way to go around the LTV restrictions. A number of studies investigated the effectiveness of LTV restrictions as a policy instrument. A recent paper by Corbae and Quintin (2015) designs a counterfactual experiment to show that the increased number of high-leverage loans originated prior to the recent financial crisis can explain over 60 percent of the rise in foreclosure rates. Another recent paper by Morgan, Regis, and Salike (2015) examines the effect of LTV on mortgage lending in ten Asian countries and finds that LTV policies have been effective. According to their estimation, countries with LTV polices have experienced annual growth of 6.7 percent in residential mortgage loans while non-LTV countries have experienced annual growth rate of 14.6 percent. Similar results on the impact of macro-prudential restrictions, including LTV, have been reported for other countries in Aikman, Bush, and Taylor (2016), Allen et al. (2016), Kellya, McCann and O'Toole (2015), Elliott et al. (2013), Wong and Tsang (2016) and Zdzienicka et al. (2015). A comprehensive study of the comparison and effectiveness of macro-prudential policies across countries can be found in Lim et al. (2011) and in Cerutti, Claessens, and Laeven (2015).

The current paper lies in the intersection of the three lines of literature that looked at the role of land share in house price volatility, mortgage default, and macro-prudential measures. Inspired by the

[5] Many Asian and European countries have imposed general LTV caps. Some countries impose more stringent LTV caps on high priced homes and non-owner occupied homes. In contrast, the U.S. has so far decided not to impose general LTV limits. A comprehensive review of the literature on macroprudential policies can be found in Galati and Moessner (2013) and BIS (2010) report.

earlier results on the role of land share in house price volatility, we investigate the role of land share in mortgage default, and examine its implications for the need to revise the LTV cap to increase its effectiveness as a macro-prudential policy measure and as a loan underwriting criterion. To our knowledge, we provide the first evidence that lenders and policy makers need to take land share into consideration in their mortgage underwriting and pricing decisions and in their design of macro-prudential policies.

3. Hypothesis Development and Estimation Strategy

Previous literature has shown that land value is more volatile than improvements value. In other words, price responses to demand shocks are larger for properties with higher land share, holding all else equal. Thus, land risk carries most of the property value risk or collateral risk. The main implication of this finding is that, ceteris paribus, price responses to demand shocks in any given market will be larger for properties with higher land share. In Appendix A, we utilize this finding to build a simple model of mortgage default. In the model, the driving force behind default is the change in house prices. As land value is more volatile than improvements value, properties with a higher land share are likely to suffer a bigger decline in property value in a down market, which in turn induces a higher risk of mortgage default. Using this simple model, we obtain the main prediction of the paper:

Hypothesis 1: All else equal, owners of properties with a higher land share are more likely to default on their mortgage loan.

We then utilize the simple model in Appendix A to show that a higher land share leads to a lower loan-to-value ratio. This prediction is also in line with the theoretical prediction in Harrison, Noordewier, and Yavas (2004) that when default cost is higher, the borrower will choose a lower loan-to-value ratio loan:

Hypothesis 2: Properties with a higher land share are more likely to be financed with loans with lower loan-to-value ratios.

Our empirical analysis uses assessment data to determine the relative valuation of a parcel's land and its improvements. A residential property is included in the analysis if it was sold over the sample period and contained an assessed value prior to the time of sale in recorder's office. Each time a property is transacted, we track the most recent assessment data before the transaction. Land share is calculated by taking the ratio of the Assessor's land value estimate to total value estimate. This approach allows for broad coverage and is not restricted to new construction.[6]

We use two-stage least square regression to estimate hypotheses 1 and 2. In the first stage, we estimate the LTV decision and test the impact of land share on LTV decision (Hypothesis 2). We then estimate the default outcome where the estimated value of LTV is included as a predictor, as LTV is likely to affect the default outcome.

$$LTV_i = \alpha_0 + \alpha_1 LS_i + \alpha_2 SF_i + \alpha_3 X_i + \alpha_4 OriginationYear_i + \alpha_5 Lender_i + \varepsilon \qquad (1)$$

$$DEF_i = \theta_0 + \theta_1 LS_i + \theta_2 \widehat{LTV}_i + \theta_3 SF_i + \theta_4 OriginationYear_i + \theta_5 Lender_i + \theta_6 OwnerOccupied_i + \theta_7 IndividualOwner_i + \epsilon \qquad (2)$$

The dependent variable in (1), LTV_i, is the loan-to-value ratio at origination and the dependent variable in (2), DF_i, is a dummy variable that equals 1 for a loan in default and 0 otherwise. LS_i captures land share and is the ratio of land value to property value in the assessment record just before the sale. SF_i is a dummy variable that equals to 1 for single-family residential and 0 for

[6] As an alternative approach, land value can be estimated by subtracting cost of construction from total value. This approach also requires an adjustment for depreciation in the value of buildings due to aging, wear and tear. Since estimating depreciation is very difficult, this alternative approach is often restricted to newly constructed buildings (e.g., Davis, et al. 2014).

condominium. X_i is a vector of property characteristics, such as age, lot size, and square footage. $OriginationYear_i$ is a dummy variable that equals 1 if a loan is originated between 2005-2007 or 0 otherwise. $Lender_i$ is a vector of dummy variables for lender type. Lender types include bank, funding/finance company, mortgage company, and federal savings bank. The omitted lender type is all other types. $\widehat{LTV}_i$ is the predicted loan-to-value ratio at origination from the first state regression. $OwnerOccupied_i$ is a dummy variable that equals 1 for owner-occupied property and 0 otherwise. $IndividualOwner_i$ is a dummy variable that equals to 1 if the owner is an individual and 0 otherwise. We use the vector of physical property characteristics X_i as an instrument for the endogenous LTV decision. The rationale is that these physical characteristics will have an impact on LTV through their effect on property value. The default probability, however, is not expected to depend on the physical characteristics of the property.[7]

4. Data

The data used in this analysis has been provided by RealtyTrac and covers transactions in Orange County, California, from January 2005 to December 2014. The sample includes transactions of single-family dwellings and condominiums.[8] The data comes from four datasets in RealtyTrac: historical assessor data, recorder data, equity data and foreclosure data. Property transactions from 2005 to 2014 are collected from the recorder data, which includes transaction time and transaction price. Recorder data also provides loan records, such as loan amount, loan origination time, and lender types. Origination LTV is calculated as the ratio of the loan amount at origination to sale value obtained from recorder data.

[7] The loan amount that the borrower is able and/or willing take will depend on his ability, as determined by his income, assets, and mortgage interest rates, to make the monthly payments associated with that loan amount. A more desired vector of property characteristics will improve the value of the property, but not the ability of the borrower to make payments. Thus, a change in property characteristics, for a given income level, could lead to a change in the LTV ratio. This expectation is indeed verified by our empirical results.

[8] Condominiums are units in a multi-family residential building where the units in the building are owned individually, rather than the entire building being owned by a single owner or partnership. As in the case of single-family homes, condominiums can be leased or owner-occupied.

As pointed out by Albouy (2015) and Beracha, Gilbert, Kjorstad, and Womack (2016), calculating land share is difficult due to the fact that land values are challenging to measure directly with existing data sources.[9] We estimate the land share of property value with a method that takes advantage of the rich information in our dataset. We track ten years of appraisal history of each property before the transaction date and match the assessor record with transaction data. We measure land share of property value as the ratio of Land Appraisal Value to Total Appraisal Value obtained from the most recent appraisal report provided by the assessor's office. This measure reflects the updated information on land value at the time of mortgage decisions. Assessor data also provides information on property structure characteristics, such as age, square footage, and property type (single family or condominium).

Assessments of property value, land value and improvements value come from assessor data. A potential criticism of using assessor data is that land share is calculated using assessment values, not transaction values, and assessed values can be subject to appraiser bias. Bostic, Longhofer, and Redfearn (2007) indirectly address this issue. In their study of the land share and house price dynamics in Wichita, Kansas, they conduct their analysis using two alternative methods of estimating land share. One method relies on assessment values. In the other method, they only use data for new construction, where they can observe the sale of a vacant lot prior to the sale of a completed home, thus enabling them to calculate land share based on land transactions data. They find the results to be qualitatively the same across the two methods of calculating the land share.[10]

It should also be added that systematic appraisal bias, to the extent it exists, is less of an issue for the current analysis. The reason is that the metric of interest here is the land share, *relative* value of land to total value, across properties. If there are systematic errors in appraisal, this will not impact *relative* value of land to total value across properties.

[9] Albouy (2015) develops an index of local amenity measures and Beracha, et al. (2016) empirically show that such an aggregate index of local amenities and land share is a close substitute in explaining house price dynamics across 238 U.S. metropolitan areas for the period of 1970 to 2013.

Another data challenge involves estimating the impact of improvement spending on property price dynamics. Davis and Heathcote (2007) address this issue and show that spending on improvements as a share of home value does not vary much over time and is not systematically correlated with the rate of house price growth.

[10] To calculate the land share, Davis, Oliner, Pinto, and Bokka (2014) also focus on newly-built homes and measure the implied value of land as the difference between the observed sale price and the estimated construction cost for the new home. By focusing on newly-built homes, they avoid the difficult task of estimating the depreciation of existing housing structures.

Default outcome of a loan is flagged as a dummy variable, equaling to 1 if the loan is in default loan and 0 otherwise. We retrieve default information from both the foreclosure data and recorder data. Foreclosure data records all the foreclosure sales information, while recorder data tracks the information on events related to default. Some loans in default in our sample have simply received a notice of default (NOD)[11] while others reached different phases of foreclosure, including foreclosure notice of trustee (NOT), real estate owned (REO), transfer to guarantor, REO liquidation, foreclosure auction, and inferred short sale.

After deleting observations with missing variables, dropping observations with LTV ratios greater than or equal to one, and excluding observations without updated assessment information prior to sale date, our final sample includes 68,818 transactions. There were 67,698 single-family home transactions and 1,120 condominium transactions. All variables are winsorized at 0.5 percent at both tails for regressions.

Figure 1 illustrates the distribution of land share for transactions in our sample over time. The land share before 2007 is in general higher than that after 2007. This feature is important: the fraction of the value of housing attributed to land in the boom period is higher than that during the bust.

Figure 2 shows the land share distribution for the two property types. It can be observed from Figure 2 that single-family homes have a bigger variation in land share than condominiums.

Tables 1, 2, and 3 describe the default activities over time. Panel A of Table 1 summarizes the proportion of loans originated in year *t* that ended in default during our sample period. As expected, a much larger percentage of loans originated in 2005 to 2007 ended up in default by the end of 2014. More than half of the loans originated in 2005 and 2006 (52 percent) and about a third of loans originated in 2007 (31 percent) in our sample subsequently went into default during our sample period. This is not surprising as mortgage loans originating during the house price boom period had lax underwriting standards and experienced a collapse in housing prices, and lending standards became much stricter following the bust in housing prices. Panel B of Table 1 displays distressed

[11] A notice of default is typically sent after 90 days of missed payments.

sales as a percentage of total transactions for each property type.[12] Single-family dwellings have a higher distressed sale ratio than condominiums. Panel C of Table 1 exhibits distressed transactions as a percentage of total transactions for each land share quantile. The raw data in Panel C confirms our prediction: properties in higher land share quantiles have higher distressed sale ratios.

Table 2 summarizes the proportion of distressed sales, as a percentage of total transactions based on transaction year. As expected, we observe significantly more distressed sales during the years 2008 to 2012, following the collapse in housing prices. In the year 2008, 47 percent of total sales were distressed sales, 41 percent in 2009, 32 percent in 2010, 31 percent in 2011, and 29 percent in 2012.

Table 3 displays the proportion of mortgages issued by different lender types. The majority of the loans in our sample are originated by banks (32 percent), mortgage companies (27 percent), funding/finance companies (18 percent), and federal savings banks (7.6 percent).

Table 4 provides summary statistics of some of the key variables, categorized by property type. For the full sample, the average sale price is $706,455, with an average age of 42 years and a living area of 1,756 square feet. The LTV has a mean value of 75.18 percent. The average LTV for a single-family dwelling is 75.15 percent, which is lower than that of a condominium (76.58 percent). The fraction of housing value attributed to land is on average 61.05 percent. Single-family dwellings have a higher land share (61.09 percent) than condominiums (58.74 percent). However, this difference pales compared to the fact that the average lot size of condominiums is less than 2.5 percent of the average lot size of single-family homes (122 versus 5,075 square feet). This should not be surprising, as single-family homes are typically built in suburban and rural areas where land is less expensive while condos tend to be built in or close to city centers where land prices are much higher.

[12] A transaction is classified as a distressed sale if the property is flagged for any of the following default outcomes: notice of default, foreclosure notice of trustee, real estate owned, transfer to guarantor, REO liquidation, foreclosure auction, and inferred short sale.

5. Results

Table 5 shows the estimation results for our model of LTV at origination. These results reveal significant coefficients for both land share and loan origination year. These estimates indicate that when land share increases by 10 percentage points, LTV decreases by 0.6 percentage point, supporting Hypothesis 2. This result is also consistent with the theoretical prediction in Harrison, Noordewier, and Yavas (2004) who show that when default cost is higher (driven by a higher land share in the current paper), LTV becomes smaller.[13] Loans originated between 2005 and 2007 are likely to have higher LTVs, due to a loose lending policy among lenders during that time period. Different lender types have different LTVs. Loans originated by banks and federal savings banks have lower LTVs than other types of lenders.

Table 6 reports the marginal effects of determinants of default outcome using a probit model. It shows that land share contributes significantly to mortgage default, supporting our main hypothesis, Hypothesis 1. When land share increases by 10 percentage points, the probability of default increases by 1.54 percentage points. Thus, when there is a negative demand shock, more volatile land value results in a larger decrease in property value, triggering a default outcome. In order to maintain the same default rate, a 10 percentage point increase in land share needs be accompanied by a 3.62 percentage point decrease in LTV.[14] Thus, compared to an area (or property) with 40 percent land share and 90 percent LTV, an area (or property) with 80 percent land share needs to have an LTV of approximately 75 percent in order to have a similar default rate.[15]

As stated above, the results of Table 5 indicate that LTV ratio, agreed to by borrowers and lenders at origination, already reacts to land share. According to Table 5, a 10 percentage point increase in land share results in a 0.6 percentage point decrease in LTV. Does that mean that the market already

[13] The lower LTV ratio could be due to either borrower's choice or lender's requirement, or a combination of the two. With the data we have available, we cannot separate the two possible sources of lower LTV ratios for higher land share loans.

[14] The coefficient of land share divided by the coefficient of predicted LTV in Table 6, 0.1537/0.4247=0.362, gives the percentage point adjustment needed in LTV for each percentage point increase in land share.

[15] Clearly, determining the precise adjustment needed in LTV to maintain the same default rate would require an examination of the question in a general equilibrium model. The interest rate, for instance, could react to changes in the land share, which would in turn change the needed adjustment in LTV. Such counterfactual analysis is out of the scope of the current paper. The focus here is on establishing the critical role that land share plays in mortgage default, and highlighting the need for an adjustment in the LTV ratio to make it more effective in curbing excessive mortgage leverage.

makes the needed adjustment in LTV? According to Table 6, the market adjustment is much smaller than the adjustment needed (3.62 percentage point decrease) in LTV in order to offset the impact of 10 percentage point increase in land share on default risk. Thus, despite the partial adjustment by the market, incorporating land share into LTV requirements by lenders and policy makers will help improve the default outcome.

Table 6 also shows that, consistent with previous literature, loans with higher LTV are more likely to default. A 10 percentage point increase in LTV increases the probability of default by 4.25 percentage points. Loans with higher LTV are more likely to become underwater when house prices drop. Loans originated between 2005 and 2007, before housing prices plummeted, have a 31 percentage point higher probability of default than loans originated after 2007. This striking difference clearly illustrates the “quality” differential of loans originated before and after 2007. Loan quality also differs across different lenders. When a loan is originated by a bank or federal savings bank, it is less likely to default; when a loan is originated by a mortgage company, it is more likely to default. It is also worth noting that loans for owner occupied properties and individual-owned properties are less likely to default.[16]

6. Conclusions

In this paper, we address the role of LTV in mortgage default outcomes from a new perspective: instead of focusing on the overall property value, we separate land value from building value and investigate the role of land share of overall property value as a determinant of default risk. Using a new property level data for properties sold in Orange County, California, between 2005 and 2014, we show that when the land share increases by 10 percentage points, the probability of default increases by 1.54 percentage points. This result is due to the fact that land value is more volatile than the improvements value. Thus, when the housing market goes down, properties with a higher land share experience a bigger drop in value, hence a higher default risk. This result suggests that, in order to

[16] A similar result was reported in a recent paper by Agarwal, Deng, Luo, and Qian (2016), who find that condominium loan defaults grew at a faster rate than single-family loan defaults in the U.S. during the 2003–07 period. Their explanation relies on the fact that the share of non-owner-occupied purchases is greater in the condominium market than in the single-family market.

maintain the same default rate, properties with a higher land share need to have a lower LTV. More specifically, a 10 percentage point increase in land share needs be accompanied by a 3.62 percentage point decrease in LTV.

The results of the paper have important implications for lenders in the pricing of default risk. Having a better assessment of default risk is also critical for investors in evaluating the sustainability and riskiness of the leveraged investment projects. Furthermore, our results suggest that macro-prudential policies, such as loan-to-value ratio restrictions, will be more effective if they pay special attention to the land component of the property value, rather than focusing simply on the overall value of the property. Lenders and policy makers can improve performance of mortgage loans if they employ property-specific LTV ratios that are a function of that property's land share, rather than setting uniform LTV standards across properties.

References

Agarwal, S., Deng, Y., Luo, C., & Qian, W. 2016. “The hidden peril: The role of the condo loan market in the recent financial crisis.” *Review of Finance*, *20*(2), 467-500.

Aikman, D., Bush, O., & Taylor, A. M. 2016. “Monetary versus macroprudential policies: causal impacts of interest rates and credit controls in the era of the UK radcliffe report” (No. w22380). National Bureau of Economic Research.

Airaudo, M., Cardani, R. and Lansing, K.J., 2013. Monetary policy and asset prices with belief-driven fluctuations. *Journal of Economic Dynamics and Control*, *37*(8), pp.1453-1478.

Albouy, D., 2015. “What Are Cities worth? Land Rents, Local Productivity, and the Capitalization of Amenity Values.” *Review of Economics and Statistics*, Forthcoming.

Allen, J., Grieder, T., Peterson, B. M., & Roberts, T. 2016. “The Impact of Macroprudential Housing Finance Tools in Canada: 2005-10.” *Bank of Canada Staff Working Paper* 2016-41.

Alonso, W. 1964. *Location and Land Use*, Harvard University Press: Cambridge.

Beracha, E., Gilbert, B. T., Kjorstad, T., and Womack, K. 2016. “On the Relation between Local Amenities and House Price Dynamics.” *Real Estate Economics*, Forthcoming.

Bank for International Settlements. 2010. “Macroprudential instruments and frameworks: a stocktaking of issues and experiences.” *BIS report submitted by the Committee on the Global Financial System*, No 38.

Bernanke, Ben and Mark Gertler, 2001, Should Central Banks Respond to Movements in Asset Prices?, *American Economic Review*, 91: 253-257.

Blanchard, O., Dell’Ariccia, G. & Mauro, P. 2010, ‘Rethinking macroeconomic policy’, *Journal of Money, Credit and Banking* 42(s1), 199–215.

Bostic, R. W., Longhofer, S. D., & Redfearn, C. L. 2007. “Land leverage: decomposing home price dynamics.” *Real Estate Economics*, *35*(2), 183-208.

Cecchetti, Stephen G., Hans Genberg, John Lipsky and Sushil Wadhwani, 2000, Asset Prices and Central Bank Policy, Geneva Report on the Global Economy.

Cerutti, E., Claessens, S., & Laeven, L. 2015. The use and effectiveness of macroprudential policies: new evidence. *Journal of Financial Stability*.

Chang, K.L., Chen, N.K. and Leung, C.K.Y., 2013. In the shadow of the United States: The international transmission effect of asset returns. *Pacific Economic Review*, *18*(1), pp.1-40.

Chen, N.K., Cheng, H.L. and Chu, H.L., 2014. Asset price and monetary policy: the effect of expectations formation. *Oxford Economic Papers*, 67: 380-405.

Corbae, D., and E. Quintin, E. (2015). Leverage and the Foreclosure Crisis. *Journal of Political Economy*, *123*(1), 1-65.

Davis, Morris A., and Jonathan Heathcote. 2007. “The Price and Quantity of Residential Land in the United States.” *Journal of Monetary Economics* 54(8): 2595-2620.

Davis, Morris A., and Michael G. Palumbo. 2008. "The Price of Residential Land in Large US Cities." *Journal of Urban Economics* 63(1): 352-84.

Davis, Morris A., Oliner, Stephen D. and Pinto, Edward J.. 2014. "House Prices and Land Prices under the Microscope: A Property-Level Analysis for the Washington, DC Area," Working paper.

Elliott, D, Feldberg, G and Lehnert, A 2013, 'The History of Cyclical Macroprudential Policy in the United States', Finance and Economics Discussion Series, Federal Reserve Board, No. 29.

Galati, G. and Moessner, R., 2013. Macroprudential policy–a literature review. *Journal of Economic Surveys*, *27*(5), pp.846-878.

Glaeser, E. L., Gyourko, J., & Saks, R. 2005. "Why have housing prices gone up?" (No. w11129). National Bureau of Economic Research.

Greenspan, Alan, 1999, General Discussion: New Challenges for Monetary Policy, Speech before a symposium sponsored by the Federal Reserve Bank of Kansas City, Jackson Hole, Wyoming, August 28th.

Harrison, David M., Noordewier, Thomas G. and Abdullah Yavas, 2004, "Do Riskier Borrowers Borrow More?" *Real Estate Economics*, 32, 385-411.

Haughwout, Andrew, James Orr, and David Bedoll. 2008. "The Price of Land in the New York Metropolitan Area." Federal Reserve Bank of New York, *Current Issues in Economics and Finance* 14(3): 1-7.

Ikromov, Nuriddin and Abdullah Yavas, 2012, Asset Characteristics and Boom and Bust Periods: An Experimental Study, *Real Estate Economics*, 40, 508-535.

IMF, "Key Aspects of Macro-prudential Policy," Background Paper, IMF 2013.

Kajuth, F., 2010. The role of liquidity constraints in the response of monetary policy to house prices. *Journal of Financial Stability*, *6*(4), pp.230-242.

Kellya, R., McCannb, F., and O'Tooleb, C. (2015). Credit conditions, macroprudential policy and house prices (No. 06/RT/15). Central Bank of Ireland.

Kok, Nils, Paavo Monkkonen, and John M. Quigley. 2014. "Land Use Regulations and the Value of Land and Housing: An Intra-Metropolitan Analysis." *Journal of Urban Economics* 81:136-48.

Kurlat, Pablo and Stroebel, Johannes, 2015, "Testing for Information Asymmetries in Real Estate Markets", *Review of Financial Studies,* 28 (8), 2429-2461.

Lei, Vivian, Charles Noussair and Charles Plott, 2001, Non-speculative bubbles in experimental asset markets: Lack of common knowledge of rational actual irrationality, *Econometrica* 69, 830-859.

Lim, C. H., Costa, A., Columba, F., Kongsamut, P., Otani, A., Saiyid, M., Wezel, T. and X. Wu (2011). Macroprudential policy: what instruments and how to use them? Lessons from country experiences. *IMF working papers*, 1-85.

Mian, Atif and Amir Sufi (2009). "The Consequences of Mortgage Credit Expansion: Evidence from the U.S. Mortgage Default Crisis," The Quarterly Journal of Economics, 124 (4), 1449{1496.

Mian, Atif and Amir Sufi, 2011, 'House prices, home equity–based borrowing, and the US household leverage crisis', The American Economic Review 101(5), 2132–2156.

Mills, E., 1967, “An aggregative model of resource allocation in a metropolitan area,” *American Economic Review*, 57, 197-210.

Mills, E., 1972, Urban Economics, Scott Foresman: Glenview, IL.

Morgan, P., Regis, P. J., and Salike, N. 2015. “LTV policy as a macroprudential tool: The case of residential mortgage loans in Asia” (No. 2015-03). Xi'an Jiaotong-Liverpool University, Research Institute for Economic Integration.

Muth, R., 1969, Cities and Housing, University of Chicago Press: Chicago.

Nichols, Joseph B., Stephen D. Oliner, and Michael R. Mulhall. 2013. “Swings in Commercial and Residential Land Prices in the United States." *Journal of Urban Economics* 73(1): 57-76.

Nutahara, Kengo. 2015. "Do credit market imperfections justify a central bank′ s response to asset price fluctuations?" *Journal of Economic Dynamics and Control* 61: 81-94.

Posey, L. and A. Yavas. 2001. Adjustable and Fixed Rate Mortgages as a Screening Mechanism for Default Risk. *Journal of Urban Economics* 29: 54-79.

Sirmans, C.F., and Barrett A. Slade. 2012. “National Transaction-based Land Price Indices.” *The Journal of Real Estate Finance and Economics*, 45, 829-845.

Smith, Vernon, Gerry Suchanek, and Arlington Williams, 1988, Bubbles, crashes, and endogenous expectations in experimental spot asset markets, *Econometrica* 56, 1119-1151.

Wong, S. K., Yiu, C. Y., & Chau, K. W. (2012). Liquidity and information asymmetry in the real estate market. *The Journal of Real Estate Finance and Economics*, *45*(1), 49-62.

Wong, E. and Tsang, A., 2016. How Does Loan-To-Value Policy Strengthen Resilience of Banks to Property Price Shocks–Evidence from Hong Kong. *International Real Estate Review*, *19*(1), pp.120-149.

Zdzienicka, A, Chen, S, Kalan, F, Laseen, S and Svirydzenka, K (2015), ‘Effects of Monetary and Macroprudential Policies on Financial Conditions: Evidence from the United States,’ IMF Working Paper, No. 15/288.

Appendix 1

In this appendix, we offer a simple model of mortgage default to show that higher land share will lead to a higher default risk. Consider a competitive lending market with risk-neutral lenders and borrowers. Let L be the loan amount and i be the interest rate. In the first period, the borrower obtains L to purchase an asset of value P_0, $P_o \geq L$ (unsecured debt is ruled out). In the second period, the borrower sells the asset and pays the lender the loan balance, the principal plus interest, $B = (1+i)L$. For simplicity, we will focus on fixed-rate mortgages where i is fixed, hence B is deterministic, though the analysis can be easily repeated for a variable-rate mortgage.

Each borrower has a current income of Y at which he/she qualifies for the mortgage offered. The borrower will enjoy income Y in the second period as well. The only uncertainty that the borrower (and the lender) faces is the uncertainty about the value of the asset in the second period. The second-period value of the asset, P, is a random variable with marginal density $f(P)$ and cumulative density $F(P)$ on the interval $[a,z]$. Default arises when the realized value of the asset is below the mortgage balance. To be more precise, the borrower will choose to default if the value of the asset plus the cost of default is less than the mortgage balance: $P + C < B$. In other words, default will happen if the property value falls enough such that $P < B - C$. Cost of default can be viewed as the discounted value of the costs associated with default in the second and subsequent periods.

Let $\delta<1$ be the borrower's discount factor. The borrower's utility function is given by:

$$Y + L - P_0 + \delta \int_a^{B-C} (Y - C) f(P) dP + \delta \int_{B-C}^{z} (Y + P - B) f(P) dP \qquad \text{(A1)}$$

In the first period, the borrower earns Y and borrows L to make the payment P_0 to purchase the asset. In the second period, if the realized property value is less than $B - C$, the borrower defaults, loses the asset to the lender and suffers the default loss C, and thus enjoys the surplus Y-C.[17] If the realized property value in the second period is greater than $B - C$, the borrower sells the asset for P, pays the lender B and enjoys the surplus $Y + P - B$. Ownership of the asset generates a certain level of utility for the borrower that makes it worthwhile to obtain the loan to purchase the asset.

[17] It is assumed that in the case of a default the borrower will consume his income Y, instead of giving it to the lender. This assumption is inconsequential for the analysis.

At the time of origination, the loan amount and the interest will be such that there will be no default if the property value does not fall. That is, at the current value of $P = P_o$, $P = P_o \geq B$, which implies $P = P_o \geq B\text{-}C$. Thus, in the case of a positive demand shock, the expected utility of the borrower will be

$$Y + L - P_0 + \delta \int_{P_0}^{z} (Y + P - B) f(P) dP \tag{A2}$$

In the case of a negative demand shock the expected utility of the borrower will be:

$$Y + L - P_0 + \delta \int_{a}^{B-C} (Y - C) f(P) dP + \delta \int_{B-C}^{P_0} (Y + P - B) f(P) dP \tag{A3}$$

Thus, if the negative demand shock is not severe enough ($P \geq B\text{-}C$), the borrower will avoid default. Default will take place only if the drop in the property value is such that $P < B\text{-}C$.

What happens if the land share of the property value is higher? Given the higher volatility of the land value vis-à-vis the improvements value, properties with a higher land share will experience a bigger potential increase in the property value when there is a positive demand shock and a bigger potential decrease in the property value when there is a negative demand shock.

If a property has a higher land share, we will capture this by magnifying the shock by a factor of *x*. We will simply reduce the lower bound *a* to *a-x* in the case of a negative price shock, and increase the upper bound *z* to *z+x* in the case of a positive price shock. This changes (A2) and (A3) to:

$$Y + L - P_0 + \delta \int_{P_0}^{z+x} (Y + P - B) f(P) dP \tag{A4}$$

and

$$Y + L - P_0 + \delta \int_{a-x}^{B-C} (Y - C) f(P) dP + \delta \int_{B-C}^{P_0} (Y + P - B) f(P) dP \tag{A5}$$

Thus, a higher land share has no impact on the borrower's probability of default if there is a positive demand shock (A2 versus A4), but increases the probability of default if there is a negative demand shock (A3 versus A5). Suppose the probability of a negative demand shock is *q* while the probability of a positive demand shock is 1-*q*. It is straightforward to obtain the main prediction of the model, Hypothesis 1.

Proposition 1: For a given *q* and for any given *L* and *i* (hence, *B)*, the borrower is more likely to default when the land share is higher.

The lender's problem is to choose an interest rate, *i*, to maximize expected profits:

$$-L+\beta\int_{a}^{B-C}Pf(P)dP+\beta\int_{B-C}^{z}Bf(P)dP$$

where β<1 is the lender's discount factor. Note that a positive price shock that increases the upper bound from *z* to *z+x* will not affect the lender's expected profits (the lender receives at most *B*, regardless of how high the price goes). A negative price shock, however, will increase the likelihood of a default by the borrower, and hence reduce the lender's expected profits. In a competitive market with zero-profit constraint, this will lead lenders to offer a lower *L* (lower loan-to-value ratio) and/or a higher *i*. Lower loan-to-value ratio provides support for our Hypothesis 2.

Table 1 Loan Default Ratios

Panel A: Percentage of Loans Originated in Year t That Ended Up in Default during the Sample Period

Loan Origination Year	Default Loans/Total Originated Loans
2005	52.42%
2006	52.27%
2007	31.30%
2008	8.69%
2009	4.09%
2010	3.91%
2011	2.97%
2012	2.90%
2013	3.72%
2014	3.22%

Panel B: Distressed Sales as a Percentage of Total Transactions for Each Property Type

Property Type	Distressed Sales /Total Transactions
Single Family Residential	19.35%
Condominium	17.75%

Panel C: Distressed Sales as a Percentage of Total Transactions for Each Land Share Quantile

Land Share Quantile	Distressed Sales/Total Transactions
1st Quantile	9.54%
2nd Quantile	11.82%
3rd Quantile	20.19%
4th Quantile	35.99%

The group of land share is cut off at 0.45, 0.64, 0.77, and 0.95.

Table 2: Percentage of Distressed Sales Based on Transaction Year

Transaction Year	Distressed Sales/Total Transactions
2005	0.30%
2006	0.87%
2007	9.53%
2008	47.21%
2009	41.13%
2010	32.47%
2011	31.59%
2012	20.88%
2013	6.93%
2014	4.40%

Table 3 Distribution of Loans Based on Lender Type

Lender Type	Percent
Bank	32.16%
Mortgage Company	27.58%
Funding/Finance Company	17.80%
Federal Saving Bank (FSB)	7.60%
Mortgage Funding Company	4.15%
Credit Union	3.28%
Mortgage Electronic Registration System (MERS)	2.40%
Holding Company	1.68%
Construction/Development Company	0.02%
Commercial Corporations	0.01%
Insurance Company	0.01%
Government Agency	0.01%
Not Known	3.30%

Table 4 Summary Statistics of Key Variables

Variable	Obs.	Mean	Std. Dev.	Min	Max
Full Sample					
Original LTV	68818	0.7518	0.1577	0.1834	1
Land Share	68818	0.6105	0.1921	0.1823	0.9541
Sale Price	68818	704,946	446,235	108,000	3,795,000
Lot Size	68818	4995	4817	0	31,873
Square Footage	68818	1756	657	600	4644
Age	68818	42.54	13.73	2	119
Single Family Residential					
Original LTV	67698	0.7515	0.1573	0.1834	1
Land Share	67698	0.6109	0.1926	0.1823	0.9541
Sale Price	67698	709,640	446,653	228,000	3,795,000
Lot Size	67698	5075	4815	0	31873
Square Footage	67698	1765	657	608	4644
Age	67698	42.73	13.70	2	119
Condominium					
Original LTV	1120	0.7658	0.1728	0.1802	1
Land Share	1120	0.5874	0.1541	0.1757	0.8964
Sale Price	1120	421,291	308,018	108,000	2,300,000
Lot Size	1120	122	770	0	10,115
Square Footage	1120	1221	398	600	4500
Age	1120	30.33	8.03	14	53

Table 5 Determinants of Original Loan-to-Value Ratio

This table presents the coefficients from the OLS regression in equation (1). The dependent variable is the LTV ratio at origination. RSFR Dummy equals to 1 for single-family dwellings and 0 for condominiums. Origination Year Dummy equals to 1 for loans originated in 2005, 2006, and 2007, 0 otherwise. The effect of lender type is captured by the last four dummy variables in the table (all other lender types are captured by the omitted lender dummy).

Variable	Coefficients	T value
Land Share	-0.06	-6.13
RSFR Dummy	0.006	2.11
Lot Size	-2.04E-07	-0.72
Square footage	-4.8E-06	-3.02
Age	0.0013	4.29
Origination Year Dummy	0.07	10.57
Bank	-0.02	-5.93
Funding/Finance Company	0.02	1.09
Mortgage Company	0.03	2.05
Federal Savings Bank	-0.01	-1.90
Constant	0.81	8.53
R Square	0.10	

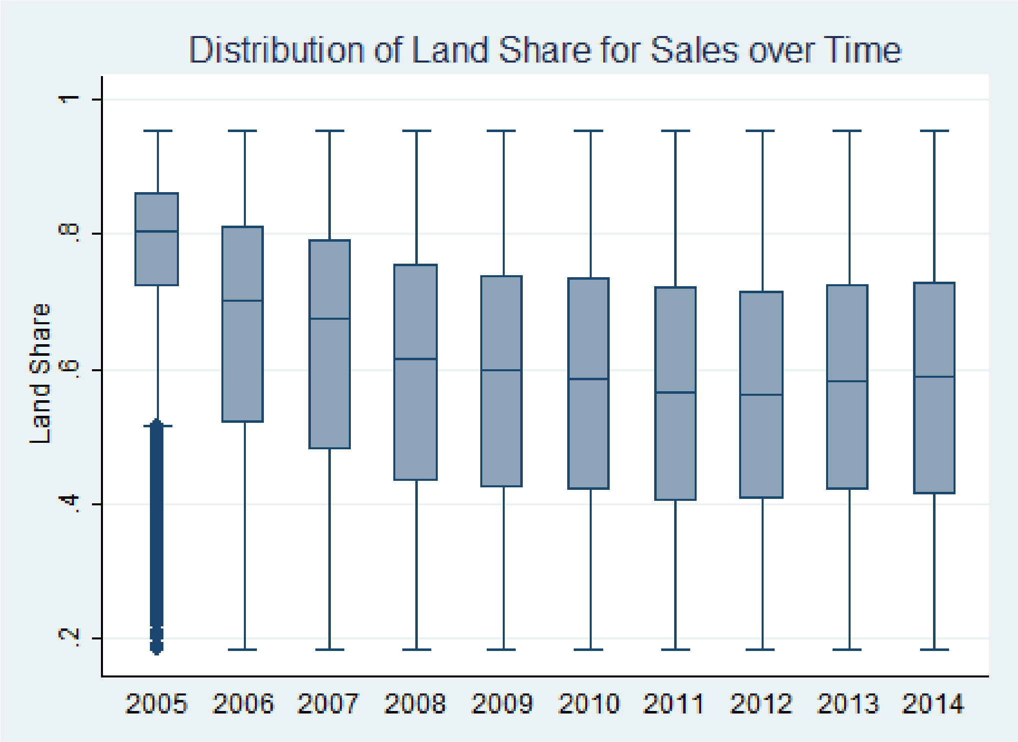
Table 6 Marginal Effects of Probit Model for Default Outcome

This table reports the marginal effect of variables on the loan default outcome in Equation 2. The dependent variable equals to 1 if the loan is in default and 0 otherwise. Default outcomes include Notice of Default, Foreclosures, Short Sales, and REOs. RSFR Dummy equals 1 for single-family dwellings and 0 for condominiums. Origination Year Dummy equals 1 for loans originated in 2005, 2006, and 2007, 0 otherwise. The effect of lender type is captured by the four lender dummy variables (all other lender types are captured by the omitted lender dummy).

Variable	Coefficients of Marginal Effect	P value
Land Share	0.1537	0
$\widehat{LTV}_i$ at Origination	0.4247	0
RSFR Dummy	0.0084	0.59
Origination Year Dummy	0.4241	0
Bank	-0.0263	0
Funding/Finance Company	0.0281	0
Mortgage Company	0.0181	0.02
Federal Savings Bank	-0.0179	0
Owner-Occupied	-0.0441	0
Individual Owner	-0.0626	0
R Square	0.4395	

Figure 1 Box Plot of Land Share for Sales over Time

This graph shows the land share for transactions in different years. The x-axis is the transaction year. The y-axis is the land share of properties being transacted.



The description of the box-plot is as follows. The box represents the distance between the 1st and 3rd quartiles of land percentage at each point in time. The split in the box represents the median value of betas at each point in time. The up whiskers show the greater of max value or 1.5 times the box (Q3-Q1). The blue box indicates the down markets defined in the previous section. The bottom whiskers show the lower of min value or 1.5 times the box (Q3-Q1). Outlier points on the top are those that are greater than 1.5 times (Q3 -Q1).

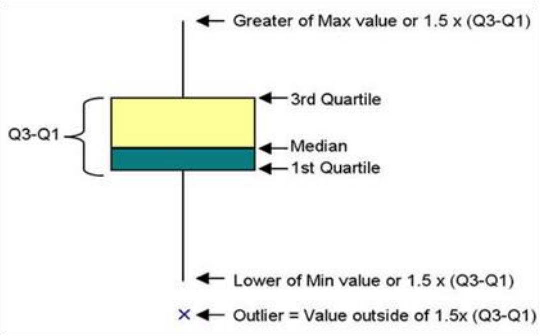
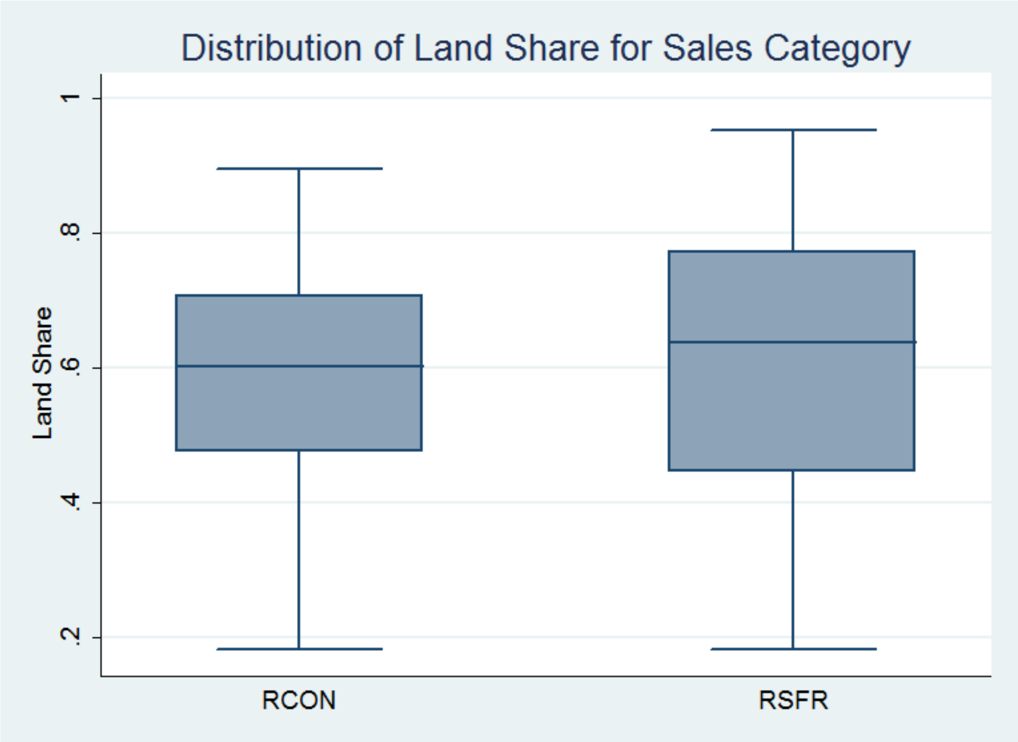


Figure 2 Box Plot of Land Share by Property Type

This graph shows the land share from assessment data for the two property types in our sample. The x-axis is the property type. The y-axis is the land share of properties. Property types are defined as follows: RCON - Condominium, RSFR – Single-Family Residence.



The description of the box-plot is as follows. The box represents the distance between the 1st and 3rd quartiles of land share at each point in time. The split in the box represents the median value of betas at each point in time. The up whiskers show the greater of max value or 1.5 times the box (Q3 – Q1). The blue box indicates the down markets defined in the previous section. The bottom whiskers show the lower of min value or 1.5 times the box (Q3 – Q1). Outlier points on the top are those that are greater than 1.5 times (Q3 – Q1).