Land-use conversion and residential recentralization: Evidence from Japan's real estate bubble in the 1980s

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Abstract

Central cities in metropolitan areas are attractive to both residents and businesses, but there is insufficient space to accommodate both. As a result, residential and commercial properties compete for land. By examining the long-term impact of a real estate bubble on the land-use pattern of Tokyo and Osaka from 1980 to 2017, we find that fluctuations in land prices have influenced demand for commercial land relative to residential land, which in turn has affected residential choices. During the period of rising land prices, land developers favored commercial development over residential purposes, which increased the daytime population in central cities and at the same time reduced the residential population. However, during the economic downturn, with the reduction in demand for commercial space, houses were favored by land developers and there was a recentralization of residents. The causal estimates show that the mechanism we propose can explain approximately 40 percent of the population growth in central Tokyo and Osaka after 1995. In addition, these land-use conversions led to changes in the housing structure in terms of building height and house size. Our evidence provides a new explanation for the recent changes in central neighborhoods observed in many advanced economies.

Keywords: residential choices; land-use conversion; gentrification; real estate bubble

JEL codes: R23; R31; H44

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1 Introduction

The share of the central city population in the major metropolitan areas (MAs) of the United States fell significantly in the second half of the 20th century. This situation has been attributed to factors including the increases in car use and highway construction (LeRoy and Sonstelie, 1983; Baum-Snow, 2007, 2019; Garcia-López, 2010), depreciation and filtering down in housing capital (Glaeser and Gyourko, 2005; Rosenthal, 2008; Brueckner and Rosenthal, 2009), racial residential segregation (Boustan and Margo, 2013), and issues in coordinating redevelopment (Rosenthal and Ross, 2015; Brooks and Lutz, 2016; Owens et al., 2019). After 2000, however, the residential distribution reversed in most densely populated urban areas. The proportion of the population as well as the relative income and proportion of college graduates began to grow again in the central neighborhoods of US MAs and European cities including London and Barcelona.

The recent residential recentralization is argued to be associated with a new neighborhood housing cycle and neighborhood externalities (Brueckner and Rosenthal, 2009; Guerrieri et al., 2013), an increasing desire to save commuting time and enjoy the non-tradable amenities in central areas (McKinnish et al., 2010; Lee and Lin, 2018; Su, 2019; Couture and Handbury, 2020), changing labor market opportunities across locations (Baum-Snow and Hartley, 2020), and policies on urban renewal and environmental justice (Gamper-Rabindran and Timmins, 2011; González-Pampillón et al., 2020).[1]

Our study adds to the abovementioned literature by providing a new explanation for residential decentralization (and recentralization) in an MA. By exploiting a real estate bubble that occurred in the major MAs of Japan as a source of variation, we present the first evidence of a mechanism where price fluctuations in the real estate market act as a determinant of residential choices within an MA through land-use conversions. This real estate bubble, beginning from the early 1980s and collapsing in the early 1990s, was among the most aggressive in the history of Japan's urban development. Violent property price fluctuations mainly occurred in a relatively short period (one decade), thereby ensuring that the demographic pattern and infrastructure construction that may affect intra-MA population dynamics remained practically unchanged. This feature allows us to clearly identify the causal relationship between land price fluctuations and residential location dynamics.

The key idea behind our study is that central cities are likely to be dominated by commercial properties when the economy is in an upswing. However, during the economic downturn, land development shifts from commercial toward residential construction. There are two theory-based reasons for this change. First, housing rents in central cities are more inelastic than office and commercial rents; that is, the price elasticity of demand for residential land is greater than that for commercial land. Second, the land price elasticity of residential building height is smaller than that of commercial buildings because the former has a smaller elasticity of substitution between land and capital. In other words, in central cities in which land prices are rising, developers tend

[1] In addition, Boustan et al. (2019) investigated whether the massive investment in high-rise condominium towers has contributed to urban gentrification. They found that condominium development has no causal impact on residents' income, although they are positively correlated.

to increase the height of buildings to make full use of the value of the sky. Commercial buildings are thus preferred over residential buildings and housing supply in central cities compresses. This intensifies the commercial/residential segregation. On the contrary, during an economic downturn, the supply of land for housing development increases relatively, thereby encouraging residential recentralization.[2]

We examine whether changes in land development strategies have affected housing supply and, in turn, residential choices by comparing the central city housing starts and population growth performance with that in surrounding areas before, during, and after the bubble period. The non-central surrounding areas are taken as the comparison group because their land price changes during the bubble period were much less significant. Therefore, land-use choices were less responsive to the bubble. Our analyses are based on 285 urban municipalities in the Tokyo and Osaka MAs (the two largest MAs of the country, covering nearly half the national population) in 1980–2017. The city of Tokyo (Osaka) is the central city of the Tokyo (Osaka) MA.

Before the empirical analysis, we first illustrate our ideas with prominent stylized facts. We find that during the bubble economy (after the bubble burst), the price of commercial land in central cities did rise (fall) much faster than the price of residential land. Therefore, housing construction in central cities condensed (expanded). Consistently, the residential population in central cities declined in the price-surging period but grew significantly after the bubble burst. On the contrary, the daytime population, which reflects the density of commercial activities, grew first and then shrank.[3] (Unless otherwise specified, the population in the study refers to the residential population; the residential population and nighttime population are interchangeable.)

Our empirical analyses proceed as follows. First, using a cross-section regression, we demonstrate that municipalities where land use focused more heavily on business during the bubble period (measured by a more significant decline in commercial land prices after the bubble burst and a lower nighttime population relative to the daytime population in 1990–1995) experienced more housing starts and more remarkable population growth in the subsequent decade. This result remains after controlling for initial population density, distance from the city center, past scale of housing starts, and past population growth. This result suggests that the more housing starts and faster population growth in these areas might have been associated with more intensive land-use conversions toward housing development after the bubble burst. Causal estimates indicate that this mechanism can explain 10–20 percent of the post-1995 housing starts and approximately 40 percent of the population growth in the central areas of our sample MAs.

Second, we are concerned about the issue of reverse causality. The upsurge of land-use conversions and housing construction in central cities triggered by the bub-

[2]"Residential recentralization" in our paper is slightly different than the implicit definition of "gentrification." The latter term is defined to represent the transformation of low-price, low-income neighborhoods into areas dominated by high-income households and high-price houses. While it is true that gentrified neighborhoods tend to be close to city centers, the analysis here is better termed "residential recentralization," namely, the conversion of the city center from commercial to more intensive residential land use.

[3]The daytime population is calculated as the nighttime population + the influx of commuters and students from other areas − the outflow of commuters and students to other areas.

ble bursting may affect population growth. At the same time, the opposite is also possible. We find that the past scale of housing starts is positively correlated with current population growth. However, lagged population growth cannot significantly predict the current intensity of housing starts. In addition, under the assumption that population growth has triggered a boom in housing construction, we expect that the price of residential land in cities with faster population growth (higher demand for residential land) should have increased relatively quickly. However, the fact is that land prices in municipalities with faster population growth have fallen more sharply, which further confirms that population growth in central cities is the result of increased housing supply, not the cause.

Third, we examine the robustness of the initial result using a difference-in-differences event-study specification. Our results still hold after controlling for the municipality-specific linear time trends, using an alternative measure of the key variable, controlling for a set of time-varying confounding factors that may be associated with residential choices but not captured by two-way fixed effects, and regressing for a subsample more likely to be involved in residential choices within the central city commuter zone. Finally, advances in transportation technology, changes in employment opportunities, and policies associated with land-use regulation could, in principle, affect residential choices. To rule out these possibilities, we check the related information and find they were largely unchanged during the study period.

We next provide extended results on the changes in the housing structure. High-rise condominiums dominated new housing supply during the post-1995 central city housing boom. Meanwhile, the proportion of commercial buildings in newly built high-rise buildings has declined significantly. Moreover, new housing supply in central cities was increasingly concentrated in large "built-to-sell" dwelling units (average floor area of 70–100 sq.m), while most housing starts in the bubble period were for small "built-to-rent" homes (40–60 sq.m). This transformation is in line with the improved housing affordability and increased central city land supply for residential development after the bubble burst.

Based on these results, we conclude that changes in land prices have affected the conversion of land use between commercial and residential uses, which in turn has affected housing supply and population growth in related areas. This mechanism partially explains the recent residential recentralization in central Tokyo and Osaka.

Our study contributes to several strands of the literature. First, we are the first study to explain the origin of residential recentralization from the perspective of land price fluctuations and endogenous land-use conversion. This supply-side explanation differs from the existing literature, which mainly employs a demand-side perspective (e.g., changes in the locations of employment opportunities and residents' preferences) or posits it as the consequence of an exogenous urban renewal policy. Second, this study is related to the literature on land-use conversion. Previous studies focus on the conversion from farmland to urbanized land (Fu et al., 2019) or brownfield land to residential buildings (Gamper-Rabindran and Timmins, 2013; Carozzi, 2020), which mainly took place in the city periphery rather than in the center because the latter has limited farmland and brownfield land. Our study is the first to document and analyze the spatial consequences of the conversion from commercial to residential land use in city centers. Third, our research contributes to a small but growing stream of the literature that identifies that volatility in real estate markets may have heterogeneous within-city effects (Kwong and Leung, 2000; Kan et al., 2004; Landvoigt et al., 2015; Liu et al., 2016). Liu et al. (2016) is particularly relevant to our study. They assessed the within-city heterogeneity in response to the real estate bubble by focusing on the US housing market (2000–2013), finding that during the bubble period, the relative prices between the small and large home-size segments of the market were stable, but that divergence emerged after the bubble burst (the price index for small houses fell more because of the higher mortgage default rate).[4] Our research differs from theirs by focusing on the heterogeneous within-city effects on residential and commercial land.

The rest of the paper is organized as follows. Section 2 presents background information. Section 3 introduces the hypotheses and data. Sections 4 and 5 detail the empirical results and additional discussion, respectively. Section 6 concludes with policy implications.

2 Background

2.1 Tokyo and Osaka MAs

We focus our analysis on the two largest MAs (Tokyo and Osaka) in Japan because during the economic bubble, land prices in large cities tend to fluctuate more than in small cities and their land use is more sensitive to land price changes. These two MAs include nine of the 47 prefectures in the country (see Figure 1a), accounting for 44.6 percent of the population (as of 2015), although the land area only accounts for 8.9 percent of the total area.[5] The economic agglomeration of the cities of Tokyo and Osaka is even more extensive. They account for only 0.6 percent of the country's land area but accommodate 9.4 percent of the residential population and 11 percent of the daytime population. Therefore, by studying these two MAs, we can systematically examine the changes in residential choices in Japan's densely populated urban areas.[6]

[Figure 1 about here]

The Tokyo and Osaka MAs are both highly polarized, with denser municipalities located closer to the central city (see Figure A1). To measure the inter-MA population dynamics, we further define a hierarchical structure with multiple levels of centrality. Regarding the Tokyo MA, the first level is the entire MA (34 million residents in 2005),

[4] We find no evidence that mortgage default rates increased significantly in Japan after the bubble burst, even for the small home-size segments of the market, which is different than the results of Liu et al. for the United States. The high savings rate of Japanese households is a possible reason.

[5] The Tokyo MA includes four prefectures: Tokyo, Kanagawa, Chiba, and Saitama. Tokyo prefecture comprises the city of Tokyo (which consists of 23 municipality-level wards) and the surrounding municipality-level cities, towns, and villages that are economically integrated with it. The Osaka MA includes five prefectures: Osaka, Kyoto, Hyogo, Nara, and Wakayama. Osaka prefecture comprises the city of Osaka (which consists of 24 wards) and dozens of municipality-level administrative units.

[6] These two MAs cover all 55 high-density (10,000 residents per sq.km or higher in 1990) urban municipalities in Japan (29 in Tokyo and 26 in Osaka).

the second is the city of Tokyo (8.3 million), and the third (fourth) is the eight (three) central municipality-level wards of Tokyo city, with 1.6 (0.3) million residents (see Figure 1b). The eight central wards perform as Tokyo's CBD, among which the density of commercial activities in the three central wards (Chiyoda, Chuo, and Minato) is the highest. The hierarchical structure of the Osaka MA is analogous, with the entire MA (19.3 million residents) as the first level, the city of Osaka (2.5 million) as the second level, and the three central wards (CBD; 200,000 residents) as the third level (Figure 1c). The land area and population size of Osaka City are much smaller than those of Tokyo City. Therefore, its CBD is relatively small, with only three wards.

2.2 Real estate bubble in the 1980s

Japan witnessed a bubble in the real estate market in the 1980s, with main property appreciation occurring in its major MAs. This bubble peaked around 1990 and then burst, resulting in a long period of land price decline. The causes of the bubble boom and burst have been carefully studied in various streams of the literature and have been attributed to external economic shocks (e.g., the 1985 Plaza Accord) and over-relaxed macroeconomic policies (Kanemoto, 1997; Nakamura and Saita, 2007).

Heterogeneous price fluctuations in commercial and residential land. The left panel of Figure 2 shows the land prices by commercial and residential use for Japan's six largest cities in 1980–2017 and the right panel shows the city of Tokyo.[7] In each group of samples, land prices increased dramatically in the 1980s. For instance, the price of commercial land in the city of Tokyo increased seven-fold between 1980 and 1990.

[Figure 2 about here]

The price fluctuations in the commercial and residential land markets have been notably different. Commercial land appreciated much more than residential land during the bubble period, while after the bubble burst, commercial properties suffered greater capital losses. For example, the commercial land price in the city of Tokyo fell to its 1980 level in 1998, whereas residential land maintained a capital return of 44 percent (taking the 1980 price as a benchmark). In other words, after the bubble burst, the decrease in demand and price of commercial space were greater than the decrease in housing (see the red lines of Figure 2), which implies a higher comparative return from residential development.[8]

[7]"*The land price index for the six largest cities*" represents the average land price changes of the six largest cities in Japan, which is publicly released every year and widely used to reflect the price fluctuations of the land market in Japan. The six largest cities are Tokyo, Osaka, Yokohama, Kobe, Kyoto, and Nagoya, of which all except Nagoya are in the Tokyo and Osaka MAs. The land price index by city is not publicly released. Hence, we can only obtain relevant data for Tokyo, which were estimated by Shimizu and Nishimura (2007) using land transaction data.

[8]These facts are in line with the analytical framework of property price fluctuations presented by Kwong and Leung (2000) and Kan et al. (2004), which shows that the price variance of residential property is likely to be lower than that of commercial property.

Changes in housing supply. Figure 3 shows the scale of housing starts in the Tokyo and Osaka MAs. Housing development in the CBDs of Tokyo and Osaka was condensed during the bubble period, as it was partially squeezed out by the commercial development there. As described in Shimizu et al. (2010), office buildings and commercial facilities were intensively constructed in Japan's central urban areas in the late 1980s and small houses and land were intensively bundled for commercial development under a strong expectation of surging office rents. On the contrary, housing rent was basically unchanged because of rent controls. According to Oizumi (1994), in the city of Tokyo, the share of office space in the total floor area of buildings for all uses increased from 11 percent in 1972 to 16 percent in 1990; in its three central wards, this figure increased from 44 to 56 percent.

[Figures 3–5 about here]

However, a housing construction boom emerged in the central cities (particularly, the CBDs) after the sharp decline in land prices.[9] Specifically, the annual housing starts in the three central wards of Tokyo remained stable below 500,000 sq.m during 1980–1993, however, this number soared to 1.7 million in 1994–2002 (Figure 3). During the bubble period, the three (eight) central wards of Tokyo accounted for less than 5 (20) percent of the total housing starts in the city, but this proportion jumped to approximately 19 (34) percent in the early 2000s (left panel of Figure 4). The city of Tokyo's share in the entire MA also rose.[10] The right panel of Figure 4 displays a similar pattern for Osaka. Indeed, the proportion of Tokyo and Osaka's residential buildings in the total floor area of building starts has been rising (i.e., the share of commercial and office buildings has declined), since the collapse of the real estate bubble (Hirayama, 2005; for more details, see in Section 5).

Consistent with the changes in housing supply, the number of house tenures in the cities of Tokyo and Osaka also decreased in the 1980s (Figure 5).[11] Then, after the downturn in property prices, housing transactions in both cities increased.

3 Hypotheses and data

Based on the abovementioned background information, we propose theory-based testable hypotheses on the impacts of land price fluctuations on residential choices to guide our empirical analysis.

During the bubble economy, the density of business activities in Tokyo and Osaka

[9] The MA-level scales of housing starts before and after the bubble burst were comparable; although the scale of housing starts dropped in 1990–1992, it quickly recovered (Figure 3). Figure A2 further compares the scale of housing starts in the Tokyo and Osaka MAs and other regions of Japan from 1980 to 2003, showing that their changes are essentially similar.

[10] Davidoff (2010) studied similar issues by focusing on Manhattan. He found that Manhattan's share of US residential construction has declined, which has been affected by changes in preferences and regulations.

[11] In addition to supply-side factors, rising housing prices also lowered housing affordability and depressed demand.

increased due to the influx of capital and jobs. This led to increasingly concentrated business activities in the CBD, which can be explained by two mechanisms: the well-known agglomeration economies in production, as illustrated in the classic urban economics literature such as Fujita and Ogawa (1982) and Lucas and Rossi-Hansberg (2002)[12], and a supply-side factor recently introduced by Ahlfeldt and McMillen (2018), who found that the land price elasticity of building height is smaller for residential than for commercial buildings because the elasticity of substitution between land and capital is smaller.[13] In the context of rising land prices, it is more desirable to develop commercial buildings in central cities than residential buildings, so residential space is squeezed out. We can therefore predict that *during the real estate bubble, residential development in central cities was compressed, causing a reduction in the nighttime population and residential decentralization*.

However, the situation reversed after the bursting of the real estate bubble. The reduction in demand for commercial land in central cities highlights the advantages of residential development because the overall residential demand is relatively stable. We therefore predict that *with the decline in land prices and decrease in demand for commercial space, land developers shift their focus from commercial to residential use, leading to an increase in the supply of housing in central cities and the recentralization of residents*.

The aforementioned facts about the heterogeneous fluctuations in land prices and changes in housing supply (Figures 2–5) justify these two mechanisms to a certain extent. Moreover, the changes in office and housing rents also coincide with the hypotheses. In central cities, the unit rent of office space is usually higher than the rent of houses when other conditions (e.g., location) are the same. Based on a privately collected database covering more than 10,000 rental contracts in the city of Tokyo from 1991 to 2004, Shimizu et al. (2010) found that only in a few peripheral areas were office rents in 1991 lower than the corresponding housing rents on average. However, with the bursting of the bubble economy, more office space rents fell below those of the corresponding housing rents. This type of price inversion even appeared in the CBD of Tokyo. This fact implies that after the bubble burst, the relative return on capital for central city housing development rose.

Although Japan's planning system prevents housing land from being used for other purposes to some extent, no regulations prohibit the conversion of commercial land into housing.[14] Therefore, land-use conversion is legally feasible in central cities, as

[12]In addition, retail firms can benefit from shopping externalities, thereby making shops cluster in shopping streets (Koster et al., 2019).

[13]Since unit construction costs increase with building height, there exists a correspondence between land price and building height. In response to rising land prices, land developers will make buildings taller. Using historical building height and land price data on Chicago, Ahlfeldt and McMillen (2018) found that it is more difficult to compensate residents than office users for the limited access to private and communal exterior space, thereby making high-rise buildings more preferable for office use than for residents. In addition, the building height elasticity of the construction cost is larger for residential buildings (the cost of height is higher for residential than for commercial buildings because of notable differences in the design of buildings). Moreover, Koster et al. (2013) suggested that office rents are higher for high-rise buildings because of within-building agglomeration economies as well as landmark and view effects.

[14]In some cases, changes in land-use nature from residential to commercial are permitted. In addition, during the bubble period, some residential buildings were informally used for commercial and office

shown by Shimizu et al. (2010). They found that because of the collapse of the bubble economy, the vacancy rate of office buildings in Tokyo soared; the recession prompted landlords to switch from commercial land to residential development. Moreover, as stated by Hideo (2014), after the bubble burst, many companies affected by the debt crisis had to sell their land assets that were previously used as parking lots or offices, which were mainly converted into high-rise condominiums.

To test the hypotheses, we examine the effects of land price changes on the scale of housing starts and population growth in central cities. Although examining the number of land-use conversions is a direct way to test our hypotheses, commercial land can be freely used for residential purposes without officially changing the land-use nature, which makes relevant data downward biased. As an alternative to the number of land-use conversions, we focus on the scale of housing starts.[15]

Although aggregate data on the population, land prices, and housing construction are all available from 1980 to 2017, spatially disaggregated data (municipality-level) are subject to some restrictions.[16] The data on housing starts (in sq.m) per capita cover 1980 to 2003; the population data are from 1980 to 2015, but we focus on the main analyses in the 1980–2003 period. The exclusion of data after 2003 is because Japan underwent a nationwide municipality consolidation in the 2000s, which was mainly implemented in 2004–2006. The economic and demographic data of affected municipalities before and after the mergers are therefore incomparable. Since land prices fluctuated sharply in 1985–1995, we do not expect the missing data after 2003 to affect the interpretation of our results. Further, the mergers did not affect Tokyo and Osaka prefectures; hence, as a robustness test, we analyze these subsamples using the data after 2003.

Our municipality-level data on annual land price changes are only available from 1993 to 2003. We therefore use the average commercial land price change in 1993, 1994, and 1995 (denoted by $ComLandPriceChg_i^{93-95}$) to reflect the extent of municipality i's land price decline after the bubble burst.[17] As shown in Figure 2, the decline in land prices between 1990 and 1995 was the most alarming. Since then, both commercial and residential land prices have fallen relatively modestly.

4 Econometric specification and evidence

Our main econometric analysis is based on cross-sectional regression, although panel data are available. Fixed-effects (within) regression allows us to address unobservable and time-invariant interference factors; however, all cross-group variation will be soaked up, leaving only the within-group variation. This method is therefore unable

purposes because office rents were higher than housing rents (Shimizu et al., 2010).

[15]New homes dominate the housing market in Japan because existing homes are discriminated against in the mortgage market and homebuyers prefer them less; for more details, see Kobayashi (2016).

[16]Our disaggregated data are obtained from various sources; see Table A1.

[17]Figure A3 shows the distribution of the value of this indicator in these two MAs (nine prefectures) and the rest of Japan (38 prefectures). Obviously, land prices mainly declined in these two MAs, with an average drop of 12.8 percentage points compared with only 3 percentage points in other prefectures. The decline in residential land prices was similar. These two MAs fell by an annual average of 5.7 percentage points, while elsewhere it was 0.2 percentage points.

to deal with the effects of variables with little within-group variation. As mentioned previously, commercial land prices mainly declined in 1990–1995, after which the price fluctuations were relatively limited (1996–2003).[18] Thus, a within estimator may remove most of the variation in our case.

4.1 Bubble bursting and the scale of housing starts

Our first regression models the link between the natural log of municipality i's annualized scale of housing starts per capita in 1996–2003 ($\ln(HS_i^{96-03})$)[19] and its commercial land price change in 1993–1995 ($ComLandPriceChg_i^{93-95}$), which is expressed as a percentage:

$$\ln(HS_i^{96-03}) = \alpha + \beta_1 ComLandPriceChg_i^{93-95} + \varepsilon_i. \quad (1)$$

β_1 is expected to be negative because municipalities that experienced more drastic commercial land price declines in 1993–1995 were likely to have stronger incentives to convert commercial properties into houses afterward.

The estimated result for the Tokyo MA, as presented in column 1 of Table 1, supports our hypotheses. The estimated β_1 is negative (-0.014) and statistically significant. We can interpret the result as follows. A one percentage point decrease in $ComLandPriceChg_i^{93-95}$ (sample mean of -14.2) implies an increase in the annualized scale of housing starts per capita for the next eight years of 1.4 percent. To be specific, if the land price of Tokyo's CBD (the eight central wards) fell by the average level of the MA in 1993–1995 (14.2 percentage points per year), instead of the actual value of 24 percentage points, its housing construction intensity of 1996–2003 would reduce from 1.83 to 1.47 sq.m per capita (a decrease of 19.7 percent).[20]

Second, we address the issue of omitted variables. The extent of the land price decline after the bubble burst may be related to fundamentals, which would affect the scale of housing investment in 1996–2003 through alternative channels (e.g., distance-specific unobservables). We thus control for the distance between a municipality and Tokyo station (the city center). As shown in Figure 6, municipalities closer to the city center experienced a more dramatic drop in commercial land prices after the bubble burst.[21] We also control for the population density in 1995, which can influence the intensity of residential development on the demand side. In addition, we include housing starts per capita in the past decade (1986–1995) to take the pre-trends into

[18] Specifically, during 1993–1995, commercial land prices in Tokyo's three central wards dropped by an average of 30.1 percent per year, but during 1996–2003, they fell by only 6.5 percent per year.

[19] Specifically, $\ln(HS_i^{96-03}) = \ln(1+$ annualized housing starts per capita in sq.m).

[20] During 1996–2003, the number of annual housing starts per capita in the eight central wards was 1.83 sq.m. If the extent of their land price decline during 1993–1995 was reduced from 24 to 14.2 percentage points per year, the counterfactual intensity of housing starts would be $\exp[\ln(1.83+1) - 0.014 \times (24 - 14.2)] - 1 = 1.47$ sq.m. Using similar calculations, this indicator for the city of Tokyo would drop from 1.25 to 1.03 (a decrease of 17.6 percent).

[21] If changes in residential land prices are used to replace changes in commercial land, the results are similar but the fitting line is less steep (Figure 6). The difference in price changes between the two types of land ($ComLandPriceChg_i^{93-95} - ResLandPriceChg_i^{93-95}$) is also positively related to the distance from the city center (with a slope (s.e.) of 0.05 (0.02) for Tokyo), which means that the relative capital loss of commercial land in central urban areas was greater, creating a stronger incentive for land-use conversion.

account. The estimated coefficient shown in column 2 of Table 1 is consistent with the baseline result: β_1 is still negative and statistically significant at the 1 percent level, although the value is reduced by half compared with column 1.

[Table 1 and Figures 6 and 7 about here]

We are also concerned about the measurement issues of $ComLandPriceChg_i^{93-95}$ since we lack information on the land price change in 1990–1992 when the real estate bubble had just burst. Given this limitation, we use an alternative measure (the nighttime population to the daytime population ratio (NDPR) in 1990 and 1995) to check that our results on the association between land price fluctuations and the subsequent scale of housing starts are robust. The lower the NDPR, the more employment-oriented the municipality's functions are, meaning that the past intensity of commercial development will be greater than that of housing development.[22] Such a municipality is therefore more likely to have experienced large land price declines and land-use conversions after the bubble burst. Data on the daytime population are only available for Tokyo and Osaka prefectures and are disclosed every five years. Therefore, we use the two-year average of 1990 and 1995 to calculate the NDPR for 1990–1995. The two measures, namely, $ComLandPriceChg_i^{93-95}$ and $NDPR_i^{90\&95}$, are closely related. As shown in Figure 7, the correlation coefficient across the municipalities of Tokyo prefecture is 0.68. The estimation result using this alternative measure is highly consistent, as shown in column 3 of Table 1. After controlling for the distance from the city center, initial population density, and pre-trends, a lower NDPR is still associated with a higher post-1995 scale of housing starts. As a reference, we present the corresponding results of this Tokyo prefecture subsample, referring to the specification for column 2; the estimated key coefficient is essentially unchanged (column 4).

We then conduct regressions with the data on Osaka, which are highly consistent with the results of Tokyo. The corresponding results are found in columns 5–8 of Table 1, which follow the same presentation order as columns 1–4.[23]

4.2 Bubble bursting and residential choices

We next examine the effects of land price fluctuations on residential population growth. Before we introduce the empirical strategy, Figure 8 displays the population growth of each hierarchy of the Tokyo and Osaka MAs from 1980 to 2017. This graph reveals many striking patterns. Although the two MAs, as a whole, exhibit solid population growth, their central locations declined significantly during the bubble period. The population of central cities then rebounded after the dramatic land price decline in

[22]The nighttime population of municipalities with many labor-intensive factories will also be much smaller than the daytime population. In this case, the lower NDPR is not related to higher commercial density, which can cause measurement problems. However, all our sample municipalities with a low NDPR are located in central urban areas, where there are few factories.

[23]We also report the result of the Osaka MA after excluding the data of Hyogo prefecture (column 1 of Table A2), because Kobe—the capital city of Hyogo—was hit by an earthquake in 1995 (the Hanshin earthquake), which led to its reconstruction in the next decade. The result after considering this confounding factor is essentially unchanged.

1990–1995. The post-1995 population increase in central city areas has been much faster than that in the wider metropolitan region.

[Table 2 and Figures 8 and 9 about here]

Figure 9 (left panel), which displays the daytime population in central cities, further supports our hypotheses. The dynamics of the daytime population were inversely proportional to those of the nighttime population, which grew in central locations during 1980–1990 but decreased after the bubble burst. More central locations exhibited stronger growth during the bubble period. For example, the three central wards of Tokyo (Osaka) reached an extremely high level of daytime population density (63,000 (51,000) people per sq.km) in 1990 but then lost 14 (16) percent of their daytime population in the subsequent two decades. Thus, the NDPR first declined (i.e., land space was increasingly dominated by commercial use) during 1980–1995 and then rebounded after 1995 (Figure 9, right panel), implying that the commercial/residential segregation in central cities first exacerbated and then weakened.

The regression model is similar to Equation (1), except that we replace the LHS variable with the average annual population growth rate, which is expressed as a percentage:

$$\frac{\ln(pop_i^{2003}) - \ln(pop_i^{1995})}{8} \times 100 = \alpha + \beta_2 ComLandPriceChg_i^{93-95} + \varepsilon_i. \qquad (2)$$

Column 1 of Table 2 shows that β_2 is estimated to be -0.047 and statistically significant at the 1 percent level for the Tokyo MA. Hence, a one percentage point decrease in $ComLandPriceChg_i^{93-95}$ implies a 0.05-point increase in the annual population growth rate for the next eight years. To be specific, if the land price of the eight central wards (the city of Tokyo) fell by the average level of the MA (14.2 percentage points) in 1993–1995, the annual population growth rate in 1996–2003 would reduce from 0.99 (0.59) to 0.53 (0.25) percentage points.[24] That is, the heterogeneous land price changes between central and non-central urban areas after the bubble burst can explain more than 40 percent of the subsequent population growth in central areas.

Similar to Table 1, we present the estimation results with additional control variables (distance from the city center, initial population density, and past population growth (1986–1995)) in column 2. The estimated β_2 is basically unchanged in both significance and magnitude. Column 3 takes the NDPR as an alternative explanatory variable and column 4 is an estimate with a subsample for Tokyo prefecture. These results are largely consistent with our hypotheses (the only exception is that the NDPR coefficient in column 3 is not statistically significant (p-value=0.14)). That is, municipalities that experienced greater declines in commercial land prices after the bubble burst have experienced more significant population growth since 1995.

Moreover, we replace the LHS variable with the average annual population growth rate over a longer period (two decades) ($\frac{\ln(pop_i^{2015}) - \ln(pop_i^{1995})}{20} \times 100$) to examine the

[24] We have $0.99 - 0.047 \times (24 - 14.2) = 0.53$ and $0.59 - 0.047 \times (21.5 - 14.2) = 0.25$ for the eight central wards and city of Tokyo, respectively ($ComLandPriceChg_i^{93-95}$ equals -24 (-21.5) for the eight central wards (the city of Tokyo)).

robustness of our findings. Columns 5 and 6 show the related results, which support our hypotheses as well. Columns 7–12 of Table 2 show all the corresponding regression results based on Osaka data, which are highly consistent with those for Tokyo (the only exception is that the coefficient of $ComLandPriceChg_i^{93-95}$ in column 10 is not significant (p-value=0.14)).[25]

4.3 Dealing with reverse causality

We are concerned about the issue of reverse causality. First, the macroeconomic factors that triggered the bursting of the economic bubble were not affected by residential choices in Japan's major cities. Indeed, the economic bubble affected other sectors such as the stock market as well. Therefore, the exogeneity assumption is satisfied in analyzing the impacts of the bubble bursting on residential recentralization. Second, we need to examine the possibility that the housing boom caused by changes in land-use patterns in central cities was simply the result of population growth there. It is also hard to hold this view because the population influx occurred after, not before, the housing construction boom. As shown in Figures 3 and 4, the housing expansion in central cities started to intensify during 1993–1995 (we show the scale of housing starts by housing type in Section 5.2, which clarifies that the housing boom started before 1995). However, population growth in central cities did not turn from negative to positive until 1995 (Figure 8).

To formally examine the causal relationship between housing starts and population growth, we introduce a simplified implementation of Granger causality testing. For a specific year t, we regress the average intensity of housing starts in municipality i in the past four years (from year $t-3$ to year t) on previous population growth $(\ln(pop_i^{t-4}) - \ln(pop_i^{t-8}))$:

$$\frac{1}{4}\sum_{a=t-3}^{t} \ln(HS_i^a) = \alpha + \gamma[\ln(pop_i^{t-4}) - \ln(pop_i^{t-8})] + \varepsilon_i. \quad (3)$$

If reverse causality exists, γ will be significantly positive; however, we find that most of the estimated slopes are not statistically significant or negative (Figure 10; left panel for Tokyo and right panel for Osaka). When $t = 1999$, the intensity of housing starts (mean 1996–1999) was not significantly correlated with population growth in the previous four years ($= \ln(pop_i^{1995}) - \ln(pop_i^{1991})$).[26] By setting t two years forward to 2000 and 2001 or two years backward to 1997 and 1998, the results are similar. There is no systematic positive correlation (only the related fitted lines are displayed in Figure 10 because of space constraints).[27]

[25] The result of the Osaka MA after excluding the data of Hyogo prefecture remain as well, which is reported in column 2 of Table A2.

[26] The regression results using a three-year lag model ($\frac{1}{3}\sum_{a=t-2}^{t}\ln(HS_i^a) = \alpha + \gamma[\ln(pop_i^{t-3}) - \ln(pop_i^{t-6})] + \varepsilon_i$) or a five-year lag model ($\frac{1}{5}\sum_{a=t-4}^{t}\ln(HS_i^a) = \alpha + \gamma[\ln(pop_i^{t-5}) - \ln(pop_i^{t-10})] + \varepsilon_i$) are similar.

[27] When $t = 2001$, we examine the relationship between the intensity of housing starts in 1998–2001 and population growth in the previous four years ($= \ln(pop_i^{1997}) - \ln(pop_i^{1993})$).

[Figures 10–12 about here]

By contrast, by exchanging the LHS and RHS variables of Equation (3), namely, using lagged housing construction intensity to predict recent population growth, we find that the relationship is consistently positive and statistically significant in all the regression exercises (Figure 11; left panel for Tokyo and right panel for Osaka). These results imply that the increasing number of housing starts after the bubble burst drove population growth in the central cities, not the reverse.

Furthermore, we consider the differential price responses between the supply-side and demand-side explanations. In the case that housing supply increased because demand was growing, we expect that residential land prices should have increased as a consequence of the positive demand shock. On the contrary, if the increasing number of housing starts was motivated by supply-side factors, the residential land price is expected to have declined (see a simple illustration in Figure A4). It is therefore straightforward to distinguish between these two mechanisms by checking the relationship between the residential land price change and scale of housing starts. They are expected to be negatively correlated if the latter explanation holds true.

Figure 12 shows the relationship between a municipality's residential land price change (mean 1993–2003; expressed as a percentage) and the natural log of housing starts per capita (mean 1993–2003, denoted by $\ln(HS_i^{93-03})$) across the Tokyo MA municipalities in the left panel and across the Osaka MA municipalities in the right panel. We find a negative correlation (solid lines). That is, the more the housing supply in a municipality increased, the more its residential land price fell. This negative correlation still exists after controlling for the distance between a municipality and the city center (dashed lines).[28] This suggests that the non-positive link between the residential land price change and intensity of housing starts in the study period does not simply reflect differences in time-invariant locational heterogeneity, which is consistent with our supply-side interpretation.

4.4 Event-study evidence

The cross-sectional analysis has a limitation since we cannot control for all the structural differences between municipalities because of our limited control variables. To address this issue, we provide further evidence on the timing of changes in the central city intensity of housing starts and population growth relative to the bubble boom and burst using a difference-in-differences event-study specification and municipality-level data for the Tokyo and Osaka MAs in 1980–2003. The regression model is as follows:

$$\ln(HS_i^t) = \alpha + \sum_{a=1981}^{2003} \rho_a (CBD_i \times time_t^a) + \delta_i + \sigma_t + (\mu_i \times t) + \varepsilon_{i,t}, \tag{4}$$

where CBD_i is a dummy variable taking the value of one for the eight central wards of Tokyo (for the case of Osaka, it refers to the three central wards since its CBD is smaller

[28] We first obtain the housing start residuals from the regression of $\ln(HS_i^{93-03})$ on ln (distance from Tokyo/Osaka station) and then regress the residuals on the residential land price change.

than that of Tokyo) and zero otherwise; $time_t^a$ is a set of individual year dummies (1981–2003), which takes the value of one if $t = a$ and zero otherwise. The intensity of housing starts in 1980 is therefore taken as the benchmark. δ_i and σ_t capture municipality and year fixed effects, respectively. The former controls for all the time-invariant differences between municipalities, while the latter controls for the time-variant changes that similarly affect all municipalities such as the negative income shock due to the bubble bursting. We also consider a municipality-specific linear time trend ($\mu_i \times t$) to capture the timing of deviations from the municipality trends. Standard errors are clustered at the municipality level.

[Figure 13 about here]

Our key coefficients of interest are ρ_a, which capture the treatment effect of the bubble boom and burst on the relative intensity of housing starts of the CBD and non-central area (the remaining municipalities in the Tokyo and Osaka MAs); the latter is taken as the comparison group because its land prices and land-use patterns were relatively stable during the bubble economy. The top panels of Figure 13 display the estimated treatment effects (ρ_a) from Equation (4) and the 95 percent confidence intervals (left panel for Tokyo MA and right panel for Osaka MA). For 1980–1984, when the bubble did not expand dramatically, the estimated treatment effects are not significant, which implies no evidence of significant deviations from the municipality trends before the boom. The estimated coefficients then become significantly negative during the boom. As the bubble burst after 1990, the estimated coefficients gradually turn positive. In sum, we find unsubtle deviations in the intensity of housing starts from the municipality-specific time trends after 1985.

By replacing the LHS variable with municipality i's population in year t ($\ln(pop_i^t)$), we obtain the related results for residential growth, which are shown in the bottom panels of Figure 13. Again, we find no evidence of significant deviations from the trends before the boom. The CBD population declined relative to the comparison group in 1985–1994 and rebounded after 1995. It is thus evident that both the scale of residential development and population growth responded to the bubble boom and burst, as we hypothesized.

To make it easier to interpret the coefficients, we consider more parsimonious model specifications by assuming that the effects of the bubble boom and burst are the same within a five-year period (1980–1984: before the bubble boom; 1985–1989: bubble booming; 1990–1994: bubble bursting; 1995–1999 and 2000–2003: recovery from the crash). In addition, we define the central city area in a more general manner. Considering the Tokyo MA as an example, our augmented regression takes the following form:

$$\begin{aligned} \ln(HS_i^t) = \alpha + \sum_{a=1}^{4} \rho_a (C3_i \times P_t^a) + \sum_{a=1}^{4} \phi_a (C8excl.C3_i \times P_t^a) + \\ \sum_{a=1}^{4} \psi_a (CCexcl.CBD_i \times P_t^a) + \delta_i + \sigma_t + (\mu_i \times t) + \varepsilon_{i,t}, \end{aligned} \tag{5}$$

where C3 is a dummy variable taking the value of one for the three central wards of

Tokyo and zero otherwise, $C8excl.C3$ is a dummy variable equal to one for the remaining five of the eight central wards of Tokyo (excluding the three central wards), and $CCexcl.CBD$ is a dummy variable denoting the remaining 15 wards of the city of Tokyo (excluding its eight central wards) (for Osaka MA, $C3$ refers to the three central wards of Osaka city (the CBD) and $CCexcl.CBD$ denotes its remaining 21 wards; $C8excl.C3$ does not apply in the case of Osaka). The peripheral municipalities outside the city of Tokyo are set as the comparison. P_t^a ($a = 1$ to 4) are period dummy variables for the four periods (1985–1989, 1990–1994, 1995–1999, and 2000–2003; 1980–1984 is set as the benchmark. The other variables are the same as in Equation (4).

[Tables 3 and 4 and Figure 14 about here]

The top panels of Figure 14 show the estimated treatment effects (ρ_a, ϕ_a, and ψ_a) from Equation (5) and the 95 percent confidence intervals, with the full regression results reported in Table 3 (columns 1 and 5 for Tokyo and Osaka, respectively). Taking the Tokyo MA as an example, relative to the base period and comparison group, the per capita scale of housing starts in the three central wards of Tokyo decreased by 24.5 ($= 1 - \exp(-0.281)$) and 45.3 percent ($= 1 - \exp(-0.603)$) during 1985–1989 and 1990–1994, respectively. Thereafter, this indicator began to rebound, which was not significantly different from the base period (relative to the comparison group) after 2000. For the groups of $C8excl.C3$ and $CCexcl.CBD$, the inter-periodic fluctuation of the estimated coefficients is relatively small, but the pattern is similar (i.e., the estimated coefficients first declined and then rebounded). The Osaka results, as shown in the top-right panel of Figure 14, and estimated results of replacing the LHS variable with $\ln(pop_i^t)$, as displayed in the bottom panels (the full regression results are reported in Table 4; columns 1 and 5 for Tokyo and Osaka, respectively), are highly consistent. Specifically, the population in the three central wards of Tokyo ($C3$) decreased by 8 ($= 1 - \exp(-0.083)$) and 16.8 percent ($= 1 - \exp(-0.184)$) in 1985–1989 and 1990–1994, respectively (compared to the control group) and the remaining five CBD wards ($CCexcl.CBD$) decreased by 3.2 and 8.4 percent. However, similar to the scale of housing starts, the gaps have both closed after 2000.

To further explore the robustness of our results, we examine many alternative specifications and samples. First, we use the natural log of the distance from the city center instead of the set of central city dummies ($C3$, $C8excl.C3$, and $CCexcl.CBD$) in Equation (5). The results displayed in columns 2 and 6 of Table 3 for Tokyo and Osaka, respectively remain sound. We find that the scale of residential development in municipalities closer to the city center became smaller during 1985–1994; however, after 2000, this gap closed. Second, we add control variables to mitigate the omitted variable problem. Municipality i's area of parks in year t as well as the number of clinics and gender balance of the residential population are included to measure amenities, the provision of public facilities, and the demographic structure, respectively, which are expected to be associated with residential choices.[29] Columns 3 and 7 of Table 3 report

[29]Data on the area of parks are obtained from the Prefectural Statistics supplied by the Prefectural Statistical Bureau. Data on the number of clinics are obtained from the Health Statistics Office, the Ministry of Health, Labour, and Welfare. The gender balance of the residential population is measured

the results for Tokyo and Osaka, respectively, which are consistent with our previous estimates, although the number of observations is lower.

Our results are also robust to the exclusion of remote peripheral municipalities. As shown in Figure A1, remote peripheral municipalities in the Tokyo and Osaka MAs are less populated; they are relatively extraneous regarding residential choices and commuter behavior in central cities. When excluding municipalities 30 km or further from Tokyo (or Osaka) station, the results remain, as presented in columns 4 and 8 of Table 3 for Tokyo and Osaka, respectively.

We finally replace the dependent variable with the natural log of the residential population and the results are highly consistent again. Columns 2–4 and 6–8 of Table 4 provide the corresponding results for Tokyo and Osaka, respectively, which follow the same presentation order as Table 3.

4.5 Other contributing factors

Aside from the mechanisms we have introduced, other factors may account for our findings. We here present several pieces of additional evidence that residential recentralization in central city areas was driven by land-use conversions rather than by these alternative explanations.

First, advances in transportation facilities could play a role in reshaping the urban spatial structure (Baum-Snow, 2007). However, we find that after 1985, there was no substantial development of the inter-regional (high-speed railroads and expressways) or intra-regional (city roads and urban rail transits) transportation infrastructures in Tokyo and Osaka.[30] Second, land-use regulation or zoning may influence the urban spatial structure and housing markets (Davidoff, 2010; Cheshire et al., 2018), which will affect the interpretation of our results. The Obuchi (1998–2000) and Koizumi (2001–2006) Cabinets adopted urban regeneration as a way for large cities to regain their competitiveness and address the recession after the bubble burst (Hirayama, 2017). Thus, policies including the deregulation of urban planning have been implemented since 1998. However, these policies favoring central city regeneration did not make substantial progress until the late 1990s, whereas the housing construction boom in central cities began in the early 1990s. Therefore, the observed central city housing boom was unlikely to be triggered by related planning policies, although they might have pushed it forward to some extent. Third, public housing or other local welfare policies may have influenced residential choices (Fiva, 2009; Tach and Emory, 2017). As discussed by Xu and Zhou (2019), public housing units in the major cities of Japan were largely built before 1980. Since then, the main effort on public housing was to maintain existing buildings. Since the vacancy rate of public housing in Tokyo and Osaka has always been low and the economic composition of tenants has been stable over time

as the absolute value of (female population/population−0.5), which is obtained from the Residential Population Survey conducted by the Local Administration Bureau, Ministry of Internal Affairs and Communications.

[30] In addition, transport revolution, if any, is likely to result in residential decentralization than recentralization. For example, there was a sharp divergence between the nighttime (declined) and daytime populations (increased) in London after the mid-19th century owing to the transport revolution from the invention of steam railways; see Heblich et al. (2020).

(Xu and Zhou, 2019), the maintenance of public housing cannot explain the central city population growth since the 1990s.

[Figure 15 about here]

Finally, changes in the location of employment opportunities can also affect residential choices (Baum-Snow and Hartley, 2020). If employment in central city grows rapidly, this may make living in the CBD more attractive. However, Figure 15 (see also the left panel of Figure 9) shows that the number of jobs in central cities did not increase after the bubble burst.

5 Changes in the housing structure

As an extension, we further examine whether land price fluctuations and residential recentralization have structurally changed the housing supply in central cities, which could inform decision-making on housing and zoning-related policies.

5.1 Residential buildings are taller

Although land in central cities became relatively cheap after the bubble burst, it is still too scarce to be used for low-density housing (e.g., detached house). Therefore, we expect that the new supply in the post-1995 central city housing boom should be mainly high-rise condominiums. In addition, the new construction of high-rise commercial and office buildings is expected to have declined relatively.

Table 5 (panel A) shows the housing supply in the city of Tokyo from 1998 to 2013 (earlier data are not available). It increased by 33 percent, much higher than the population growth of 12 percent over the same period. The situation in Osaka was similar, where housing supply grew rapidly (panel B).[31] Further, condominiums in buildings with six stories or more were the largest source of new housing supply after 1998, among which those in buildings with 15 stories or more grew the most.

[Tables 5–7 about here]

Table 6 further displays the stock and locations of Tokyo prefecture's high-rise buildings (data for other prefectures are not available) in 1980–2010. The number of high-rise buildings grew rapidly, among which buildings with 13 stories or more increased the most. The high-rise buildings newly built during our study period were mainly concentrated in the central city. Moreover, the more central the location, the higher the proportion of residents living in high-rise buildings. For Chuo, Chiyoda, and Minato (the three central wards of Tokyo) in 2015, 64, 50, and 46 percent of households lived in buildings with 11 stories or more, respectively (data sources: the 2015 National Population Census). For the remaining five wards of Tokyo's CBD, this figure is

[31]Since housing construction takes a certain amount of time, the housing stock in 1998 was mainly housing units built before the bubble burst.

marginally lower, ranging between 21 and 47 percent, but still much higher than the average of the entire Tokyo city (16 percent). This ratio is further lower in areas outside Tokyo. The situation in Osaka is similar.

Next, Table 7 reports the number of new high-rise buildings distinguished by commercial and residential use. According to our hypotheses, owing to land-use conversion, commercial (residential) use should have reduced (increased). Table 7 confirms that the proportion of super high-rise buildings (60 meters or higher) used for residential purposes in Tokyo prefecture indeed increased (related data for Osaka prefecture are not available). For the super high-rise buildings built during the bubble period (some were completed between 1990 and 1994 because construction took several years), only about 15 percent were used for residential purposes. However, in the following decades, more new developments focused on residential purposes and the proportion of commercial and office uses fell. The latter coincides with the fact that the daytime population of the central city decreased after the bubble burst, as shown in Figure 9.

Although seemingly fragmented, the discussion above verifies that after the bubble burst, land development in central cities was increasingly focused on high-rise condominiums. Although the data in Tables 5–7 come from various sources and are subject to limited availability (i.e., the definitions of high-rise buildings and geographical scope differ), we do not expect the reliability of the above discussion to be substantially compromised because all the stylized facts are compatible with each other.

5.2 House size is larger

The structure of housing starts in terms of house size changed substantially after the bubble burst. Figure 16 displays the average floor space of housing starts in our sample MAs and central cities. They all declined in the 1980s and then increased after the bursting of the real estate bubble. Figure A5 shows the intensity of housing starts distinguished by "built-to-sell" (mainly condominiums) and "built-to-rent" housing (mainly single-bedroom apartments).[32] Note that the average floor area of "built-to-sell" housing (70–100 sq.m) is significantly larger than that of "built-to-rent" housing (40–60 sq.m), although they are both smaller than owner-occupied houses (110–140 sq.m) (see Figure A6). We find that during the bubble period, the scale of housing starts on "built-to-rent" dwellings peaked, perhaps because of surging housing prices, which lowered the affordability of decent housing. After the bubble burst, land developers began to build larger dwellings in central cities because of improved affordability, leading to the dominance of "built-to-sell" housing since the early 1990s.

[Table 8 and Figures 16 and 17 about here]

Moreover, we find that the more central the location, the more significant the changes in the average dwelling size of housing starts after the bubble economy. By replacing the

[32]Between 1980 and 2017, "build-to-sell" and "build-to-rent" housing accounted for more than 70 percent of the new housing supply in the Tokyo and Osaka MAs. For central cities, this proportion was above 80 percent.

LHS variable of Equation (5) with the ratio of "built-to-sell" dwellings in total housing starts, we find that this ratio first declined in central cities during the bubble period and then increased after the bubble burst (columns 1 and 3 of Table 8 for Tokyo and Osaka, respectively); further, more central areas fluctuated more on this indicator. To avoid the bias from changes in the construction scale of owner-occupied homes, which were less market-driven, we take the proportion of "built-to-sell" dwellings to total "built-to-sell" and "built-to-rent" dwellings (*sell_ratio*) as the dependent variable. The results remain the same (columns 2 and 4). This changing housing development strategy is consistent with the increasing income of residents in central cities accompanied by residential recentralization. For example, the taxable income of the residents in the three central wards of Tokyo was 1.37 times that of the city average during 1990–1995. This figure increased to 1.61 in 2005 and 1.69 in 2015 (data sources: the Residential Population Survey of Japan, various years).[33]

This housing development strategy only changed in our sample MAs. For other prefectures, the changes in *sell_ratio* are relatively limited (the left panel of Figure 17). More specifically, the changes in the housing development strategy were highly correlated with the degree of land price changes. The right panel of Figure 17 shows the change in *sell_ratio* at the prefecture level between 1986–1990 (during the bubble boom) and 1996–2000 (after the bubble burst), which is negatively associated with $ComLandPriceChg_{93-95}$. The *sell_ratio* of the Tokyo and Osaka MAs (prefecture average) in 1996–2000 increased by 30 and 11 percentage points from their levels in 1986–1990, respectively. On the contrary, for those prefectures not significantly affected by the real estate bubble, this indicator remained basically unchanged.[34] This provides further support for our view. That is, if the changes in the housing development strategy in our sample areas were caused by factors such as changes in national building standards, taxation, and residents' preferences, rather than land price fluctuations, other prefectures should have shown similar trends.

6 Concluding remarks

We identify a new supply-side cause of residential recentralization by studying the effects of a real estate bubble and its bursting on intra-MA residential choices in the Tokyo and Osaka MAs. In response to land price fluctuations in central cities, land developers tend to increase (decrease) housing construction and decrease (increase) commercial development when land prices fall (rise). Consequently, housing supply in central cities increases (decreases), thereby encouraging residential recentralization (suburbanization). These endogenous changes in land development strategy influence residential choices and the urban spatial structure.

Since relative demand for these two types of land changes significantly with the economic cycle, rigid and immutable land-use regulations, if any, may exacerbate

[33]These facts are consistent with the changes in income composition found in existing studies of gentrification. However, it is worth emphasizing that the scope of the current analysis does not formally include changes in residents' income across locations due to limited data availability.

[34]If changes in residential land prices are used to replace changes in commercial land prices, the negative correlation still exists (dashed line in the right panel of Figure 17).

land market frictions to some extent, resulting in a decline in efficiency. To make more informed policy and investment decisions, publicizing longitudinal data on the vacancy rates (or rents) of residential and commercial properties and the population (both daytime and nighttime) at the micro level may help local governments, land developers, and property holders identify changes in demand for specific land types. On the one hand, facilitating the timely implementation of land-use conversions when land demand has undergone structural changes can improve efficiency. On the other hand, residential space needs to be offered in balance to ensure that the central city can perpetuate the agglomeration economies in production and grow sustainably. Otherwise, commercial-to-residential conversions may come at the expense of urban productivity. In addition, because of the need to change building standards, switching between the residential and commercial functions of a building is complicated in practice. Therefore, complex residential and commercial buildings that allow for the more flexible conversion of commercial and residential functions without tearing down and rebuilding the structure are worth investment in central cities.

Our findings for Tokyo and Osaka are representative of those in other large MAs globally. For instance, there has been a large increase in the number of offices and shops converted into apartments in London and other British cities since 2015.[35] This boom is partly down to the new "Permitted Development Rights" approved in 2015, which allow developers to proceed without conventional planning permission (Collinson, 2016; McDonald, 2018). Similar land-use conversions have also occurred in New York, San Francisco, and Chicago (Jackson, 2014) as well as in Sydney (Cummins, 2014; Cranston, 2018).[36] In addition to advanced economies, China has also been open to converting vacant commercial buildings and land into residential use after the softening of the land designation rules in 2016, calling for more commercial spaces to be converted into housing in its large cities as a way to ease the oversupply of offices and shopping malls (The State Council of the People's Republic of China, 2016; Cooper, 2019). An immediate application of our research is to assess the impact of the coronavirus outbreak on the hospitality industry. The epidemic caused travel to almost cease in the first half of 2020, and the hotel occupancy rate has declined severely. As a result, many hotels in downtown districts as well as related companies that have been devastated by the epidemic have been permanently closed. The findings of the current research indicate that these spaces may be used for residential purposes in the future. As a result, the epidemic may unintentionally affect the future spatial structures of cities.

[35] The rate of office-to-residential conversions in England went up by nearly 40 percent between 2016 and 2017, which was due to many small businesses being forced to shut down due to the mounting cost of business rates (Zoopla Property Group, 2019).

[36] The returns on residential development make a commercial-to-residential conversion competitive, which took place not only in Class B office buildings across Manhattan's commercial districts, but also in well-known high-rise buildings such as the Sony Building (Putzier, 2014).

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Table 1: Land price changes and the scale of housing starts.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Tokyo MA				Osaka MA			
	ln(housing starts per capita) (mean 1996–2003)				ln(housing starts per capita) (mean 1996–2003)			
Commercial land price change (%)	-0.014	-0.007		-0.014	-0.010	-0.008		-0.008
(mean 1993–1995)	(0.003)	(0.002)		(0.004)	(0.002)	(0.003)		(0.003)
NDPR (mean 1990&1995)			-0.202				-0.468	
			(0.071)				(0.072)	
ln(distance from city center)		-0.102	-0.142	-0.152		-0.023	0.013	-0.097
		(0.032)	(0.026)	(0.028)		(0.023)	(0.026)	(0.037)
ln(population per sq.km 1995)		-0.020	-0.131	-0.184		0.002	-0.013	-0.067
		(0.017)	(0.053)	(0.053)		(0.019)	(0.028)	(0.039)
ln(housing starts p.c.) (mean 1986–1995)		0.341	0.677	0.525		0.354	0.488	0.597
		(0.070)	(0.240)	(0.229)		(0.142)	(0.155)	(0.186)
Obs.	163	163	47	47	122	122	56	56
R-sq	0.294	0.440	0.698	0.729	0.201	0.294	0.712	0.492

Notes: The constant term coefficients are not reported. Robust standard errors are in parentheses.

Table 2: Land price changes and residential population growth.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Tokyo MA						Osaka MA					
	residential population growth rate (%)						residential population growth rate (%)					
	(mean 1996–2003)				(mean 1996–2015)		(mean 1996–2003)				(mean 1996–2015)	
Commercial land price change	-0.047	-0.043		-0.062		-0.037	-0.024	-0.030		-0.024		-0.046
(%) (mean 1993–1995)	(0.008)	(0.009)		(0.018)		(0.014)	(0.010)	(0.011)		(0.016)		(0.018)
NDPR (mean 1990&1995)			-0.765		-0.865				-1.757		-2.615	
			(0.515)		(0.378)				(0.493)		(0.401)	
ln(distance from city center)		-0.285	-0.299	-0.292	-0.460	-0.499		-0.122	-0.010	-0.430	-0.058	-0.673
		(0.107)	(0.206)	(0.201)	(0.153)	(0.164)		(0.095)	(0.169)	(0.134)	(0.136)	(0.158)
ln(population per sq.km 1995)		0.068	-0.172	-0.358	-0.169	-0.401		-0.059	-0.325	-0.662	-0.159	-0.643
		(0.052)	(0.270)	(0.235)	(0.213)	(0.214)		(0.077)	(0.176)	(0.139)	(0.156)	(0.157)
population growth rate (%)		0.340	0.319	0.305	0.177	0.071		0.204	0.295	0.080	0.181	-0.080
(mean 1986–1995)		(0.046)	(0.204)	(0.164)	(0.154)	(0.129)		(0.043)	(0.157)	(0.178)	(0.161)	(0.200)
Obs.	163	163	47	47	47	47	122	122	56	56	55	55
R-sq	0.166	0.453	0.153	0.303	0.587	0.592	0.049	0.175	0.417	0.251	0.656	0.453

Notes: The constant term coefficients are not reported. Robust standard errors are in parentheses. For columns 11–12, the sample size is reduced from 56 to 55 because the city of Sakai in Osaka prefecture merged the surrounding rural areas in 2006, making its data before and after 2006 incomparable.

Table 3: Event-study results for the scale of housing starts.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Tokyo MA				**Osaka MA**			
	ln(housing starts per capita)				ln(housing starts per capita)			
C3 * yr 1985–89	-0.281		-0.321	-0.280	-0.259		-0.222	-0.262
	(0.101)		(0.114)	(0.102)	(0.080)		(0.071)	(0.082)
C3 * yr 1990–94	-0.603		-0.664	-0.558	-0.554		-0.533	-0.551
	(0.089)		(0.101)	(0.092)	(0.184)		(0.179)	(0.187)
C3 * yr 1995–99	-0.207		-0.259	-0.188	-0.240		-0.141	-0.303
	(0.209)		(0.212)	(0.212)	(0.289)		(0.303)	(0.297)
C3 * yr 2000–03	0.149		0.091	0.150	0.063		0.135	-0.008
	(0.325)		(0.317)	(0.329)	(0.327)		(0.366)	(0.334)
(C8-C3) * yr 1985–89	-0.081		-0.075	-0.080				
	(0.052)		(0.058)	(0.054)				
(C8-C3) * yr 1990–94	-0.225		-0.230	-0.179				
	(0.063)		(0.076)	(0.066)				
(C8-C3) * yr 1995–99	-0.043		-0.022	-0.023				
	(0.061)		(0.080)	(0.069)				
(C8-C3) * yr 2000–03	-0.009		0.049	-0.008				
	(0.074)		(0.080)	(0.082)				
(CC-CBD) * yr 1985–89	-0.013		-0.014	-0.012	-0.018		-0.027	-0.022
	(0.026)		(0.027)	(0.028)	(0.032)		(0.039)	(0.036)
(CC-CBD) * yr 1990–94	-0.111		-0.126	-0.065	-0.204		-0.228	-0.201
	(0.035)		(0.035)	(0.040)	(0.049)		(0.075)	(0.055)
(CC-CBD) * yr 1995–99	-0.051		-0.061	-0.032	-0.194		-0.190	-0.257
	(0.044)		(0.050)	(0.054)	(0.068)		(0.100)	(0.088)
(CC-CBD) * yr 2000–03	-0.022		-0.015	-0.021	-0.126		-0.148	-0.197
	(0.052)		(0.059)	(0.063)	(0.080)		(0.119)	(0.096)
ln(dist.) * yr 1985–89		0.035				0.019		
		(0.015)				(0.013)		
ln(dist.) * yr 1990–94		0.125				0.095		
		(0.019)				(0.022)		
ln(dist.) * yr 1995–99		0.044				0.057		
		(0.024)				(0.028)		
ln(dist.) * yr 2000–03		-0.015				0.020		
		(0.034)				(0.031)		
Municipality-specific linear trends	X	X	X	X	X	X	X	X
Two-way FEs	X	X	X	X	X	X	X	X
Controls			X				X	
Subsample (<30km)				X				X
Obs.	3,860	3,860	2,895	1,905	2,930	2,930	2,184	1,620
R-sq	0.448	0.447	0.482	0.473	0.404	0.384	0.411	0.415

Notes: CBD refers to C8 in Tokyo and C3 in Osaka. The constant term coefficients are not reported. Standard errors (clustered at the municipality level) in parentheses.

Table 4: Event-study results for population growth.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Tokyo MA				**Osaka MA**			
	ln(residential population)				ln(residential population)			
C3 * yr 1985–89	-0.083		-0.085	-0.083	-0.029		-0.039	-0.035
	(0.008)		(0.003)	(0.009)	(0.011)		(0.008)	(0.011)
C3 * yr 1990–94	-0.184		-0.185	-0.177	-0.096		-0.114	-0.094
	(0.012)		(0.005)	(0.012)	(0.010)		(0.015)	(0.011)
C3 * yr 1995–99	-0.144		-0.156	-0.136	-0.091		-0.126	-0.081
	(0.011)		(0.013)	(0.012)	(0.006)		(0.012)	(0.008)
C3 * yr 2000–03	-0.002		-0.015	-0.008	-0.007		-0.051	0.002
	(0.005)		(0.017)	(0.006)	(0.012)		(0.015)	(0.013)
(C8-C3) * yr 1985–89	-0.033		-0.028	-0.032				
	(0.005)		(0.005)	(0.007)				
(C8-C3) * yr 1990–94	-0.088		-0.082	-0.081				
	(0.009)		(0.007)	(0.010)				
(C8-C3) * yr 1995–99	-0.079		-0.075	-0.071				
	(0.008)		(0.009)	(0.008)				
(C8-C3) * yr 2000–03	-0.007		-0.006	-0.013				
	(0.008)		(0.011)	(0.009)				
(CC-CBD) * yr 1985–89	-0.019		-0.017	-0.019	-0.000		-0.001	-0.006
	(0.004)		(0.004)	(0.005)	(0.006)		(0.006)	(0.006)
(CC-CBD) * yr 1990–94	-0.049		-0.048	-0.041	-0.003		-0.001	-0.001
	(0.010)		(0.010)	(0.011)	(0.008)		(0.008)	(0.008)
(CC-CBD) * yr 1995–99	-0.033		-0.033	-0.025	0.002		0.002	0.012
	(0.007)		(0.008)	(0.008)	(0.007)		(0.009)	(0.008)
(CC-CBD) * yr 2000–03	0.014		0.014	0.008	0.023		0.022	0.032
	(0.003)		(0.006)	(0.005)	(0.006)		(0.009)	(0.006)
ln(dist.) * yr 1985–89		0.013				-0.001		
		(0.003)				(0.002)		
ln(dist.) * yr 1990–94		0.037				0.006		
		(0.005)				(0.004)		
ln(dist.) * yr 1995–99		0.031				0.007		
		(0.004)				(0.003)		
ln(dist.) * yr 2000–03		-0.003				-0.002		
		(0.002)				(0.002)		
Municipality-specific linear trends	X	X	X	X	X	X	X	X
Two-way FEs	X	X	X	X	X	X	X	X
Controls			X				X	
Subsample (<30km)				X				X
Obs.	3,860	3,860	2,895	1,905	2,930	2,930	2,184	1,620
R-sq	0.939	0.936	0.946	0.929	0.908	0.903	0.920	0.858

Notes: CBD refers to C8 in Tokyo and C3 in Osaka. The constant term coefficients are not reported. Standard errors (clustered at the municipality level) in parentheses.

Table 5: Housing stock in the cities of Tokyo and Osaka.

			Condominium (# stories)					
Year	Housing stock	Detached house	1–5	6–10	11–14	15+	Tenement house	Others
Panel A: the city of Tokyo								
1998	3,468.8	925.1	1,718		714.6		75	36
2003	3,842.4	996.6	1,747.6	565	368.7	73.3	68.1	23.2
2008	4,177.7	1,012.2	1,807.9	672.7	468	134	61.6	21.2
2013	4,601.6	1,060.7	1,880.9	800.8	556	203.2	75.8	24.1
Δ1998–2013	1,132.8	135.6	162.9		845.4		0.8	-11.9
(%)	(33%)	(15%)	(9%)		(118%)		(1%)	(-33%)
Panel B: the city of Osaka								
1998	1,102.7	233.7	336.9		392.1		132.1	7.9
2003	1,186.9	298.9	314.1	259.6	172.1	49.1	88.4	4.6
2008	1,262.1	303.6	294.3	301.2	201.3	87.5	70.4	3.8
2013	1,343.2	334.1	283.3	331.4	234.4	112.8	43.7	3.4
Δ1998–2013	240.5	100.4	-53.6		286.5		-88.4	-4.5
(%)	(22%)	(43%)	(-16%)		(73%)		(-67%)	(-57%)

Notes: Data on the number of dwelling units (in thousand) classified by building structure are only available at the major city level (data sources: the Housing and Land Survey of Japan, various years). The data in areas denoted gray refer to the total number of condominium units in the buildings of "6–10 stories," "11–14 stories," and "15 stories or more," because separate data are not available. "Condominium" here also includes the small-sized single-bedroom apartments.

Table 6: The locations of high-rise buildings in Tokyo prefecture.

		Number of buildings			Proportion		
		# stories			# stories		
Year	Area	9–12	13–29	30+	9–12	13–29	30+
1980	central 3	2,095	176		40%	26%	
	central 8	3,476	359		66%	53%	
	the city of Tokyo	4,966	666		95%	99%	
	Tokyo prefecture	5,236	672		100%	100%	
1990	central 3	3,793	287	12	36%	23%	38%
	central 8	6,464	599	26	62%	49%	81%
	the city of Tokyo	9,925	1,174	32	94%	96%	100%
	Tokyo prefecture	10,506	1,223	32	100%	100%	100%
2000	central 3	4,854	489	34	31%	19%	39%
	central 8	8,967	1,131	66	57%	45%	75%
	the city of Tokyo	14,578	2,263	86	92%	90%	98%
	Tokyo prefecture	15,811	2,517	88	100%	100%	100%
2010	central 3	6,023	1,090	134	28%	21%	50%
	central 8	11,587	2,451	207	55%	48%	78%
	the city of Tokyo	19,315	4,640	260	91%	91%	97%
	Tokyo prefecture	21,157	5,121	267	100%	100%	100%
(Δ1980-2010)	central 3	187%	595%				
relative to 1980	central 8	233%	640%				
	the city of Tokyo	289%	636%				
	Tokyo prefecture	304%	702%				

Notes: The reported data refer to the number of all high-rise buildings in Tokyo prefecture, including both the residential buildings and buildings for other purposes (data sources: the Tokyo Prefectural Statistical Yearbook, various years). Related data for other prefectures in our sample are not available. The data in areas denoted gray refer to the total number of buildings with "13–29 stories" and "30 stories or more," because separate data are not available.

Table 7: The types of super high-rise buildings in Tokyo prefecture.

Completion time of the building	Number of super high-rise buildings (2015): All purposes	Residential	Residential & commercial complex	Commercial, office, and others	Residential / All purposes
1980–84	45	4	0	41	9%
1985–89	55	10	14	31	18%
1990–94	140	20	34	86	14%
1995–99	118	20	36	62	17%
2000–04	213	75	49	89	35%
2005–09	273	108	68	97	40%
2010–14	174	48	53	73	28%

Notes: The data shown in the table refer to the number of super high-rise buildings (over 60 meters in height) in 2015 (data sources: the Annual Report of Architectural Statistics 2016, which was released by the Tokyo Metropolitan Urban Development Bureau).

Table 8: Examining the changes in housing structure.

	(1)	(2)	(3)	(4)
	Tokyo MA		Osaka MA	
	"built-to-sell" / all housing starts	"built-to-sell" / "built-to-sell&rent"	"built-to-sell" / all housing starts	"built-to-sell" / "built-to-sell&rent"
C3 * yr 1985–89	-0.267	-0.261	-0.231	-0.191
	(0.038)	(0.054)	(0.049)	(0.058)
C3 * yr 1990–94	-0.279	-0.306	-0.158	-0.084
	(0.085)	(0.085)	(0.090)	(0.107)
C3 * yr 1995–99	0.041	-0.033	0.164	0.199
	(0.162)	(0.168)	(0.121)	(0.140)
C3 * yr 2000–03	0.148	0.081	0.218	0.212
	(0.189)	(0.175)	(0.140)	(0.157)
(C8-C3) * yr 1985–89	-0.218	-0.188		
	(0.026)	(0.038)		
(C8-C3) * yr 1990–94	-0.232	-0.208		
	(0.026)	(0.046)		
(C8-C3) * yr 1995–99	-0.140	-0.193		
	(0.055)	(0.098)		
(C8-C3) * yr 2000–03	-0.142	-0.217		
	(0.078)	(0.129)		
(CC-CBD) * yr 1985–89	-0.136	-0.113	-0.106	-0.081
	(0.022)	(0.023)	(0.031)	(0.040)
(CC-CBD) * yr 1990–94	-0.137	-0.111	-0.157	-0.085
	(0.029)	(0.029)	(0.056)	(0.070)
(CC-CBD) * yr 1995–99	-0.038	-0.042	0.003	0.071
	(0.042)	(0.043)	(0.075)	(0.094)
(CC-CBD) * yr 2000–03	-0.015	-0.039	0.083	0.141
	(0.053)	(0.058)	(0.087)	(0.107)
Municipality-specific linear trends	X	X	X	X
Two-way FEs	X	X	X	X
Obs.	3,860	3,860	2,930	2,930
R-sq	0.501	0.540	0.404	0.378

Notes: CBD refers to C8 in Tokyo and C3 in Osaka. Constant term coefficients are not reported. Standard errors (clustered at the municipality level) in parentheses.

Table A1: Summary statistics.

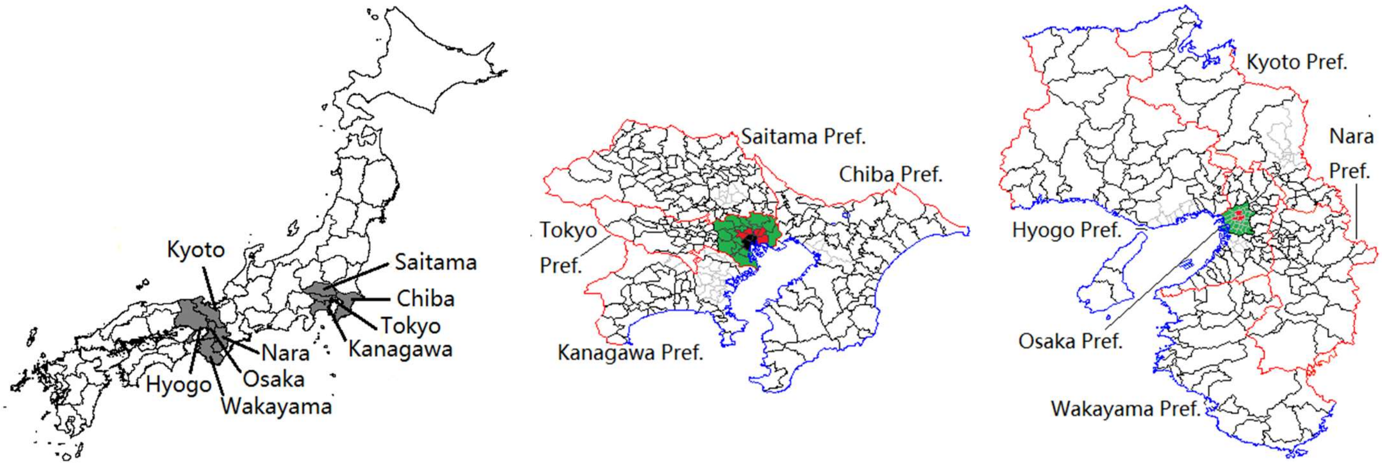
	Tokyo MA					Osaka MA				
Variable	Obs	Mean	Std.Dev.	Min	Max	Obs	Mean	Std.Dev.	Min	Max
Panel A: cross-sectional data										
housing starts (sq.m) p.c. (mean 86–95)	163	1.15	0.28	0.65	3.02	122	0.96	0.32	0.50	3.55
housing starts (sq.m) p.c. (mean 96–03)	163	1.02	0.37	0.57	3.59	122	0.94	0.33	0.51	2.62
population growth rate (%) (mean 86–95)	163	0.75	1.20	-3.11	6.54	122	0.12	1.24	-2.83	8.87
population growth rate (%) (mean 96–03)	163	0.48	0.65	-1.00	3.17	122	0.11	0.71	-1.56	2.40
population growth rate (%) (mean 96–15)	47	0.83	0.62	-0.15	3.37	55	0.24	0.79	-0.90	2.81
com. land price change (%) (mean 93–95)	163	-14.25	5.71	-31.73	-1.80	122	-13.19	7.13	-28.33	3.40
NDPR (mean 90&95)	47	1.00	0.35	0.04	1.52	56	1.01	0.27	0.09	1.37
population per sq.km 95 (in thousand)	163	6.11	4.44	0.22	18.83	122	5.36	4.72	0.12	17.95
distance from the Tokyo/Osaka station (km)	163	33.02	18.57	1.00	99.79	122	33.23	27.81	1.00	113.30
Panel B: panel data (1980–2003)										
population (in thousand)	3,860	176.44	142.27	22.79	799.76	2,930	136.18	118.08	22.93	810.48
housing starts (sq.m) p.c.	3,860	1.07	0.42	0.25	8.71	2,930	0.95	0.48	0.25	6.00
"built-to-sell" (relative to all housing starts)	3,860	0.29	0.17	0	0.90	2,930	0.30	0.18	0	0.89
"built-to-sell" (relative to "built-to-sell&rent")	3,860	0.53	0.22	0	1.00	2,930	0.54	0.24	0	1.00

Notes: NDPR: the nighttime population to the daytime population ratio. "built-to-sell" (relative to all housing starts): the ratio of "built-to-sell" dwellings in total housing starts (in sq.m). "built-to-sell" (relative to "built-to-sell&rent"): the proportion of "built-to-sell" dwellings to total "built-to-sell" and "built-to-rent" dwellings. Data on residential population are obtained from the Residential Population Survey conducted by the Local Administration Bureau, Ministry of Internal Affairs and Communications. Data on daytime population are obtained from the Tokyo Prefectural Statistical Yearbook and the Osaka Prefectural Statistical Yearbook (various years; reported in a five-year frequency). Data on housing starts are obtained from the Annual Report of Architectural Statistics, which is released by the Ministry of Land, Infrastructure, Transport, and Tourism (Department of Information Management, Policy Bureau); data for 2007 are missing. A municipality's distance from the core of the central city (Tokyo station and Osaka station for the Tokyo and Osaka MAs, respectively) is based on the longitude-latitude distance measure.

Table A2: Considering the Hanshin earthquake that occurred in the Osaka MA in 1995.

	(1)	(2)
	Osaka MA (excl. Hyogo prefecture)	
	ln(housing starts per capita) (mean 1996–2003)	residential population growth rate (%) (mean 1996–2003)
Commercial land price change (%)	-0.006	-0.022
(mean 1993–1995)	(0.003)	(0.011)
ln(distance from city center)	-0.047	-0.165
	(0.029)	(0.121)
ln(population per sq.km 1995)	-0.005	-0.047
	(0.025)	(0.101)
ln(housing starts p.c.)	0.448	
(mean 1986–1995)	(0.148)	
population growth rate (%)		0.258
(mean 1986–1995)		(0.094)
Obs.	94	94
R-sq	0.332	0.161

Notes: The constant term coefficients are not reported. Robust standard errors are in parentheses. The data of Hyogo prefecture (damaged by the Hanshin earthquake) are excluded.



(a) The major MAs (b) Tokyo MA (c) Osaka MA

Figure 1: The hierarchical structure of the Tokyo and Osaka MAs.

Notes: (a): The location of the Tokyo and Osaka MAs. (b): The zoomed view of the Tokyo MA. The black area indicates the three central wards of Tokyo city, the area marked red (plus the three central wards) indicates the eight central wards, and the area marked green (plus the eight central wards) indicates the city of Tokyo (622 sq.km). (c): The zoomed map of the Osaka MA. The area marked red indicates the three central wards of Osaka city, and the green area (plus the three central wards) indicates the city of Osaka (223 sq.km). The red, blue, black, and gray lines in (b) and (c) are prefectural boundaries, coastal lines, municipality-level city/town/village boundaries and municipality-level ward boundaries, respectively.

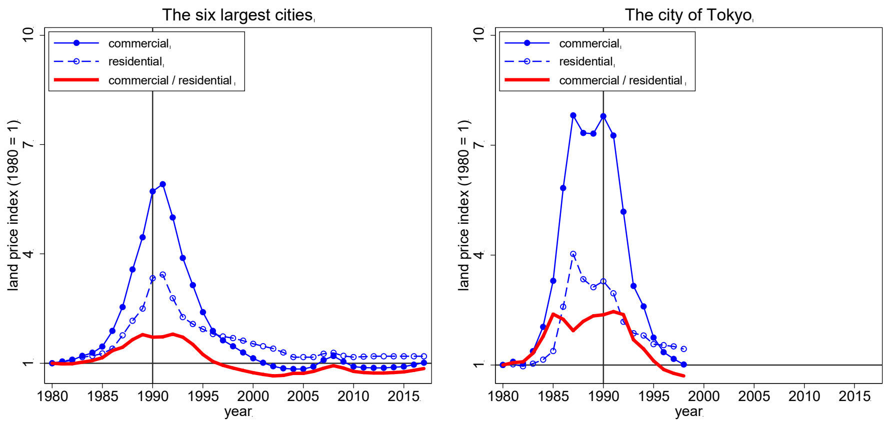


Figure 2: Land price fluctuations in the major cities of Japan.

Notes: Data for the six largest cities are obtained from the Japan Statistics Yearbook (various years). Data for the city of Tokyo are obtained from Shimizu and Nishimura (2007), which are only available in 1980–1998.

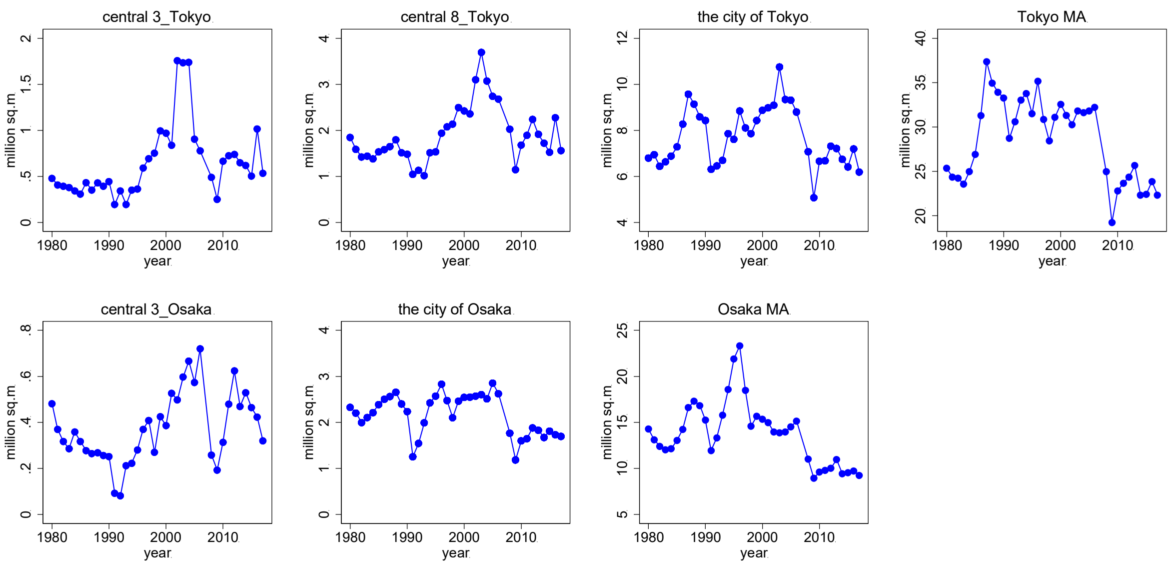


Figure 3: The scale of housing starts.

Notes: See data sources in Table A1 (data for 2007 are missing).

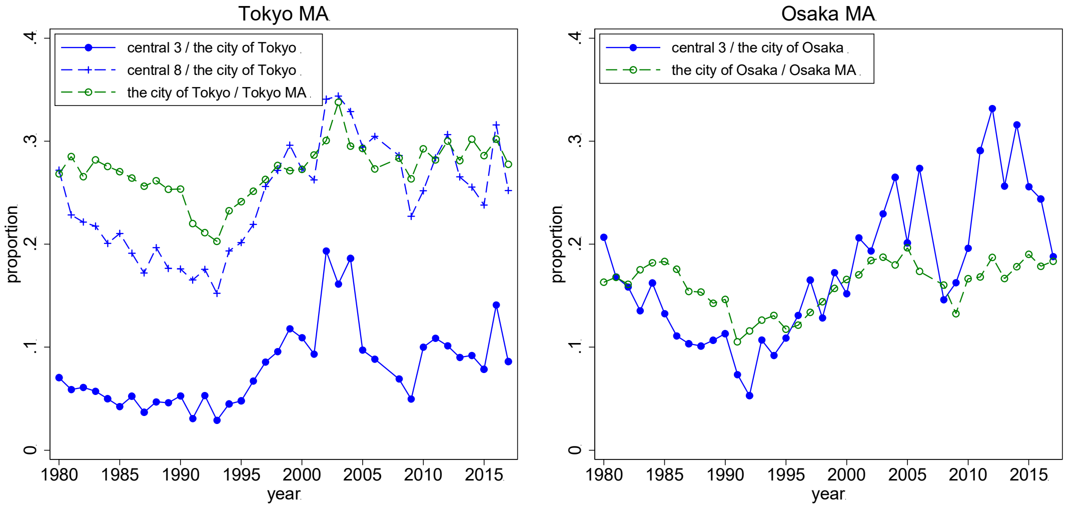


Figure 4: The intensity of housing starts in central urban areas.

Notes: See data sources in Table A1 (data for 2007 are missing).

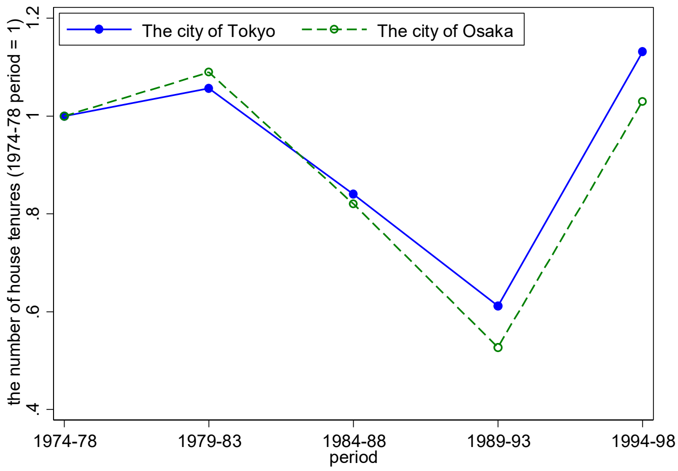


Figure 5: The number of house tenures.

Notes: Data sources: Hirayama (2005); the raw data are reported in the Housing Survey of Japan (1978, 1993) and the Housing and Land Survey of Japan (1998).

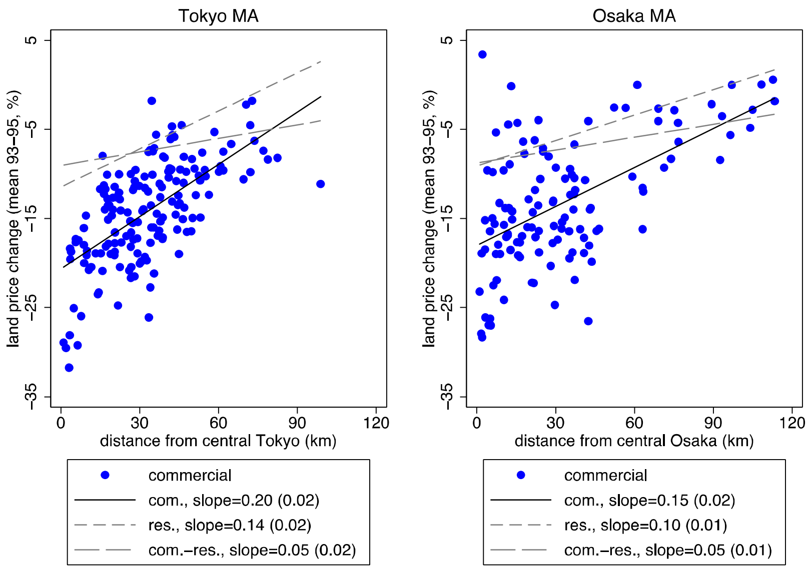


Figure 6: Land price changes against the distance from city center.

Notes: Central Tokyo (Osaka) refers to the Tokyo (Osaka) station for Tokyo (Osaka) MA. "*com.-res.*" denotes a municipality's commercial land price change (mean 1993–1995) minus the related residential land price change (mean 1993–1995). Robust standard errors are reported in parentheses. See data sources in Table A1.

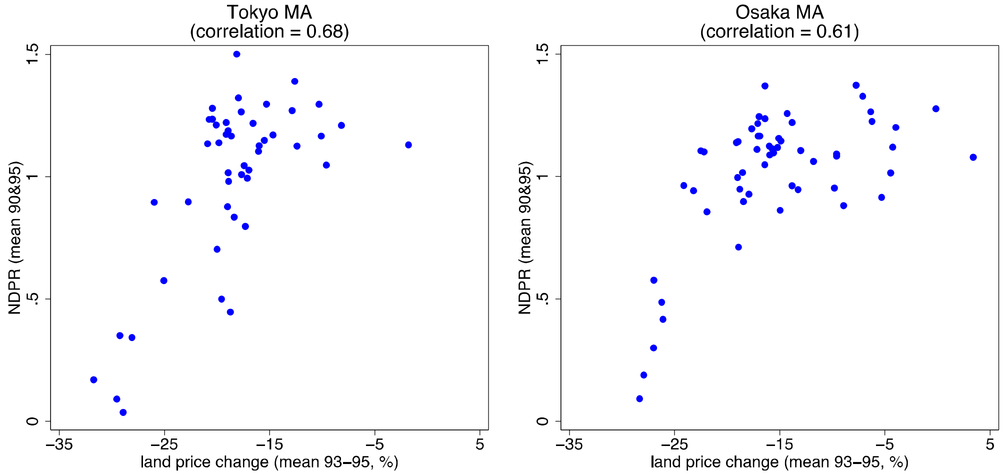


Figure 7: NDPR against the commercial land price changes.

Notes: See data sources in Table A1. Data are only available for the urban municipalities in Tokyo and Osaka prefectures.

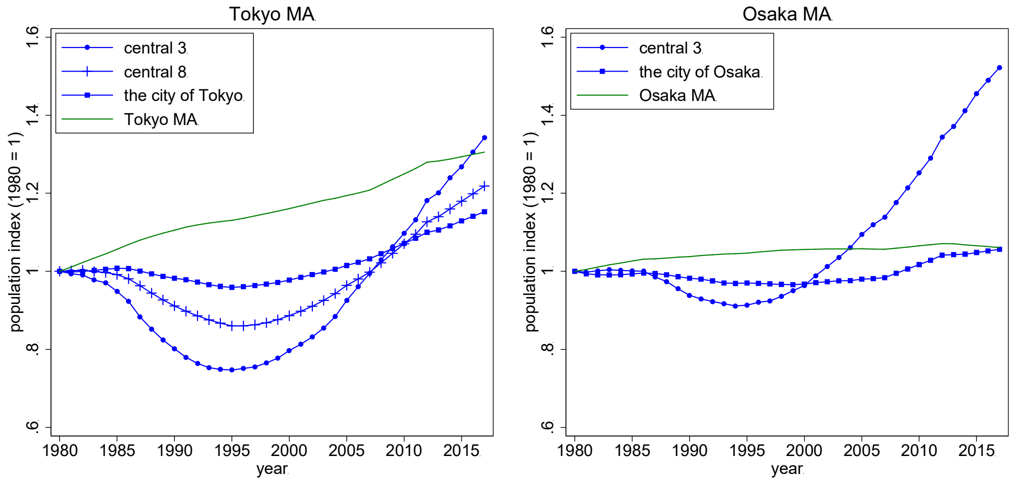


Figure 8: Residential population growth in the Tokyo and Osaka MAs.

Notes: See data sources in Table A1.

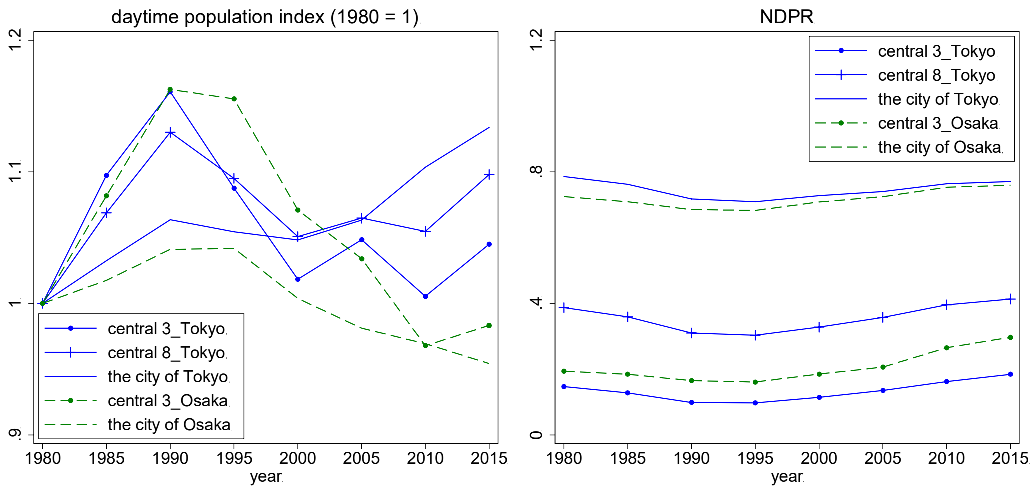


Figure 9: Daytime population growth in the Tokyo and Osaka MAs.

Notes: See data sources in Table A1.

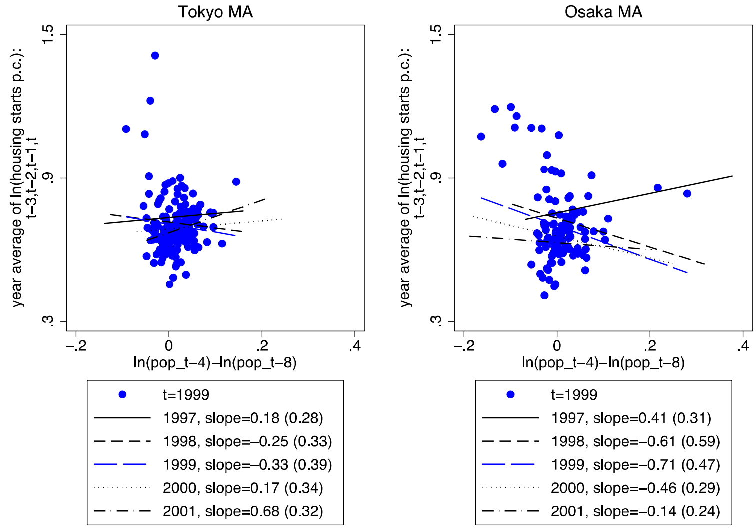


Figure 10: Housing starts against lagged population growth.

Notes: Robust standard errors are reported in parentheses.

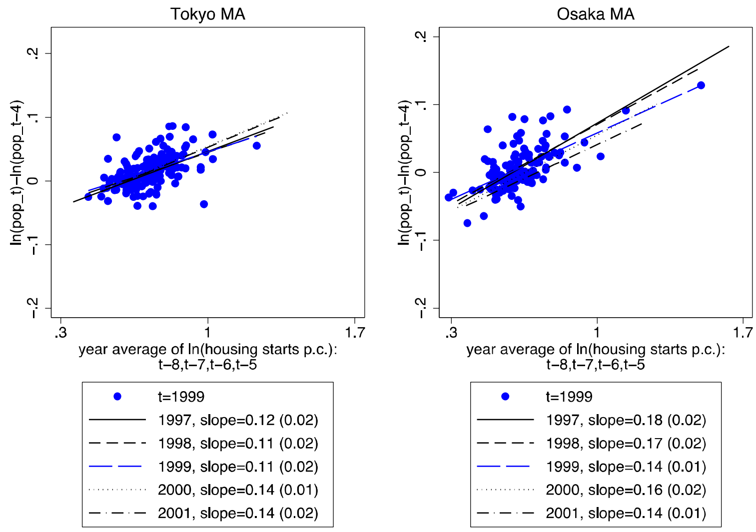


Figure 11: Changes in population size against lagged housing starts.

Notes: Robust standard errors are reported in parentheses.

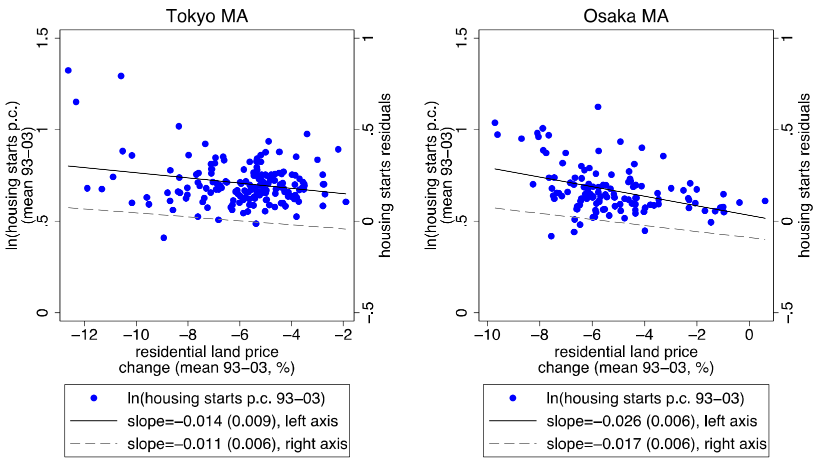


Figure 12: Housing starts against residential land price changes.

Notes: Robust standard errors are reported in parentheses.

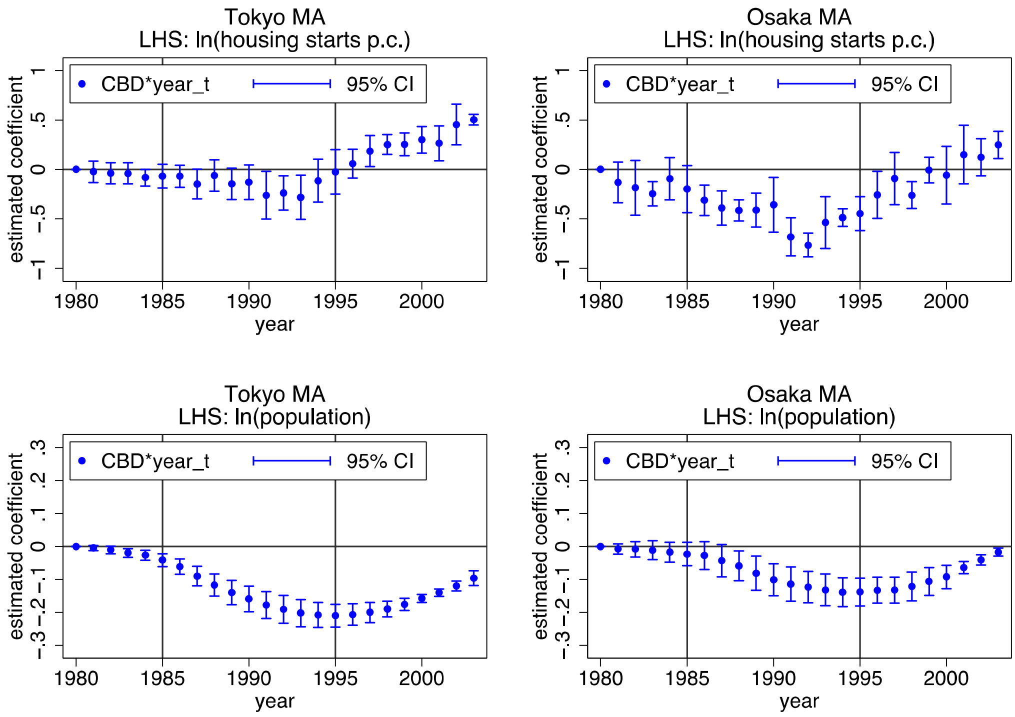


Figure 13: Event-study treatment effects for the real estate bubble boom and burst.

Notes: Sample includes all urban municipalities in the Tokyo and Osaka MAs from 1980–2003; all specifications include municipality fixed effects, year fixed effects and municipality-specific linear time trends. The top-left (top-right) panel shows the effects on the scale of housing starts across all urban municipalities in the Tokyo (Osaka) MA (Equation (4)); the panels at the bottom show the effects on ln(population). The vertical lines in each panel show the estimated 95 percent confidence intervals, based on standard errors clustered on municipalities.

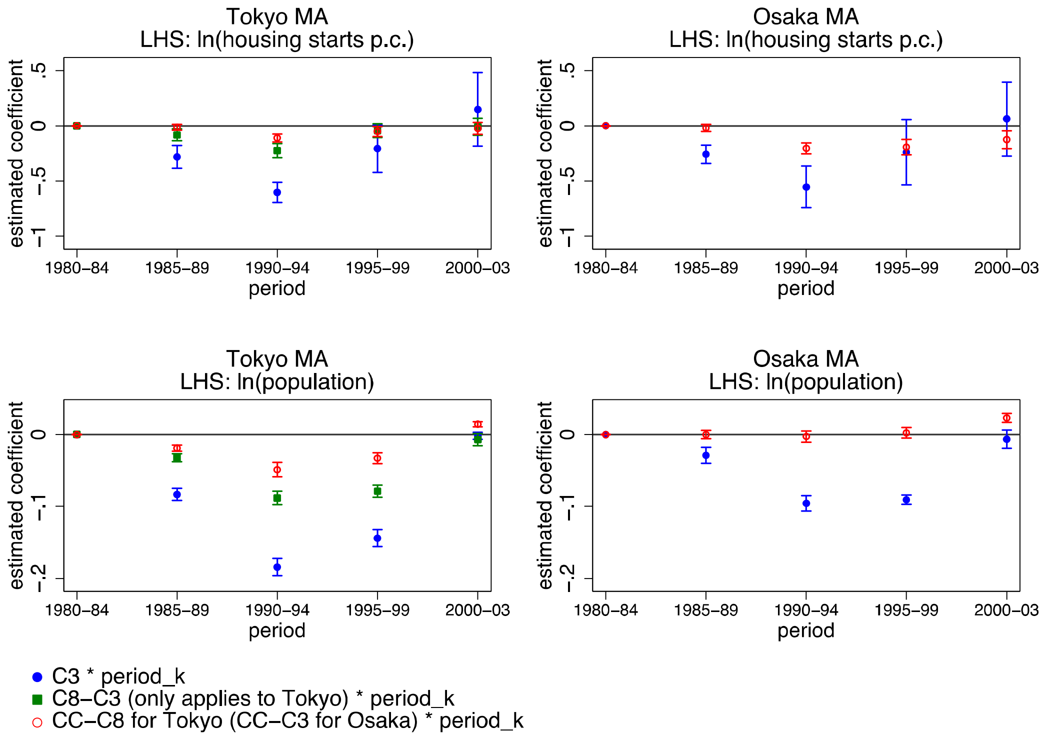


Figure 14: Event-study treatment effects by period.

Notes: Sample includes all urban municipalities in the Tokyo and Osaka MAs from 1980–2003; all specifications include municipality fixed effects, year fixed effects and municipality-specific linear time trends; estimated coefficients and standard errors are reported in Tables 3 and 4. The top-left (top-right) panel shows the effects on the scale of housing starts across all urban municipalities in Tokyo (Osaka) MA (Equation (5)); the panels at the bottom show the effects on ln(population). The vertical lines in each panel show the estimated 95 percent confidence intervals, based on standard errors clustered on municipalities.

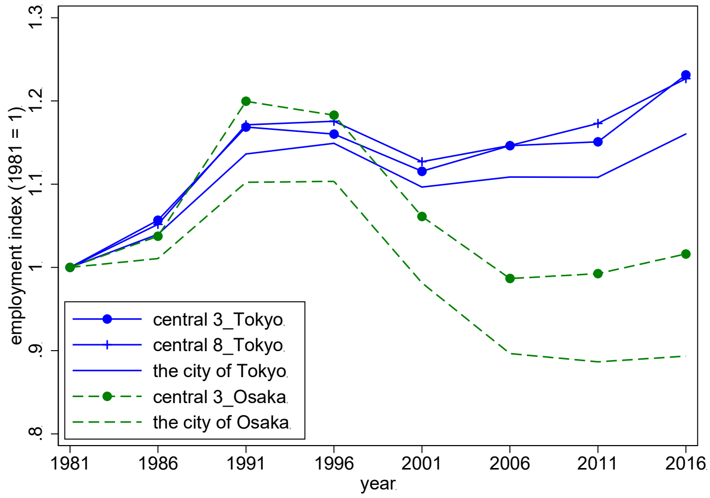


Figure 15: Employment growth.

Notes: Data are reported in a five-year frequency (1981–2016; data sources: the National Population Census of Japan conducted by the Statistics Bureau, Ministry of Internal Affairs and Communications).

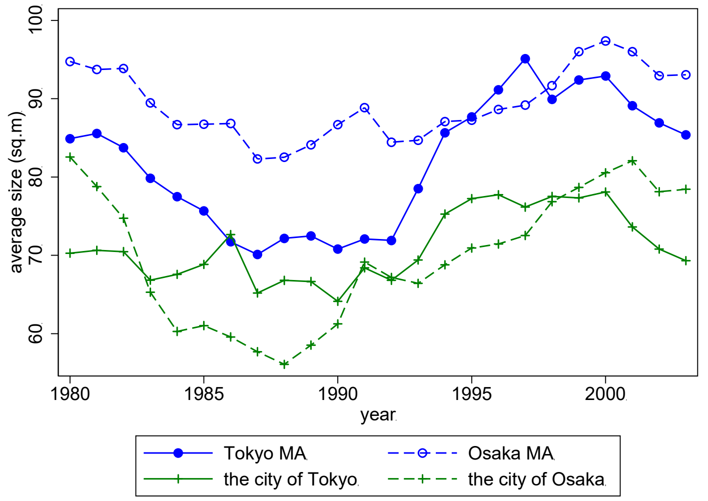


Figure 16: The average house size in the new housing supply.

Notes: The reported data refer to the municipality mean by year. See data sources in Table A1.

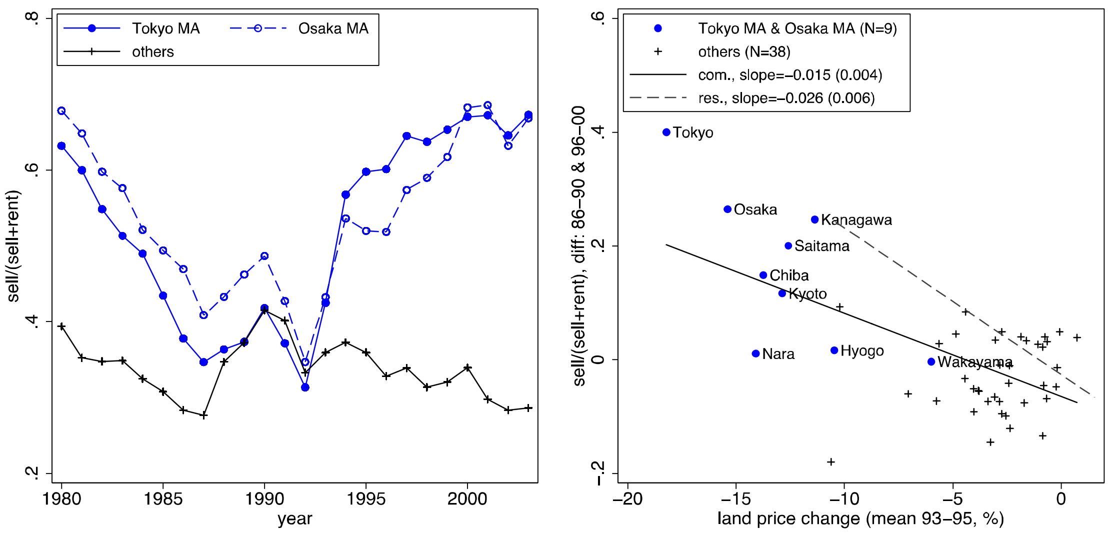


Figure 17: Changes in the types of housing starts and cross-prefecture variation.

Notes: The data reported in the right panel (the y-axis) refer to the change of *sell_ratio* (the proportion of "built-to-sell" dwellings to total "built-to-sell" and "built-to-rent" housing starts) at the prefecture level between 1986–1990 (during the bubble boom) and 1996–2000 (after the bubble burst).

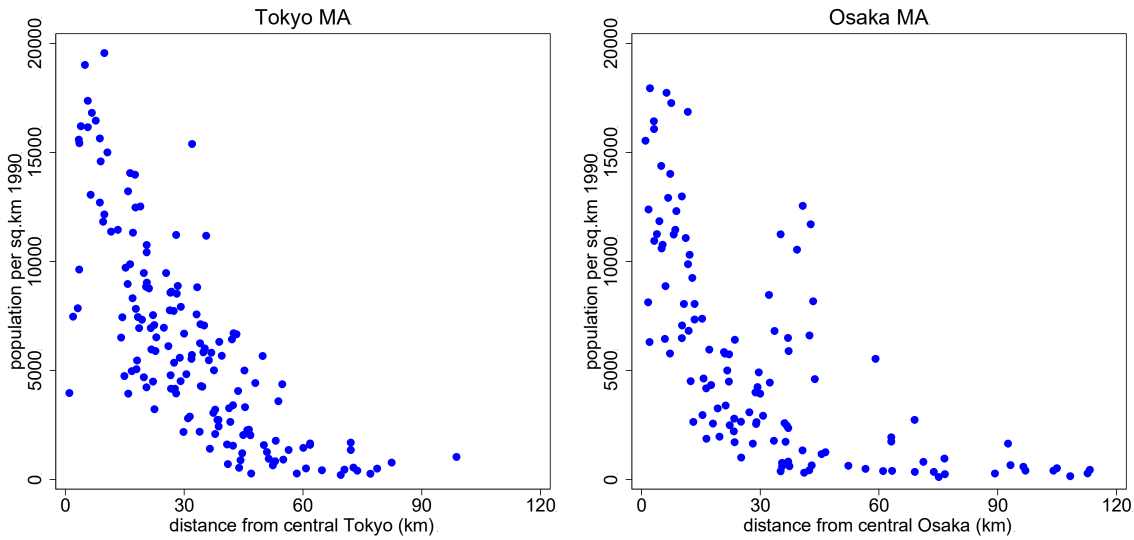


Figure A1: Population density against the distance from city center.

Notes: Central Tokyo (Osaka) refers to the Tokyo (Osaka) station for the Tokyo (Osaka) MA. See data sources in Table A1.

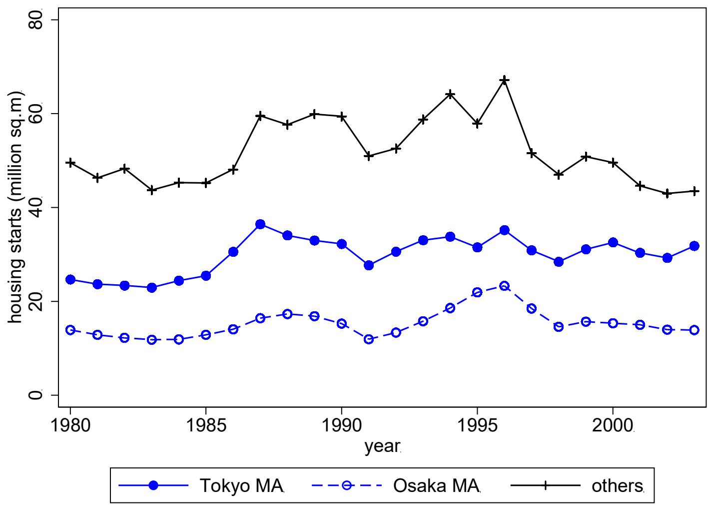


Figure A2: Number of housing starts in the major MAs and other regions.

Notes: See data sources in Table A1.

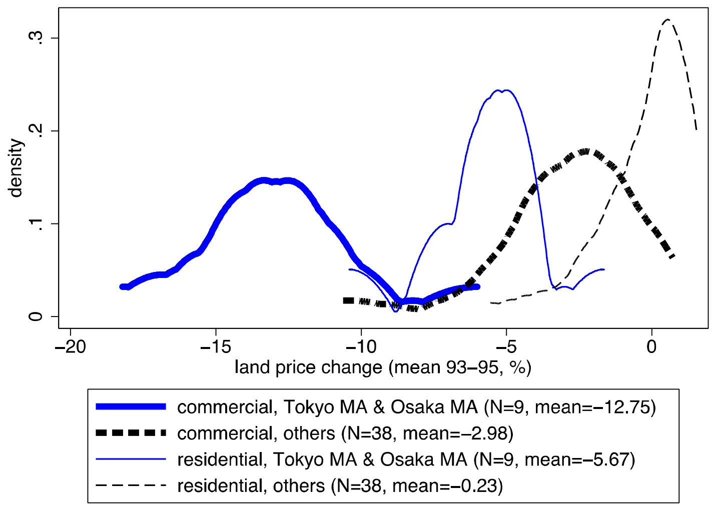
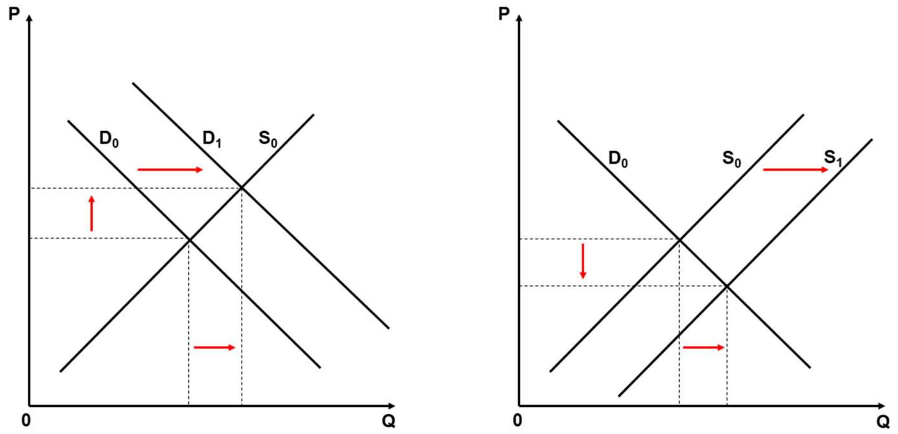


Figure A3: Land price changes in the major MAs and other regions.

Notes: See data sources in Table A1.



(a) Demand shock: P↑ & Q↑

(b) Supply shock: P↓ & Q↑

Figure A4: The heterogeneous impacts of demand shocks and supply shocks on land prices.

Notes: (a) As the demand of residential land (or, housing) increases (from D_0 to D_1), the equilibrium land price (P) increases. (b) As the supply of residential land (or, housing) increases (from S_0 to S_1), the equilibrium land price decreases.

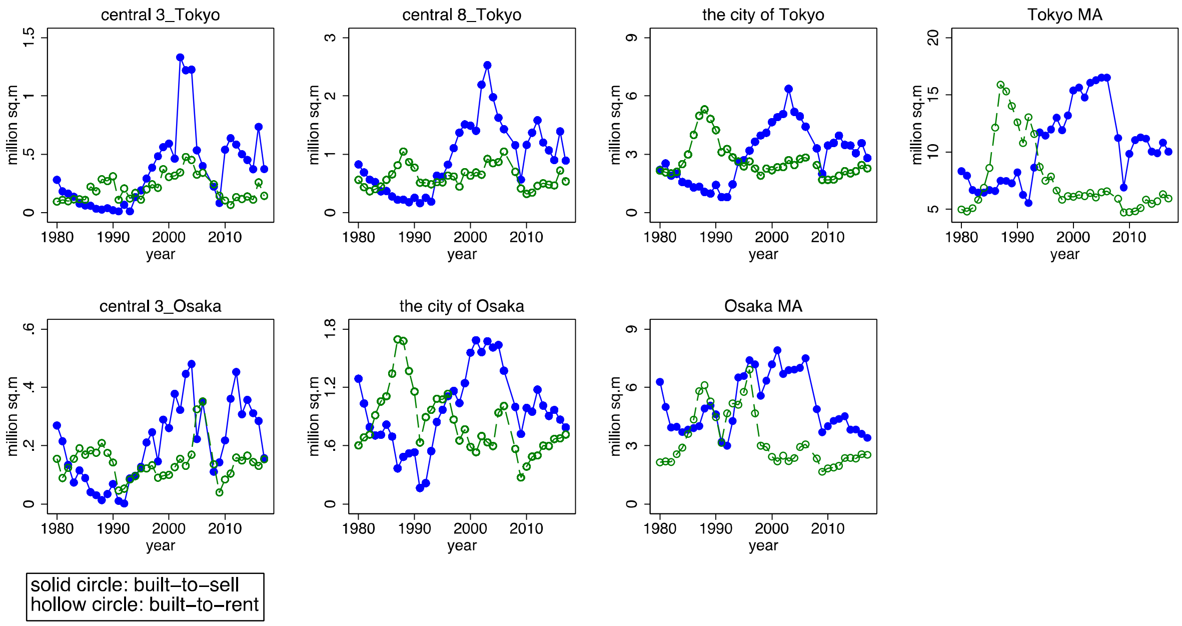


Figure A5: The scale of housing starts by house type.

Notes: See data sources in Table A1. Data for 2007 are missing.

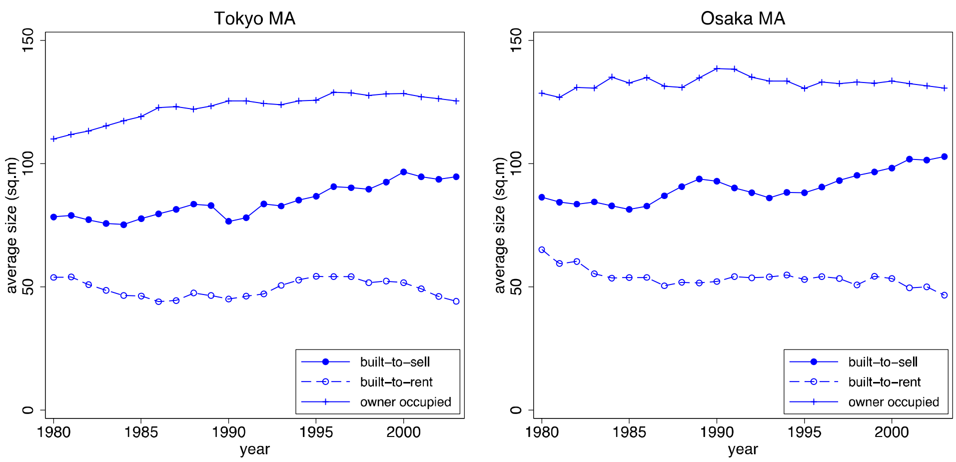


Figure A6: The average floor area of the three house types.

Notes: See data sources in Table A1.