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The Dynamics of Housing Price and Land Price in Urban versus Rural Contexts

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Abstract

The literature shows three distinct perspectives on the relationship between housing prices and land prices: The cost-driven perspective says land prices contribute to housing prices; the derived-demand perspective claims housing prices affect land prices; and the mutual causation perspective identifies a bidirectional relationship. The question remains as to which is the leading market. Though all three perspectives have empirical support, no theory exists to illustrate the mechanisms of the relationship between the two prices. We propose a theoretical framework that allows reconciliation of these perspectives. We hypothesize that price dynamics depend on the context of external shocks for price changes – in developed areas, housing prices more likely trigger changes in land prices, while in rural areas land price changes more likely cause housing price changes. Based on monthly sales data (years 1970-2011) of housing and vacant land in 32 Georgia counties in the United States, we use both Granger causality test and 3-stage simultaneous equations model for empirical tests. Our results conform closely to theoretical expectations, shed light on the trends, fluctuations, and regional variation in housing prices, and carry important policy implications for property assessment, local economic development, and infrastructure investment.

Key words: housing price; land price; relationship; regional variation

JEL codes: H54, R14, R21

1. Introduction

The relationship between land prices and housing prices has long been controversial, with three distinct perspectives in the literature (Glaeser, Gyourko, & Saks, 2005; Potepan, 1996; Poterba, 1991; Wen & Goodman, 2013). Under the cost-driven perspective, land prices, as one of the costs of housing, contribute to housing prices. The derived demand perspective claims that housing prices are determined by the price bid function and affect land prices. The third perspective, mutual causation, combines the supply and demand sides of the housing market to identify a bidirectional relationship between the two – Rising housing prices lead to an increase in land prices, and increased land prices aggregate the cost of housing, thus housing prices. The question remains as to *whether housing or land is the leading market*.

While there are many empirical results confirming all the different opinions of government departments, real estate developers, and academic scholars, there is no fundamental *theory* to illustrate the mechanism of the relationship between land and housing prices. The three interrelated submarkets (housing, land, and rental markets) proposed by Potepan (1996) represent a good distinction between the land and housing markets. By analyzing the fundamentals of the determinants of both land and housing prices and connecting these fundamentals with the three submarkets, this paper proposes an integrated theoretical framework to explain the interaction of land prices and housing prices. Our framework successfully illustrates the different relationships between land prices and housing prices in different scenarios, which can be potentially used to explain the controversial empirical results. Briefly, as discussed in Capozza and Helsley (1989), the price of *urban* land has four additive components: the value of agricultural land rent, the cost of conversion, the value of accessibility, and the value of expected future rent increases (a growth premium). In a highly developed urban area, the first three components are approximately fixed; only the change of the fourth component (i.e., future rent) will cause or be affected by a change in housing prices. In this scenario, when housing prices change, the magnitude of the change of land prices is determined by the rental market and the proportion of capitalized future rent in land prices. In contrast, in a rural area, especially along the suburban fringes, besides the rent value, the accessibility of land can also be substantially changed due to urban development. At the urban fringe, the spatial characteristics are one of the determining factors of land prices (Chicoine, 1981; Hushak & Sadr, 1979). These two components of land prices can usually change more significantly as a result of urbanization or the establishment of a certain project. As concluded in Capozza and Helsley (1989), the growth premium may create a large gap between the price of land in a suburban area and the value of agricultural rentals. Scholars also found that for various reasons—speculation, residential attachment, and uncertainty—the land which is sold for development is likely to be sold at a premium to its value in its current use (Evans, 1983, 2004; Neutze, 1987; Titman, 1985). Therefore, the change in land prices in the suburban/semi-rural scenario, to a large extent, may play a leading role and cause a dramatic change in housing prices. Note that while we use the word *cause* in the statement, housing and land price changes did not necessarily *cause* each other, but it indicates which happened first.

In this paper, we propose a theoretical framework that the relationship between changes or dynamics in housing prices and land prices depends on the causes for the changes in different contexts. In a developed area, it is more likely that housing prices lead to changes in land prices, while in an area in the process of urbanization, the change in land prices is more likely to cause a change in housing prices. In the empirical section, using parcel-level repeat sales data of both land and housing units in the state of Georgia, we construct a 3SLS model. The results closely conform to our theoretical expectations. The rest of this paper is organized as follows. The next section reviews the literature on housing prices and land prices, especially the relationship between the two. The third section provides a theoretical framework by connecting the markets of housing and land. The fourth section introduces the data set and the repeat sales index used in the paper, describing the trends of housing and land prices in different contexts. The fifth section elaborates on empirical analysis and regression results. The final section concludes this paper.

2. Literature Review

Housing market dynamics in different circumstances have been studied by many scholars (DiPasquale & Wheaton, 1994; Engle, Lilien, & Watson, 1985; Ferreira & Gyourko, 2011). However, very little literature has systematically investigated the housing price mechanism over a significantly long period of time, specifically, across boom and bust years of the economic cycle. A recent paper by Harding, Rosenthal, and Sirmans (2007) is among the first to decompose real housing price changes into three systematic parts: price inflation, age-related depreciation, and the contribution of maintenance. Partly because of data unavailability, most research fails to control for both maintenance and age-related depreciation. While it is an important issue for housing prices, land prices are fundamentally different. Capozza and Helsley (1989) decomposed the price of *urban* land into four additive components and concluded that, in rapidly growing cities, the growth premium can easily account for half of the average price of land. Shonkwiler and Reynolds (1986) also concluded that the distance to a metropolitan area is directly related to land price, and Colwell and Munneke (1997) found that the rate of price decline with distance from an urban center was overestimated, but it exists and is significant. At the urban fringe, property-specific and spatial characteristics are proposed as the determinants of land prices (Chicoine, 1981; Hushak & Sadr, 1979). Davis and Heathcote (2007) and Davis and Palumbo (2008) analyze the trend of U.S. residential land price by separating housing values as replacement costs of physical housing structures (i.e., construction costs). Ahlfeldt and McMillen (2014) provide a spatial history of land values in Chicago from 1919 to 2010. In this stream of literature, scholars assume that land capitalizes the market value of a home's location and find that residential land values have appreciated over a wide range, implying that housing is much more land intensive than it used to be.

There is empirical evidence for three perspectives on the relationship between housing prices and land prices. Under the perspective that changes in land prices caused changes in housing prices, evidence has been found in the United States (Glaeser et al., 2005), the United Kingdom (Evans, 1987), Hong Kong (Hui, 2004; Peng & Wheaton, 1993), and also China (Deng, Gyourko, & Wu, 2012). However, some studies suggested that only very small fraction of the variation in house prices may be explained by land cost changes (Poterba, 1991) and housing price is in a dominant position as a whole, i.e., the influence of housing price on land price is greater than that of land price on housing price (Wen & Goodman, 2013). Scholars demonstrated both theoretically and empirically that housing demand causes land price changes (Alonso, 1964; Manning, 1988; Muth, 1971, 1972; Witte, 1975). Mutual causation (bidirectional relationship) was also found by scholars examining different data series based on the Granger (1969) causality test (Huang & Du, 2010; Ooi & Lee, 2004) and the simultaneous equations approach and/or 2SLS/3SLS regression methods (Wen & Goodman, 2013; Wu & Zheng, 2011). Some scholars distinguish long-term effects from short-term effects. For example, based on quarterly data in Finland, Oikarinen (2014) found that although the housing price response is generally slow, new information regarding market fundamentals is more rapidly reflected in housing prices than in land prices, and econometric results indicate that housing price movements cause land price changes. However, in the long run, housing prices, instead of land prices, will adjust toward the equilibrium between housing and land prices and construction costs. Consistently, Du, Ma, and An (2011) found that in the four top-tier municipalities of China, in the short term, housing prices are Granger caused by land prices, while there exists a long-term equilibrium between the two. On the basis of China's 35 large and medium cities panel data from 1998 to 2006, Huang and Du (2010) also concluded that land price and housing price have a long term equilibrium relationship, but they are unbalanced in a short run with weak disequilibrium correct mechanism.

An example from Davis and Palumbo (2008) shows that in 1998, for single-family home values in San Francisco and Milwaukee, land in San Francisco represented 81% of total home value and house 19%, while land in Milwaukee represented only 33% of total home value and house 67%. From 1999 to 2004, land price in both cities increased 90%, and house prices (construction costs) increased 5% in San Francisco and 8% in Milwaukee. Thus, the actual increase in home prices is 74% (0.81*0.9 + 0.19*0.05) for San Francisco and 35% (0.33*0.9 + 0.67*0.08) for Milwaukee. Finally, the share of land value in total home value increased significantly, especially for Milwaukee. The land price increases at the same percentage, but tells different stories about home value changes. This example sheds light on how the relationships between land and housing prices can have a large impact on the price dynamics of different localities. An obvious inference is that in a more developed area, land value occupies a higher proportion of total home value. Thus, a comparison of the relationships between land value proportion and indicators of development in different areas can provide an implication of comparative land price, i.e., *relative to other areas*, whether the land price appropriately reflects the development and public service provision or at least partly because of other speculative behaviors.[1] Also, as indicated in Rose (1989), constraints, both natural and contrived by man, by limiting the availability of land, cause the price of land and of housing to be higher. Another reason of different land value shares could be that San Francisco's land supply is highly constrained by water whilst Milwaukee's expansion is only limited by Lake Michigan on one side.

3. Theoretical Framework

In this section, we construct a theoretical framework based on the existing literature, combining the linkages between markets for housing and (urban and rural) land. Potepan (1996) derived a theoretical framework of the metropolitan housing market, indicating simultaneous determination of rent, housing price, and undeveloped land price. Oikarinen (2014) refined this model to analyze the differences between urban land prices and housing price adjustments.

Briefly, housing prices (P_H) and vacant land prices (P_L) should be at equilibrium in the following two equations:

$$P_H = P_H(P_L, C, D)$$

$$P_L = P_L(P_H, C, S)$$

where *C* is construction cost, *D* denotes variables/characteristics that influence housing demand, and *S* stands for the factors that determine land supply. Intuitively, housing prices and land prices are dependent of each other; thus, the housing rental price equation is:

$$R = R(P_H, P_L, C, D, S).$$

A large body of empirical research based on this framework has investigated the interrelationship between housing prices and land prices, but the results have been inconsistent, even controversial,

[1] Note that this is not a reference of absolute land price but a relative comparison. It is a topic for another paper which will not be further extended here.

which is, we argue, because most research takes the status of land as static, that is, either in an urban or rural status. Therefore, research in that rein fails to account for a very important component of land characteristics.[2] Here, we use L to indicate land characteristics and the land price equation changes to:

$$P_L = P_L(L, P_H, C, S).$$

As indicated in Capozza and Helsley (1989), the price of *urban* land can be divided into four additive components: the value of agricultural land rent, the cost of conversion, the value of accessibility, and the value of expected future rent increases (a growth premium). Thus, the location of a piece of land is a significant factor determining the land's price. Conversion costs can be different, and the urban-rural difference would cause huge variation in the value of accessibility. Land characteristics, thus, should include land location, the urbanization index of the lot, and accessibility to amenities (Diamond, 1980). Putting these land characteristics into the equation may considerably increase the explanatory power for land prices.

As this point, however, the theoretical framework still cannot tell the direction of the relationship between housing prices and land prices. Actually, it is unambiguous that the *absolute* values of housing and land are mutually dependent. The controversial point among most existing studies is the relationship between the *changes* in housing prices and land prices, and which of the two plays the leading role. Under this perspective, the reasons for the changes are very important and deserve due attention. However, most studies fail to identify the fundamental reasons for the housing/land price changes.

[2] When calculating the land price index, some studies control for basic land characteristics, such as the land size and the distance to the Central Business District (CBD), but from the knowledge of the authors, none of them controls for urban and rural differences.

We assume that the changes are induced by external shock(s) denoted by A; the change (denoted by Δ) in the external factors of housing prices and land prices are all functions of the external shocks,

$$\Delta D = \Delta D(A)$$

$$\Delta L = \Delta L(A)$$

$$\Delta S = \Delta S(A).$$

Changes in these factors are determined by the features of the shocks. Demand shocks usually have a direct impact on the housing market, while supply shocks on land. Thus, instead of analyzing price changes between housing and land, it is more direct to investigate demand and supply. As shown in Figure 1, we extend the analyses of Capozza and Helsley (1989) that not only *urban* land, but also the value of most *residential* land in urban and rural areas has four additive components: the value of agricultural land rent, the cost of conversion, the value of accessibility, and the value of expected future rent increases (a growth premium). For the house value, we follow Davis and Heathcote (2007) and Davis and Palumbo (2008) to assume that house values are equal the replacement costs of its physical structure (construction costs). Thereby, other elements including public services and neighborhood characteristics are all capitalized into land values. When the supply or demand changes, the supply always starts from land while demand starts from house. Land price and house price are linked with each other, but the change of demand has a direct effect on house while supply on the land side.

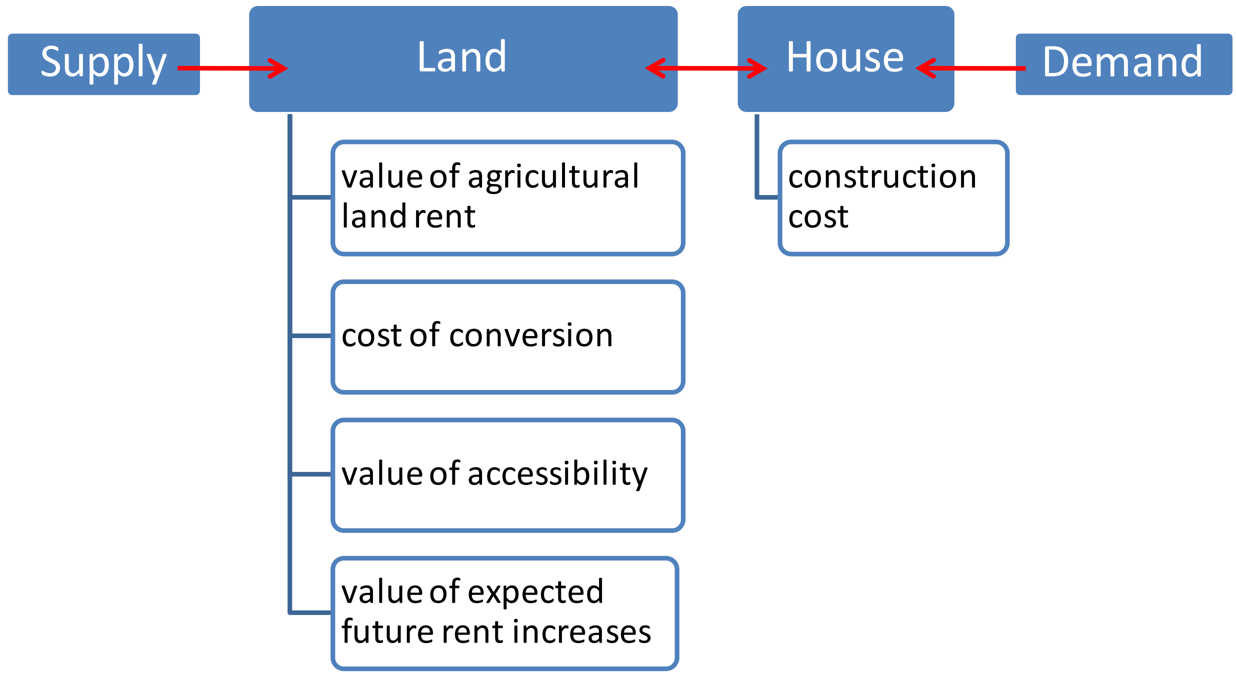

Figure 1: Theoretical framework of the dynamics between land price and housing price

There are two sides of land supply changes. One is urbanization which increases the amount of feasible land to be developed, and the other is the process of lower-value land (e.g., rural land in suburban areas) entering in the market due to policy relaxation of land restriction. If changes occur mostly in the process of urbanization, which greatly changes (decreases) the cost of conversion and (increases) value of accessibility for certain lands, the price changes can account for a large proportion of total land price. These shocks increase the supply of urbanized land and increase the average land prices within a certain area. In this scenario, land price increases will lead to housing price increase. If the other side happens more (i.e., much lower-price land enters into the market), land price will decrease. Therefore, from the demand side, housing price changes always have a positive relationship with land price changes; however, from the supply side, the relationship is unclear about how land supply changes will affect house price changes. The direction is inconclusive since more supply tends to decrease land price while more urbanization tends to increase the land value. Take China as an instance for the urbanization process, during times of rapid development, when some land was auctioned at a very high price, the price of housing units near this land rose immediately to reflect the higher land price (expected more urbanized amenities, thus more value of accessibility):

$$A \rightarrow \Delta P_L \rightarrow \Delta P_H.$$

On the other hand, sometimes the shocks change the housing demand in the market. If external shocks happen in a well-developed area and cause an inflow of population, inducing an increase in the housing demand, housing price changes will lead to land price changes:[3]

$$A \rightarrow \Delta P_H \rightarrow \Delta P_L.$$

Based on the above discussion, we develop the following two consecutive hypotheses/propositions, with the second hypothesis grounded on the first one.

H1: *The relationship between the dynamics of housing prices and land prices depends on the effect of the external shock.*

(1) When the external shock mainly changes housing demand, housing price changes will lead to land price changes, especially if land is in short supply;

(2) *When the external shock mainly changes land characteristics or land supply due to urbanization or policy restriction, land price changes will lead to housing price changes;* and

[3] Based on the theoretical framework, we note that house price change does not *cause* land price change. Instead, the house demand and price change is a *trigger* on land price change, of which the housing price change *leads to* land price change. Therefore, we are cautious to use the word "cause" in the relationship between housing price and land price.

(3) When the external shock changes both housing demand and land supply, the relationship will be bidirectional, and the magnitude will be dependent on the intensity/magnitude of the external shocks in each direction.

***H2**: In a developed area, it is more likely that changes in housing prices lead to changes in land prices, while in an area under an urbanization process, the changes in land prices are more likely to cause changes in housing prices.*

Note that if much new lower-price land enters into the market, it will help stabilize and even lower land prices, thus housing prices. Therefore, the causal direction is inconclusive. One example is that land price declined between 1930 and 1950 due to the widespread adoption of the automobile which makes the rapid increase in the quantity of land within reasonable commuting distance of city centers. After this effect withers away, land price started to increase again since 1950s.[4]

4. Data and Repeat Sales Index

For this study, we assemble a repeat sales panel data set from 1970 to 2011 for 32 Georgia counties (strongly balanced), of which 19 are metro (urban) counties and 13 are non-metro (rural) counties. Metro counties are defined as those with more than 70% urban population; the rest are non-metro counties.[5] For these sampled counties, the data covers all sales data of housing and vacant land from 1970. This data set contains detailed information including the exact date of each sale, and more valuably, most sales are identified by a categorical variable

[4] Davis and Heathcote (2007) also pointed out that the explanation for the U-shape in the value of land needs a more formal evaluation.

[5] The urban/rural population data is retrieved from http://www2.census.gov/geo/ua/PctUrbanRural_County.xls. The 2012 American Community Survey (ACS) estimates are the first to include tabulations for the 2010 Census Urban Area definitions and Urban/Rural classification. See more detail in U.S. census: http://www.census.gov/geo/reference/ua/urban-rural-2010.html.

indicating whether they were sold as housing units or just vacant land and whether they were fair market sales or not. We cleaned this data set and compiled it into monthly and quarterly data, including both housing unit sales and vacant land sales. Figure 2 describes the distribution of sales data collected in Georgia counties.

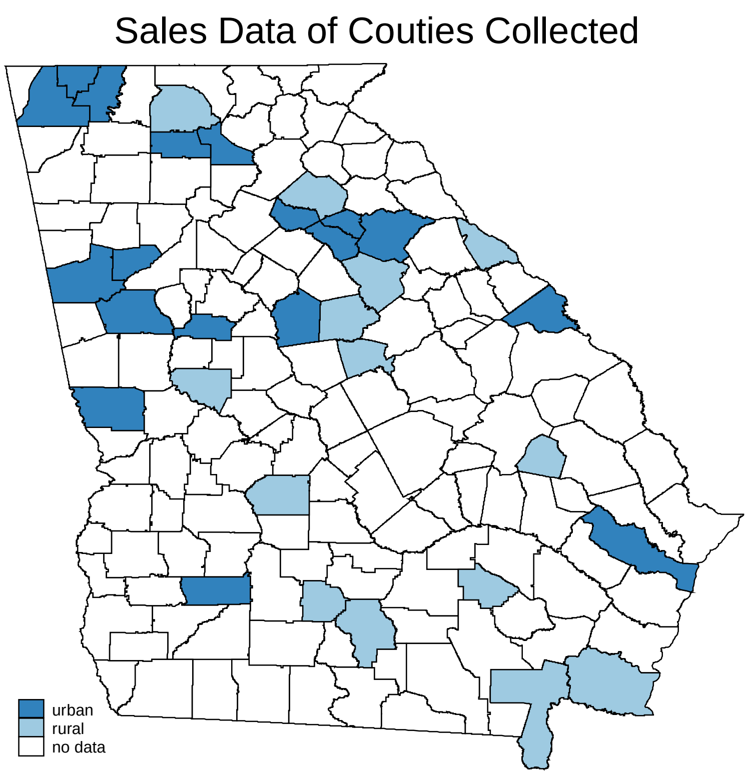

Figure 2: The distribution of sales data collected in Georgia counties (urban and rural)

4.1 Data

This data set is different from the commonly used repeat sales data in several ways. First, while most studies used solely housing data *or* land data, this set includes data for both housing and vacant land. Especially, the data for land sales are often scarce, since urban land is traded infrequently (Ooi & Lee, 2004). Partly for this reason, research on the relationship between land and housing prices have started only in recent years, and all these studies have used the hedonic equation method to construct a land price index (Ooi & Lee, 2004). Given the prominence of the location of land, the hedonic method is subject to a high probability of omitted variable bias. Our data set is among the first to use repeat sales data of land to conduct related research. Second, the existing research mostly uses data from Metropolitan Statistical Areas (MSA) or data from a specific city/county which represent only metro areas, or just one specific region and thereby is subject to limited generalizability. In contrast, this data set is a very good representation of the state of Georgia and includes nearly three dozen counties in the metro and non-metro areas (categories); it allows for the investigation of local-level differences in the same market environment (state-level). Third, this data set covers a relatively long period, from 1970 to 2011 (42 years), a duration which includes five full economic cycles (1970-1976, 1977-1984, 1985-1992, 1993-2001, and 2002-2011). The data set helps us to investigate the interaction of housing prices and land prices in different circumstances of economic change. For instance, for the impact on housing and land prices, the recent Great Recession was quite different from previous economic downturns, since it was directly related to or even caused by the drop in the housing market. Finally, the greatest advantage of this data set is that it is a repeat sales data set. Since the location and spatial characteristics of land are determining factors of land prices, it is very important to control for these factors to investigate price changes. Because location and spatial characteristics are complicated and sometimes data are not available, we can never include all of the important characteristics. Thus, using repeat sales data is the best way to have all these characteristics controlled. Due to the lack of data mainly in vacant land sales, this study is to our knowledge the first using repeat sales data to examine the relationship between housing prices and land prices.

4.2 Price index

We construct price indexes using the same methodology as has been employed with repeat sales data, a methodology first developed by Bailey, Muth, and Nourse (1963), later popularized by K. E. Case and Shiller (1987, 1989), and now widely used in scholarly research and practical applications (B. Case & Quigley, 1991; Harding et al., 2007; Rosenthal, 2014).[6] The standard repeat sales model supposes that the prices of a house sold twice in periods t and $t+\tau$ are denoted as (Harding et al., 2007):

$$P_t = e^{\gamma_t} f(\boldsymbol{X_t};\ \boldsymbol{\beta_t}), \text{ and}$$

$$P_{t+\tau} = e^{\gamma_{t+\tau}} f(\boldsymbol{X_{t+\tau}};\ \boldsymbol{\beta_{t+\tau}})$$

where $f(\boldsymbol{X};\ \boldsymbol{\beta})$ is an unknown function of the structural and neighborhood characteristics of housing ($\boldsymbol{X}$) and the corresponding coefficients ($\boldsymbol{\beta}$). As the typical repeat sales model assumes that both $\boldsymbol{X}$ and $\boldsymbol{\beta}$ are unchanged between periods t and $t+\tau$, we can get

$$\ln(P_{t+\tau}) - \ln(P_t) = \gamma_{t+\tau} - \gamma_t + \mu_{t+\tau}$$

where $\mu_{t+\tau}$ is the error term, and the term $f(\boldsymbol{X};\ \boldsymbol{\beta})$ is cancelled out in the equation. For each pair i of transactions (initial/first sale and repeat/second sale), the model becomes[7]

$$\ln\left(\frac{P_{t+\tau,i}}{P_{t,i}}\right) = \sum_{t=1}^{\tau_i} \gamma_t\, D_{t,i} + \mu_{t,i}$$

where $D_{t,i}$ takes the value -1 if for transaction i, period t is the period of the initial sale, +1 if the period of the repeat sale, and 0 if otherwise for each pair of transactions.[8] With the assumption

[6] This methodology has been used in practice as S&P/Case-Shiller home price indices (Source: http://us.spindices.com/index-family/real-estate/sp-case-shiller).

[7] Some properties were sold more than twice. We divided these transactions into different pairs of repeat sales. For instance, for sales happening in Periods 1, 2, and 3, the transaction pairs (1, 2) and (2, 3) can be used in the calculation of the index.

[8] Specifically, in two periods t and t', this equation can be illustrated as follows: $\ln\left(\frac{P_{t',i}}{P_{t,i}}\right) = \sum_{t=1}^{\tau_i} \gamma_t\, D_{t,i} + \mu_{t,i}$, where $t = 0, 1, \dots, \tau - 1$, and $t' = 0, 1, \dots, \tau$.

that both the characteristics of housing units and the corresponding coefficients are unchanged between the two transaction periods, as indicated in K. E. Case and Shiller (1989), the variance of noise may increase with the interval between sales, mainly due to age-related housing depreciation and housing maintenance (Harding et al., 2007). In this paper, we control for age-related depreciation with a non-linear depreciation function. Note that we do not control for maintenance investment as in Harding et al. (2007); however, instead of decomposing the components of housing price changes, we investigate the relationship between changes in housing prices and land prices. The housing price index without accounting for maintenance will not have a significant influence on our conclusion. Therefore, the final format of the housing price index equation is as follows:

$$\ln\left(\frac{P_{t+\tau,i}}{P_{t,i}}\right) = \sum_{t=1}^{\tau_i} \gamma_t D_{t,i} + \beta \ln(\tau_i) + \mu_{t,i}$$

where β is the elasticity of housing price changes with respect to the interval between two sales (τ_i). As mentioned above, with repeat sales data for both housing and land, we can calculate indexes of both housing and land, based on the repeat sales model in order to avoid omitted variable bias.

5. Methodology, Models, and Results

As illustrated in the literature review, due to the two-way relationship between land prices and housing prices, many studies conducted the Granger causality test to investigate the relationship; and some used simultaneous equation models. In this article, we apply both to respective sub-data sets as mutual robustness checks. Based on the above repeat sales index, we first calculate the price indexes of housing and land in different contexts and provide some intuitive descriptions. Then, we design the models and conduct necessary econometric tests. The following sub-sections detail the results and analyses.

5.1 Descriptive analyses

Our sales data set includes a sample of 32 counties in the state of Georgia. To confirm the validity and generalizability of our research, we checked whether our data could represent, at least, the state of Georgia. Figure 3 provides the monthly price index of our data set in comparison with the Freddie Mac Housing Price Index (FMHPI) for Georgia and the United States.[9] We found that the index of our data set closely approximate the Freddie Mac index for Georgia, indicating that the sample of 32 counties is very representative of Georgia.[10] Studies showed that a major reason for the boom and bust of housing market was due to planning constraints on the availability of land (Green, Malpezzi, & Mayo, 2005; Malpezzi, 1999; Malpezzi & Maclennan, 2001). Based on the statistics in Figure 3, however, the State of Georgia is untroubled since the boom and bust was much less evident.

[9] Source of the Freddie Mac House Price Index: http://www.freddiemac.com/finance/fmhpi/.

[10] We also calculated the quarterly price index of our data set and compared it with the quarterly report from the Federal Housing Finance Agency (FHFA) (http://www.fhfa.gov/Default.aspx?Page=87); similarly, the sample data set from the 32 counties is a good representation of Georgia.

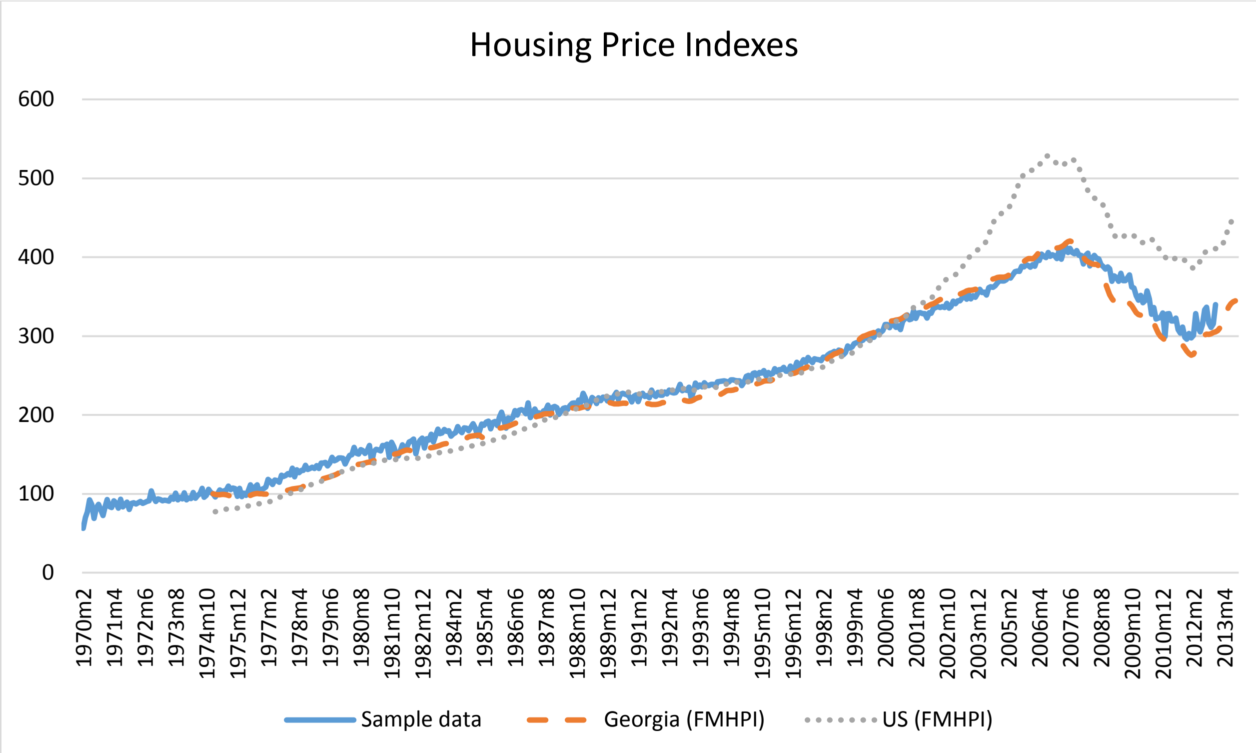

Figure 3: Comparison of housing price indexes from sample data, Georgia, and the U.S.

Notes: Housing unit sales with price increases higher than 20 times or decreases more than 60 percent are deleted.

As hypothesized in the theoretical framework, in a developed area, housing prices are more likely to lead to changes in land prices, since the value of accessibility was already included in the land value. For undeveloped rural areas, on the other hand, in the process of urbanization, the change in land accessibility can account for a large proportion of land values, thus promoting higher land prices. Figure 4 compares the different trends between the housing price index and land price index in metro counties and non-metro counties.[11] The trends of housing price indexes are similar in metro and non-metro counties. In metro counties, the land price index obviously lags behind the housing price index, while in non-metro counties, the land

[11] The trends of land price indexes are more volatile due to the lower frequency of land sales compared to housing sales.

price index shows a very similar trend to the housing price index, indicating a greater incremental value embedded in the land. These results accurately capture our propositions about the changes in housing prices and land prices. Note that the land price index in metro counties does not increase much is partly due to the fact that the data we used here is newly added *vacant* land sales which should be mainly in urban fringes.[12]

The change in the accessibility value of land usually comes from a switch from rural parcels to urban parcels as a result of urbanization or urban sprawl. To illustrate this effect in detail, Figure 5 compares the trends of the housing price index and the land price index for urban and rural parcels with fixed parcel classes, that is, either urban or rural. In this case, the trends capture only the value changes within urban or rural parcels, ruling out the value changes from switching rural parcels to urban parcels. In this case, both trends show similar results – changes in land price indexes lag behind changes in housing price indexes. Figures 4 and 5 demonstrate that changes in land prices in rural counties, to a large extent, come from the urbanization of rural parcels, in which the changes lie in the value of accessibility, the third component of land value in Capozza and Helsley (1989).

[12] The land price index here is not exactly the land share of home as defined but the vacant land price index, however, it also captures the trend of land prices but more on less or newly developed areas, which underestimate the magnitude of land price changes.

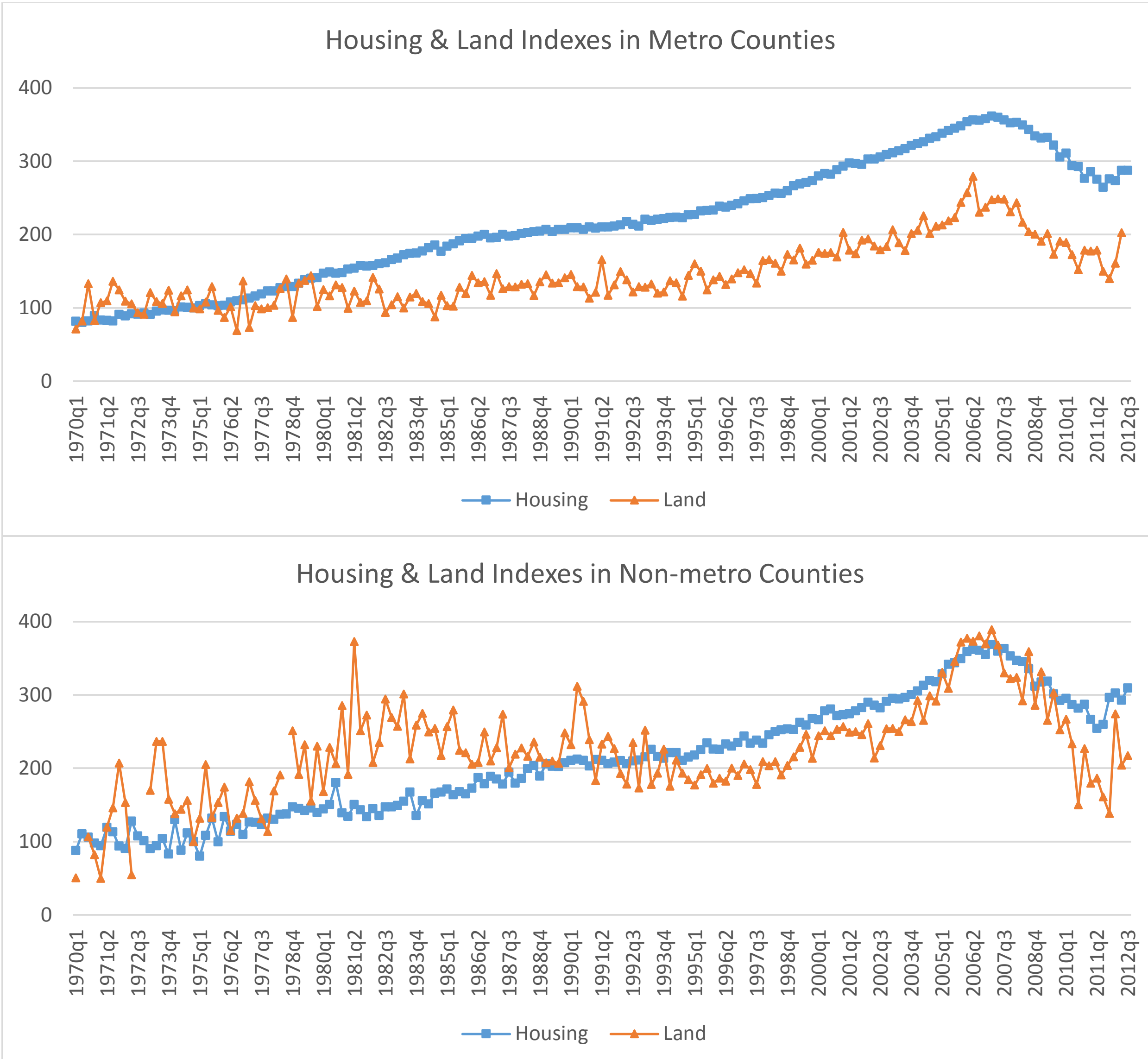

Figure 4: Housing and land price indexes in metro and non-metro counties

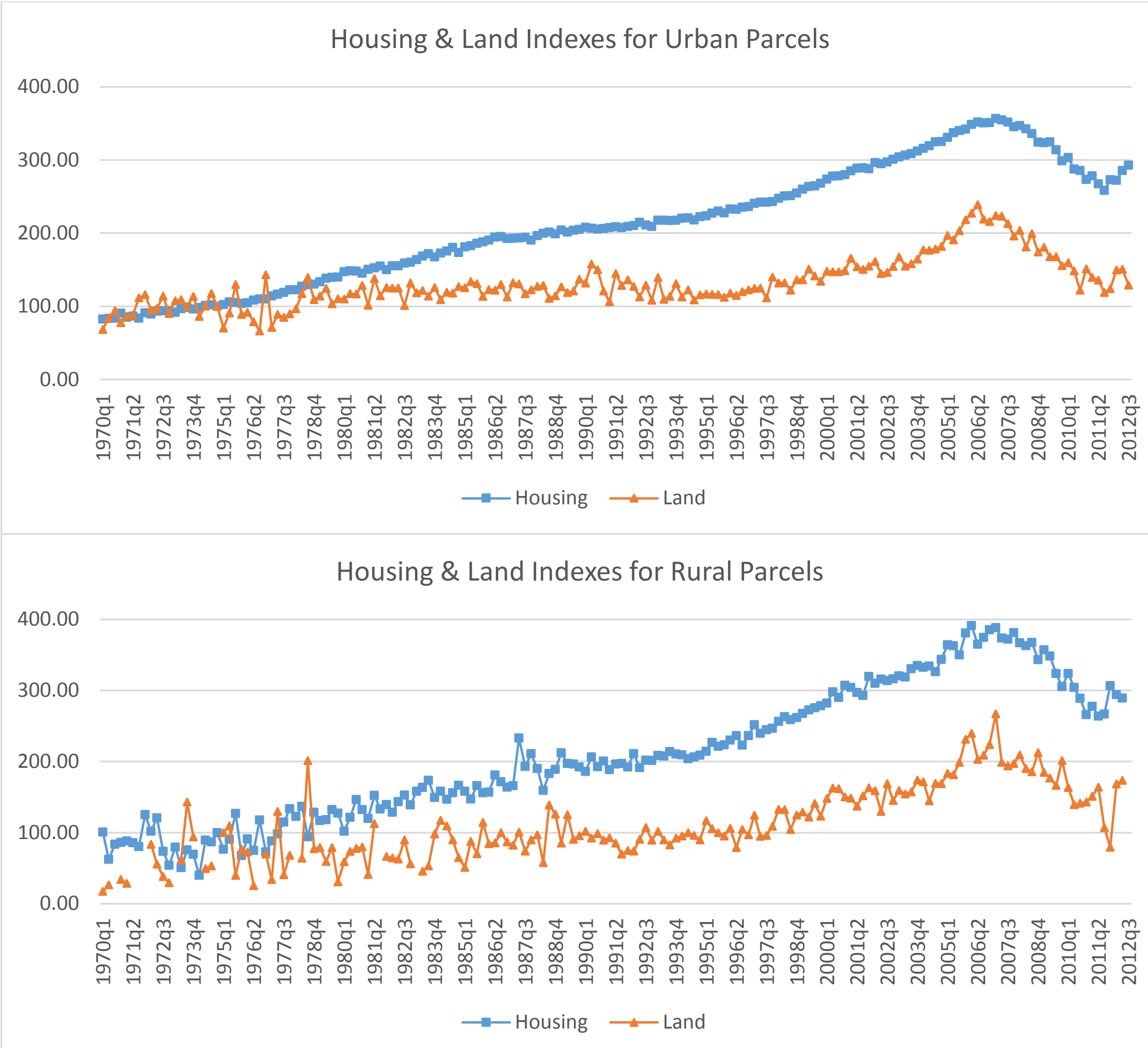

Figure 5: Housing and land price indexes for urban and rural parcels

Figure 6 provides further evidence that there are much higher volumes of new sales of vacant land than repeat sales during the period of a rapid increase in the land price index (1998-2007, the lower panel), while the two sales are approximately similar during other periods (the upper panel). According to theory, this trend happens most often at the urban fringes, which is consistent with the conclusion in the literature (Davis & Heathcote, 2007; Davis & Palumbo,

2008) that, from 1984 to the end of 2004, the value of residential land as a ratio of the total market value of housing increased from 32 percent to about 50 percent.

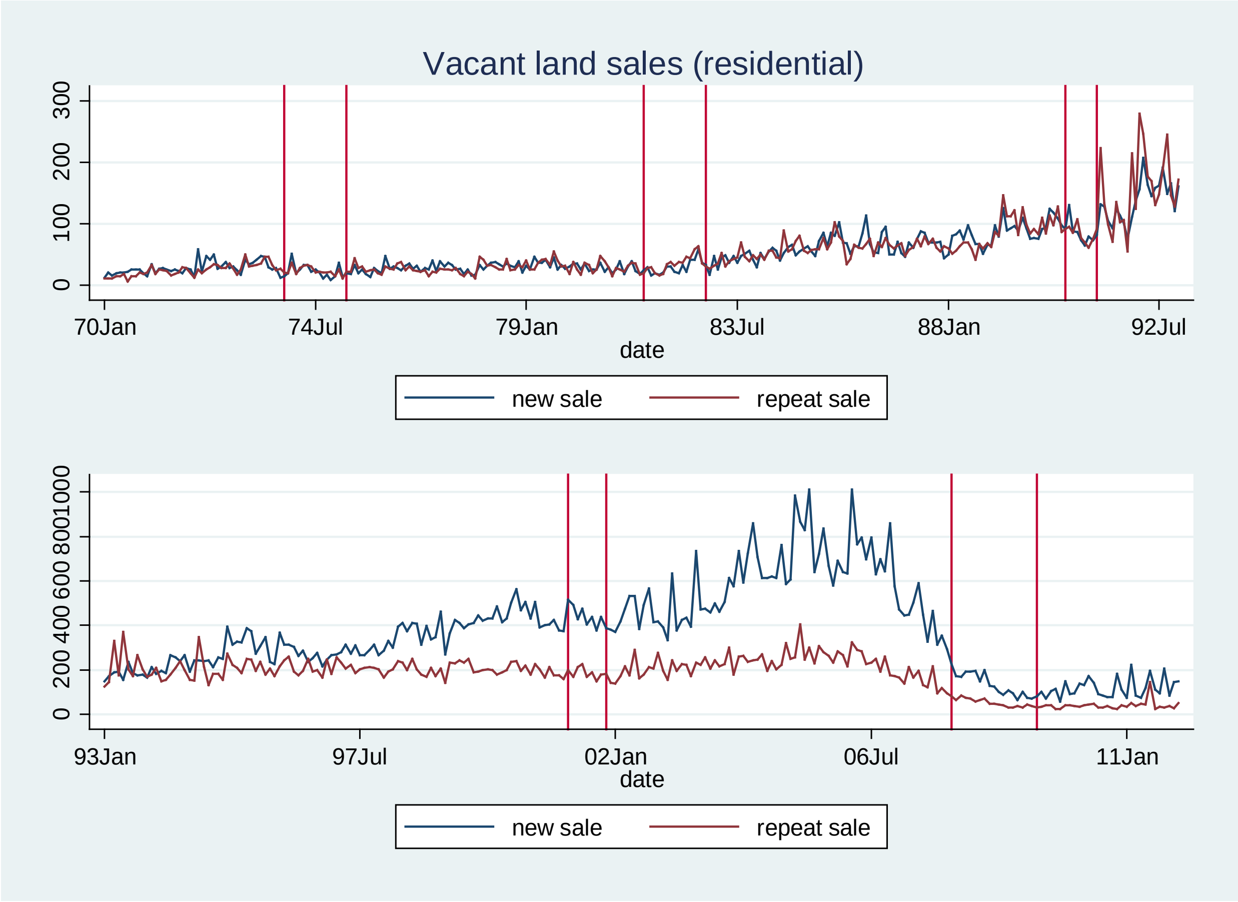

Figure 6: Trends of new sales and repeat sales of vacant land

5.2 The Granger causality test

In this section, we apply the cointegration analysis and Granger causality test, as is done in most studies, to examine the relationship between housing prices and land prices (Du et al., 2011; Ooi & Lee, 2004) and analyze both the long- and short-term dynamics. A general Granger causality test includes an examination to determine if the housing price index and the land price index are stationary and cointegrated. Thus, we first conduct the unit-root tests on both the two indexes and the first differenced series of the indexes. After the unit-roots are determined, we evaluate whether there is a long-term relationship between the housing price and land price indexes. The following cointegration regressions are run with the data sets for both the urban and the rural county sub-groups:

$$HP_t = \alpha_1 + \beta_1 LP_t + u_t$$

$$LP_t = \alpha_2 + \beta_2 HP_t + v_t$$

where HP_t and LP_t are price indexes for housing and land, respectively. The error term u_t and v_t are also called error correction terms for HP_t and LP_t, correspondingly (Du et al., 2011). If the housing and land prices are both cointegrated, these error terms will be stationary.

However, as also mentioned in Ooi and Lee (2004), a linear combination of two non-stationary series may also be stationary, and if such a stationary linear combination exists, the two non-stationary series are said to be cointegrated (Engle & Granger, 1987). The stationary linear combination (i.e., the cointegrating equation) is interpreted as a long-term equilibrium relationship between the two series. For the two cointegrated series, the error correction terms are needed in the Granger causality test to prevent model misspecification and loss of information about the long-term contemporaneous relationship (Eng, 1994; Fung & Isberg, 1992). The error correction models are as follows:

$$\Delta HP_t = \alpha + \sum_{i=1}^{m} \alpha_i \Delta HP_{t-1} + \sum_{j=1}^{n} \beta_j \Delta LP_{t-1} + \gamma \hat{u}_{t-1} + \eta_t$$

$$\Delta LP_t = \tilde{\alpha} + \sum_{i=1}^{p} \tilde{\alpha}_i \Delta LP_{t-1} + \sum_{j=1}^{q} \tilde{\beta}_j \Delta HP_{t-1} + \delta \hat{v}_{t-1} + \xi_t$$

where ΔHP_t and ΔLP_t are the first differences in housing and land prices. $\hat{u}_{t-1}$ and $\hat{v}_{t-1}$ are predicted values of the lagged error correction terms from the cointegration regressions. The optimal periods of lags (*m*, *n*, *p*, *q*) are determined based on the Akaike Information Criterion (AIC) (Du et al., 2011; Ooi & Lee, 2004).

According to the results in Table 1, the null hypothesis (i.e., there is a unit root) cannot be rejected for both housing and land prices. The critical value to be significant at the 1% level is -3.487. The test statistics of housing price and land price series are -1.559 (p-value 0.587) and -2.673 (p-value 0.079), respectively. Therefore, we can conclude that the series of housing and land prices are non-stationary. However, based on the results for the first differences of the two series, the test statistics are -17.802 and -20.593 with p-values much less than 1%, and the null hypotheses are both rejected at the 1% level. Thereby, the first differences of housing and land prices are both stationary. From the Johansen (1988) cointegration test, based on statistics used to determine the number of cointegrating equations in a vector error-correction model (Stata code *vecrank*), the eigenvalue and trace statistic both indicate that there is one cointegrating equation between the series of housing and land prices, implying a long-term equilibrium relationship between the two markets. The stability test, with 2 eigenvalues less than one, also confirms the stability of the bivariate model.

Table 1: Augmented Dickey–Fuller unit-root tests

Time series	Level	First Difference
Housing price Index	-1.559	-17.802***
Land price index	-2.673	-20.593***

Note: *** denotes being significant at the 1% level with a critical value of -3.487.

In 1990, The HOME Investment Partnership Program (HOME Program) was created by the National Affordable Housing Act.[13] In 1997, the Multifamily Housing Finance and Development Program was organized by the Georgia Department of Community Affairs.[14] These acts provided funds to support affordable housing initiatives or rental programs, which increased the demand for vacant land and provided more land supply for housing in the market. Thus, to take into consideration the policy changes and the business cycles covered in the sample period, we divided the data into two subsets, one from 1970 to 1992, the other from 1993 to 2011. Then, we ran the regressions using the full sample and the two subsamples, respectively.

Table 2: Vector error-correction model for housing and land prices

	(1) All years	(2) 1970-1992	(3) 1993-2011
Housing			
L._ce1	0.0081	-0.0021	-0.0742*
	(0.0074)	(0.0085)	(0.0447)
LD.housing	-0.0277	-0.3656***	0.1397
	(0.0768)	(0.1020)	(0.1220)
LD.land	**0.0591****	0.0168	0.0178
	(0.0241)	(0.0219)	(0.0591)
Constant	1.2165***	1.9532***	0.2679
	(0.3429)	(0.3270)	(0.5998)
Land			
L._ce1	-0.2503***	-0.7971***	-0.2228*
	(0.0645)	(0.1377)	(0.1179)
LD.land	-0.3581***	-0.1178	-0.3879***
	(0.0725)	(0.1030)	(0.1237)
LD.housing	**0.5230****	0.4073	**0.6426****
	(0.2315)	(0.4805)	**(0.2553)**
Constant	-0.1143	0.0174	0.1124
	(1.0329)	(1.5404)	(1.2554)
Observations	169	89	76

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

[13] Source: http://www.dca.state.ga.us/housing/housingdevelopment/programs/HOMErental.asp. The HOME Investment Partnership Program (HOME Program), created by the National Affordable Housing Act of 1990, provides funds to state and local governments to support affordable housing initiatives. The Georgia Housing and Finance Authority (GHFA) is the Participating Jurisdiction (PJ) and recipient of the State of Georgia's allocation of funds from the federal HOME Investment Partnership (HOME) program. GHFA contracts with the Georgia Department of Community Affairs (DCA) to administer the programs funded by this HOME allocation.
[14] Source: http://www.dca.state.ga.us/housing/housingdevelopment/programs/OAH.asp.

The results in Table 2 show that in the full sample period (1970-2011, column 1), the housing and land price series have mutual (bidirectional) causal relationships. The coefficient of lagged difference of land price on difference of housing price (β_j) is around 0.06 and the coefficient of lagged difference of housing price on difference of land price ($\tilde{\beta}_j$) is around 0.52; both are significant at the 5% level. The results imply that overall the land price changes cause 6% of housing price changes in the following year while housing changes cause 52% land price change. It is very reasonable that it needs a long time for the land value to spread into home value due to the long construction cycle, while the land value itself often reflects *expected* value of its location. From 1970 to 1992 (column 2), the relationship is not significant. From 1993 to 2011 (column 3), the change in housing prices very clearly caused a change in land prices, in which 64% of the housing price increase will disseminate into the land price. However, the land price change did not cause the housing price change because of the new development of vacant land (new sales), which increased the land supply and canceled out the effect of land price on housing price. As described in Figure 6, during the period 1998-2007, there was a much larger amount of new sales of vacant land than repeat sales entering into the market.

We also analyze the relationship based on different subsets for metro/non-metro *counties* and urban/rural *parcels*. As shown in Table 3, the results for urban and rural parcels after 1992 (column 3) clearly illustrate that for urban parcels, changes in housing price lead/cause land price changes, while for rural parcels, changes in land prices lead to housing price changes. These results conform very well with the proposed hypotheses in Section 2. For urban parcels, in the long run, partly due to the fixed supply of both land and housing, the relationships between them are often bidirectional (i.e., two-way causal relationships between housing and land prices).

Table 3: Vector error-correction model for different categories

		(1)	(2)	(3)
		All years	**1970-1992**	**1993-2011**
Metro counties	L/H	**0.0567***** **(0.0190)**	**0.0328*** **(0.0171)**	0.0694 (0.0476)
	H/L	0.2960 (0.3152)	-0.7209 (0.6366)	**0.6924**** **(0.3153)**
Non-metro counties	L/H	0.0173 (0.0225)	0.0120 (0.0317)	-0.0348 (0.0343)
	H/L	0.0418 (0.2223)	-0.3334 (0.2923)	**0.7125**** **(0.3621)**
Urban parcels	L/H	**0.0477**** **(0.0223)**	0.0178 (0.0211)	0.0103 (0.0540)
	H/L	**0.5675**** **(0.2539)**	0.4579 (0.5187)	**0.7181***** **(0.2617)**
Rural parcels	L/H	-0.0007 (0.0514)	-0.036 (0.0745)	**0.1649*** **(0.0887)**
	H/L	-0.0173 (0.1057)	-0.0213 (0.1313)	-0.0350 (0.1731)

Notes: L/H indicates the effect of land price on housing price, and H/L indicates the effect of housing price on land price.
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Besides the housing programs from the 1990s (decreasing housing prices), another stream in the housing market is the decrease in the mortgage interest rates, especially since 2001, and the popularity of owning a house (increasing housing prices). Thus, the net effect of the relationship between housing and land prices can be arbitrary. As proposed in the theory, the effects will be based on the characteristics of external shocks. The increased demand for personally-owned housing units with low down payment requirements and low interest rates promoted the housing prices of the late 1990s and early 2000s. The uncommon housing demand also explains why the housing prices did not decline as much as predicted by Mankiw and Weil (1989), after the exhaustion of the baby boom effect.[15]

[15] By Mankiw and Weil (1989), since the housing demand distribution on age indicates that a larger proportion of younger population goes with a higher demand on housing, the aging of the baby boomer's generation should induce a decreasing demand.

5.3 Simultaneous equations model

In this section, we conduct further analyses with the simultaneous equations model.[16] The model is specified as follows:

$$HP_t = \alpha_0 + \alpha_1 LP_t + \alpha_2 HP_{t-1} + \boldsymbol{\gamma_1 X_1} + \varepsilon_t$$

$$LP_t = \beta_0 + \beta_1 HP_t + \beta_2 LP_{t-1} + \boldsymbol{\gamma_2 X_2} + \mu_t$$

where HP and LP are housing and land prices. Both price series are in the log format; thus, coefficients α_1 and β_1 indicate elasticity. $\boldsymbol{X_1}$ and $\boldsymbol{X_2}$ are two vectors of exogenous factors influencing housing prices and land prices, respectively.

In the above two equations, an increase in the error term (for instance, ε_t) in one equation will cause an increase in an explanatory variable in the other equation, which means that the assumption of no correlation between the error term and the explanatory variable is violated. Therefore, the simultaneous equations model should be introduced. For this, two models are available. One is the limited information methods, including two-stage least squares (2SLS); the other is the full information methods or system methods, including three-stage least squares (3SLS). For the 2SLS method, the first stage is to regress each endogenous variable on all the exogenous variables using ordinary least squares (OLS) and to get the fitted values of the endogenous variables. The second stage is to use the exogenous variables and *fitted values* of endogenous variables to regress the original equations in the first stage to yield consistent estimators. This two-stage estimation is consistent but inefficient if we do not take into account the correlation across equations and the exogenous variables from other equations. 3SLS is an extension of 2SLS; it estimates all coefficients of different equations to form a weight matrix and re-estimates the models using the estimated matrix. So, the first two stages are the same as in

[16] When the data are shown to be non-stationary, the simultaneous equations model can be used if the two series are cointegrated, for details see chapter 19 in Hamilton (1994).

2SLS, and the third stage involves the application of feasible generalized least-squares (FGLS) for all equations. The advantage of the 3SLS is that it accounts for the correlations across equations and, thus, improves the large sample efficiency.

In the simultaneous equations model, just as in the Granger causality test, we use real housing and land prices as dependent variables. For the land price equation, the exogenous variables include real interest rates, property tax as a ratio of own source revenue, intergovernmental grants as a ratio of total revenue, per capita total expenditures, and infrastructure expenditures as a ratio of total expenditures. For the housing price equation, the exogenous variables include those in the land price equation and three other variables indicating housing demand: per capita personal income, unemployment rate, and population growth. Based on the availability of the exogenous variables, we use data from 1985 to 2011. In Table 4, we compare the results of OLS, 2SLS, and 3SLS for each equation. The results are similar, though sometimes the standard errors differ.

The results indicate that in the entire period (1985-2011) in general, the housing price dynamics lead/cause the changes in land prices, while the land prices follow housing prices. This can be explained by the trend on population growth and cropland area changes: In Georgia, the population living in cities had a more than 40% increase from around 2.8 million in 1990 to 4 million in 2011; however, the cropland area reduced only around 18% (urbanization process tends to erode cropland) from 8.7 million acres in 1997 to 7.1 million acres in 2012.[17] These statistics indicate that the increase of population was accompanied by the increase of population density instead of by a proportional exploration/development of rural land. Thus, the price changes are mostly from the demand side on housing rather than from the supply side on land.

[17] The population data is from the U.S. Census and the cropland data is from USDA Census of Agriculture.

Table 4: Simultaneous equation model from 1985 to 2011

Variables	Housing price equation OLS	2SLS	3SLS	Land price equation OLS	2SLS	3SLS
land price	0.0359	-0.0047	-0.0087			
	(0.0230)	(0.1302)	(0.1306)			
housing price				**1.2813*** **	**1.4162*** **	**1.4162*** **
				(0.1784)	**(0.2030)**	**(0.1949)**
housing price (lag)	0.8828***	0.9501***	0.9551***			
	(0.0479)	(0.2320)	(0.2168)			
land price (lag)				0.2459***	0.1945**	0.1945**
				(0.0896)	(0.0979)	(0.0940)
real interest rate	-0.0030*	-0.0031*	-0.0032*	0.0004	0.0023	0.0023
	(0.0018)	(0.0018)	(0.0017)	(0.0063)	(0.0066)	(0.0063)
property tax/own source revenue	-0.1923*	-0.1292	-0.1131	0.9193***	1.1779***	1.1779***
	(0.1079)	(0.1867)	(0.2307)	(0.3305)	(0.4130)	(0.3967)
grant/total revenue	-0.1283	-0.0191	0.0119	1.5086**	1.8502**	1.8502**
	(0.2348)	(0.3568)	(0.4214)	(0.7333)	(0.9097)	(0.8737)
per capita total expenditure, in 1000	-0.1894*	-0.2358	-0.2394	-0.7311***	-0.8595***	-0.8595***
	(0.1099)	(0.1574)	(0.1848)	(0.1998)	(0.2505)	(0.2406)
infrastructure/total expenditure	0.0736	0.1172	0.1164	1.0975*	1.0658*	1.0658*
	(0.1452)	(0.2079)	(0.1958)	(0.5989)	(0.6066)	(0.5826)
per capita personal income, in 1000	10.7036	9.7552	8.8184			
	(6.5848)	(6.8558)	(7.0217)			
unemployment rate	-0.4129	-0.4905	-0.5423			
	(0.3282)	(0.3312)	(0.4149)			
population growth	0.0050	0.0054	0.0056			
	(0.0042)	(0.0043)	(0.0043)			
Constant	0.5954**	0.4478	0.4711	-3.8263***	-4.3551***	-4.3551***
	(0.2833)	(0.7082)	(0.5211)	(0.6708)	(0.7786)	(0.7478)
Observations	104	104	104	107	104	104
R^2	0.969	0.968	0.968	0.847	0.835	0.835

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

For various reasons, the housing demand shows a big jump during this period, especially after the late 1990s as part of the nationwide housing bubble.

Table 5: Relationship between housing and land prices for different categories and periods

		All years	1985-1997	1998-2011
All	L/H	-0.0087 (0.1306)	0.1946 (0.1746)	0.2708 (0.3269)
	H/L	**1.4162***** **(0.1949)**	-0.2348 (0.8424)	**1.9946***** **(0.3859)**
Metro counties	L/H	0.4965 (0.6562)	-0.2828 (0.2842)	**-1.0504***** **(0.3797)**
	H/L	**1.4366***** **(0.1921)**	0.5469 (0.7070)	**1.5877***** **(0.3113)**
Non-metro counties	L/H	-0.0786 (0.3885)	-2.2642 (4.4366)	-0.8985 (1.1375)
	H/L	**1.7570***** **(0.2854)**	**3.7997**** **(1.6243)**	**2.1958***** **(0.3530)**

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Notes: L/H indicates the effect of land price on housing price, and H/L indicates the effect of housing price on land price.

In Table 5, we divide the data into two periods, before 1997 and after 1998. The results are very different between the two periods and between metro and non-metro counties. From 1985 to 1997, the coefficients of the housing price are mostly insignificant; while from 1998 to 2011, the coefficients are significant, and the elasticity of housing prices on land prices is around 2 for the full sample and 1.6 for metro counties, implying the significant impact of housing demand increases on land prices, particularly when land supply is limited. The different coefficients during different periods imply that from 1985 to 1997 the population expanded to non-metro counties, pushing up the housing demand and housing price and that from 1998 to 2011 the population started to flow to the suburban areas of metro counties, triggering higher housing demand and new vacant land sales.

As illustrated in the theoretical framework, the reason why land prices did not lead the home price changes is that, as described earlier, from 1998 to 2011 many more new sales of vacant land entered the market than in the prior years, which partly lowered the land prices in the context of increased housing demand. Especially for metro counties, the coefficient of land price is negative, which means that land supply in this period is so large that it slows down the housing price appreciation. If there is no extra land supply, the housing prices will be much higher than they are now due to the high demand on housing. However, since there is a construction stage from a sale of vacant land to an available housing unit, when land supply increases suppress land prices, housing prices can still keep an increasing trend without *immediate* supply increase. Thereby, the relationship between land price and housing price are negative in this period.

6. Conclusion and Discussion

This paper has proposed a theoretical framework that allows reconciliation of the three distinct perspectives prevalent in the literature on the dynamic relationship between housing prices and land prices. Using a long panel data set of representative metro and rural counties in the state of Georgia, we have conducted empirical investigation of the dynamics between the two prices within metro as well as non-metro counties during different time periods. We find that in the long run, there is a cointegrating long-term equilibrium between housing prices and land prices. In the short run, the relationship depends on the context which includes socioeconomic changes (like urbanization) and the external shocks (on the housing or the land markets, demand or supply shocks). For metro counties, since land supply is more limited, increased housing demand pushes up housing prices and leads to changes in land prices. The elasticity of housing prices on land prices is approximately 1.5 and may go above 2. In non-metro counties where land supply increases quickly, new land supply contributes to the stability of land prices and thereby housing prices. For rural land in a fast-urbanization area, land prices can increase tremendously due to big changes in the value of accessibility in the land.

The results of this study shed light on the fundamentals of the trends, fluctuations, and regional variation in housing prices. Because the link between housing prices and land prices depends on their contexts, policy makers should pay more attention to local characteristics rather than copying from other localities. For local economy, changes in land prices and housing prices are very significant factors influencing the impact of pro-development policies. Property tax design is another area for which policy makers need to take these results into consideration.

While the ratio of property tax in total local revenue exerts varying impacts on housing prices and land prices over different periods in our sample, the ratio signifies different amounts/types of capitalization of public services on housing and land. Infrastructure investment has much greater impacts on land prices than on housing prices, and the impacts are larger in rural areas than in urban areas.

The usual caveats apply. This paper is a first step in proposing our framework. More detailed examinations are needed to explore multiple aspects that this paper has not yet done. We also look forward to other empirical research to justify or falsify the theoretical hypotheses we have formulated in this paper.

References

Ahlfeldt, Gabriel M., & McMillen, Daniel P. (2014). Land Values in Chicago, 1913–2010: A City's Spatial History Revealed. *Land Lines, Lincoln Institute of Land Policy, 26*(2), 15-21.

Alonso, William. (1964). *Location and land use: Toward a general theory of land rent.*: Harvard University Press.

Bailey, Martin J., Muth, Richard F., & Nourse, Hugh O. (1963). A Regression Method for Real Estate Price Index Construction. *Journal of the American Statistical Association, 58*(304), 933-942. doi: 10.2307/2283324

Capozza, Dennis R, & Helsley, Robert W. (1989). The fundamentals of land prices and urban growth. *Journal of Urban Economics, 26*(3), 295-306.

Case, Bradford, & Quigley, John M. (1991). The dynamics of real estate prices. *The Review of Economics and Statistics*, 50-58.

Case, Karl E, & Shiller, Robert J. (1987). Prices of single family homes since 1970: New indexes for four cities: National Bureau of Economic Research Cambridge, Mass., USA.

Case, Karl E, & Shiller, Robert J. (1989). The efficiency of the market for single-family homes: National Bureau of Economic Research Cambridge, Mass., USA.

Chicoine, David L. (1981). Farmland values at the urban fringe: an analysis of sale prices. *Land Economics, 57*(3), 353-362.

Colwell, Peter F, & Munneke, Henry J. (1997). The structure of urban land prices. *Journal of Urban Economics, 41*(3), 321-336.

Davis, Morris A, & Heathcote, Jonathan. (2007). The price and quantity of residential land in the United States. *Journal of Monetary Economics, 54*(8), 2595-2620.

Davis, Morris A, & Palumbo, Michael G. (2008). The price of residential land in large US cities. *Journal of Urban Economics, 63*(1), 352-384.

Deng, Yongheng, Gyourko, Joseph, & Wu, Jing. (2012). Land and House Price Measurement in China (Vol. 18403): National Bureau of Economic Research.

Diamond, Douglas B. (1980). The relationship between amenities and urban land prices. *Land Economics, 56*(1), 21-32.

DiPasquale, Denise, & Wheaton, William C. (1994). Housing market dynamics and the future of housing prices. *Journal of Urban Economics, 35*(1), 1-27.

Du, Hongyan, Ma, Yongkai, & An, Yunbi. (2011). The impact of land policy on the relation between housing and land prices: Evidence from China. *The Quarterly Review of Economics and Finance, 51*(1), 19-27.

Eng, Ong Seow. (1994). Structural and vector autoregressive approaches to modelling real estate and property stock prices in Singapore. *Journal of Property Finance, 5*(4), 4-18.

Engle, Robert F, & Granger, Clive WJ. (1987). Co-integration and error correction: representation, estimation, and testing. *Econometrica: Journal of the Econometric Society*, 251-276.

Engle, Robert F, Lilien, David M, & Watson, Mark. (1985). A dymimic model of housing price determination. *Journal of Econometrics, 28*(3), 307-326.

Evans, Alan W. (1983). The determination of the price of land. *Urban Studies, 20*(2), 119-129.

Evans, Alan W. (1987). *House prices and land prices in the South East: a review*: House-Builders' Federation (HBF).

Evans, Alan W. (2004). *Economics, real estate and the supply of land*: Blackwell Publishing.

Ferreira, Fernando, & Gyourko, Joseph. (2011). Anatomy of the beginning of the housing boom: US neighborhoods and metropolitan areas, 1993-2009: National Bureau of Economic Research.

Fung, Hung-Gay, & Isberg, Steven C. (1992). The international transmission of Eurodollar and US interest rates: a cointegration analysis. *Journal of Banking & Finance, 16*(4), 757-769.

Glaeser, Edward L., Gyourko, Joseph, & Saks, Raven E. (2005). Why Have Housing Prices Gone Up? *American Economic Review, 95*(2), 329-333. doi: 10.1257/000282805774669961

Granger, Clive WJ. (1969). Investigating causal relations by econometric models and cross-spectral methods. *Econometrica: Journal of the Econometric Society*, 424-438.

Green, Richard K, Malpezzi, Stephen, & Mayo, Stephen K. (2005). Metropolitan-specific estimates of the price elasticity of supply of housing, and their sources. *American Economic Review*, 334-339.

Hamilton, James Douglas. (1994). *Time series analysis*. Princeton, New Jersey: Princeton university press

Harding, John P, Rosenthal, Stuart S, & Sirmans, CF. (2007). Depreciation of housing capital, maintenance, and house price inflation: Estimates from a repeat sales model. *Journal of Urban Economics, 61*(2), 193-217.

Huang, Zhong-Hua, & Du, Xue-Jun. (2010). Land price and housing price, who decides whom: Based on panel data Granger causality analysis. *Applied Economics*, 1665-1670. doi: 10.1109/ICMSE.2010.5720006

Hui, Eddie Chi-man. (2004). An empirical study of the effects of land supply and lease conditions on the housing market: A case of Hong Kong. *Property Management*, *22*(2), 127-154.

Hushak, Leroy J, & Sadr, Kazem. (1979). A spatial model of land market behavior. *American Journal of Agricultural Economics*, *61*(4), 697-702.

Johansen, Søren. (1988). Statistical analysis of cointegration vectors. *Journal of economic dynamics and control*, *12*(2), 231-254.

Malpezzi, Stephen. (1999). A simple error correction model of house prices. *Journal of Housing Economics, 8*(1), 27-62.

Malpezzi, Stephen, & Maclennan, Duncan. (2001). The long-run price elasticity of supply of new residential construction in the United States and the United Kingdom. *Journal of Housing Economics*, *10*(3), 278-306.

Mankiw, N Gregory, & Weil, David N. (1989). The baby boom, the baby bust, and the housing market. *Regional Science and Urban Economics, 19*(2), 235-258.

Manning, Christopher A. (1988). The determinants of intercity home building site price differences. *Land Economics, 64*(1), 1-14.

Muth, Richard F. (1971). The derived demand for urban residential land. *Urban Studies*, *8*(3), 243-254.

Muth, Richard F. (1972). *The demand for non-farm housing*: MacMillan, New York.

Neutze, Max. (1987). The supply of land for a particular use. *Urban Studies, 24*(5), 379-388.

Oikarinen, Elias. (2014). Is Urban Land Price Adjustment More Sluggish than Housing Price Adjustment? Empirical Evidence. *Urban Studies, 51*(8), 1686-1706. doi: 10.1177/0042098013497409

Ooi, Joseph TL, & Lee, Sze-Teck. (2004). Price Discovery between residential land & housing markets. *Journal of Housing Research, 15*(2), 95-112.

Peng, Ruijue, & Wheaton, William C. (1993). Effects of restrictive land supply on housing in Hong Kong: an econometric analysis. *Journal of Housing Research, 5*(2), 263-291.

Potepan, Michael J. (1996). Explaining Intermetropolitan Variation in Housing Prices, Rents and Land Prices. *Real Estate Economics, 24*(2), 219-245. doi: 10.1111/1540-6229.00688

Poterba, James M. (1991). House price dynamics: the role of tax policy and demography. *Brookings Papers on Economic Activity*(2), 143.

Rose, Louis A. (1989). Urban land supply: Natural and contrived restrictions. *Journal of Urban Economics, 25*(3), 325-345. doi: 10.1016/0094-1190(89)90054-5

Rosenthal, Stuart S. (2014). Are private markets and filtering a viable source of low-income housing? Estimates from a “repeat income” model. *The American Economic Review, 104*(2), 687-706.

Shonkwiler, J Scott, & Reynolds, John E. (1986). A note on the use of hedonic price models in the analysis of land prices at the urban fringe. *Land Economics*, *62*(1), 58-63.

Titman, Sheridan. (1985). Urban land prices under uncertainty. *The American Economic Review*, 505-514.

Wen, Haizhen, & Goodman, Allen C. (2013). Relationship between urban land price and housing price: Evidence from 21 provincial capitals in China. *Habitat International, 40*, 9-17. doi: 10.1016/j.habitatint.2013.01.004

Witte, Ann Dryden. (1975). The determination of interurban residential site price differences: a derived demand model with empirical testing. *Journal of Regional Science*, *15*(3), 351-364.

Wu, Lei, & Zheng, Xiaoping. (2011). Determination of urban land and housing prices in China a simultaneous equations approach. *The Ritumeikan economic review: the bi-monthly journal of Ritumeikan University*, *60*(4), 552-567.