DSSR

Discussion Paper No. 76

Condominium Prices and Inflation: The Role of Financial Inflows and Transaction Volumes in Japan

Jun Nagayasu

March , 2018

Data Science and Service Research
Discussion Paper

Center for Data Science and Service Research
Graduate School of Economic and Management
Tohoku University
27-1 Kawauchi, Aobaku
Sendai 980-8576, JAPAN

Condominium Prices and Inflation: The Role of Financial Inflows and Transaction Volumes in Japan

Jun Nagayasu[‡]

Abstract

We investigate the dynamics of condominium prices by using a new dataset containing national and regional data on prices and disaggregate transaction volumes for Japan. In particular, we are interested in the role of capital inflows and transaction volumes, which have recently been discussed worldwide as important determinants of property prices. First, by using the multivariate cointegration method, we show that the condominium market has not experienced real estate bubbles since 2008. We document several economic fundamentals; notably, real income, mortgage rates, and capital flows, have influenced the long-term trend in condominium prices. Second, on some occasions, we find that condominium price inflation can be explained by transaction volumes, which are positively linked to information inflows, consistent with the market microstructure model. Transaction volumes influence price inflation in Tokyo, in particular at times of high market activities.

Keywords: Real estate market, condominium price, transaction volume, unit root, cointegration, Japan
JEL classification: R2, C5

[‡]Tohoku University, Graduate School of Economics and Management, Address: 27-1 Kawauchi, Aoba-ku, Sendai, Miyagi 980-8576 JAPAN. Email: jun.nagayasu.d8@tohoku.ac.jp, Tel: +81 22 795 6265, Fax: +81 22 795 6270. The earlier version of this paper was presented at the Housing Research & Advanced Foundation of Japan as well as the biannual meetings of the Japanese Economic Association and the Japan Society of Monetary Economics. I made substantial changes to the previous version circulated as "The bubbles and inflation in the Japanese condominium market", and the first two sections of this paper are generally the same as the ones in the early version. I would like to thank Kei Harano, Miki Seko, Kazuto Sumita, Masayuki Susai and Norifumi Yukutake for useful comments and discussion. I also thank Gabriel Cordoba for research assistance.

1 Introduction

The analysis of residential property prices is important for a number of reasons. First, a place to live is a necessity like food. Second, residential property is often the most expensive item that people purchase in their entire lives. Because it forms a significant part of their wealth, the bursting of real estate market bubbles has catastrophic effects on the quality of life. Thus, a number of studies have been conducted in order to investigate changes in the prices of residential properties, especially houses, and the recent macroeconomic analyses consider the real estate market as essential factor in explaining business cycles and financial crises (Leung 2004, Jorda et al. 2016).

Traditionally, housing prices have been analyzed based on economic fundamentals. Macroeconomists consider such economic fundamentals as mortgage rates, household income, and housing stock while analyzing housing prices (Ashworth and Parker 1997, Meese and Wallace 2003, Abelson et al. 2005, Stevenson 2008). More micro-oriented analyses consider population and the location of residence (Cameron et al. 2006). However, these economic fundamentals are not always sufficient to explain housing price movements. During bubble periods, non-economic factors (e.g., consumer expectations) are believed to have more influence over housing prices than economic fundamentals. Because bubbles are unobservable, previous studies often have regarded sizable deviations of market prices from economic fundamentals as evidence of bubbles (Black et al. 2006, Muellbauer and Murphy 2008, McMillan and Speight 2010).

More recent theoretical research has utilized information about the volume of housing transactions (e.g. Stein 1995, Ortalo-Magne and Rady 2006). Transaction volume is believed to explain transitory movements or volatility in housing prices, and is expected to be positively correlated to housing prices. Following such theoretical developments, recent research has examined the usefulness of transaction volume in explaining housing prices in advanced countries such as Finland (Oikarinen 2012), the United States (US) (Akkoyun et al. 2013), the United Kingdom (UK) (Andrew and Meen 2003, Tsai 2014), and the Netherlands (de Wit et al. 2013). Similarly, capital inflows are discussed as important determinants of housing prices in advanced countries (Sa et al. 2014, Sa and Wieladek 2015).

Against this background, we investigate the recent price movements of condominiums in Japan, which have not been examined as a main research topic so far, probably because of lack of statistical data available to researchers.[1] Although there are several types of residences, like (detached) houses and multi-family residences (e.g., condominiums or apartments), we focus only on condominiums, which are called "apartments" or "mansions" in Japan, for the following two reasons. First, with a relatively high population density, living in a condominium is a popular choice, even for couples with children. Indeed, according to the 2011 Population Census (Kokusei-chosa) of Japan, approximately 41.6% of households live in condominiums. This proportion is higher in urban areas such as Tokyo (67.7%), Kanagawa (54.9%), and Osaka (54.1%).[2] The trend of living in condominiums has increased in recent years, while other types of residences have become less popular. Second, in line with the popularity of condominiums, their prices have behaved differently from those of other types of real estate during the past decade. Notably, after the collapse of the Lehman Brothers (2008), the sharp increase in condominium prices outpaced other real estate prices. Condominium prices reached a record high (46 million yen on average) in 2015, and today the condominium market, which seems to be exhibiting early warning signs of a potential bubble, is of great interest to market participants and analysts.

This paper departs from previous studies since we introduce capital inflows and transaction volumes into the standard pricing model. This modification is motivated by increases in real estate acquisition by non-Japanese people as well as recent research on changes in the value of other financial assets, such as stocks and exchange rates (e.g., Campbell et al. 1993, Lyons 1995, Barron and Karpoff 2004). Previous studies used a market microstructure model, i.e., a Bayesian mechanism through which prices were updated through an inflow of new private information to traders (O'Hara 1997), and transaction volume was incorporated in order to link changes in asset prices to traders' information and expectations. Increases in the volume of transactions will raise the proportion of informed traders in the market and thus help them make appropriate financial decisions, leading to the theoretically predicted price changes. We analyze the relation-

[1]Studies of the overall Japanese residential property market, which includes real estate types other than condominiums, are rather limited due, in part, to the lack of data. For example, Adams and Fass (2010) who studied 15 international housing markets did not cover the Japanese market.

[2]The proportion of people living in condominiums in urban cities in Japan is higher than the European average of 41.1% (as of 2013) and the New York average of 51%.

ship between condominium price inflation and transaction volume by trader type at both national and regional levels in Japan. To our knowledge, this is the first attempt to utilize such disaggregated data. Furthermore, given that price inflation is likely to contain extreme values, this relationship will be examined using the quantile regression method that estimates the effects of transaction volumes on price inflation at different quantiles of data.

2 Theoretical Determinants of Condominium Prices

The majority of previous studies define financial bubbles as temporary phenomena where asset prices deviate significantly from economic fundamentals, using the present value models.[3] Based on finance literature on stock prices, the relationship between prices (P) and economic fundamentals (F) can be expressed in terms of returns (r) on investment as:

$$r_{t+1} = (P_{t+1} + F_{t+1})/P_t - 1 \tag{1}$$

where subscript t represents time ($t = 1, \ldots, T$). Eq. (1) is popular in equity price research, and dividends are universally used as economic fundamentals. In terms of prices, this return equation can be shown with an expectation notation, E, as:

$$P_t = E_t \left[\frac{P_{t+1} + F_{t+1}}{1 + r_{t+1}} \right] \tag{2}$$

Eq. (2) shows that future economic values will determine the present prices. Solving this identity forwardly to infinity, we can obtain the following dynamic relationship between prices and economic fundamentals.

$$P_t = E_t \left[\sum_{h=0}^{\infty} \left(\prod_{k=0}^{h} \left(\frac{1}{1 + r_{t+k}} \right) \right) F_{t+h} + \lim_{h \longrightarrow \infty} \prod_{k=0}^{h} \left(\frac{1}{1 + r_{t+k}} \right) P_{t+h} \right] \tag{3}$$

In other words, the present prices are determined by the expected values of P and F. When the product of future prices and discount factors does not diminish to an insignificant level, the market is often considered to have experienced rational bubbles. In statistical

[3]Theoretical explanations of movements in condominium prices can be considered as identical to those of detached houses since they are economic goods with similar characteristics.

terminology, this is a case where P and F are not cointegrated. On the other hand, the market is said to be tranquil when this product becomes insignificant, and cointegration exists between P and F. To put this concept into practice, it is important to understand what composes economic fundamentals.

The simplest form of fundamental determinants of housing prices consists only of rental costs (Meese and Wallace 1994, Phillips and Yu 2011), mortgage rates (McGibany and Nourzad 2004), residential land (Ooi and Lee 2006), or household income (Gallin 2006). Renting is another alternative to purchasing a house, i.e., an opportunity cost. A mortgage rate is considered as closely associated with the user cost of residential capital based on the neoclassical investment model (Kearl and Mishkin 1977). Thus, for a mortgage rate to have an expected influence on property markets, a country should possess developed capital and financial markets. While a mortgage rate can be considered to influence the supply-side as it is closely linked with a variety of interest rates, McGibany and Nourzad (2004) argue that its effect is predominantly demand-oriented. Land availability may be increasingly important in areas with limited landmass and/or heavy government regulation. Finally, the price-income relationship of houses is closely linked to housing affordability, which represents the difficulty of purchasing a house.

A pricing model may comprise both demand- and supply-side factors such as real income and the user cost of capital (e.g., Oikarinen 2012). Other possible variables considered are private sector housing starts (Drake 1993, Ashworth and Parker 1997), real credit to the private sector (Hofmann 2004), construction costs (Adams and Fass 2010), employment (Meese and Wallace 2003), and capital inflows (Sa and Wieladek 2015). In short, there are several variables that can possibly explain housing price movements in theory, but there is little consensus among researchers regarding the exact definition of fundamental determinants of housing prices.

Moreover, there is no clear theoretical consensus on whether these explanatory variables determine permanent or transitory movements in housing prices. Probably, transaction volume, which is considered a determinant of housing price inflation, is a very rare exception. The distinction between permanent and transitory factors becomes key in this study since we base our analysis on a concept of integration where a permanent relationship is statistically equivalent to the presence of cointegration, and transitory price movements should be captured by stationary variables.

The theoretical relationship between prices (inflation) and transaction volumes has been developed in the market microstructure model using Bayesian learning. The information prevalence indicates the increased number of informed traders, which results in expected price changes. Therefore, in the field of finance, the motivation for considering transaction volume is to capture investors' information that is relevant to short-term movements in asset prices. Considering transaction volume is also consistent with technical analysts view that trading volume influences asset prices (Karpoff 1987).

While using transaction volumes to explain movements in property markets is relatively rare in the analysis of real estate markets worldwide and has certainly never been done for Japan, they have been used to explain movements in stock prices and exchange rates. Most previous studies reported a positive correlation between trading volume and contemporaneous asset returns. For example, a positive relationship between stock returns and trading volume was reported by Karpoff (1987) and Gervais et al. (2001). Karpoff stated two stylized facts from previous literature: a positive relationship between volume and the absolute value of changes in stock prices, and a positive relationship between trading volume and changes in stock prices. Gervais et al. argued that this high volume premium is created by stock's visibility, which results in increased demand. Furthermore, trading volume is often discussed in finance literature as having a very high positive correlation with information; in other words, more information is conveyed to equity investors when trading volumes are high. In exchange rate studies, order flows, which are transaction volumes with signs, are used to explain intraday changes in exchange rates that happen within very short time periods (Lyons 1995, Evans and Lyons 2002).[4]

Stein (1995) underscored the importance of down-payments among property markets using transaction volumes, and went on to demonstrate numerically that the positive relationship between prices and volume is more robust for volatility implications. Furthermore, this relationship is shown to be stronger for repeat buyers who put existing homes on sale prior to purchasing new ones than for first-time buyers. Follain and Velz

[4]In financial research, high frequency (intraday) data are used to capture short-term movements.In contrast, in this study monthly data are used because that is the frequency of data available. Monthly data are appropriate for analyzing the real estate market, since trades in the real estate market are much less frequent compared to equity and foreign exchange markets.

(1995) documented the negative relationship between home prices and home sales when down-payments are significant.

3 Data Summary and Preliminary Analyses

We use a unique dataset that allows us to investigate Japanese real estate markets. Indeed, until recently, the dataset for Japan's real estate markets has not been well organized, which is one of the reasons that Japanese real estate markets were not been fully analyzed in the past. Only recently, as part of an IMF initiative, did Japan's Ministry of Land, Infrastructure, Transport and Tourism (MLIT) start compiling Japanese real estate data and disseminating them on the MLIT website. These data are available at the national and regional levels; however, due to limited data availability on that website and the need for consistency with other statistical data used in this study, our regional analysis focuses on four prefectures that are generally large, in terms of landmass and population: Hokkaido, Tokyo, Nagoya, and Osaka. Of these four prefectures, Hokkaido is the only one that is not a metropolitan area and where the population is declining (Table 1).

Monthly condominium price data are based on the settlement prices and are available from April 2008 (see Table 1).[5] Further, condominium price indexes (2010=100, Figure 1) cover mainly secondary condominiums traded in the private sector and are constructed from Hedonic regression considering different characteristics of condominiums such as the area, size, location, and age of the building. Other considerations are whether the condominium is renovated and/or south-facing. This figure, with 2010 as a base year for the price index, shows that condominium prices have been increasing most rapidly in Hokkaido, a non-metropolitan area where economic recovery from the Lehman Shock (2008) was initiated much later than the metropolitan areas and which now faces a strong demand for condominiums due to an inflow of people from rural areas.

Figure 2 shows the peculiarity of condominium prices (Condominium) compared to prices of other types of real estate such as residential land (Land), detached houses (House) and overall residential property (Overall). In particular, inflation in the condominium market is noticeably higher than inflation in other real estate markets, while prices of

[5]While empirical results may be sensitive to data frequency (e.g., Berkovec and Goodman 1996, Akkoyun et al. 2013), we do not focus on the low frequency due to the limited number of observations.

other types of real estate appear to be more highly correlated among themselves. Increases in condominium prices are notable since those of residential land have been in a declining trend. This phenomenon is also demonstrated in the correlation matrix (Table 2). Condominium price inflation is plotted by fractional points of data (Figure 3). A steep slope at low and high fractions of data in this figure presents extremely high and low inflation that cannot be observed frequently.

Data on transaction volumes for the nation and for the four regions are obtained from the MLIT. The national level data show that about 13,000 transactions are recorded each month and a third of the total transactions take place in Tokyo (Table 1). Furthermore, unlike the data used by previous studies that analyzed real estate markets of other countries, these data are also available by the type of trader. To be more specific, four types of transaction volumes are recorded for condominiums: from individuals (Ind) to Ind, from Ind to companies (Com), from Com to Ind, and from Com to Com. Among these four types of transactions, Ind to Com-sale accounts for most of the transactions. Here, companies cover a broad range of general corporations in the private sector. In this study, we use this information to identify who has contributed most to condominium price inflation. The aggregate transaction volume is plotted in Figure 4. We see a typical transaction phenomenon in Japan; there are significant increases in transaction during spring, which coincides with business people's movement at the end of fiscal year (March). However, we do not observe any notable seasonality in condominium prices in Figure 1.

In addition to real estate data, economic determinants of condominium prices based on previous literature are gathered. Net monthly migration data for each region of Japan are available from the Japan's Ministry of Internal Affairs and Communications (MIAC).[6] We would expect an increased inflow of people to increase the demand for condominiums resulting in a rise in condominium prices, all else being constant. For the national level analysis, we use monthly data on Japanese population obtained from the MIAC.

Data on other variables, such as employee compensation, mortgage rates, and new housing (condominium) construction-starts are not available at a regional level; in those cases, we use national data. The number of new condominium construction-starts is introduced in order to capture supply-side changes in the real estate market. For the

[6]The MIAC's migration data are based on information from local registers (Jumin-hyo).

mortgage rate, we use the floating rates for city housing loans. The real mortgage rate is then calculated, based on Fisher equation, by subtracting expected inflation from the nominal rate (i_t); expected inflation is assumed to be equal to observed inflation (Δp_t, in which p is the consumer price index (CPI) in logarithmic form).[7] Monthly CPI at the national level were obtained from Datastream, and monthly CPI at the regional level were obtained from Japan's MIAC.

International capital inflows are considered to capture additional demand originating from foreign countries and are thought to contribute to creation of bubbles in large cities such as London, New York, and Sydney. As a proxy for cross-border positions of a country via-a-vis other countries, the Bank for International Settlements (BIS) compiles claims and liabilities using gross information from banks balance sheets in 43 countries, mainly advanced and emerging countries. Following Bruno and Shin (2015) who show an acceleration of global financial flows since 2000, we use data on liabilities as a proxy for financial inflows from the BIS Locational Statistics. Since our study focuses mainly on domestic issues, capital flow data are expressed in terms of the Japanese yen and are re-expressed in real terms using the CPI. All data are available on a monthly basis except employee compensation and capital flows; monthly employee compensation and financial flows are converted from quarterly data.[8]

As a preliminary investigation, we check time-series properties of our data since the presence of bubbles can be detected by analyzing a linear combination of nonstationary variables. Table 3 reports the results of the conventional unit root test (i.e., the Augmented Dickey-Fuller (ADF) test) applied to real condominium prices, mortgage rates, income, and capital flows.[9] Determining the appropriate lag length by the Akaike information criterion (AIC), the ADF tests are conducted for both the level and the first difference of the data. With the null hypothesis of the unit root against the alternative hypothesis of the stationarity, we generally find that our key variables are nonstationary and are indeed integrated of order one, I(1). We fail to reject the null hypothesis for data in level, but can reject it for the differenced data. Therefore, the standard multivariate cointegration test (Johansen 1991) can be used to analyze the presence of bubbles in the

[7] Changes in inflation formation (i.e., Δp_{t+1}) would not alter the overall conclusion.

[8] A function (cubic-match last) of Eviews 8 is used for frequency conversion.

[9] While not reported here due to limited space, other explanatory variables used in the paper are found to be I(0).

condominium market. A failure to reject the null for real condominium prices implies that nominal condominium prices have not moved in tandem with prices of general consumption goods, i.e., the CPI, again pointing to peculiar movements in condominium prices.

Finally, Table 4 reports a causal relationship between condominium price inflation and transaction volumes. There is evidence of unidirectional causality from transaction volumes to condominium price inflation. This is determined by Granger non-causality tests, which reject the null hypothesis that transaction volumes do not affect price inflation but fail to reject the null hypothesis that condominium price inflation does not influence transaction volumes. However, this unidirectional causality can be found only in aggregate data, and disaggregate data do not show clear causal relationships.

4 Empirical Results

4.1 Condominium Prices and Economic Fundamentals

We use time-series methods; in particular, the relationship between condominium prices and their determinants is investigated by use of cointegration (Engle and Granger 1987). The cointegration method has been applied in the analysis of housing markets by a number of researchers (Hendry 1984, Meese and Wallace 2003, McGibany and Nourzad 2004, Gallin 2006, Adams and Fass 2010, Oikarinen 2012, De Wit et al. 2013). Given that housing prices have often been characterized as following a nonstationary process, cointegration is attractive because it allows us to test for the presence of bubbles, as well as to model a long-run path and the dynamics of prices to return to this path. More specifically, we use a vector error correction model (VECM), which is a popular statistical model used to analyze nonstationary (especially I(1)) time-series data. The I(1) assumption is in line with statistical characteristics of many economic and financial data (Nelson and Plosser 1982).

The VECM can be expressed in the context of the Johansen approach (1991) that has a number of attractive features. First, the VECM extends the standard vector autoregression (VAR) model and incorporates error correction models (ECMs) and nonstationary variables. The VAR suffers from a misspecification bias when data are nonstationary and contain cointegration. Second, unlike the Engle-Granger method based on a single equation specification, the Johansen approach accommodates more than one cointegrating relationships. When modelling even a partial economy, economic theories can predict multiple cointegration (steady-states). Third, because all key nonstationary variables ($\mathbf{y}$) are endogenous, there is no need to consider a causal relationship among them. The VECM can be derived from the standard VAR(p):

$$\mathbf{y}_t = A\mathbf{y}_{t-1} + A_2\mathbf{y}_{t-2} + \cdots + A_p\mathbf{y}_{t-p} + e_t \tag{4}$$

where $t = 1, \ldots, T$ and $e_t \sim N(0, \sigma_e^2)$. A matrix $\mathbf{y}$ consists of K nonstatioinary (I(1)) time-series variables. This VAR can be transformed to the VECM(p) that can be expressed with extra variables (z) as:

$$\Delta\mathbf{y}_t = a + \sum_{i=1}^{p} b_i\Delta\mathbf{y}_{t-i} + cECM_{t-1} + f\mathbf{z}_{t-1} + u_t \tag{5}$$

where $c = -(I - \sum_{i=1}^{p} A_i)$ and $b_i = -\sum_{j=i+1}^{p} A_i$ The residual follows the standard normal, $u_t \sim N(0, \sigma_u^2)$ and Δ is the difference operator. In our study, $\mathbf{y}$ is a vector of real condominium prices, income, mortgage rates, and capital inflows; and $\mathbf{z}$ consists of stationary variables such as transaction volumes, housing starts, net migration (or population changes), and centered seasonal dummies.[10] Eq. (5) deals with an endogeneity issue in $\mathbf{y}$, but not between $\mathbf{y}$ and $\mathbf{z}$; therefore, the lagged $\mathbf{z}$ is used to ensure exogeneity of this matrix. The choice of economic variables is determined by the availability and the stationarity of data, and this equation will be estimated by the maximum likelihood method (Johansen 1991).

In order to specify Eq. (5), we need to identify the number of cointegrating vectors (r). This identification can be investigated by decomposing parameter, c, into adjustment and cointegrating parameters (α and β respectively):

$$H_1(r) : c = \alpha\beta^{'} \tag{6}$$

α measures the speed of adjustment to return to the long-run path. In the presence of

[10] Our model specification is similar to that of Adam and Fass (2010).

a long-run relationship, cointegrating parameter β is super-consistent and the ECM is stationary I(0). Then, according to the Granger Representation Theorem (Engle and Granger 1987), α should be $-1 < \alpha < 0$. A value for parameter α that is close to -1 indicates fast adjustment to return to the long-run path, and a parameter α value that is close to 0 indicates slow adjustment to the long-run path. In contrast, when there is no long-run relationship among $\mathbf{y}$, α will not lie within this theoretical range, which implies that there are significant deviations of prices from economic fundamentals and this is traditionally considered evidence of bubbles.

The number of cointegrating vectors is equal to the rank of c (rank(c)), which can be evaluated by the significance of characteristic roots (λ_i) of c. Using λ_i, we can construct trace statistics to find the presence and the number (r) of cointegrating vectors.

$$\lambda(r) = -T \sum_{i=r+1}^{n} \ln(1 - \lambda_i) \tag{7}$$

This is known as a trace statistic and evaluates the null of rank $(c) = r$ against the alternative of rank $(c) > r$, where $0 < r < K$.[11] When λ_i is insignificant, the trace statistic becomes zero and yields evidence of no cointegration. The trace statistic does not follow the conventional distribution, and thus we use the critical values provided by Osterwald-Lenum (1992) in order to evaluate the null hypothesis.

The results from the Johansen multivariate cointegration approach are summarized in Table 5, where the AIC is used for the selection of lag lengths in order to minimize size distortions (Lutkepohl and Saikkonen 1999). We find evidence of one cointegration (i.e., one equilibrium condition) in all regions from the full sample analysis (2008M1-2017M4). The null hypothesis of no cointegration can be rejected, while we fail to reject the hypothesis of $r > 1$. Finding cointegration in our specification implies the absence of bubbles in the condominium market.[12] Furthermore, while our research is confined to condominium markets, our conclusion of no bubbles in this market implies the absence of bubbles in the Japanese property market in general. This is in line with Figure 2 where prices of other property markets have shown a rather slow recovery after Lehman's

[11] We use trace statistics to identify the number of cointegration following the recommendation of Lutkepohl et al. (2001), but maximum eigenvalue tests also yield similar results.

[12] The conclusion of no bubbles is consistent with that of Nagayasu (2016) who used the explosive (right-hand side) unit root tests.

collapse, and this trend has not changed significantly in recent times.

The unique cointegrating relationship (ECM parameters) is presented in Table 6, where following the conventional presentation format, ECM is presented as $\ln(P_t) - \beta_1 \ln(Mortage\ rate_t) - \beta_2 \ln(Income_t) - \beta_3 \ln(Capital\ inflow_t) - \beta_4)$ and thus the parameter of condominium prices is normalized. Theoretically speaking, real condominium prices are positively correlated with real employee compensation and cross-border capital inflows ($\beta_2, \beta_3 < 0$), and negatively correlated with the real mortgage rate ($\beta_1 > 0$). The ECMs are plotted in Figure 5, which, consistent with the results from the Johansen approach, suggests the stationarity of ECMs. A sharp deviation of ECMs in early 2014 may be a reflection of the economic impacts of the consumption tax that was increased from 5% to 8% in April 2014. It had led to an increase in the demand for condominiums before the implementation of the hike.

Our results show that the coefficients for real mortgage rates and financial flows have the expected sign in all cases. In contrast, the sign of the coefficient for real compensation varies by region. It is positively associated with real condominium prices in relatively large regions, such as Tokyo, Osaka, and Aichi, but is negatively associated with real condominium prices in Hokkaido where the recovery of the real economy after Lehman's collapse lagged behind that of the metropolitan areas. Our result is consistent with Sa and Wieladek (2015) who find a positive and persistent effect of capital inflows originating from a saving glut on real prices of houses in the US. Thus, we confirm that purchase of real estates by nonresidents is a worldwide phenomenon.

4.2 Condominium Price Inflation and Transaction Volumes

As summarized in Section 2, price volatility is theoretically linked with transaction volumes, which in turn are related to the amount of information in the market. Generally, it is believed that there is more information in the real estate market at times of bubbles. Although no evidence of bubbles is found in the Japanese condominium market, a positive relationship has generally existed between price inflation and transaction volumes in recent periods. That is to say, more transactions took place during times when condominium prices were high (Table 7). This phenomenon remains valid for all combinations of trades, with one exception: transactions from companies to individuals. Given possible heterogeneous responses of condominium price inflation to changes in transaction volumes at different quantile points, we use a quantile regression method, which estimates different effects along quantiles of covariates (Koenker and Bassett 1978).

The quantile regression is a popular statistical approach in economic and financial analyses (Koenker and Hallock 2001) and is considered more robust than the ordinary least squares (OLS) when data contain extreme values. Although this advantage of the quantile regression has been widely recognized, it has not been frequently used in analysis because of the complexity involved in the estimation compared to the OLS. However, IT developments over the past decades make this regression method more accessible to researchers. The major distinction between these methods can be highlighted by their minimization problems. That is, while the OLS estimates the unconditional population mean ($\mathrm{E}(y)$), the quantile regression estimates conditional expectation function, $\mathrm{E}(y|x)$, for the τth quantile.

We apply the quantile method to the autoregressive distributed lag (ADL) model, which is dynamic and thus captures more appropriately a data generating process than a static model.[13] For a bivariate case where both y and x are stationary, the standard ADL(p,q) can be expressed as:

$$y_t = \sum_{i=1}^{p} a_i y_{t-i} + \sum_{i=0}^{q} b_i x_{t-i} + \varepsilon_t \tag{8}$$

where the residual, ε_t, follows the normal distribution. When y and x are I(1), Eq. (8) is more appropriately transformed to Eq. (9) with possible cointegration between y and x.

$$\begin{aligned}\Delta y_t =& \delta \mathrm{ECM}_{t-1} + \sum_{i=1}^{p-1} \alpha_i \Delta y_{t-i} + \sum_{i=0}^{q-1} \phi_i \Delta x_{t-i} + \psi z_{t-1} + e_t \\ =& \theta m_t + e_t\end{aligned} \tag{9}$$

Like the VECM, this equation contains a vector of exogenous and stationary variables (z) and an ECM. The lagged value of z has been considered to ensure exogeneity of this vector. Based on this standard ADL with an ECM, the quantile ADL evaluated at the

[13]The ADL is used here because, to our knowledge, developments in the quantile VAR are still premature, and to some extent, our finding of one coinegration justifies the reduced form.

τth quantile ($\tau \in [0, 1]$) can be expressed as:

$$\Delta y_t = \delta(\tau)\mathrm{ECM}_{t-1} + \sum_{i=1}^{p-1} \alpha_i(\tau)\Delta y_{t-i} + \sum_{i=0}^{q-1} \phi_i(\tau)\Delta x_{t-i} + \psi(\tau) z_{t-1} + u_t \tag{10}$$

This model differs from models that take into account the recent developments in quantile regression models and are based on a quantile-dependent cointegration in a context of a reduced form (Xiao 2009) and the ADL (Cho et al. 2015). A quantile-dependent cointegration implies heterogeneous cointegrating parameters (β) along quantiles and the presence of multiple equilibria in the market. But, this statistical implication is not usually considered by the standard economic theory on housing prices. After all, we maintain here the finding of one equilibrium in the condominium market from the Johansen test, and the parameters are estimated by minimizing Eq. (11)

$$\min_{\theta \in \mathbb{R}} \sum_{i=1}^{T} \rho_\tau (y_i - \theta m_t) \tag{11}$$

where $\rho_\tau(u) = u(\tau - I(u < 0))$, or $\rho_\tau(u) = -(1-\tau)u$ if $u < 0$ and $\rho_\tau(u) = \tau u$ if $u \geq 0$ (Koenker and Bassett 1978). When $\tau = 0.5$, the model becomes the least absolute deviation estimation. With 4 nonstationary variables and the maximum lag order equal to 4, we estimate Eq. (11) for different combinations of lag lengths by the OLS and choose the best model out of 500 combinations using the AIC. Once the specification of the best model has been decided we use the quantile regression for its estimation.

The marginal effects from the quantile regression are summarized in Table 8, where transaction volumes are evaluated at the 95% quantile level. The results in this table are based on the specification of the quantile regression that is generally consistent with the VECM. We use the steady-state condition summarized in Table 6, and z contains transaction volumes, construction-starts, population changes, centered seasonal dummies. Furthermore, the specification of ADL is ADL(1, 2, 0, 0) for a nation, ADL(4, 0, 1, 0) for Hokkaido, ADL(2, 0, 1, 2) for Tokyo, ADL(4, 0, 0, 2) for Aichi, and ADL(3, 0, 0, 0) for Osaka. Since all ADLs contain the lagged endogenous variables, inflation inertia exists in the condominium market. Price inertia is a common phenomenon not only in the real estate market but also in the goods market.

This table shows that while the marginal effects are often positive, they are insignificant in most cases. Exceptions are Tokyo and the nation, where transaction volumes are shown to influence price inflation positively and significantly at the conventional significance level (see also Figure 6). It follows that, consistent with the market microstructure model, increases in transaction volumes is closely associated with property price increases in selected regions and only at high quantiles. The disaggregate analysis suggests that transaction volumes are often positive but are insignificant in many cases; however, trading among individuals has been found to be an important kind of transaction in Tokyo. This may suggest that compared to institutional traders, heterogeneity in information is more sizable among individuals, who do not collect relevant information regularly and comprehensively.

The fact that the relationship between transaction volumes and property price inflation is somewhat weaker in Japan compared to analyses of other countries may be related to market imperfections. Mortgage loans are expected to be repaid by the ages of 70 to 75, and most private transactions in Japan are carried out by first-time buyers, who have an average age of 35 and who are more likely to face liquidity constraints (due to down-payments). Hayashi et al. (1988) demonstrated that lack of developments in these markets led consumers to save for down-payments and to acquire residential property later in life. Further, Japan's secondary real estate market is shallow compared to those of other developed countries: existing houses accounted for 37% of total home sales in Japan in 2012, which is substantially lower than in the US (78%) and France (66%). This situation has resulted from the Japanese housing policy following World War II, which was designed to increase the number of available accommodations regardless of quality. The insignificant relationship between price inflation and transaction volumes may also be due to other market imperfections (e.g., lack of transparency about properties) that amplifies the down-payment effect.

Further analysis is conducted for a nation and Tokyo by calculating marginal effects at 15, 35, 55, and 75% quantile levels in order to check the robustness of our finding from the 95% quantile level. The results from these quantiles are consistent with our expectations (Table 9). A statistically significant and positive relationship can be found when transaction volumes are evaluated at their higher quantiles and transactions take place among individual traders. In Tokyo, there is a tendency of a statistical significant relationship above a 75% quantile level from aggregate data on transaction volumes and above 55% from disaggregate data on transaction volumes between individual traders. The data from other combinations of traders seem to increase the significant quantile level in aggregate data. In short, while the relationship between real estate inflation and transaction volumes is found to be relatively weak in Japan compared to other advanced countries, our region- and trader-specific findings of some significant relationships are valuable results given the lower trade frequency in the condominium market.

5 Conclusion

In this paper, we have studied the recent movement of condominium prices in Japan, focusing on the roles of transaction volumes and international financial flows. This research topic is important because, for many people, a residence is the most expensive product they purchase in their lifetime and any price increase will significantly affect their quality of life. Furthermore, in Japan condominiums are a very common type of housing, and their price increases have outpaced those of other types of residential properties.

By using the concept of integration, we have then shown that there is no evidence of bubbles in the Japanese real estate market; the trend in condominium prices can be explained through economic fundamentals like employee compensation, mortgage rates, and cross-border financial positions of a country. Furthermore, consistent with theoretical predictions of the market microstructure model, transaction volume contains information that is useful for explaining transitory movements in condominium prices during times of high economic activities in Tokyo. That is, increases in volume are associated with price inflation in the condominium market, but this trend is limited to Tokyo alone. Other regions did not show any significant relationship between them. A relatively weak role of transaction volume may reflect the imperfection of Japan's condominium market. Although geographically limited, the finding on the role of transaction volumes in explaining real estate prices is noteworthy since condominiums are traded less frequently compared to other financial assets such as stocks and currencies.

References

Abelson, P., R. Joyeux, G. Milunovich, and D. Chung (2005). Explaining house prices in australia: 1970-2003. *Economic Record 81*, 96–203.

Adams, Z. and R. Fuss (2010). Macroeconomic determinants of international housing markets. *Journal of Housing Economics 19*, 38–50.

Akkoyun, H. C., Y. Arslan, and B. Kanik (2013). Housing prices and transaction volume. *Journal of Housing Economics 22*, 119–134.

Andrew, M. and G. Meen (2003). House price appreciation, transactions and structural change in the british housing market: A macroeconomic perspective. *Real Estate Economics 31*(1), 99–116.

Ashworth, J. and S. C. Parker (1997). Modelling regional house prices in the UK. *Scottish Journal of Political Economy 44*(3), 225–246.

Barron, O. E. and J. M. Karpoff (2004). Information precision, transaction costs, and trading volume. *Journal of Banking & Finance 28*, 1207–1223.

Berkovec, J. A. and J. L. Goodman Jr (1996). Turnover as a measure of demand for existing homes. *Real Estate Economics 24*, 421–440.

Black, A., P. Fraser, and M. Hoesli (2006). House prices, fundamentals and bubbles. *Journal of Business Finance & Accounting 33*, 1535–1555.

Bruno, V. and H. S. Shin (2015). Capital flows and the risk-taking channel of monetary policy. *Journal of Monetary Economics 71*(Supplement C), 119 – 132.

Cameron, G., J. Muellbauer, and A. Murphy (2006). Was there a british house price bubble? evidence from a regional panel. *Department of Economics Discussion Paper Series*.

Campbell, J. Y., S. J. Grossman, and J. Wang (1993). Trading volume and serial correlation in stock returns. *Quarterly Journal of Economics*, 905–939.

Cho, J. S., T. hwan Kim, and Y. Shin (2015). Quantile cointegration in the autoregressive distributed-lag modeling framework. *Journal of Econometrics 188*(1), 281 – 300.

De Wit, E. R., P. Englund, and M. K. Francke (2013). Price and transaction volume in the dutch housing market. *Regional Science and Urban Economics 43*, 220–241.

Drake, L. (1993). Modelling UK house prices using cointegration: an application of the johansen technique. *Applied Economics 25*(9), 1225–1228.

Engle, R. F. and C. W. J. Granger (1987). Co-integration and Error Correction: Representation, Estimation, and Testing. *Econometrica 55*(2), 251–276.

Evans, M. D. D. and R. K. Lyons (2002). Order flow and exchange rate dynamics. *Journal of Political Economy 110*(1), 170–180.

Follain, J. R. and O. T. Velz (1995). Incorporating the number of existing home sales into a structural model of the market for owner-occupied housing. *Journal of Housing Economics 4*(2), 93 – 117.

Gallin, J. (2006). The long-run relationship between house prices and income: Evidence from local housing markets. *Real Estate Economics 34*(3), 417–438.

Gervais, S., R. Kaniel, and D. H. Mingelgrin (2001). The high-volume return premium. *Journal of Finance 56*, 877–919.

Hayashi, F., T. Ito, and J. Slemrod (1988). Housing finance imperfections, taxation, and private saving: a comparative simulation analysis of the united states and japan. *Journal of the Japanese and International Economies 2*, 215–238.

Hendry, D. (1984). *Econometric modelling of house prices in the United Kingdom*. Oxford: Basil Blackwell.

Hofmann, B. (2004). The determinants of bank credit in industrialized countries: Do property prices matter? *International Finance 7*(2), 203–234.

Johansen, S. (1991). Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models. *Econometrica 59*(6), 1551–1580.

Jorda, O., M. Schularick, and A. M. Taylor (2016). The great mortgaging: housing finance, crises and business cycles. *Economic Policy 31*(85), 107–152.

Karpoff, J. M. (1987). The relationship between price changes and trading volume: a survey. *Journal of Financial and Quantitative Analysis 22*, 109–126.

Kearl, J. R. and F. S. Mishkin (1977). Illiquidity, the demand for residential housing, and monetary policy. *Journal of Finance 32*(5), 1571–1586.

Koenker, R. and G. Bassett (1978). Regression quantiles. *Econometrica 46*(1), 33–50.

Koenker, R. and K. F. Hallock (2001). Quantile regression. *Journal of Economic Perspectives 15*(4), 143–156.

Leung, C. (2004). Macroeconomics and housing: a review of the literature. *Journal of Housing Economics 13*(4), 249 – 267. Housing and the Macroeconomy: The Nexus.

Lutkepohl, H. and P. Saikkonen (1999). Order selection in testing for the cointegrating rank of a var process. In R. F. Engle and H. White (Eds.), *Cointegration, Causality, and Forecasting*, pp. 168–199. Oxford University Press.

Lutkepohl, H., P. Saikkonen, and C. Trenkler (2001). Maximum eigenvalue versus trace tests for the cointegrating rank of a var process. *Econometrics Journal 4*(2), 287–310.

Lyons, R. K. (1995). Tests of microstructural hypotheses in the foreign exchange market. *Journal of Financial Economics 39*, 321–351.

McGibany, J. M. and F. Nourzad (2004). Do lower mortgage rates mean higher housing prices? *Applied Economics 36*(4), 305–313.

McMillan, D. G. and A. Speight (2010). Bubbles in uk house prices: evidence from estr models. *International Review of Applied Economics 24*(4), 437–452.

Meese, R. and N. Wallace (1994). Testing the present value relation for housing prices: Should i leave my house in San Francisco? *Journal of Urban Economics 35*(3), 245 – 266.

Meese, R. and N. Wallace (2003). House price dynamics and market fundamentals: the parisian housing market. *Urban Studies 40*, 1027–1045.

Muellbauer, J. and A. Murphy (2008). Housing markets and the economy: the assessment. *Oxford Review of Economic Policy 24*, 1–33.

Nagayasu, J. (2016). Inflation and Bubbles in the Japanese Condominium Market. MPRA Paper 71192, University Library of Munich, Germany.

Nelson, C. R. and C. I. Plosser (1982). Trends and random walks in macroeconomic times series: some evidence and implications. *Journal of Monetary Economics 10*, 139–162.

O'Hara, M. (1997). *Market Microstructure Theory.* Malden: Blackwell Publishing.

Oikarinen, E. (2012). Empirical evidence on the reaction speeds of housing prices and sales to demand shocks. *Journal of Housing Economics 21*, 41–54.

Ooi, J. and S.-T. Lee (2006). Price discovery between residential & housing markets. *Journal of Housing Research 15*(2), 95–112.

Ortalo-Magne, F. and S. Rady (2006). Housing market dynamics: on the contribution of income shocks and credit constraints. *Review of Economic Studies 73*, 459–485.

Osterwald-Lenum, M. (1992). A note with quantiles of the asymptotic distribution of the maximum likelihood cointegration rank test statistics1. *Oxford Bulletin of Economics and Statistics 54*(3), 461–472.

Phillips, P. C. and J. Yu (2011). Dating the timeline of financial bubbles during the subprime crisis. *Quantitative Economics 2*, 455–491.

Sa, F., P. Towbin, and T. Wieladek (2014). Capital inflows, financial structure and housing booms. *Journal of the European Economic Association 12*(2), 522–546.

Sa, F. and T. Wieladek (2015). Capital inflows and the U.S. housing boom. *Journal of Money, Credit and Banking 47*(S1), 221–256.

Stein, J. C. (1995). Prices and trading volume in the housing market: a model with down-payment effects. *Quarterly Journal of Economics 110*, 379–406.

Stevenson, S. (2008). Modeling housing market fundamentals: empirical evidence of extreme market conditions. *Real Estate Economics 36*, 1–29.

Tsai, I.-C. (2014). Ripple effect in house prices and trading volume in the UK housing market: new viewpoint and evidence. *Economic Modelling 40*, 68–75.

Xiao, Z. (2009). Quantile cointegrating regression. *Journal of Econometrics 150*(2), 248 – 260. Recent Development in Financial Econometrics.

Table 1: Basic summary and sources of the data

		Mean	Std Dev	Unit	Source
Condominium nominal prices					
	Nation	108.917	11.670	Index, 2010=100	MLIT
	Hokkaido	120.785	21.295		MLIT
	Tokyo	108.137	12.541		MLIT
	Aichi	107.751	11.579		MLIT
	Osaka	108.824	11.060		MLIT
CPI					
	Nation	97.912	1.643	Index, 2010=100	Datastream (JPCONPRCE)
	Hokkaido	97.678	1.842	Index, 2010=100	e-Stat
	Tokyo	98.646	1.313		e-Stat
	Aichi	97.975	1.604		e-Stat
	Osaka	98.200	1.618		e-Stat
Transaction volumes (Aggregate)					
	Nation	13171.940	2260.124	Unit	MLIT
	Hokkaido	408.688	72.879		MLIT
	Tokyo	3974.642	718.964		MLIT
	Aichi	594.661	111.667		MLIT
	Osaka	1566.596	285.601		MLIT
Transaction volumes (Individuals to Individuals)					
	Nation	6458.853	1212.712	Unit	MLIT
	Hokkaido	229.826	45.933		MLIT
	Tokyo	1626.064	387.873		MLIT
	Aichi	330.358	73.057		MLIT
	Osaka	756.817	143.069		MLIT
Transaction volumes (Individuals to Companies)					
	Nation	2566.807	688.062	Unit	MLIT
	Hokkaido	78.578	22.629		MLIT
	Tokyo	828.973	227.138		MLIT
	Aichi	116.615	30.262		MLIT
	Osaka	324.239	109.218		MLIT
Transaction volumes (Companies to Individuals)					
	Nation	3725.688	786.436	Unit	MLIT
	Hokkaido	89.661	25.089		MLIT
	Tokyo	1342.817	297.544		MLIT
	Aichi	134.248	33.864		MLIT
	Osaka	433.211	98.038		MLIT
Transaction volumes (Companies to Companies)					
	Nation	411.312	93.055	Unit	MLIT
	Hokkaido	10.587	5.756		MLIT
	Tokyo	174.551	48.771		MLIT
	Aichi	13.431	6.142		MLIT
	Osaka	51.917	22.376		MLIT
Migration (net)					
	Hokkaido	-706.762	1434.605	People	e-Stat
	Tokyo	5569.147	9131.710		e-Stat
	Aichi	765.101	1872.332		e-Stat
	Osaka	54.881	1015.528		e-Stat
National		9642.609	2739.391	People	e-Stat
Employee compensation		257768.400	5939.042	Billion yen	Datastream (JPCOMEMPB)
Construction starts (apartments)		9640.101	2739.327	Unit	Datastream(JPHOUSAPP)
Mortgage rates		2.508	0.107	%	Datastream (JPFHOUSE)
Cross-border position		121886.5	19273.39	Millions US$	BIS
Exchange rate		97.91509	13.91131	Yen/Dollar	Datastream (JAPAYE$)

Notes: The Ministry of Land, Infrastructure, Transport and Tourism (MLIT). The e-Stat is a data set organized by the Ministry of Internal Affairs and Communication. The code numbers are stated in the bracket for variables from Datastream. All data were downloaded on a monthly basis except employee compensation which is converted from quarterly to monthly using the function (cubic-match last) in Eviews 8. The sample period is from 2008M4 to 2017M4.

Table 2: Correlation between real estate markets

	Overall	Residential land	Housing prices	Condominium
Overall	1.000			
Residential land	0.247	1.000		
House	0.598	0.753	1.000	
Condominium	0.829	-0.310	0.079	1.000

Notes: Correlation based on nominal prices.

Table 3: ADF unit root tests for key data

	Level	Difference	
Real condominium prices			
Nation	1.392	-3.409	*
Hokkaido	1.569	-4.568	**
Tokyo	1.062	-3.252	*
Aichi	0.745	-3.211	*
Osaka	1.870	-3.379	*
Real mortgage rate			
Nation	-2.732	-3.989	**
Hokkaido	-2.824	-3.841	**
Tokyo	-2.471	-4.22	**
Aichi	-2.112	-4.518	**
Osaka	-1.873	-4.577	**
Real income			
Nation	-2.182	-3.266	*
Hokkaido	-2.423	-2.692	+
Tokyo	-1.158	-3.614	**
Aichi	-2.099	-3.431	*
Osaka	-1.523	-3.750	**
Real external flow			
Nation	-0.849	-2.949	*
Hokkaido	-0.870	-2.912	*
Tokyo	-0.811	-2.966	*
Aichi	-0.816	-2.966	*
Osaka	-0.814	-2.998	*

Notes: Statistics significant at 10% (+), 5% (*) and 1% (**) levels.

Table 4: Causality tests between condominium prices and transaction volumes

Null Hypothesis:	Obs.	F-Statistic	Prob.
National level			
Transaction volume does not cause price inflation	96	1.905	0.048
Price inflation does not cause transaction volume		0.659	0.785
Hokkaido			
Transaction volume does not cause price inflation	97	1.079	0.390
Price inflation does not cause transaction volume		1.219	0.290
Tokyo			
Transaction volume does not cause price inflation	96	1.031	0.431
Price inflation does not cause transaction volume		0.950	0.504
Aichi			
Transaction volume does not cause price inflation	96	0.958	0.496
Price inflation does not cause transaction volume		0.930	0.522
Osaka			
Transaction volume does not cause price inflation	96	1.629	0.103
Price inflation does not cause transaction volume		1.587	0.115

Notes: The causality test is based on the heterogeneous panel model.

Table 5: Johansen cointegration tests

Rank	Parms	LL	Eigenvalue	Trace statistic		5% critical value
Nation						
0	80	1127.582	.	65.160	*	53.120
1	88	1143.795	0.272	32.732		34.910
2	94	1152.732	0.161	14.858		19.960
3	98	1158.837	0.113	2.649		9.420
4	100	1160.162	0.026			
Hokkaido						
0	80	975.016	.	57.628	*	53.120
1	88	989.157	0.242	29.347		34.910
2	94	996.675	0.137	14.311		19.960
3	98	1001.659	0.093	4.342		9.420
4	100	1003.830	0.042			
Tokyo						
0	80	1237.229	.	57.285	*	53.120
1	88	1248.897	0.205	33.949		34.910
2	94	1259.413	0.186	12.915		19.960
3	98	1263.909	0.084	3.924		9.420
4	100	1265.871	0.038			
Aichi						
0	48	995.122	.	67.897	*	53.120
1	56	1015.697	0.327	26.746		34.910
2	62	1025.408	0.170	7.325		19.960
3	66	1028.267	0.054	1.607		9.420
4	68	1029.070	0.015			
Osaka						
0	48	1050.226	.	76.643	*	53.120
1	56	1071.220	0.332	34.655		34.910
2	62	1081.881	0.185	13.334		19.960
3	66	1087.408	0.101	2.280		9.420
4	68	1088.548	0.022			

Notes: The endogenous variables are the condominium price, mortgage rate, income, and capital inflow from abroad. Statistics significant at a 5% (*) level.

Table 6: Cointegrating relationships

	Coef	Std. Err	t-statistic	p-value	95% Conf Interval	
Nation						
Mortgage rate	0.408	0.049	8.380	0.000	0.312	0.503
Income	-2.539	0.901	-2.820	0.005	-4.305	-0.773
Capital inflow	-0.240	0.039	-6.220	0.000	-0.315	-0.164
Constant	21.682	.	.	.	.	.
Hokkaido						
Mortgage rate	1.310	0.241	5.440	0.000	0.838	1.782
Income	2.226	4.856	0.460	0.647	-7.290	11.743
Capital inflow	-0.583	0.218	-2.680	0.007	-1.009	-0.156
Constant	-14.187	.	.	.	.	.
Tokyo						
Mortgage rate	0.446	0.082	5.440	0.000	0.285	0.606
Income	-1.265	1.254	-1.010	0.313	-3.724	1.194
Capital inflow	-0.660	0.139	-4.760	0.000	-0.932	-0.388
Constant	13.438	.	.	.	.	.
Aichi						
Mortgage rate	0.386	0.044	8.710	0.000	0.299	0.473
Income	-3.024	0.657	-4.610	0.000	-4.311	-1.737
Capital inflow	-0.180	0.033	-5.480	0.000	-0.245	-0.116
Constant	24.865	.	.	.	.	.
Osaka						
Mortgage rate	0.094	0.030	3.170	0.002	0.036	0.153
Income	-3.236	0.418	-7.750	0.000	-4.055	-2.417
Capital inflow	-0.226	0.023	-10.000	0.000	-0.270	-0.182
Constant	27.787	.	.	.	.	.

Notes: The statistics are based on the Johansen test, and the parameter for the condominium price is normalized.

Table 7: Transaction volumes by quantiles of condominium prices

	Quantile (%)	Mean	Std. Dev.	Min	Max
Aggregate	25	12723.000	1919.257	9803	18188
	50	11994.000	1563.750	8974	17517
	75	13426.630	2314.210	11016	21088
	100	14560.740	2421.598	10638	21333
Disaggregate					
Com to Com	25	415.714	92.182	288	703
	50	379.556	87.591	234	539
	75	385.815	71.350	293	580
	100	464.000	98.773	296	733
Com to Ind	25	4305.071	744.433	3195	6532
	50	3479.481	601.659	2399	5217
	75	3439.259	767.980	2477	5556
	100	3657.481	726.161	2583	5670
Ind to Com	25	1867.214	252.857	1410	2479
	50	2216.296	228.869	1880	2747
	75	2720.000	307.759	2277	3618
	100	3489.630	435.512	2567	4667
Ind to Ind	25	6122.964	1043.652	4498	9360
	50	5916.407	847.119	4403	9026
	75	6863.556	1362.864	5355	11343
	100	6944.926	1249.128	5185	10271

Notes: Condominium prices are classified according to the quantile; and the higher the quantile, the more expensive the condominiums.

Table 8: Marginal effects from the quantile regressions

	Margin	Delta-method Std. Err.	t-statistic	p-value	95% Conf.	Interval
	Aggregate					
Nation	0.005	0.003	2.080	0.040	0.000	0.011
Hokkaido	0.000	0.008	-0.020	0.983	-0.017	0.017
Tokyo	0.008	0.003	2.550	0.012	0.002	0.014
Aichi	0.018	0.010	1.770	0.081	-0.002	0.039
Osaka	0.004	0.005	0.910	0.364	-0.005	0.014
	Disaggregate					
Hokkaido						
Com to Com	0.005	0.008	0.630	0.528	-0.011	0.022
Com to Ind	0.016	0.009	1.790	0.077	-0.002	0.033
Ind to Com	0.002	0.009	0.200	0.839	-0.017	0.020
Ind to Ind	-0.007	0.008	-0.820	0.414	-0.023	0.010
Tokyo						
Com to Com	0.005	0.005	1.060	0.291	-0.005	0.015
Com to Ind	0.000	0.006	0.050	0.958	-0.012	0.013
Ind to Com	-0.003	0.006	-0.440	0.658	-0.015	0.010
Ind to Ind	0.018	0.007	2.460	0.016	0.004	0.033
Aichi						
Com to Com	0.001	0.005	0.280	0.778	-0.009	0.012
Com to Ind	0.009	0.008	1.040	0.303	-0.008	0.025
Ind to Com	0.011	0.007	1.630	0.106	-0.002	0.025
Ind to Ind	0.005	0.011	0.470	0.643	-0.017	0.027
Osaka						
Com to Com	0.001	0.005	0.150	0.884	-0.009	0.010
Com to Ind	0.007	0.006	1.210	0.228	-0.005	0.019
Ind to Com	0.005	0.005	0.960	0.338	-0.005	0.016
Ind to Ind	-0.004	0.009	-0.4606	0.650	-0.023	0.014

Notes: Statistics are obtained at the 95% quantile.

Table 9: Marginal effects from the quantile regressions

Quantile(%)	Margin	Delta-method Std. Err.	t-statistic	p-value	95% Conf. Interval	
Nation	Aggregate					
75	0.003	0.001	2.810	0.006	0.001	0.006
55	0.003	0.001	2.640	0.010	0.001	0.005
35	0.002	0.001	1.980	0.051	0.000	0.004
15	0.002	0.001	1.040	0.301	-0.001	0.004
Tokyo	Aggregate					
75	0.004	0.002	2.470	0.015	0.001	0.008
55	0.002	0.002	1.620	0.109	-0.001	0.006
35	0.001	0.002	0.720	0.474	-0.002	0.005
15	0.000	0.002	-0.200	0.842	-0.005	0.004
	Dissagregate					
75						
Com to Com	0.004	0.002	1.510	0.135	-0.001	0.008
Com to Ind	0.002	0.002	0.920	0.361	-0.002	0.006
Ind to Com	0.000	0.003	-0.010	0.993	-0.007	0.007
Ind to Ind	0.009	0.003	2.680	0.009	0.002	0.016
55						
Com to Com	0.003	0.002	1.680	0.097	0.000	0.006
Com to Ind	0.003	0.002	1.700	0.092	0.000	0.006
Ind to Com	0.003	0.002	1.630	0.106	-0.001	0.006
Ind to Ind	0.003	0.002	2.070	0.041	0.000	0.007
35						
Com to Com	0.002	0.002	1.040	0.302	-0.002	0.006
Com to Ind	0.003	0.002	1.470	0.145	-0.001	0.008
Ind to Com	0.004	0.002	1.790	0.077	0.000	0.009
Ind to Ind	-0.002	0.003	-0.730	0.467	-0.007	0.003
15						
Com to Com	0.001	0.003	0.370	0.714	-0.005	0.007
Com to Ind	0.004	0.003	1.150	0.255	-0.003	0.010
Ind to Com	0.006	0.004	1.440	0.153	-0.002	0.015
Ind to Ind	-0.008	0.005	-1.550	0.125	-0.018	0.002

Notes: Statistics are obtained at the 75, 55, 35, and 15% quantiles.

Figure 1: Regional condominium price indexes (nominal values, 2008M4-2017M4)

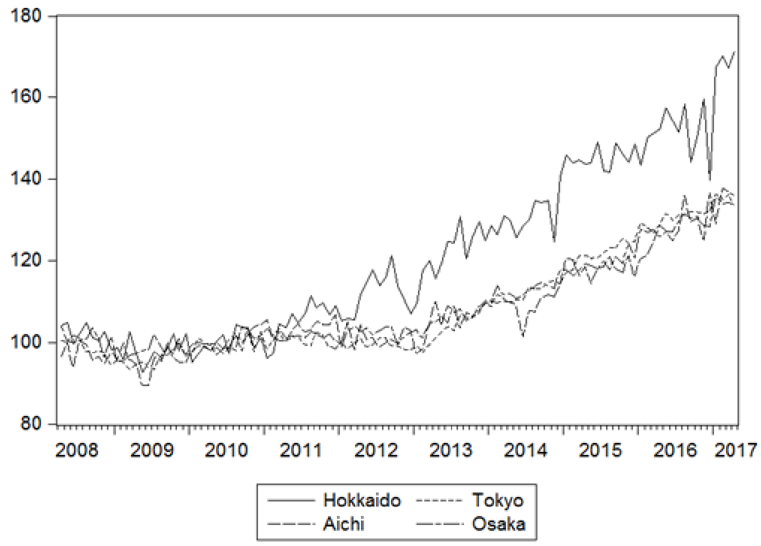


Figure 2: Real estate price indexes (national average, nominal values, 2008M4-2017M4)

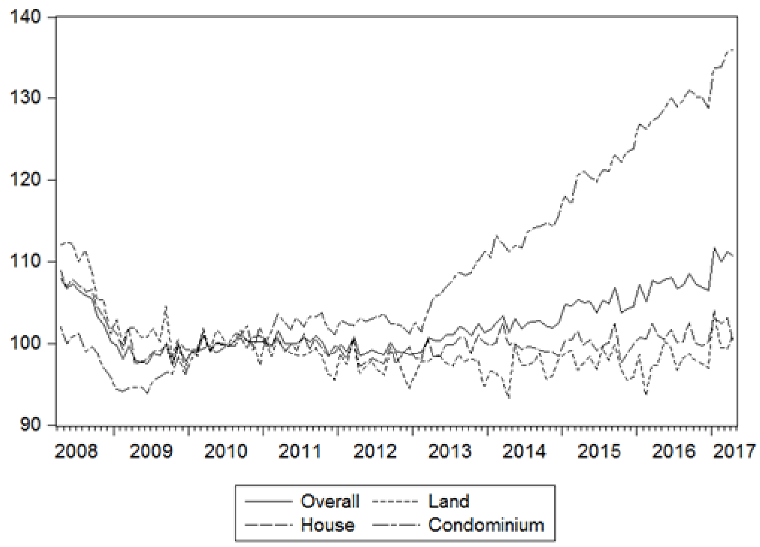


Figure 3: A fraction of condominium price inflation (National average)

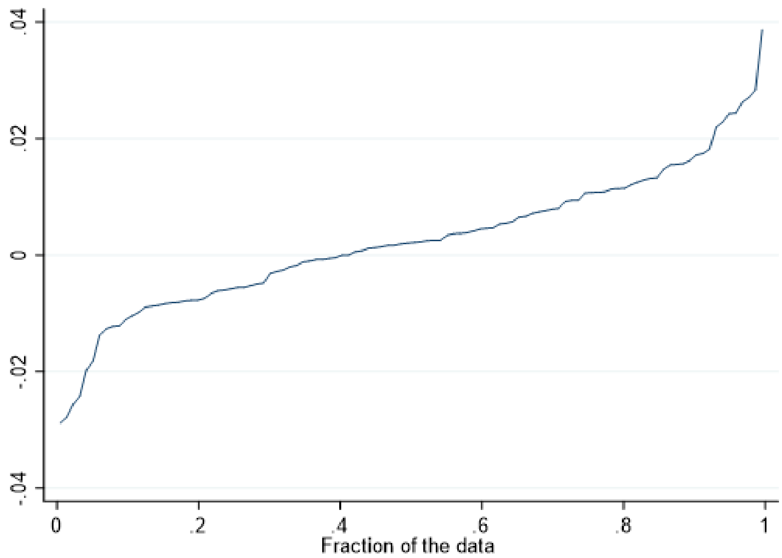


Figure 4: Transaction volumes (National aggregates)

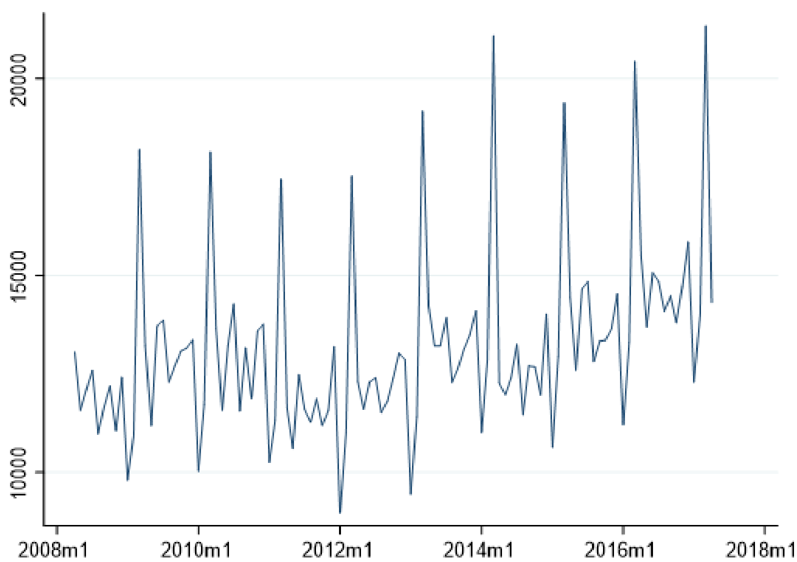
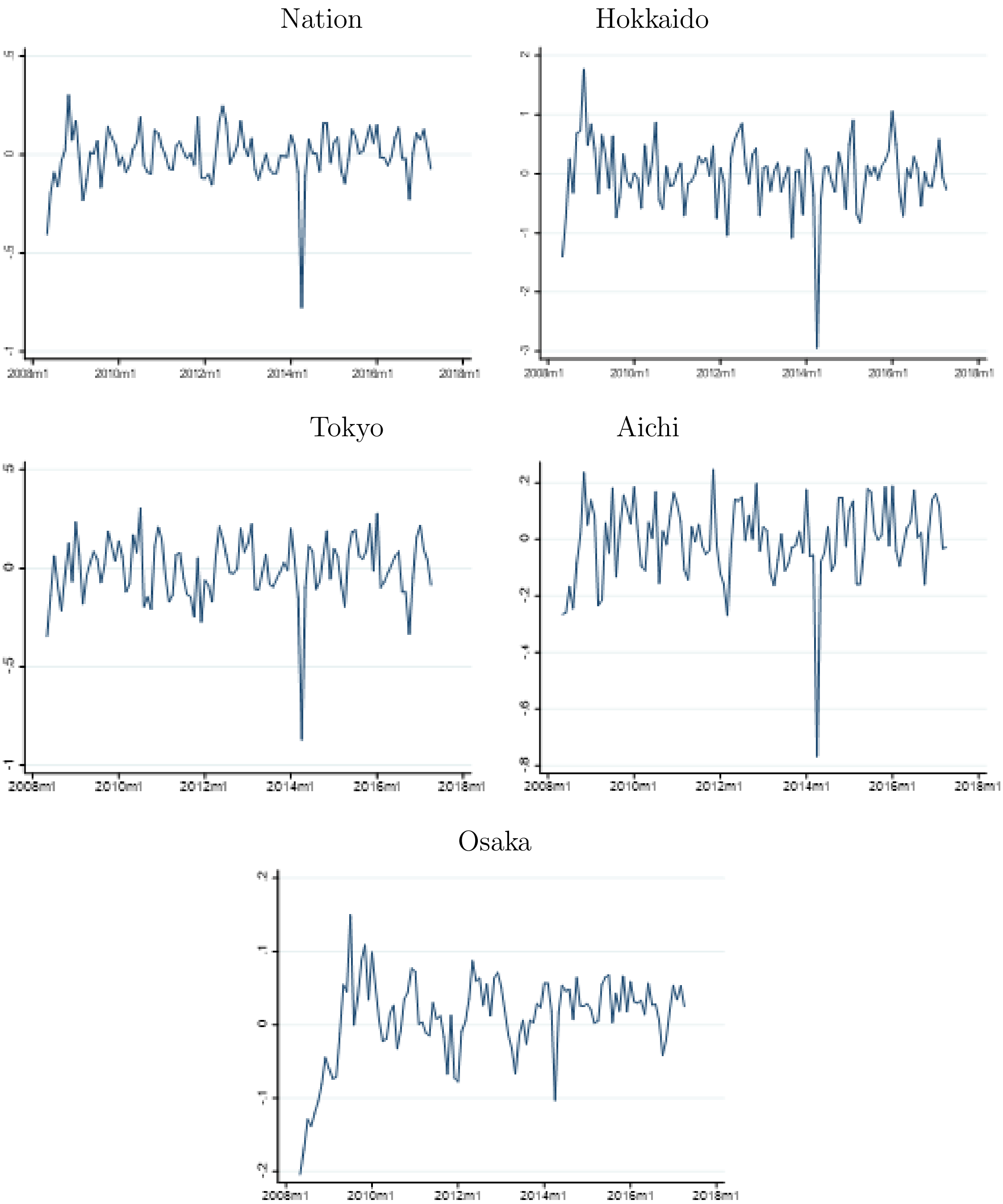
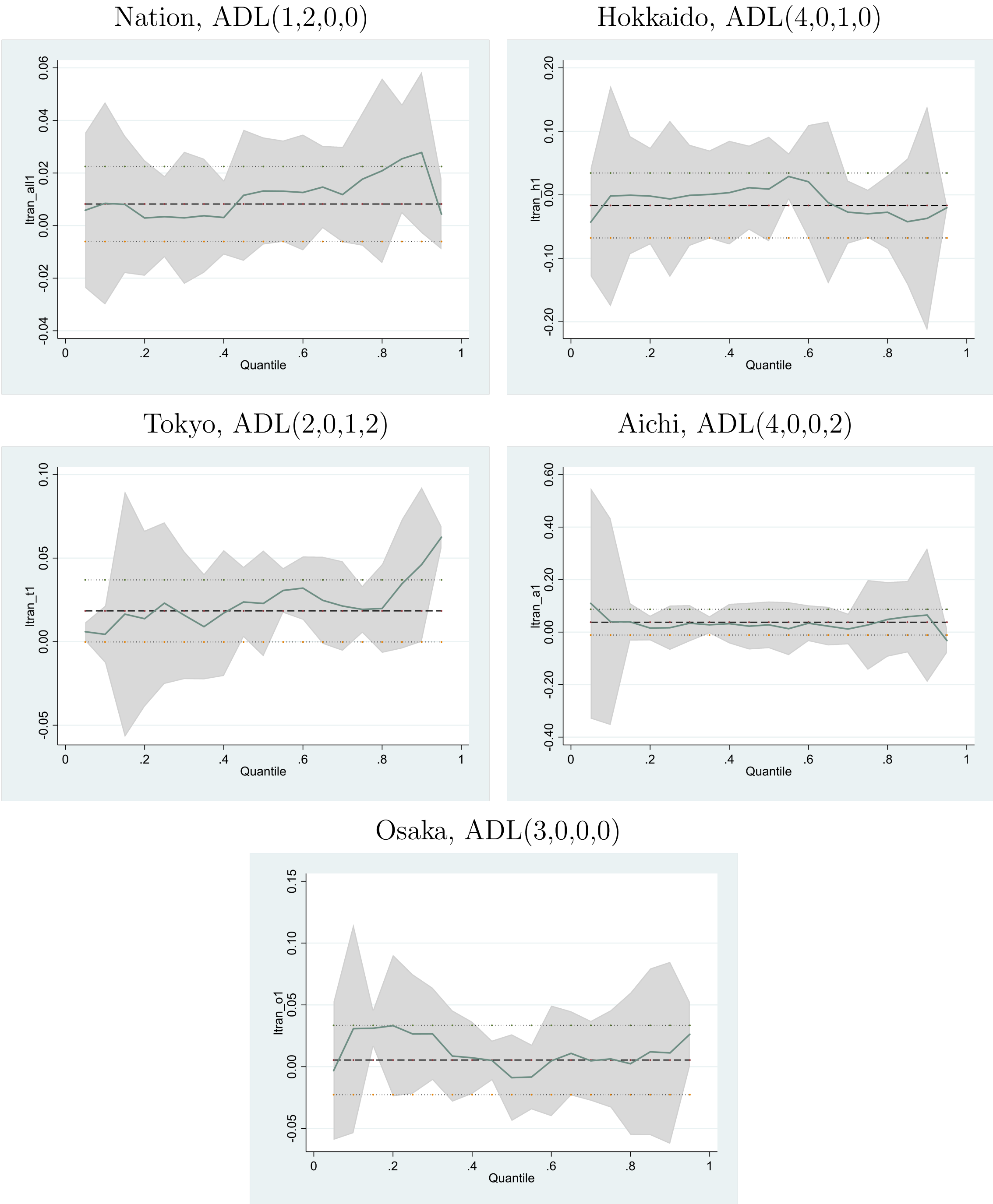


Figure 5: Disequilibrium conditions inferred from cointegration analyses



Note: The error correction models based on Table 6.

Figure 6: Quantile regression results from aggregate data



Note: OLS estimates and confidence intervals are also shown with dot lines.