Overinvestments and Housing Bubbles in China

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By
Qiqi Qiu
(Ph.D Candidate in Economics)

(Committee of Dissertation)

Supervisor: Professor Junmin Wan

Professor Shin-ichi Fukuda

Professor Konari Uchida

Professor Mitsuo Takase

Professor Ko Nishihara

Graduate School of Economics
Fukuoka University

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Chapter 1

Introduction

1.1 Research objectives and motivation

There is currently a housing bubble in China, as reported by Wan (2018a and 2018b) and Wan and Qiu (2020). This dissertation aimed to clarify the extent of any overinvestment in the real economy, such as the real estate and construction sectors. On August 23, 2021, real estate firms were instructed by the People's Bank of China and Ministry of Housing and Urban-Rural Development of China to resolve the financial crisis in the real estate market, including the debt crisis of the Evergrande Group.[1] The Chinese government has acknowledged the need to guard against systematic financial risk emanating from the real estate sector. One source of financial risk is the debt associated with overinvestment (Wan 2018a). Hence, identification of overinvestment and formulation of remedial policies could help to stabilize the real economy and society as a whole.

Housing prices in China have continually risen over the past 20 years, where the housing bubble has become a major issue in China. The existence of a bubble was demonstrated empirically by Wan (2018a and 2018b) and Wan and Qiu (2020). The corporate, household and banking sectors have been significantly affected by this bubble. Wan and Qiu (2020) reported that 13 housing-related industries may be overinvested in the housing market. Moreover, speculative saving by householders has occurred in association with the housing bubble in China (Wan 2015). As an internationally impactful spillover effect of the housing bubble, speculative saving has caused an imbalance between current accounts in the U.S. and China, which precipitated the U.S.–China Trade War (2021a). It is found that non-perform loans (NPLs) have been raised by housing bubble in Wan (2018a).

A question naturally arises as to whether the activities of real estate firms and the construction industry in China have influenced the housing bubble. As such, these entities are the research objects of this dissertation. we follow Wan and Qiu (2020) using the q approach to analyze these two sectors.

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[1] https://www.moodys.com/zh-cn/credit-ratings/Hengda-Real-Estate-Group-Company-Limited-credit-rating-830343731/ratings/view-by-class

1.2 Structure of the thesis

In Chapter 2, a literature review on the transmission mechanism from the housing bubble to housing-related industry sectors is provided. We discuss whether the demand-side theory of Wan (2021) can be applied to analyze the transmission from house prices to the Producer Price Index (PPI), based on the Granger causality test.

In Chapter 3, we empirically examine whether 19 real estate firms are being affected by the housing bubble in China, and whether there is overinvestment in these firms. We estimate the rate of depreciation for these firms, and use the Marginal and Average *q* to analyze corporate investment therein. The stock market has crashed many times, which could "squeeze out" the bubble, according to Wan (2018b). Against this background, We compare our Marginal and Average *q* values with those of Chrinko and Schaller (2001).

In Chapter 4, we show that the construction sector is key to the transmission from the housing bubble to housing-related sectors in China, where 28.7% of the GDP of China is derived from this sector (Rogoff and Yang 2021). In a literature review, we summarize and compare studies on construction sector investment and housing prices.

In Chapter 5, we use macro data to estimate the Marginal *q*, to further characterize the investment in the construction sector in China. We also report the average ratio between the total output value of housing construction and the construction sector overall for the period 2001–2019; using an input-output table, this was 62%.[2] The construction sector accounts for 6.69% of the total workforce of China,[3] and thus is important for China's economy. Hence, it is necessary to analyze the relationship between the housing bubble and construction sector investment in China.

1.3 Main findings of the thesis

The most important finding of this thesis is that overinvestment in the real estate and construction sectors is caused by the housing bubble in China. The Chapter 2 shows literature survey of empirical (e.g., Qiu and Wan 2018) and theoretical studies (e.g., Wan 2021b) revealed a transmission mechanism from house prices to the PPI. The Chapter 3 shows that the economic depreciation theory of Wan (2019) can explain the depreciation rate by

[2, 7] Estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Depreciation Expense as Accounting Item (DEAI). The before-tax Marginal and Average q values calculated herein were close to those for Japan in the 1980s, according to Ogawa et al. (1994). A high Marginal q in a housing bubble era indicates that real estate firms obtain additional profit from the bubble through speculative investment. It was found that the before- and after-tax Marginal q values were significantly higher than the Average q, while the after-tax Marginal q was significantly higher than the Average q, according to various tests. Tobin q theory can be used to explain the investment behaviors of the 19 real estate firms in China studied herein. Regarding the elasticity values, the before- and after-tax Marginal and Average q were lower than the Marginal q in industrial sectors, according to Wan and Qiu (2020).

In Chapter 4, we found that the demand-side theory of Wan (2021b) can be used to analyze transmission from the housing bubble to the construction sector in China. It is necessary to analyze the relationship between construction sector investment and the housing bubble using the framework of Wan (2021b).

Finally, in the Chapter 5, the development of a system for machinery leasing in the construction sector has reduced investment in fixed assets in this sector in China. Hence, the depreciation rate cannot be estimated via the Perpetual Inventory Method (PIM) for the construction sector. The Average value of the depreciation rate by DEAI was close to those for the US and Japan, as reported by Suga and Nomura (2018), while the before-tax Marginal q was close to that for Japan in the 1980s, as reported by Ogawa et al. (1994). Economic depreciation theory and Tobin q theory can explain the DEAI and investment in the construction sector in China.

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Chapter 2

Transmission from Housing Price to Producer Price Index: A Survey[1]

Abstract

Housing prices in China have formed a major bubble that has caused domestic issues, such as demand shortage, and international issues, such as trade imbalance between the U.S. and China. This chapter reports a survey on transmission from housing prices to the Producer Price Index (PPI), to analyze why housing bubbles induce such issues, particularly from the perspective of industrial sectors. According to conventional theory supported by numerous empirical studies, PPI may affect housing price by the cost driver of factor input. Wan's (2021a) recent transmission or demand driving theory suggests that housing prices may have a significant impact on PPI. Qiu and Wan (2018) conducted Granger causality tests by province and Wan and Qiu (2020) performed the same tests nationwide and concluded that the transmission hypothesis expanded by demand driving theory may explain the relationship between housing prices and PPI in China. Hence, it is crucial for China that the existing housing bubble end with a soft landing and that the formation of a new housing bubble is prevented (Wan 2018a, 2021c).

JEL classification: E13, E22, D24

Keywords: China, cost driving, demand driving, Granger causality test, PPI, housing price, transmission theory

[1] This chapter is from Qiu (2021b).

2.1 Introduction

2.1.1 The rationale behind the survey

Housing prices have had a range of impacts on China. We reviewed the existing literature on these impacts from both domestic and international perspectives. Wan (2018b) analyzed the relationship between housing prices and bad bank loans in the Chinese context and found that the housing bubble was a key contributor to the rise of non-performing loans (NPLs). It also emerged that the housing bubble may lead to overinvestment from the financial side. Kuang and Liu (2015) analyzed the impact of housing prices and inflation rates on household consumption and economic growth by constructing a new theoretical model of general equilibrium and using data from 35 major cities in China from the period 1996–2010. They found that the impact of inflation on housing prices is stronger than the reverse result, that family income has a positive impact on housing prices, and that economic growth has a greater impact than inflation on housing prices.

The above mentioned studies highlighted the economic problems caused by the rapid rise of housing prices in China. China’s domestic housing prices affect not only the economy but also various other aspects. Clark et al. (2020) conducted a large sample data analysis on the relationship between house prices and fertility in China and anticipated that the rise in housing prices during the period 2013–2017 would lead to a decline in fertility and asserted a negative correlation between house prices and fertility. Wrenn et al. (2019) analyzed the relationship between housing prices and the first marriage rate in China. Empirical analysis using micro data of urban housing prices and the first marriage rate in China from 2000 to 2005 revealed that rising house prices in China led to a decline in the first marriage rate.

Bubble tests identified housing bubbles in 36 of China’s major cities (Wan 2015, 2018, Wan and Qiu 2020). The rapid growth of China's housing prices has become a key concern for the global economy and has contributed to several problems, such as the inefficient investment caused by housing bubbles. Wan and Qiu (2020) empirically demonstrated that overinvestment in housing-related sectors is among the housing bubble’s negative effects.

The above are examples of domestic studies on the social and economic impact of China's rising house prices. Next, we summarize some literature on the global impact of China's housing prices. Qiu and Wan (2018) analyzed the spillover of overinvestment of industry sectors resulting from China's housing bubble on international trade and argued that overinvestment and over-capacity in industrial sectors, such as iron, steel, and coal mining, have given rise to trade disputes with the U.S. in relation to China's steel and other export products.

Wan (2021) proposed the speculative savings hypothesis to analyze the U.S.–China trade war. The housing bubble placed the excessive savings of China's households under resource constraint, while U.S. households' under-savings did not come under resource constraint because of the dollar's status as a key currency. This happened simultaneously in China and the U.S. Through this new theory, the author suggests that restraining the real estate bubble may alleviate the tension of the trade war by mitigating the trade imbalance between the U.S. and China.

However, the precise mechanisms by which housing prices affect industrial investment by sector from the theoretical and empirical perspectives remain unclear. Herein, we conduct a literature survey on the transmission from housing price to factor price (e.g., the Producer Price Index as a proxy) based on existing theories and empirical results. Through this work, we may obtain a better understanding of why the overinvestment issue exists and how it may be overcome in China by clarifying the transmission from housing prices to the Producer Price Index (PPI).[2]

2.1.2 Contribution of this chapter

We conducted a survey on transmission from housing prices to the PPI. Conventional theory predicts that the PPI may affect housing prices via the cost driving of factor input. By contrast, housing prices may have a significant impact on the PPI via transmission theory. Granger causality tests conducted by province and

[2] The PPI, as a price index that can be more quickly affected by housing prices, is more suitable for analyzing the effects of price trans mission than the Consumer Price Index (CPI). Although the CPI will also be affected by housing prices in the general equilibrium model, the PPI will be more directly affected. Therefore, this study selects PPI as a proxy variable for analyzing housing price transmission.

nationwide in China support the transmission hypothesis or demand driving theory. Thus, we may conclude that transmission theory might satisfactorily explain the relationship between housing prices and PPI in China. This suggests that the current housing bubble in China may cause greater harm than is conventionally anticipated via transmissions among industrial sectors. Hence, it is crucial for China that the existing housing bubble end with a soft landing and that the formation of a new housing bubble is prevented (Wan 2018a, 2021c).

2.1.3 Organization of the chapter

The remainder of this chapter is organized as follows. The conceptual framework is presented in Section 2; Section 3 presents the empirical results of Qiu and Wan (2018); and in Section 4, we summarize the conclusions and discuss possible avenues for future research.

2.2 Conceptual framework for transmission between housing price and PPI

2.2.1 Determinants of housing price and transmission from PPI to housing price

According to conventional theory, the PPI may affect housing prices by the cost driving effect of factor input because the PPI affects housing prices through its influence on construction material prices. Zhang et al. (2012) used time series data to analyze empirically the factors that promote the growth of housing prices in China from multiple perspectives, including increases in land prices and PPI nationwide. This evidence supports the cost driving hypothesis.

Wang and Zhang (2014) analyzed the impact of basic factors, such as urban registered permanent residence population, wage income, land supply, and cost reduction on housing prices in China. Through empirical analysis using housing price, population, and income data from 35 major cities in China for the period 2002–2008, the increasing house prices in most cities were shown to be affected by basic factors. The rise in housing prices in some coastal cities may be due to investment, among other reasons. This supports Zhang et al.'s (2012) conclusion, which was also consistent with the cost driving hypothesis. Li and Chand (2013) analyzed the impact of the market on housing prices using house price data from 29 provinces in China as of 2009. The results show that income, construction cost, marriage, and land costs affect house prices. These findings also support a typical cost driving hypothesis.

Wen et al. (2014) conducted an empirical study to determine whether China's educational facilities affect housing prices. The study used data on housing prices and educational facilities in 660 communities in Hangzhou, China, to perform spatial econometric analysis. It was found that improvements in teaching quality in primary and junior middle schools promoted increases in housing prices in corresponding school districts. Housing prices also increased with the reduction in distance from kindergartens, high schools, and universities This is a typical example of housing prices being pushed up by the cost of education and supports the cost-driving hypothesis.

2.2.2 Transmission from housing prices to PPI

Wan and Qiu (2020) conducted an empirical analysis of the transmission relationship between housing price and industrial sector investment in China, using the input-out table as an important transmission connection tool to identify which sector showed overinvestment, and the Granger causality test was applied based on national housing price, PPI, and Marginal q value. Their study found that housing prices showed Granger causality in relation to the PPI while the opposite relationship was rejected. This evidence is contrary to the literature, such as Zhang et al. (2012). Thus, it seems puzzling that housing price affects PPI in China.

Several studies examined the transmission relationship between housing prices and the PPI in China, including Cook et al. (2018), Rogoff and Yang (2021), Liu and Xiong (2018), and Hau and Ouyang (2018). Although these studies constructed a theoretical framework for transmission, they were not comprehensive because analyses of price and quantity and analyses of general equilibrium were not involved in the process of transmission analysis. Cook et al. (2018) and Rogoff and Yang (2021) used input-output tables without applying neoclassical theory, while Liu and Xiong (2018) and Hau and Ouyang (2018) used a neoclassical economic model without an input-out table. By contrast, Wan (2021a) proposed a general equilibrium model of price transmission theory combining a neoclassical model with an input-output table to analyze the impact of housing price on PPI. Thus, Wan (2021a) initiated the application of demand driving theory to the housing bubble's transmission effect. Contrary to the cost driving theory, the demand-driving or transformation hypothesis predicts that housing price will have an impact on PPI.

Wan (2021a) proposed a transmission theoretical framework combining neoclassical economics theory with an input-output table to study the impact of house prices on other industrial sectors. This new theory explicitly models household, housing-related industries, material industries, and non-housing industries by connecting input-output tables with a general equilibrium model to clarify the transmission of the price and quantity for each sector. Under this theoretical framework, the housing bubble will have an impact on both housing-related (overinvestment or crowding in effect) and non-housing industries (underinvestment or crowding out effect). This theory may also explain why a downward trend in CPI is evident during the housing bubble period in both China and Japan. The findings may also contribute to explaining U.S.–China trade disputes caused by trade imbalances from the industrial sector's perspective (Wan 2021b).

2.3 Empirical study on the transformation between housing price and PPI

2.3.1 Data source on time series data of housing prices and PPI

Qiu and Wan (2018) collected time series data on average selling prices of commercialized residential properties for 31 provinces and autonomous regions in China from 2000 to 2016 from the China National Bureau of Statistics (http://data.stats.gov.cn/). Qiu and Wan (2018) also collected time series PPI data for 31 provinces and autonomous regions in China for the period 2000–2016 from the China National Bureau of Statistics (http://data.stats.gov.cn/).

2.3.2 Granger causality test

Qiu and Wan (2018) used Toda and Yamamoto's (1995) method for the Granger causality test. Here, we explain why the Granger (1969) method was not applicable for causality tests in Qiu and Wan (2018). Following Wan (2015), Wan (2018), and Qiu and Wan (2018), the bubble test found that during the period 2004–2017, housing prices showed explosive processes in 31 of China's provinces and major cities. That is, price bubbles were evident in China's housing prices. We know that the Granger (1969) method strictly requires stationary data and cannot be applied directly to explosive data. However, Toda and Yamamoto (1995) proposed an approach to mitigate these requirements by relaxing the data's stationarity. Therefore, Qiu and Wan (2018) adopted Toda and Yamamoto's (1995) method for their causality test of housing prices and PPI in China.

The following Granger causality test functions are based on Toda and Yamamoto (1995):

$$x_t = \sum_{i=1}^{s} \lambda_i x_{t-i} + \sum_{j=1}^{s} \delta_j y_{t-j} + u_{2t}, \quad (1)$$

$$y_t = \sum_{i=1}^{s} \alpha_i x_{t-i} + \sum_{j=1}^{s} \beta_j y_{t-j} + u_{1t}. \quad (2)$$

Housing price and PPI at time *t* are represented by y_t and x_t, respectively. The null hypotheses to be tested are

$\boldsymbol{H_0}$: $\delta_j = 0$, $j = 1 \ldots s$, which means that housing price does not Granger cause PPI;

$\boldsymbol{H_0}$: $\alpha_i = 0$, $j = 1 \ldots s$, which means that PPI does not Granger cause housing price.

If neither hypothesis is rejected, no Granger causality is identified between housing price and PPI. If the first hypothesis is rejected, Granger causality is evident between housing price and PPI. If the second hypothesis is rejected, Granger causality is evident between PPI and housing prices. If neither hypothesis is rejected, a bi-directional causality relationship is identified between housing prices and PPI.

2.3.3 Selection of lag length and empirical results

A long lag is better in theory but is limited by sample size. In Qiu and Wan (2018), the sample size was 16. When one lag was chosen, Granger causality was identified between PPI and housing prices in 12 out of 31 provinces, while 18 out of 31 provinces showed Granger causality between housing price and PPI. When two lags were chosen, Granger causality was identified between PPI and housing prices in 11 out of 31 provinces, while Granger causality was observed between housing prices and PPI in 29 out of 31 provinces. When three lags are chosen, Granger causality was evident between PPI ad housing prices in 13 out of 31 provinces, while Granger causality was observed between housing price and PPI in 31 out of 31 provinces (i.e., all provinces). Although the results are sensitive to lag length selection, it is clear that the impact of housing price on PPI is stronger than the impact of PPI on housing price. These results support the transmission hypothesis developed by Wan (2021a).

2.4 Summary and Implications

2.4 .1 Summary

The housing bubble in China has caused domestic issues, such as demand shortage, and the international issue of trade imbalance between the U.S. and China. This study is a literature survey on the relationship between housing prices and PPI in China, to analyze why housing bubbles induce such issues, particularly from the perspective of the industrial sectors. In theory, causality between housing prices and PPI has two modes: on one hand, PPI may affect housing prices in line with cost (or supply) driving theory. On the other hand, according to demand driving theory, housing prices may affect PPI.

Based on Granger causality test results regarding housing prices and PPI in China, as reported in the existing literature, it was found that the Granger causality of housing prices on PPI is stronger than Granger causality of PPI on housing prices. The demand driving theory may be more suitable than the cost driving theory for explaining the current relationship between housing prices and PPI in China. Therefore, we believe that the ongoing rise in housing prices has affected the PPI in China. This indicates that housing prices may affect enterprise investment via the corporate profit oriented by PPI.

2.4.2 Implications

Analysis of the relationship between housing prices and investment in construction sector in China (Qiu 2021a) will involve analysis of the transmission relationship. Although the relationship between housing prices and investment is closer in the construction sector than in the industrial sector, the transmission relationship must still be analyzed in detail. We believe that in the next study of the transmission relationship between housing prices and construction investment, we must not only apply the data derived from the input-output table but also determine the transmission data pertaining to quantity and price, which requires detailed industrial data. Where such detailed industrial data cannot be obtained, we will use an input-output table combined with a Granger causality test and the transmission theoretical framework developed by Wan (2021a) for our analysis. This will allow us to clarify the role of housing prices in construction investment and determine whether this transmission effect can still be attributed to demand driving.

Through this survey, we have attained a fuller understanding of why overinvestment issues have emerged in China. If overinvestment in the construction sector is also confirmed by further study, the extent of serious damage to both the industrial and construction sectors caused by the housing bubble will be determined via transmission theory. In this case, the prevention of a new housing bubble and a soft landing for the existing housing bubble are crucial for China, as noted by Wan (2018a, 2021c).

2.4.3 Issues left for future research

Regarding unresolved issues in the literature, we should note that the Granger causality test on the transformation relationship is only a part of the transmission effect, since no linkage is present between quantity and price by sector. If quantity and price data of industrial output by sector or by enterprise can be used together with a panel Granger causality test, results that are more comprehensive could be obtained. Furthermore, a structural model for general equilibrium analysis is required.

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Chapter 3

Residential Investments and Housing Price: *q* Analysis by Listed Real Estate Firms in China during 2002-2020[1]

Abstract

This chapter estimates the depreciation rate by Depreciation Expense as Accounting Item (DEAI) with and without inventory, the before- and after-tax Marginal *q*, and the Average *q* of the top 19 listed real estate firms in China. The Average values of these firms' before-tax Marginal *q* and Average *q* are higher than the value of real estate firms in 1980s Japan. The value of before- and after-tax Marginal *q* is significantly higher than the value of Average *q* in China, similar to the real estate sector and almost all sectors in Japan in Ogawa et al. (1994), while strikingly opposite to findings in Chirinko and Schaller (2001) whereby Average *q* was higher than Marginal *q* for Japan's listed firms during the 1980s. The high Marginal *q* value suggests that real estate firms obtain bubble profit by selling bubbly housing. The before- and after-tax Marginal *q* and Average *q* of the China Evergrande Group drastically decreased from 13.8307, 8.0304, 2.0198 in 2010 to 1.1330, 0.5213, 0.9791 in 2020, respectively. Thus there are overinvestments in the China Evergrande Group and the other similar firms based on Tobin's *q* theory. The depreciation rate and investment can be explained by economic depreciation theory and Tobin's *q* theory using panel estimations. This indicates overinvestment caused by bubbly Marginal *q* in China's real estate sector.

JEL classification: E13, E22, D24

Keywords: after-tax Marginal *q*, Average *q*, before-tax Marginal *q*, China, investment, overinvestment, listed real estate firms

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1 This chapter is from Qiu and Wan (2021a), and the author thanks Professor Junmin Wan for the permission of use of manuscript.

3.1 Introduction

3.1.1 Debt crisis of real estate firms in China

The bond of China's largest real estate firm—the China Evergrande Group—was rated Ca by Moody's assessment on September 7, 2021. It was reported that many defaulted debts may ensue in the U.S. bond market (Nikkei, September 11, 2021), indicating a considerable possibility of default for the influenced firm.[2] Chinese real estate firms headed by the China Evergrande Group defaulted on central debt and were instructed by the People's Bank China and the Ministry of Housing and Urban-Rural Development of China on August 23, 2020 to prevent a systemic financial crisis.[3] The China Evergrande Group experienced a double crash in share and bond prices and was subsequently similarly instructed again by the People's Bank China and the China Banking and Insurance Regulatory Commission on August 19, 2021.[4] Real estate firms' debt default has clearly been an intensifying issue in China. Herein, we analyze the potential reasons for this.

3.1.2 Housing bubble, stock price bubble, and real investment of real estate firms

As real estate firms are housing suppliers, there is a natural tendency to assume that the current phenomenon has been caused by the housing market's intensifying bubble. Several studies have highlighted serious housing bubbles in major cities and nationwide in China, including Wan (2015, 2018a and 2018c) and Wan and Qiu (2020). Herein, we investigate possible causes of this debt crisis. The debt's major purpose is investment and speculation on land, fixed assets, and inventory; therefore, the major reason for the debt crisis may be overinvestment driven by the additional profit derived from making and selling housing in a price bubble.

Bubbles and crashes are also known to affect China's stock markets (Wan 2018c). The top 19 real estate firms have been listed, highlighting empirical and theoretical problems with respect to how investors evaluate or price real estate firms by creating

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[2] https://www.moodys.com/zh-cn/credit-ratings/Hengda-Real-Estate-Group-Company-Limited-credit-rating-830343731 /ratings/view-by-c lass

[3] http://www.pbc.gov.cn/goutongjiaoliu/113456/113469/4075935/index.

[4] http://www.cbirc.gov.cn/cn/view/pages/ItemDetail.html?docId=1002663&itemId=915&generaltype=0

a bubble. Based on Tobin's Marginal q theory, the marginal product of selling bubbly housing may induce additional corporative profit to increase Marginal q. Moreover, based on Tobin's Average q theory, stock market evaluations of bubbly profit (flow, the first source of stock market bubble) and fixed capital (the second source of stock bubble) may increase Average q. While the stock markets witnessed numerous price crashes, no nationwide crash occurred in China's real estate market. Herein, we will clarify how the real investment of real estate firms has been affected by q theory within both housing price bubbles and stock price bubbles under different market structures and different investors. We will compare further our methodology and results with the situation in Japan to identify differences or similarities, since the stock market and real estate market in Japan crashed in 1989 and 1991, respectively.

3.1.3 Contributions

We used data from the 19 listed real estate firms to estimate the depreciation rate in China. We used the same data to estimate these firms' before- and after-tax Marginal q and Average q. The Average value of before-tax Marginal q here is significantly higher than that of real estate firms in 1980s Japan, as reported by Ogawa et al. (1994). The high value of before- and after-tax Marginal q could be from the housing bubble, which could induce overinvestment. We further found that the before-tax Marginal q is significantly higher than the after-tax Marginal q and Average q, and the after-tax Marginal q is significantly higher than the Average q. Our findings are similar to those from Japan during the 1980s, as reported by Ogawa et al. (1994) but strikingly dissimilar from Chirinko and Schaller's (2001) findings pertaining to 1980s Japan wherein Average q equaled the summation of Marginal q and the stock price bubble. Replacement and new fixed and inventory investments can be explained by Marginal and Average q theory; hence, overinvestment issues may arise for real estate firms during housing bubble eras.

The China Evergrande Group has been in debt crisis. The before- and after-tax Marginal q and Average q drastically decreased from 13.8307, 8.0304, 2.0198 in 2010 to 1.1330, 0.5213 (<1), 0.9791(<1) in 2020, respectively. The q with value lower than

1 after the bubble crash implies that there are overinvestments based on Tobin q theory, thus there are overinvestments in the China Evergrande Group and the other similar firms.

3.1.4 Structure of this chapter

The remainder of the chapter is organized as follows. The research question and the hypotheses are presented in Section 2. Section 3 describes the data sources and the estimations of depreciation rate, before- and after-tax Marginal q and Average q. The empirical specifications and results are summarized in section 4. Section 5 summarizes the conclusions.

3.2 Research question and hypotheses

3.2.1 Housing bubble, investment, and *q* in real estate firms in China

In view of the serious housing bubble in China, real estate firms may derive additional profit from selling housing within a price bubble. Thereby, both the Marginal and Average q will have bubbly profit. Regarding the relationship between investment and q under a housing bubble; we predict the following:

Hypothesis 1: The depreciation rate of real estate firms in China is raised by the ratio of profit after tax because replacement investment could be accelerated by economic depreciation theory (Wan 2019).

Hypothesis 2: The investment behavior of real estate firms in China can be explained by the Marginal and Average q, whereby these q may include additional profits from the bubble (Tobin 1963, 1969).

The main point of the above two hypotheses would that overinvestments may occur because of bubbly Marginal q and bubbly Average q.

3.3 Depreciation rate, Marginal *q*, Average *q* and investment of the 19 listed real

estate firms

3.3.1 Panel data on the 19 listed real estate firms

We collected panel data from the balance sheets via the official homepages of the 19 listed real estate firms by year. We selected the top 20 real estate firms through the 2019–2021 comprehensive strength evaluation list of Chinese real estate development firms of the China Real Estate Association (http://cp.fangchan.com/#/). We excluded real estate firms dominated by leasing and construction businesses and those without annual financial reports. We also collected the yearly Average stock price of each firm from the website (https://cn.investing.com/equitie).

3.3.2 Estimations of depreciation rates by DEAI

Total Value of Fixed Assets with and without inventory

Owing to the particularity of real estate firms, the fixed assets in the balance sheets of real estate firms account for a small portion of the total assets, while the inventory accounts for a large portion of the total assets, and the profits of real estate enterprises are mainly derived from the inventory by speculative motive. Therefore, inventory should be included in the total value fixed assets (TVFA), and TVFA with inventory should be similar to the fixed assets of real estate firms. Compared with Ogawa et al.'s (1994) findings, which omitted land price from the estimation of q in Japan's real estate firms, the profits of real estate firms here are mainly derived from the sale of bubbly housing, and land premium cannot be excluded because the land, inventory, and TVFA are indivisible. We use the following formula to estimate TVFA with inventory:

$$TVFAHI_{it} = TVFA_{it} + Inventroy_{it}, \quad (1)$$

where

$TVFA_{it}$: total value of fixed assets of *i* real estate firm at time *t.*

$TVFAHI_{it}$: total value of fixed assets with inventory of *i* real estate firm at time *t.*

Estimation of depreciation rate by DEAI

We estimate the depreciation rate by DEAI, following Wan and Qiu (2021).[5] The particularity of real estate firms leads to two types of depreciation rate by DEAI: the first is the TVFA without inventory, and the second is the TVFA with inventory, which is used to estimate Marginal q in this study. We control inflation by the Average value of the Price Index for Investment in Fixed Assets (PIIFA) to estimate the two types of depreciation rate. DEAI with and without inventory is estimated using the following formula:

$$\delta_{DEAI-it\ (with\ inventory)} = \frac{(AD_{\ it} - AD_{\ it-1})/PIIFA_t}{TVFAHI_{\ it-1}},$$

$$\delta_{DEAI-it\ (without\ inventory)} = \frac{(AD_{\ it} - AD_{\ it-1})/PIIFA_t}{TVFA_{\ it-1}}, \tag{2}$$

where

$\delta_{DEAI-it(with\ inventory)}$: depreciation rate values by DEAI with inventory of *i* real estate firm at time *t*;

$\delta_{DEAI-it(without\ inventory)}$: depreciation rate by DEAI without inventory of *i* real estate firm at time *t*; and

$AD_{\ it}$: the accumulated depreciation of *i* real estate firm at time *t.*

Table 3.1 shows the two types of depreciation rate by DEAI for the 19 listed real estate firms. Figure 3.1 shows the trend of the two kinds of Average values of the 19 listed real estate firms by year.

3.3.3 Estimation of before- and after-tax Marginal *q* and Average *q*

Estimation of before- and after-tax Marginal q of the 19 listed real estate firms

We estimated the before- and after-tax Marginal q of 19 real estate firms in China. Because we used TVFA with inventory as the fixed assets to estimate the ratio of profits before and after tax and Marginal q, the Average value of depreciation rate by DEAI with inventory is used to estimate the Marginal q of the 19 listed real estate firms. We also estimated the interest ratio of the 19 listed real estate firms by firm data

[5] Due to the rise of housing price, the inventory in the fixed assets of real estate firms has increased, and the depreciation rate by perpetual inventory method (PIM) will be negative; we do not report the depreciation rateby PIM, but they are available upon requests.

on interest payments by year, and the average interest ratio value of each firm is used to estimate the Marginal q. We estimated Marginal q following Ogawa et al. (1994), Wan and Qiu (2020), and Qiu and Wan (2021) using the following formula:

$$Mq_{\,it} = \frac{\pi_{it}}{P^{I}_{it}} \frac{1+r_i}{r_i+\delta_{\,DEAI-i}}, \tag{3}$$

where

$Mq_{\,it}$: before- and after-tax Marginal *q* of *i* real estate firm at time *t*;

π_{it}: ratio of total profit before- and after-tax (with inventory) of *i* real estate firm at time *t*;

P^{I}_{it}: investment of *i* real estate firm at time *t*;

$\delta_{\,DEAI-i}$: average value of depreciation rate by DEAI (with inventory) of *i* real estate firm during the sample period; and

r_i: average value of interest payments of industrial sectors of *i* real estate firm during the sample period.

Table 3.2 shows the before-tax and after-tax Marginal *q* values by year for the 19 listed real estate firms in China. Figure 3.2 and Figure 3.3-3.21 show the trend of the average value by year and annual before- and after-tax Marginal *q* of the 19 listed real estate firms in China.

Estimation of Average q of the 19 listed real estate firms

We estimated the Average *q* of the 19 listed real estate firms in China. We followed Tobin (1963) and Tobin (1969) to estimate the Average *q* using the following formula:

$$Aq_{\,it} = \frac{EMV_{it}+TD_{it}}{TA_{it}}, \tag{4}$$

where

$Aq_{\,it}$: Average *q* of *i* real estate firm at time *t*;

$EMV_{\,it}$: equity market value (*Average Stock Price of Per Share*×*All Shares*) of *i* real estate firm at time *t*;

TD_{it}: total book value of debt of *i* real estate firm at time *t*; and

TA_{it}: total book value of assets of *i* real estate firm at time *t*..

The value of the Average q of 19 listed real estate firms in China by year is shown in Table 3.2. The trend of the average value by year and annual Average q of the 19 listed real estate firms are shown in Figure 3.2 and Figure 3.3-3.21, respectively.

As described in the first section of this study, the China Evergrande Group has been in debt crisis to experience a double crash in share and bond prices. The before- and after-tax Marginal q and Average q drastically decreased from 13.8307, 8.0304, 2.0198 in 2010 to 1.1330, 0.5213 (<1), 0.9791(<1) in 2020, respectively. We term the high q here as bubble Marginal q and bubble Average q, and predict that this bubble q could be lower than 1 after the bubble crush. The q with value lower than 1 after the bubble crash implies that there are overinvestments based on Tobin q theory. We conclude that there are overinvestments in the China Evergrande Group and the other similar firms.

Estimation of overinvestment of Evergande Group

We also estimated the ratio of bubble profit in the total profit for Marginal q of Evergande Group. We consider the investment caused by bubble profit as the overinvestment. Following Wan (2021c), the total profit is expressed as

$$E_{it}(total\,profit_{it+1}) = E_{it}(f_{it+1} + \Delta b_{it+1}). \tag{5}$$

f_{it+1}: the fundamental profit of i firm at $t+1$ time.

Δb_{it+1}: the bubble profit of i firm at $t+1$ time.

The value of inventory (i.e. housing) increases with bubbly price of housing, hence we use the imputed value of the inventory as the proxy of bubble profit as follows,

$$\Delta b_{it+1} = inventory_{it} - inventory_{it-1} \tag{6}$$

$$E_{it}(ratio\ of\ bubble_{it+1}) = \frac{E_{it}(\Delta b_{it+1})}{E_{it}(total\,profit_{it+1})} = \frac{inventory_{it} - inventory_{it-1}}{total\,profit_{it+1}}. \tag{7}$$

Table 3.3 shows the ratio of bubble profit to the total profit for Marginal q of Evergande Group. The average value of ratio of bubble profit to the total profit for the before-tax Marginal q is lower than that for the after-tax Marginal q, and it implies that government obtains an additionally large source of revenue by collecting additional tax from the bubble profit.

Data issues and their solutions

We used the AD to estimate the annual depreciation of fixed assets (DFA). Owing to the liquidation or reduction of fixed assets, the AD decreased, resulting in a negative annual depreciation. Since DEAI should not be negative in theory, we used the average value to replace the negative values of some firms for some years (Sunac China Holdings Limited for 2010, Kaisa Group Holdings Ltd., China Merchants Shekou Industrial Zone Holdings Co., Ltd. for 2020, and Yango Group for 2014). Green Land was backdoor listed before 2015, and so there were outliers of DEAI and q, which we replaced with the average value. The Jinke Property Group Co., Ltd. and China Fortune Land Development Co., Ltd. were engaged in manufacturing before 2011 and 2012, respectively, and so we excluded these previous data. The data replaced by the average are underlined in Tables 3.1 and 3.2.

3.4 Empirical specifications and estimated results

3.4.1 Depreciation rate by DEAI and ratio of profit

We consider the empirical specification following Wan and Qiu (2021) to analyze whether the depreciation rate by DEAI (with and without inventory) of the 19 listed real estate firms can be explained by the economic depreciation hypothesis (Hypothesis 1) by Wan (2019).

$$\delta_{DEAI-it\,(with\,inventory)} = \alpha_0 + \alpha_1 RPFHI_{it} + \alpha_2 RHIFA_{it} + \theta_i + \eta_t + \kappa_{mt},$$

$$\delta_{DEAI-it\,(without\,inventory)} = \beta_0 + \beta_1 RPFHI_{it} + \beta_2 RHIFA_{it} + \tau_i + \rho_t + \varepsilon_{mt}, \quad (8)$$

where

$RPFHI_{it}$: *Total Profits After Tax* $_{it}$ / *TVFAHI* $_{it-1}$ of i real estate firm at time t. We confirm the economic depreciation hypothesis that the *RPFHI* may have a positive and significant impact on DEAI (with and without inventory).

$RHIFA_{it}$: *TVFAHI* $_{it}$ / *Total Assets* $_{it-1}$ of i real estate firm at time t. We consider that *RHIFA* may capture the impact of the fixed asset sizes of different firms on the depreciation rate.

α_1, α_2, β_1 and β_2 are coefficients, α_0 and β_0 are constant terms, τ_i and θ_i are firm-specific effects, ρ_t and η_t are time effects (time trend or dummy by year), and ε_{mt} and κ_{mt} are random errors, respectively. We use panel estimation with fixed effects and robust standard errors to obtain the parameters and draw inferences.

3.4.2 Investment, Marginal *q*, and Average *q*

We consider the following empirical specifications of the investment function based on Abel (1980), Chirinko (1993), Ogawa et al. (1994, 2019) and Wan and Qiu (2020):

$$\frac{I_{it}}{K_{it-1}} = \zeta_0 + \zeta_1 q_{it} + \zeta_2 RHIFA_{it} + \mu_i + \gamma_t + \varepsilon_{it}, \qquad (9)$$

where

$\frac{I_{it}}{K_{it-1}}$: Investment / *TVFAHI* $_{it-1}$ of *i* real estate firm at time *t*;

q_{it} : before-tax Marginal q, after-tax Marginal q, and Average q of *i* real estate firm at time *t*; and ζ_1 and ζ_2 are coefficients and ζ_0, μ_i, γ_t, and ε_{it} are the constant term, firm-specific effects, time effects (time trend or dummy by year), and random errors, respectively.

We use the panel estimation method with fixed effects and robust standard errors to obtain the parameters and draw inferences. The specification of Eq. (9) can test Hypothesis 2.

Following Chirinko (1993, Eq. (17)) and Wan and Qiu (2020), we consider the structural form of the adjustment cost model for Marginal and Average q.

$$\frac{I_{it}}{K_{it-1}} = \tau + \frac{1}{a}(q_{it} - 1)P^I_{it} + \zeta_2 RTHIA_{it} + \mu_i + \gamma_t + \varepsilon_{mt}, \qquad (10)$$

where
a and τ are parameters of quadratic adjustment cost function.

We also use the specification of Eq. (10) to test Hypothesis 2 by the structural form of the adjustment cost model for Marginal and Average q.

3.4.3 Empirical results

Depreciation rate by DEAI of 19 listed real estate firms

The average yearly depreciation rate values of the 19 listed real estate firms by

EDAI (with and without inventory) during the period 2002–2020 are shown in Figure 3.1.The depreciation rate values of the 19 listed real estate firms by DEAI are shown in Table 3.1. Table 3.3 shows the summary statistics of the DEAI and other related variables. Table 3.4 shows the empirical results. The profits after tax of the 19 listed real estate firms have a significant impact on the depreciation rate by DEAI (with and without inventory), regardless of controlling for size of fixed asset, time trend, and year dummies. This result supports Wan's (2019) economic depreciation hypothesis.

Investment of 19 listed real estate firms

Figure 3.2 shows the average value of before- and after-tax Marginal *q* and Average *q* of 19 listed real estate firms by year from 2002 to 2020. The values of before- and after-tax Marginal *q* and Average *q* of each of the 19 listed real estate firms are shown in Table 3.2 and visualized in Figure 3.3-3.21, respectively. The mean values of before- and after-tax Marginal *q* and Average *q* in this study are 2.5780, 1.6883, and 1.3590, respectively. The before-tax Marginal *q* and Average *q* are higher than the 1.54 and -0.1896 values of Japanese real estate firms in the 1980s, as reported by Ogawa et al. (1994). That high value of Marginal *q* implies that the firm makes an additional profit from the housing bubble by demand-side driving theory in Wan (2021a). A part of the investment caused by the bubble profit could be considered as overinvestment. The result of this study is close to that of Japan in 1980s by Ogawa et al. (1994). Difference tests revealed that the value of before-tax Marginal *q* is significantly higher than the after-tax Marginal *q* and Average *q* in the 19 listed real estate firms in China. Difference tests also revealed that the after-tax Marginal *q* is significantly higher than the Average *q*. The result here may be explained by the fact that the Marginal *q* includes more profit from the housing bubble than the Average *q* in the 19 listed real estate firms and is simply opposite to the results that Chirinko and Schaller (2001) reported for 1980s Japan.

Tables 3.5 and 3.6 present the empirical results for reduced form and structural form with adjustment cost, respectively. The before- and after-tax Marginal *q* and Average *q* have significant impacts on the investment regardless of controlling for size of fixed assets, time trend, and year dummies. These results indicate that Tobin's q theory explains the investment behavior of the 19 listed real estate firms and support Hypothesis 2. The elasticity values of the before- and after-tax Marginal q and Average q are 0.1594, 0.1072, and 0.1059, respectively. The elasticity here is lower than the before-tax Marginal q (0.2412) of the 13 housing-related industries studied by Wan and Qiu (2020).

Why Marginal q is lager than Average q in 19 real estate firms in China?

Wan (2021c) explains the above fact as follows. One listed firm has a tradable asset (*A>0*), a tradable stock share (*S>0*), and a tradable corporate bond (*B>0*) bubbles from three different asset markets. When the bubble profits have been considered, if there are enough speculators in these three different asset markets, the Marginal q will be larger than Average q. The asset price of one listed firm is expressed by Wan (2021c) as,

$$p_{Ait}=f_{Ait}+b_{Ait}. \tag{11}$$

p_{Ait} : the asset price of *i* firm at *t* time.

f_{Ait} : the fundamental term of *i* firm at *t* time.

b_{Ait} : the bubble term of *i* firm at *t* time.

One part of bubble profit of the asset as is distributed to stock owners as additional dividend, and the stock price is expressed by Wan (2021c) as,

$$p_{Sit}=f_{Ait}+\beta\times b_{Ait}+b_{Sit} \tag{12}$$

p_{Sit} : the stock market price of *i* firm at *t* time.

$\beta\times b_{Ait}$: the bubble profit of the asset distributed to stock owners of *i* firm at *t* time ($0<\beta<\frac{S+B}{S}$).

b_{Sit} : the bubble of *i* firm at *t* time formed in the stock market.

Another part of bubble profit of the asset is distributed to bond owners as additional return, and the bond price is expressed by Wan (2021c) as,

$$p_{Bit}=f_{Ait}+\beta'\times b_{Ait}+b_{Bit}. \tag{13}$$

p_{Bit} : the bond market price of *i* firm at *t* time.

$\beta' \times b_{Ait}$: the bubble profit of the asset distributed to bond owners of i firm at t time in the bond market ($0 < \beta' \equiv 1-(\beta-1)\frac{S}{B} < \frac{S+B}{S}$).

b_{Bit} : the bubble term of *i* firm at *t* time formed in the bond market.

The relationship of Tobin's Marginal and Average q with bubblesin three markets by Wan (2021c) as follows,

$$Tobin\ Marginal\ q_{it}{=}f\_mq_{Ait} + b\_mq_{Ait} \tag{14}$$

$$Tobin\ Average\ q_{it}{=}f\_mq_{Ait} + \beta \times b\_mq_{Ait} + b\_aq_{Sit}. \tag{15}$$

$Tobin\ Marginal\ q_{it}$: the Marginal q of *i* firm at *t* time.

f_mq_{Ait} : the fundamental term of Marginal q of *i* firm at *t* time.

b_mq_{Ait} : the bubble term of Marginal q of *i* firm at *t* time.

$Tobin\ Average\ q_{it}$: the Average q of *i* firm at *t* time.

$\beta \times b\_mq_{Ait}$: the bubble term from asset side distributed to stock owners of *i* firm at *t* time.

b_aq_{Sit} : the bubble term formed in the stock market of *i* firm at *t* time.

In the special case with $b_{Sit} = 0$ ($b\_aq_{Sit} = 0$),

$$Tobin\ Marginal\ q_{it} > Tobin\ Average\ q_{it}$$

$$b\_mq_{Ait} > \beta \times b\_mq_{Ait} \text{ for } 0 < \beta < 1. \tag{16}$$

Wan (2021c) argues that there is short sale constraint in the housing market while no short sale constraints in stock and bond markets, hence bubbles in the stock and bond markets are likely to crash (i.e. $b_{Sit} = 0$) while crash of housing bubble is likely to be postponed (b_{Ait}>0). To sum up, Wan (2021c) shows that triple bubbles in the asset, stock and bond markets could cause higher Tobin Marginal q compared with Tobin Average q.

3.5 Conclusion

We estimated the depreciation rate by DEAI (with and without inventory) of 19 listed real estate firms in China. The mean values of DEAI without and with inventory for the 19 listed real estate firms are 0.1104 and 0.0034 (used for estimation of Marginal q), respectively. We found that the depreciation rate by DEAI (without and with inventory) of the 19 listed real estate firms is accounted for by economic depreciation theory.

We also estimated the before- and after-tax Marginal q and Average q of the 19 listed real estate firms. The average before- and after-tax Marginal q and Average q values are 2.5780, 1.6883, and 1.3590, respectively. We further estimated the ratio of bubble profit to the total profit for the before- and after-tax Marginal q of Evergande Group, and found that the average values of ratios are 0.5623 and 0.9626, respectively. The before-tax Marginal q and Average q values (1.5400 and -0.1896, respectively) of real estate firms in 1980s Japan, as reported by Ogawa et al. (1994), are lower than those observed in this study. The value of before-tax Marginal q is significantly higher than the values of after-tax Marginal q and Average q of 19 listed real estate firms in China, as confirmed by the difference test. The difference test also verified that the after-tax Marginal q value is significantly higher than the Average q values of the 19 listed real estate firms in China. The elasticities of the before- and after-tax Marginal q and Average q on investment for the 19 listed real estate firms are 0.1594, 0.1072, and 0.1059, respectively. This elasticity of the before-tax Marginal q (0.1594) is lower than that of the 13 housing-related industries (0.2412) studied by Wan and Qiu (2020). Finally, we found that the investment of the 19 listed real estate firms in China can be accounted for by bubbly Tobin's Marginal and Average q theory.

The implications of the empirical results are as follows. The high Marginal q values of the 19 listed real estate firms suggest that firms may obtain bubble profits from the housing bubble in line with demand-side driving theory (Wan 2021a, c). Via bubbly Marginal q, the investment behavior of the 19 listed real estate firms may be interpreted as overinvestment. The higher before-tax Marginal q compared with the after-tax Marginal q indicates that the before-tax Marginal q should derive greater profit from the bubble than the after-tax Marginal q and Average q. The higher after-tax Marginal q compared with Average q suggests that the after-tax Marginal q includes more profit from the bubble than Average q. The Marginal q may include more profit from the bubble than the Average q of the 19 real estate firms because the stock market has experienced several bubble bursts. A stock market burst may cause the bubble in the stock price to be squeezed out, as argued by Wan (2018c). This suggests that the Average q is smaller than the Marginal q of the real estate sector and almost all sectors in 1980s Japan, as reported by Ogawa et al. (1994), which contrasts with the findings of Chirinko and Schaller's (2001) study on Japan during the 1980s. The low elasticity values of before- and after-tax Marginal q and Average q may imply that the 19 listed real estate firms have higher adjustment costs than the 13 housing-related industries that Wan and Qiu (2020) investigated. This may point toward overinvestment in the 19 listed real estate firms in China. Compared with Wan and Qiu's (2020) findings from industrial sectors, Wan's (2018b, 2021d) examination of banking sectors, and Qiu and Wan's (2021b) findings from the construction sector, this study offers new evidence to help identify overinvestment issues in real estate firms that operate as makers and sellers of housing bubbles.

The China Evergrande Group has been in debt crisis to experience a double crash in share and bond prices. The before- and after-tax Marginal q and Average q drastically decreased from 13.8307, 8.0304, 2.0198 in 2010 to 1.1330, 0.5213 (<1), 0.9791(<1) in 2020, respectively. The q with value lower than 1 after the bubble crash implies that there are overinvestments in the asset side based on Tobin q theory and Wan (2021c). Hence, we conclude that there are overinvestments in the China Evergrande Group and the other similar firms.

To resolve overinvestment issues in the industrial, construction, and banking sectors as argued by Wan (2021d), we must first solve the problem of overinvestment in real estate firms. A bubble crash in the real estate sector could cause financial system risk; thus, it is necessary to ensure a soft landing for house prices, following Wan (2018a, 2021b). Future studies should analyze the impact of the housing bubble on local housing firms using data from local listed real estate firms and by incorporating macro policy variables. Our methods and results should be compared with those reported by Chirinko and Schaller (2001).

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Table 3.1: Depreciation rates of the 19 listed real estate firms by Depreciation Expense as Accounting Item (DEAI) with and without inventory.

Year	**Evergrande Group**		**China Fortune Land Development Co., Ltd.**		**Sunac China Holdings Limited**		**Agile**		**Kaisa Group Holdings Ltd.**		**China Merchants Shekou Industrial Zone Holdings Co., Ltd.**		**Seazen Holdings Co., Ltd.**	
	DEAI without inventory	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**
2009	0.1248	0.0048												
2010	0.2499	0.0043			0.2622	0.0013	0.0253	0.0018	0.1835	0.0020				
2011	0.2185	0.0049			0.4728	0.0009	0.0303	0.0017	0.1131	0.0011				
2012	0.0810	0.0038	0.1260	0.0013	0.3085	0.0003	0.0461	0.0029	0.2656	0.0017				
2013	0.0875	0.0048	0.1604	0.0010	0.4229	0.0004	0.0374	0.0029	0.2044	0.0018				
2014	0.0858	0.0050	0.1222	0.0017	0.2519	0.0003	0.0288	0.0027	0.4058	0.0045				
2015	0.0819	0.0048	0.0932	0.0019	0.3468	0.0004	0.0519	0.0043	0.1045	0.0011			0.0768	0.0015
2016	0.0614	0.0026	0.1130	0.0026	0.3500	0.0005	0.0697	0.0060	0.1277	0.0012	0.0594	0.0012	0.0567	0.0024
2017	0.0794	0.0024	0.0938	0.0017	0.4011	0.0017	0.0689	0.0072	0.1035	0.0014	0.0516	0.0012	0.0679	0.0023
2018	0.0575	0.0019	0.1490	0.0018	0.0205	0.0023	0.0678	0.0061	0.0681	0.0020	0.0347	0.0006	0.0860	0.0018
2019	0.0580	0.0021	0.1390	0.0027	0.0238	0.0030	0.0879	0.0070	0.0820	0.0031	0.1199	0.0019	0.0922	0.0010
2020	0.0436	0.0018	0.0591	0.0015	0.0238	0.0030	0.0802	0.0069	0.1350	0.0020	0.0664	0.0012	0.0130	0.0001
Avg.	0.1024	0.0036	0.1173	0.0018	0.2622	0.0013	0.0540	0.0045	0.1630	0.0020	0.0664	0.0012	0.0654	0.0015

Source: Authors' estimations based on data from the balance sheets.

Table 3.1: Depreciation rates of the 19 listed real estate firms by Depreciation Expense as Accounting Item (DEAI) with and without inventory (cont.).

Year	China Aoyuan Property Group Limited		Country Garden		Cifi Group		China Vanke Co., Ltd.		Green Town		Yango Group	
	DEAI without inventory	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**
2007	0.6169	0.0234	0.1158	0.0165								
2008	0.0674	0.0016	0.0928	0.0121			0.0828	0.0007			0.0669	0.0011
2009	0.0326	0.0010	0.0646	0.0073			0.0246	0.0004	0.0557	0.0028	0.1064	0.0010
2010	0.0478	0.0011	0.0585	0.0053			0.0487	0.0007	0.0406	0.0024	0.0610	0.0005
2011	0.0669	0.0050	0.0516	0.0052			0.0572	0.0005	0.0491	0.0019	0.2181	0.0013
2012	0.2821	0.0157	0.0443	0.0047	0.1144	0.0010	0.0493	0.0004	0.0784	0.0030	0.5605	0.0036
2013	0.0877	0.0028	0.0411	0.0056	0.0473	0.0003	0.0586	0.0004	0.0624	0.0041	0.3760	0.0010
2014	0.0586	0.0012	0.0415	0.0046	0.1701	0.0005	0.0617	0.0004	0.0337	0.0028	0.1642	0.0009
2015	0.0603	0.0012	0.0291	0.0027	0.2558	0.0008	0.0757	0.0005	0.0322	0.0031	0.3847	0.0002
2016	0.0812	0.0012	0.0426	0.0034	0.1914	0.0003	0.0808	0.0010	0.0245	0.0022	0.1642	0.0008
2017	0.0979	0.0011	0.0190	0.0012	0.1285	0.0003	0.0539	0.0007	0.0156	0.0012	0.3643	0.0032
2018	0.1519	0.0014	0.0740	0.0031	0.3913	0.0008	0.1871	0.0021	0.0514	0.0035	0.0104	0.0002
2019	0.0757	0.0013	0.0508	0.0014	0.1684	0.0003	0.0574	0.0008	0.0539	0.0036	0.0366	0.0006
2020	0.0526	0.0009	0.0797	0.0019	0.2750	0.0004	0.0571	0.0007	0.0406	0.0024	0.0248	0.0005
Avg.	0.1271	0.0042	0.0575	0.0053	0.1936	0.0005	0.0688	0.0007	0.0448	0.0027	0.1952	0.0012

Source: Authors' estimations based on data from the balance sheets.

Table 3.1: Depreciation rates of the 19 listed real estate firms by Depreciation Expense as Accounting Item (DEAI) with and without inventory (cont.).

Year	**Poly Development Holding Group Co., Ltd**		**Hangzhou Binjiang Real Estate Groiup Co., Ltd.**		**Gemdale Group**		**R&F Group**		**Green Land**		**Jinke Property Group Co., Ltd.**	
	DEAI without inventory	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**	**DEAI without inventory**	**DEAI with inventroy**
2002					0.0429	0.0086						
2003					0.0394	0.0038						
2004					0.0735	0.0034			0.0490	0.0124		
2005					0.0752	0.0034	0.0370		0.0512	0.0044		
2006					0.0780	0.0025	0.1969	0.0028	0.0308	0.0129		
2007					0.0335	0.0006	0.0651	0.0095	0.0427	0.0013		
2008					0.2585	0.0011	0.0656	0.0069	0.0189	0.0045		
2009	0.1153	0.0005	0.1602	0.0025	0.1043	0.0003	0.0525	0.0086	0.0136	0.0146		
2010	0.1545	0.0005	0.2024	0.0015	0.1580	0.0003	0.0606	0.0055	0.0005	0.0001		
2011	0.1593	0.0005	0.4278	0.0024	0.1787	0.0004	0.0481	0.0052	0.0004	0.0001	0.2264	0.0025
2012	0.0978	0.0006	0.1190	0.0020	0.0789	0.0002	0.0628	0.0059	0.0400	0.0056	0.1633	0.0010
2013	0.0785	0.0006	0.1394	0.0019	0.2126	0.0006	0.0498	0.0051	0.0780	0.0019	0.0648	0.0009
2014	0.0596	0.0005	0.1546	0.0020	0.1347	0.0005	0.0537	0.0048	0.0760	0.0218	0.1167	0.0014
2015	0.0718	0.0007	0.1914	0.0020	0.1388	0.0005	0.0460	0.0032	0.0778	0.1176	0.1097	0.0020
2016	0.0568	0.0006	0.2266	0.0022	0.1556	0.0006	0.0745	0.0061	0.0041	0.0001	0.0730	0.0025
2017	0.1082	0.0011	0.1107	0.0011	0.0618	0.0010	0.4150	0.0381	0.0710	0.0013	0.0211	0.0008
2018	0.1098	0.0010	0.1261	0.0012	0.0697	0.0009	0.0393	0.0075	0.1297	0.0032	0.0777	0.0017
2019	0.1380	0.0013	0.2229	0.0009	0.0752	0.0007	0.0333	0.0051	0.1218	0.0050	0.1072	0.0016
2020	0.0175	0.0002	0.0594	0.0004	0.0581	0.0005			0.0621	0.0037	0.0605	0.0012
Avg.	0.0973	0.0007	0.1784	0.0017	0.1067	0.0016	0.0867	0.0082	0.0510	0.0124	0.1020	0.0015

Source: Authors' estimations based on data from the balance sheets.

Table 3.2: Before-tax Marginal q , after-tax Marginal q , and Average q of the 19 listed real estate firms.

Year	Evergrande Group			China Fortune Land Development Co., Ltd.			Sunac China Holdings Limited			Agile			Kaisa Group Holdings Ltd.		
	Before-tax Marginal *q*	**After-tax Marginal *q***	**Average *q***	**Before-tax Marginal *q***	**After-tax Marginal *q***	**Average *q***	**Before-tax Marginal *q***	**After-tax Marginal *q***	**Average *q***	**Before-tax Marginal *q***	**After-tax Marginal *q***	**Average *q***	**Before-tax Marginal *q***	**After-tax Marginal *q***	**Average *q***
2009	2.8300	2.1855													
2010	13.8307	8.0304	2.0198				12.0381	7.1428	2.0148	7.6927	4.4752	1.8425	9.8116	6.6742	1.4625
2011	8.2667	4.7814	1.9703				10.5981	7.1582	2.0934	5.3187	2.3948	1.2769	3.9701	2.6692	1.5509
2012	3.6190	2.0152	1.4159	7.0960	5.2568	0.3509	1.8138	2.8154	2.0574	3.3302	1.6275	1.1433	2.1625	1.3997	1.2139
2013	3.7160	2.0059	1.3348	6.4911	4.8626	0.8238	3.3740	2.0737	1.3712	2.8710	1.5711	1.1590	2.2907	1.2718	1.3250
2014	3.6522	2.1095	1.1672	5.4274	4.0776	1.3795	2.3333	1.5388	1.1274	2.5248	1.2694	0.8762	0.4241	-0.3761	1.3543
2015	2.7515	1.5173	1.4339	5.1098	3.6673	3.1200	2.5455	2.0127	1.0549	1.3014	0.4834	0.7277	0.0336	-0.2429	1.0119
2016	2.1079	1.0074	1.6133	5.1240	3.5213	1.9854	2.4318	1.6207	2.4039	1.7510	0.7136	0.8609	0.3575	-0.0665	1.1805
2017	2.6187	1.2523	1.2863	5.0169	3.4519	1.8285	3.1262	2.3742	2.2305	4.1019	1.7526	1.1249	1.3433	0.6133	1.2329
2018	2.9520	1.5497	1.0582	4.4058	2.9832	0.9220	2.1344	1.2990	1.2290	4.1301	1.7792	1.3415	1.3635	0.5780	0.9957
2019	1.5019	0.6792	1.1249	5.0414	3.3263	1.2192	2.8259	1.8701	1.4043	2.7156	1.5108	1.0612	1.7898	0.7872	1.0221
2020	1.1330	0.5213	0.9791	1.5887	0.9483	0.8677	2.6861	1.8464	1.1297	2.8191	1.6082	0.9902	2.0006	1.0055	0.9274
Avg.	4.0816	2.3046	1.4003	5.0334	3.5662	1.3886	4.1734	2.8865	1.6470	3.5051	1.7442	1.1277	2.3225	1.3012	1.2070

Source: Authors' estimations based on data from the balance sheets.

Table 3.2: Before-tax Marginal q , after-tax Marginal q , and Average q of the 19 listed real estate firms (cont.).

Year	China Aoyuan Property Group Limited			Country Garden			Cifi Group			China Vanke Co., Ltd.			Green Town		
	Before-tax Marginal *q*	**After-tax Marginal *q***	**Average *q***	**Before-tax Marginal *q***	**After-tax Marginal *q***	**Average *q***	**Before-tax Marginal *q***	**After-tax Marginal *q***	**Average *q***	**Before-tax Marginal *q***	**After-tax Marginal *q***	**Average *q***	**Before-tax Marginal *q***	**After-tax Marginal *q***	**Average *q***
2007	12.5562	6.2821	6.0401	19.5970	12.0954	11.1325									
2008	-0.3776	0.2430	0.9232	4.9985	2.1688	2.5275				2.0538	1.5073	1.8961			
2009	1.0321	0.7834	1.1160	2.4589	1.6043	1.6952				2.1613	1.6127	1.6806	0.8566	0.5958	1.7757
2010	1.2649	0.6212	0.8948	2.9900	1.9212	1.5036				2.8419	2.1038	1.8257	1.2921	0.8249	1.6490
2011	1.4549	0.8616	1.0160	3.3261	2.0213	1.5002				2.5625	1.8805	1.4514	0.6689	0.9386	0.9532
2012	1.9408	1.1868	0.9594	2.8902	1.7239	1.4027	3.2879	2.3398	1.4436	2.1849	1.6241	1.3394	1.1425	1.1665	0.7478
2013	1.1918	0.7086	1.2692	3.0245	1.9862	1.7311	2.6292	1.8040	1.4356	0.6579	0.6579	1.2688	2.3697	1.5520	1.1109
2014	0.8197	0.4430	1.0357	2.1852	1.4166	1.2978	2.7440	1.6503	1.0414	0.7444	0.7546	1.0186	2.5275	0.7909	0.8934
2015	0.8318	0.4006	1.1183	1.4044	0.9195	1.2611	3.5045	2.2757	1.4554	0.6624	0.6624	1.2423	1.4899	0.2800	0.9684
2016	0.7254	0.3502	1.1392	1.6162	1.0323	1.5955	2.5074	1.6404	1.2453	0.7299	0.7299	1.5026	0.7583	0.4496	0.9821
2017	0.9252	0.4981	1.5973	2.6710	1.6508	1.8920	5.0156	3.0712	1.6267	2.2604	1.6446	1.4863	1.1249	0.4701	1.2092
2018	1.0025	0.4237	1.3704	2.9101	1.7755	1.6313	3.6329	2.2851	1.5172	2.3076	1.6855	1.3544	0.9995	0.3004	1.0053
2019	1.0165	0.5013	1.4613	2.2815	1.4113	1.1754	2.0170	1.3452	1.2262	2.0386	1.4684	1.1507	1.0130	0.4005	1.0008
2020	0.9454	0.4898	1.0110	1.5710	0.9941	1.0276	1.4865	0.9929	1.0552	1.7647	1.3134	1.0536	0.9573	0.5130	1.0396
Avg.	1.8093	0.9852	1.4966	3.8518	2.3372	2.2410	2.9805	1.9338	1.3385	1.7670	1.3573	1.4054	1.2667	0.6902	1.1113

Source: Authors' estimations based on data from the balance sheet of firms.

Table 3.2: Before-tax Marginal q , after-tax Marginal q , and Average q of the 19 listed real estate firms (cont.).

Year	**Poly Development Holding Group Co., Ltd**			**Hangzhou Binjiang Real Estate Groiup Co., Ltd.**			**Gemdale Group**			**R&F Group**			**Green Land**		
	Before-tax Magrinal *q*	**After-tax Marginal *q***	**Average *q***	**Before-tax Magrinal *q***	**After-tax Marginal *q***	**Average *q***	**Before-tax Magrinal *q***	**After-tax Marginal *q***	**Average *q***	**Before-tax Magrinal *q***	**After-tax Marginal *q***	**Average *q***	**Before-tax Magrinal *q***	**After-tax Marginal *q***	**Average *q***
2003							1.6554	0.7407							
2004							1.0156	0.5628	0.6922				4.9301	3.0869	0.8257
2005							0.9610	0.7550	0.6645	7.1123	7.1123	1.3250	1.7180	1.4561	0.4343
2006							1.1031	0.7370	1.2162	10.0523	6.8840	1.5492	2.4984	1.9833	1.0117
2007							1.1145	1.3097	1.9225	18.3110	12.0015	2.3205	2.5462	2.4647	1.0450
2008							1.7795	0.5050	1.2736	5.4682	3.3874	0.9483	6.3775	5.2116	0.9442
2009	2.2900	1.7062	1.5803	2.6315	1.9777	1.1878	0.7114	0.5851	1.4996	4.8080	2.8908	1.0790	4.3972	3.5740	1.3160
2010	2.1110	1.5695	1.6068	3.3427	2.4643	1.3245	0.7560	0.6657	1.4511	4.2140	2.3270	0.9928	4.8906	3.6561	1.3934
2011	1.5714	1.1492	1.2101	1.4731	1.0946	1.1244	0.8980	0.7089	1.2293	4.8618	2.5638	0.8835	2.4910	2.1146	1.4204
2012	1.5202	1.1210	1.2597	1.1662	0.8601	1.0132	0.9464	0.5765	1.0673	4.6772	2.6360	0.9432	0.9669	0.8500	1.2310
2013	1.4492	1.0679	1.1701	1.1546	0.8262	0.9294	0.7909	0.5536	1.1172	4.9058	2.9139	1.1812	0.6414	0.4902	1.1630
2014	1.3527	1.0115	1.1018	0.7137	0.4954	0.8256	0.7747	0.5569	0.9676	2.7833	1.7830	0.9035	3.1457	2.4223	1.6490
2015	1.4600	1.0729	1.1377	1.1646	0.8454	1.2320	0.7979	0.5392	1.1491	2.2096	1.2787	0.8173	1.0221	0.6932	1.1303
2016	1.3752	1.0072	1.1274	1.7129	1.1990	1.1734	0.6992	0.9497	1.1102	2.1768	1.2941	1.0170	0.8504	0.5534	1.1422
2017	1.4415	1.1037	1.4070	2.0684	1.6326	1.2625	1.2409	1.1210	1.2780	4.8435	3.6442	1.0739	0.9401	0.6624	1.0572
2018	1.3882	1.0145	1.1635	3.2628	2.4249	1.3713	1.3815	1.2247	1.2350	1.9184	0.9886	1.0308	1.1076	0.7313	1.1839
2019	1.8133	1.3476	1.1366	1.8862	1.3869	1.3464	1.5289	1.1794	1.0895	1.6202	0.8972	0.9766	1.1800	0.8080	1.0527
2020	1.5272	1.1641	1.1269	1.0554	0.7822	1.1973	1.4878	0.9327	1.0922	1.2464	0.7165	0.8361	1.0324	0.7110	1.1466
Avg.	1.6083	1.1946	1.2523	1.8027	1.3324	1.1656	1.0913	0.7891	1.1797	5.0755	3.3324	1.1174	2.3962	1.8511	1.1263

Source: Authors' estimations based on data from the balance sheet of firms.

Table 3.2: Before-tax Marginal q, after-tax Marginal q, and Average q of the 19 listed real estate firms (cont.).

Year	**Jinke Property Group Co., Ltd.**			**Seazen Holdings Co., Ltd.**			**Yango Group**			**China Merchants Shekou Industrial Zone Holdings Co., Ltd.**		
	Before-tax Magrinal *q*	**After-tax Marginal *q***	**Average *q***	**Before-tax Magrinal *q***	**After-tax Marginal *q***	**Average *q***	**Before-tax Magrinal *q***	**After-tax Marginal *q***	**Average *q***	**Before-tax Magrinal *q***	**After-tax Marginal *q***	**Average *q***
2008							0.9754	0.8325	0.7487			
2009							1.8198	1.3721	0.8070			
2010							4.7344	3.5094	1.1031			
2011							1.8804	1.2757	1.5645			
2012	1.0688	0.8038	1.2031				2.4384	1.7815	1.0250			
2013	0.6605	0.4932	1.0273				1.2437	0.8350	1.9740			
2014	0.2866	0.3282	1.1377				1.2078	0.8419	1.3202			
2015	0.4983	0.3444	1.2445	0.8804	0.6420		0.9693	0.7115	1.7329			
2016	0.5288	0.4243	1.0606	0.9199	0.6767	0.5430	0.6746	0.4703	1.7116	3.0330	2.2429	2.2879
2017	0.7021	0.5452	1.4759	1.4883	1.1131	0.8113	0.6701	0.4143	1.6672	4.0483	2.9306	1.4527
2018	0.8409	0.6489	1.3886	1.5077	1.1674	2.5574	0.4977	0.3043	1.1558	3.6314	2.6484	2.2639
2019	0.9040	0.6894	1.3035	0.9225	0.6903	1.4868	0.4899	0.3127	1.0655	2.7813	2.0076	3.0352
2020	0.9861	0.7857	1.0764	0.7198	0.5330	1.2008	0.6629	0.4127	1.0348	1.7356	1.2176	2.9128
Avg.	0.7196	0.5626	1.2131	1.0731	0.8038	1.3199	1.4050	1.0057	1.3008	3.0459	2.2094	2.3905

Source: Authors' estimations based on data from the balance sheet of firms.

Table 3.3:Ratio of bubble profit in the total profit for Marginal q for Evergande Group.

Year	Evergrande Group	
	Ratio of bubble profit in the total profit for before-tax Magrinal *q*	**Ratio of bubble profit in the total profit for after-tax Marginal *q***
2009	0.2616	0.5784
2010	0.0560	0.1067
2011	0.2557	0.5348
2012	0.5801	1.2137
2013	0.8478	1.5374
2014	0.5910	1.0233
2015	0.4486	0.8311
2016	0.5537	0.9943
2017	0.3300	0.5706
2018	0.1576	0.2768
2019	2.9098	3.7680
2020	-0.2440	-0.3728
Avg.	0.5623	0.9219

Source: Authors' estimations based on data from the balance sheets.

Table 3.4: Summary statistics of the 19 listed real estate firms.

Variable	Obs	Median	Mean	Std. Dev.	Min	Max
Depreciation Expense as Accounting Item $_{(t)}$ / Total Value of Fixed Assets without Inventory $_{(t-1)}$	224	0.0757	0.1104	0.1036	0.0004	0.6169
Depreciation Expense as Accounting Item $_{(t)}$ / Total Value of Fixed Assets with Inventory $_{(t-1)}$	225	0.0017	0.0034	0.0087	0.0001	0.1176
Before-tax Marginal $q_{(t)}$	224	1.8016	2.5780	2.6496	-0.3776	19.5970
After-tax Marginal $q_{(t)}$	224	1.2083	1.6883	1.7070	-0.3761	12.0954
Average $q_{(t)}$	221	1.2031	1.3590	0.8377	0.3509	11.1325
[Beforetax Marginal $q_{(t)}$ - 1]*Price Index for Investment in Fixed Assets	224	0.8114	1.5973	2.6821	-1.3945	18.8248
[Aftertax Marginal $q_{(t)}$ - 1]*Price Index for Investment in Fixed Assets	224	0.2108	0.6967	1.7279	-1.3930	11.2313
[Average $q_{(t)}$ - 1]*Price Index for Investment in Fixed Assets	221	0.2166	0.3674	0.8457	-0.6571	10.2566
Investment $_{(t)}$/ Total Value of Fixed Assets $_{(t-1)}$	226	0.1375	0.2054	0.2532	0.0004	1.8949
Total Profits After Tax $_{(t)}$ / Total Value of Fixed Assets with Inventoory$_{(t-1)}$	226	0.0689	0.0880	0.0828	-0.0250	0.6284
Total Value of Fixed Assets with Inventory$_{(t)}$ / Total Assets $_{(t-1)}$	223	0.7770	1.0587	3.8246	0.2618	57.7888
Year	361	2011	2011	5.484828	2002	2020

Source: Authors' estimations based on data from the balance sheets.

Table 3.5a: Determinants of depreciation rate by Depreciation Expense as Accounting Item (DEAI) of the 19 listed real estate firms (Panel estimation with fixed effect and robust standard errors (FE)).

Independent Variables	Dependent variable = Depreciation Expense as Accounting Item $_{(t)}$ / Total Value of Fixed Assets without Inventory $_{(t-1)}$			
Total Profits After Tax $_{(t)}$ / Total Value of Fixed Assets with Inventory $_{(t-1)}$	0.3189 *	0.3205 *	0.3865 **	0.3965 **
	(0.1778)	(0.1787)	(0.1663)	(0.1703)
Total Value of Fixed Assets with Inventory $_{(t)}$ / Total Assets $_{(t-1)}$		0.0023 ***		0.0019 ***
		(0.0004)		(0.0006)
Constant	1.1481	1.0521	-0.0221	-0.0251
	(4.0261)	(4.0525)	(0.0261)	(0.0262)
Year	-0.0005	-0.0005		
	(0.0020)	(0.0020)		
Year 2002 (Dropped)				
Year 2003			0.0221 *	0.0221 *
			(0.0110)	(0.0113)
Year 2004			0.0779 ***	0.0651 ***
			(0.0152)	(0.0148)
Year 2005			0.055 **	0.0804 ***
			(0.0234)	(0.0200)
Year 2006			0.0915 ***	0.0904 ***
			(0.0224)	(0.0207)
Year 2007			0.0700	0.0665
			(0.0632)	(0.0645)
Year 2008			0.0881 **	0.0881 **
			(0.0352)	(0.0352)
Year 2009			0.0722 ***	0.0666 ***
			(0.0141)	(0.0127)
Year 2010			0.0769 ***	0.0766 ***
			(0.0166)	(0.0166)
Year 2011			0.1305 ***	0.1243 ***
			(0.0263)	(0.0274)
Year 2012			0.1308 ***	0.132 ***
			(0.0317)	(0.0316)
Year 2013			0.1176 ***	0.1189 ***
			(0.0263)	(0.0264)
Year 2014			0.1125 ***	0.1142 ***
			(0.0156)	(0.0157)
Year 2015			0.1235 ***	0.1253 ***
			(0.0244)	(0.0245)
Year 2016			0.1069 ***	0.1087 ***
			(0.0193)	(0.0191)
Year 2017			0.1121 ***	0.1134 ***
			(0.0316)	(0.0312)
Year 2018			0.0932 ***	0.0948 ***
			(0.0246)	(0.0247)
Year 2019			0.0891 ***	0.0909 ***
			(0.0187)	(0.0187)
Year 2020			0.0651 ***	0.0673 ***
			(0.0196)	(0.0199)
Observations	225	222	225	222
R-squared	0.0914	0.1045	0.1604	0.1696
Number of firms	19	19	19	19

Note: Robust standard errors in parentheses (FE), *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 3.5b: Determinants of depreciation rate by Depreciation Expense as Accounting Item (DEAI) of the 19 listed real estate firms (Panel estimation with fixed effect and robust standard errors (FE)).

Independent Variables	Dependent variable = Depreciation Expense as Accounting Item $_{(t)}$ / Total Value of Fixed Assets with Inventory $_{(t-1)}$			
Total Profits After Tax $_{(t)}$ / Total Value of Fixed Assets with Inventory $_{(t-1)}$	0.0135 *	0.0136 *	0.0222 **	0.0223 **
	(0.0071)	(0.0071)	(0.0078)	(0.0079)
Total Value of Fixed Assets with Inventory $_{(t)}$ / Total Assets $_{(t-1)}$		0.0000		0.0000
		(0.0000)		(0.0000)
Constant	-0.1454	-0.1601	0.0071 ***	0.0071 ***
	(0.2409)	(0.2562)	(0.0017)	(0.0017)
Year	0.0001	0.0001		
	(0.0001)	(0.0001)		
Year 2002 (Dropped)				
Year 2003			-0.0033 ***	-0.0033 ***
			(0.0005)	(0.0005)
Year 2004			-0.0048 ***	-0.0033 ***
			(0.0008)	(0.0007)
Year 2005			-0.0088 **	-0.0089 **
			(0.0035)	(0.0036)
Year 2006			-0.0086 ***	-0.0087 ***
			(0.0030)	(0.0030)
Year 2007			-0.0087 **	-0.0088 **
			(0.0038)	(0.0039)
Year 2008			-0.0068 ***	-0.0069 ***
			(0.0017)	(0.0017)
Year 2009			-0.0058 ***	-0.0061 ***
			(0.0010)	(0.0009)
Year 2010			-0.0092 ***	-0.0093 ***
			(0.0009)	(0.0009)
Year 2011			-0.0076 ***	-0.0078 ***
			(0.0007)	(0.0007)
Year 2012			-0.0057 ***	-0.0058 ***
			(0.0012)	(0.0012)
Year 2013			-0.0064 ***	-0.0065 ***
			(0.0007)	(0.0007)
Year 2014			-0.0049 ***	-0.005 ***
			(0.0017)	(0.0016)
Year 2015			0.0004	0.0003
			(0.0073)	(0.0072)
Year 2016			-0.0059 ***	-0.0059 ***
			(0.0010)	(0.0009)
Year 2017			-0.0049 **	-0.0049 **
			(0.0021)	(0.0021)
Year 2018			-0.006 ***	-0.0061 ***
			(0.0010)	(0.0009)
Year 2019			-0.0058 ***	-0.0058 ***
			(0.0011)	(0.0010)
Year 2020			-0.006 ***	-0.006 ***
			(0.0011)	(0.0010)
Observations	224	222	224	222
R-squared	0.0142	0.0143	0.0758	0.0766
Number of firms	19	19	19	19

Note: Robust standard errors in parentheses (FE), *** p<0.01, ** p<0.05, * p<0.1.

Table 3.6a: Determinants of investments in the 19 listed real estate (reduced form).
(Panel estimation with fixed effect and robust standard errors (FE))

Independent Variables	Dependent variable = $Investment_{(t)}$ / Total Value of Fixed Assets with $Inventory_{(t-1)}$			
Before-tax Marginal $q_{(t)}$	0.0207 **	0.0206 **	0.0151 *	0.0143 *
	(0.0081)	(0.0083)	(0.0078)	(0.0072)
Total Value of Fixed Assets with $Inventory_{(t)}$ / Total $Assets_{(t-1)}$		-0.0229		-0.0851
		(0.0940)		(0.1053)
Constant	-21.727 ***	-20.7271 ***	0.1109 ***	0.2181 *
	(7.0225)	(5.8527)	(0.0329)	(0.1215)
Year	0.0109 ***	0.0104 ***		
	(0.0035)	(0.0029)		
Year 2003 (Dropped)				
Year 2004			-0.0379	-0.1083 **
			(0.0244)	(0.0483)
Year 2005			-0.0317	-0.0551
			(0.0302)	(0.0664)
Year 2006			0.0886	0.0684
			(0.0640)	(0.0628)
Year 2007			0.0638	0.0546
			(0.1022)	(0.1030)
Year 2008			-0.0389	-0.0764
			(0.0374)	(0.0635)
Year 2009			0.0435	0.0219
			(0.0443)	(0.0688)
Year 2010			0.0097	-0.0199
			(0.0360)	(0.0435)
Year 2011			0.0263	0.0003
			(0.0339)	(0.0524)
Year 2012			-0.0146	-0.0451
			(0.0446)	(0.0568)
Year 2013			-0.0164	-0.0450
			(0.0334)	(0.0559)
Year 2014			-0.0120	-0.0487
			(0.0332)	(0.0593)
Year 2015			0.0027	-0.0367
			(0.0370)	(0.0612)
Year 2016			0.1496 ***	0.1096
			(0.0444)	(0.0669)
Year 2017			0.265 **	0.233 ***
			(0.0932)	(0.0669)
Year 2018			0.1302 **	0.0888
			(0.0501)	(0.0632)
Year 2019			0.0478	0.0049
			(0.0323)	(0.0556)
Year 2020			0.0462	-0.0033
			(0.0434)	(0.0696)
Observations	224	221	224	221
R-squared	0.0620	0.0604	0.2143	0.2197
Number of firms	19	19	19	19

Note: Robust standard errors in parentheses (FE), *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 3.6b: Determinants of investments in the 19 listed real estate (reduced form).
(Panel estimation with fixed effect and robust standard errors (FE))

Independent Variables	Dependent variable = $Investment_{(t)}$ / Total Value of Fixed Assets with $Inventory_{(t-1)}$			
After-tax Marginal $q_{(t)}$	0.0320 **	0.0327 **	0.0224 *	0.0221 **
	(0.0119)	(0.0123)	(0.0114)	(0.0105)
Total Value of Fixed Assets with $Inventory_{(t)}$ / Total $Assets_{(t-1)}$		-0.0226		-0.0849
		(0.0919)		(0.1043)
Constant	-22.4369 ***	-21.3437 ***	0.1221 ***	0.2272 *
	(7.3873)	(6.1734)	(0.0284)	(0.1208)
Year	0.0112 ***	0.0107 ***		
	(0.0037)	(0.0031)		
Year 2003 (Dropped)				
Year 2004			-0.0405	-0.1134 **
			(0.0276)	(0.0484)
Year 2005			-0.0606	-0.0652
			(0.0402)	(0.0672)
Year 2006			0.0770	0.0552
			(0.0667)	(0.0635)
Year 2007			0.0635	0.0483
			(0.1176)	(0.1187)
Year 2008			-0.0474	-0.0855
			(0.0423)	(0.0660)
Year 2009			0.0299	0.0094
			(0.0430)	(0.0688)
Year 2010			0.0018	-0.0298
			(0.0338)	(0.0434)
Year 2011			0.0171	-0.0097
			(0.0330)	(0.0529)
Year 2012			-0.0277	-0.0580
			(0.0428)	(0.0567)
Year 2013			-0.0266	-0.0550
			(0.0329)	(0.0561)
Year 2014			-0.0213	-0.0576
			(0.0315)	(0.0589)
Year 2015			-0.0070	-0.0458
			(0.0370)	(0.0619)
Year 2016			0.1391 ***	0.1000
			(0.0470)	(0.0693)
Year 2017			0.2551 **	0.2232 ***
			(0.0942)	(0.0694)
Year 2018			0.1217 **	0.0807
			(0.0482)	(0.0631)
Year 2019			0.0383	-0.0040
			(0.0284)	(0.0549)
Year 2020			0.0364	-0.0123
			(0.0381)	(0.0680)
Observations	224	221	224	221
R-squared	0.0600	0.0604	0.2127	0.2191
Number of firms	19	19	19	19

Note: Robust standard errors in parentheses (FE), *** p<0.01, ** p<0.05, * p<0.1.

Table 3.6c: Determinants of investments in the 19 listed real estate (reduced form).
(Panel estimation with fixed effect and robust standard errors (FE))

Independent Variables	Dependent variable = Investment$_{(t)}$ / Total Value of Fixed Assets with Inventory $_{(t-1)}$			
Average $q_{(t)}$	0.0599 **	0.0635 *	0.0456 **	0.0509 *
	(0.0271)	(0.0322)	(0.0211)	(0.0281)
Total Value of Fixed Assets with		-0.0737		-0.1210
Inventory$_{(t)}$ / Total Assets$_{(t-1)}$		(0.1076)		(0.1112)
Constant	0.0599 **	0.0635 *	0.0456 **	0.0509 *
	(0.0271)	(0.0322)	(0.0211)	(0.0281)
Year	0.0074 *	0.0066 *		
	(0.0036)	(0.0032)		
Year 2004 (Dropped)				
Year 2005			-0.0098	0.0556
			(0.0147)	(0.0338)
Year 2006			0.1094	0.1782 **
			(0.0822)	(0.0667)
Year 2007			0.0436	0.1048
			(0.0686)	(0.0714)
Year 2008			-0.0285	0.0187
			(0.0467)	(0.0460)
Year 2009			0.0493	0.1077 **
			(0.0542)	(0.0449)
Year 2010			0.0366	0.0933 *
			(0.0502)	(0.0461)
Year 2011			0.0350	0.0995 ***
			(0.0482)	(0.0266)
Year 2012			-0.0144	0.0465
			(0.0661)	(0.0399)
Year 2013			-0.0229	0.0403
			(0.0524)	(0.0337)
Year 2014			-0.0175	0.0353
			(0.0541)	(0.0284)
Year 2015			0.0053	0.054 *
			(0.0520)	(0.0289)
Year 2016			0.1258 *	0.1736 ***
			(0.0651)	(0.0442)
Year 2017			0.2489 **	0.3064 ***
			(0.1060)	(0.0977)
Year 2018			0.1172 *	0.1625 ***
			(0.0609)	(0.0459)
Year 2019			0.0320	0.0757 **
			(0.0520)	(0.0282)
Year 2020			0.0304	0.0659
			(0.0475)	(0.0381)
Observations	221	219	221	219
R-squared	0.0682	0.0732	0.2127	0.2252
Number of firms	19	19	19	19

Note: Robust standard errors in parentheses (FE), *** p<0.01, ** p<0.05, * p<0.1.

Table 3.7a: Determinants of investments in the 19 listed real estate (adjustment cost model).
(Panel estimation with fixed effect and robust standard errors (FE))

Independent Variables	Dependent variable = $Investment_{(t)}$ / Total Value of Fixed Assets with $Inventory_{(t-1)}$			
[Before-tax Marginal $q_{(t)}$ - 1]*Price Index for Investment in Fixed Assets	0.0205 **	0.0204 **	0.015 *	0.0141 *
	(0.0080)	(0.0082)	(0.0077)	(0.0071)
Total Value of Fixed Assets with Inventory $_{(t)}$ / Total Assets $_{(t-1)}$		-0.0229		-0.0851
		(0.0940)		(0.1053)
Constant	-21.7058 ***	-20.7065 ***	0.1261 ***	0.2324 *
	(7.0183)	(5.8496)	(0.0254)	(0.1221)
Year	0.0109 ***	0.0104 ***		
	(0.0035)	(0.0029)		
Year 2003 (Dropped)				
Year 2004			-0.0379	-0.1083 **
			(0.0244)	(0.0483)
Year 2005			-0.0317	-0.0551
			(0.0302)	(0.0664)
Year 2006			0.0886	0.0684
			(0.0640)	(0.0628)
Year 2007			0.0638	0.0546
			(0.1022)	(0.1030)
Year 2008			-0.0389	-0.0764
			(0.0374)	(0.0635)
Year 2009			0.0435	0.0219
			(0.0443)	(0.0688)
Year 2010			0.0097	-0.0199
			(0.0360)	(0.0435)
Year 2011			0.0263	0.0003
			(0.0339)	(0.0524)
Year 2012			-0.0146	-0.0451
			(0.0446)	(0.0568)
Year 2013			-0.0164	-0.0450
			(0.0334)	(0.0559)
Year 2014			-0.0120	-0.0487
			(0.0332)	(0.0593)
Year 2015			0.0027	-0.0367
			(0.0370)	(0.0612)
Year 2016			0.1496 ***	0.1096
			(0.0444)	(0.0669)
Year 2017			0.265 **	0.233 ***
			(0.0932)	(0.0669)
Year 2018			0.1302 **	0.0888
			(0.0501)	(0.0632)
Year 2019			0.0478	0.0049
			(0.0323)	(0.0556)
Year 2020			0.0462	-0.0033
			(0.0434)	(0.0696)
Observations	224	221	224	221
R-squared	0.0620	0.0604	0.2143	0.2197
Number of firms	19	19	19	19

Note: Robust standard errors in parentheses (FE), *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 3.7b: Determinants of investments in the 19 listed real estate (adjustment cost model).
(Panel estimation with fixed effect and robust standard errors (FE))

Independent Variables	Dependent variable = Investment$_{(t)}$ / Total Value of Fixed Assets with Inventory $_{(t-1)}$			
[After-tax Marginal $q_{(t)}$ - 1]*Price Index for Investment in Fixed Assets	0.0316 ** (0.0118)	0.0323 ** (0.0122)	0.0221 * (0.0113)	0.0219 ** (0.0103)
Total Value of Fixed Assets with Inventory $_{(t)}$ / Total Assets$_{(t-1)}$		-0.0226 (0.0919)		-0.0849 (0.1043)
Constant	-22.4048 *** (7.3805)	-21.311 *** (6.1682)	0.1445 *** (0.0176)	0.2494 * (0.1223)
Year	0.0112 *** (0.0037)	0.0107 *** (0.0031)		
Year 2003 (Dropped)				
Year 2004			-0.0405 (0.0276)	-0.1134 ** (0.0484)
Year 2005			-0.0606 (0.0402)	-0.0652 (0.0672)
Year 2006			0.0770 (0.0667)	0.0552 (0.0635)
Year 2007			0.0635 (0.1176)	0.0483 (0.1187)
Year 2008			-0.0474 (0.0423)	-0.0855 (0.0660)
Year 2009			0.0299 (0.0430)	0.0094 (0.0688)
Year 2010			0.0018 (0.0338)	-0.0298 (0.0434)
Year 2011			0.0171 (0.0330)	-0.0097 (0.0529)
Year 2012			-0.0277 (0.0428)	-0.0580 (0.0567)
Year 2013			-0.0266 (0.0329)	-0.0550 (0.0561)
Year 2014			-0.0213 (0.0315)	-0.0576 (0.0589)
Year 2015			-0.0070 (0.0370)	-0.0458 (0.0619)
Year 2016			0.1391 *** (0.0470)	0.1000 (0.0693)
Year 2017			0.2551 ** (0.0942)	0.2232 *** (0.0694)
Year 2018			0.1217 ** (0.0482)	0.0807 (0.0631)
Year 2019			0.0383 (0.0284)	-0.0040 (0.0549)
Year 2020			0.0364 (0.0381)	-0.0123 (0.0680)
Observations	224	221	224	221
R-squared	0.0600	0.0604	0.2127	0.2191
Number of firms	19	19	19	19

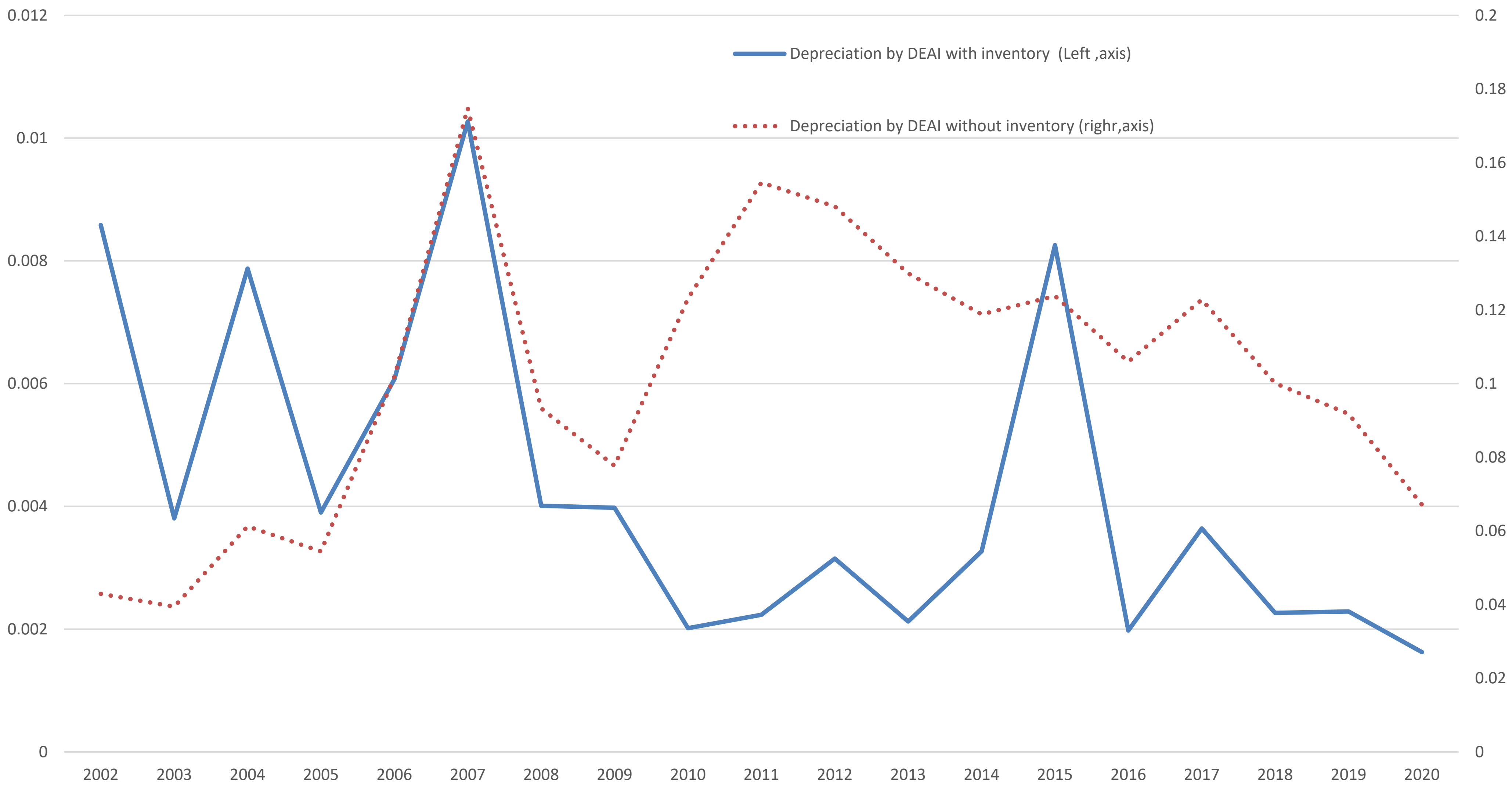
Note: Robust standard errors in parentheses (FE), *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 3.7c: Determinants of investments in the 19 listed real estate (adjustment cost model). (Panel estimation with fixed effect and robust standard errors (FE))

Independent Variables	Dependent variable = $Investment_{(t)}$ / Total Value of Fixed Assets with $Inventory_{(t-1)}$			
[Average $q_{(t)}$ - 1]*Price Index for Investment in Fixed Assets	0.0592 **	0.0628 *	0.045 **	0.0503 *
	(0.0268)	(0.0318)	(0.0208)	(0.0278)
Total Value of Fixed Assets with $Inventory_{(t)}$ / Total $Assets_{(t-1)}$		-0.0737		-0.1210
		(0.1076)		(0.1112)
Constant	-14.8084 *	-13.0142 *	0.1383 ***	0.1815 **
	(7.3225)	(6.3723)	(0.0414)	(0.0820)
Year	0.0074 *	0.0066 *		
	(0.0036)	(0.0032)		
Year 2004 (Dropped)				
Year 2005			-0.0098	0.0556
			(0.0147)	(0.0338)
Year 2006			0.1094	0.1782 **
			(0.0822)	(0.0667)
Year 2007			0.0436	0.1048
			(0.0686)	(0.0714)
Year 2008			-0.0285	0.0187
			(0.0467)	(0.0460)
Year 2009			0.0493	0.1077 **
			(0.0542)	(0.0449)
Year 2010			0.0366	0.0933 *
			(0.0502)	(0.0461)
Year 2011			0.0350	0.0995 ***
			(0.0482)	(0.0266)
Year 2012			-0.0144	0.0465
			(0.0661)	(0.0399)
Year 2013			-0.0229	0.0403
			(0.0524)	(0.0337)
Year 2014			-0.0175	0.0353
			(0.0541)	(0.0284)
Year 2015			0.0053	0.054 *
			(0.0520)	(0.0289)
Year 2016			0.1258 *	0.1736 ***
			(0.0651)	-0.0442
Year 2017			0.2489 **	0.3064 ***
			(0.1060)	(0.0977)
Year 2018			0.1172 *	0.1625 ***
			(0.0609)	(0.0459)
Year 2019			0.0320	0.0757 **
			(0.0520)	(0.0282)
Year 2020			0.0304	0.0659
			(0.0475)	(0.0381)
Observations	221	219	221	219
R-squared	0.0682	0.0732	0.2127	0.2252
Number of firms	19	19	19	19

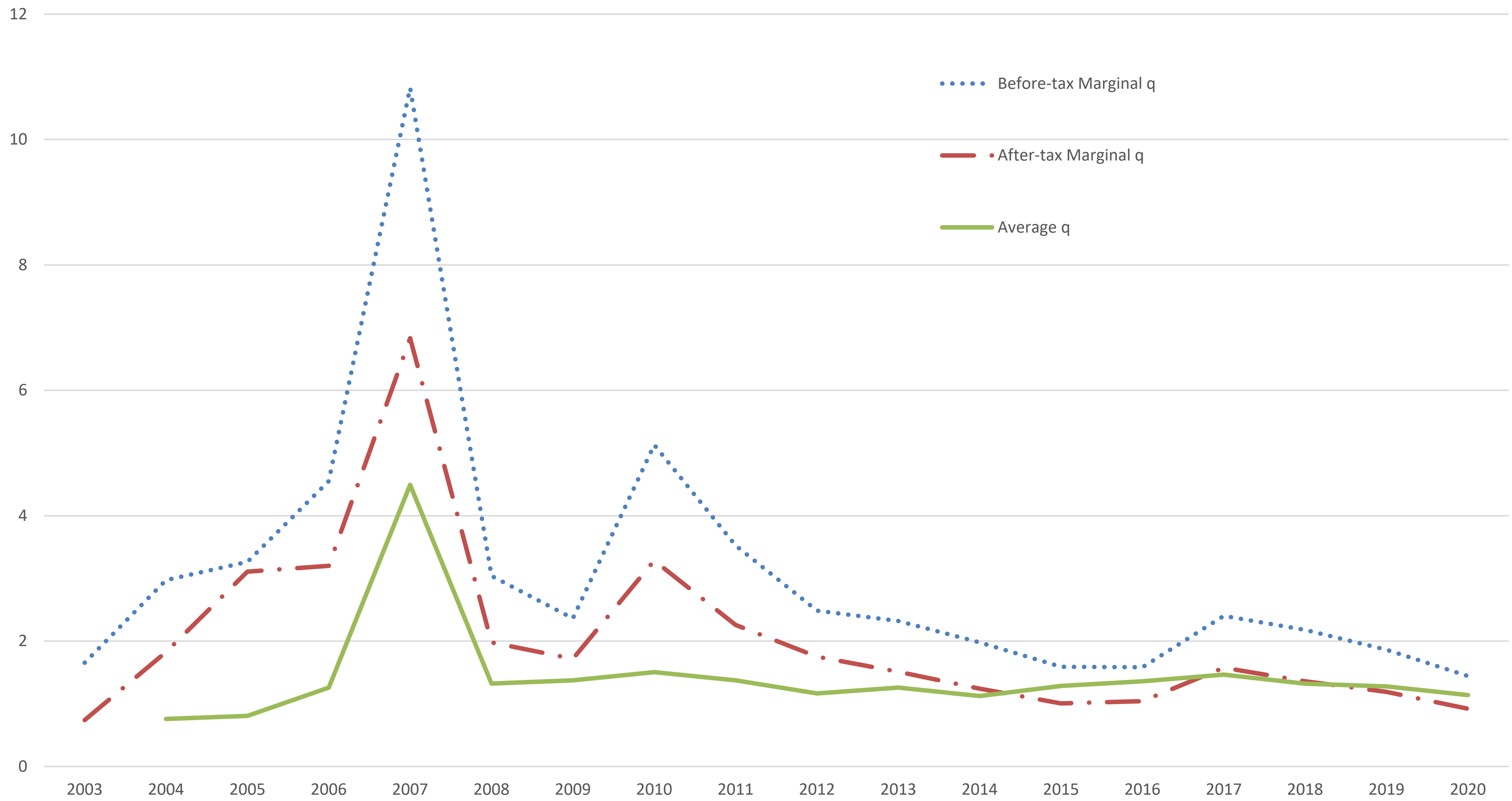
Note: Robust standard errors in parentheses (FE), *** p<0.01, ** p<0.05, * p<0.1.

Figure 3.1: Average value of Depreciation Expense as Accounting Item (DEAI) with and without inventory of the 19 listed real estate firms by year.



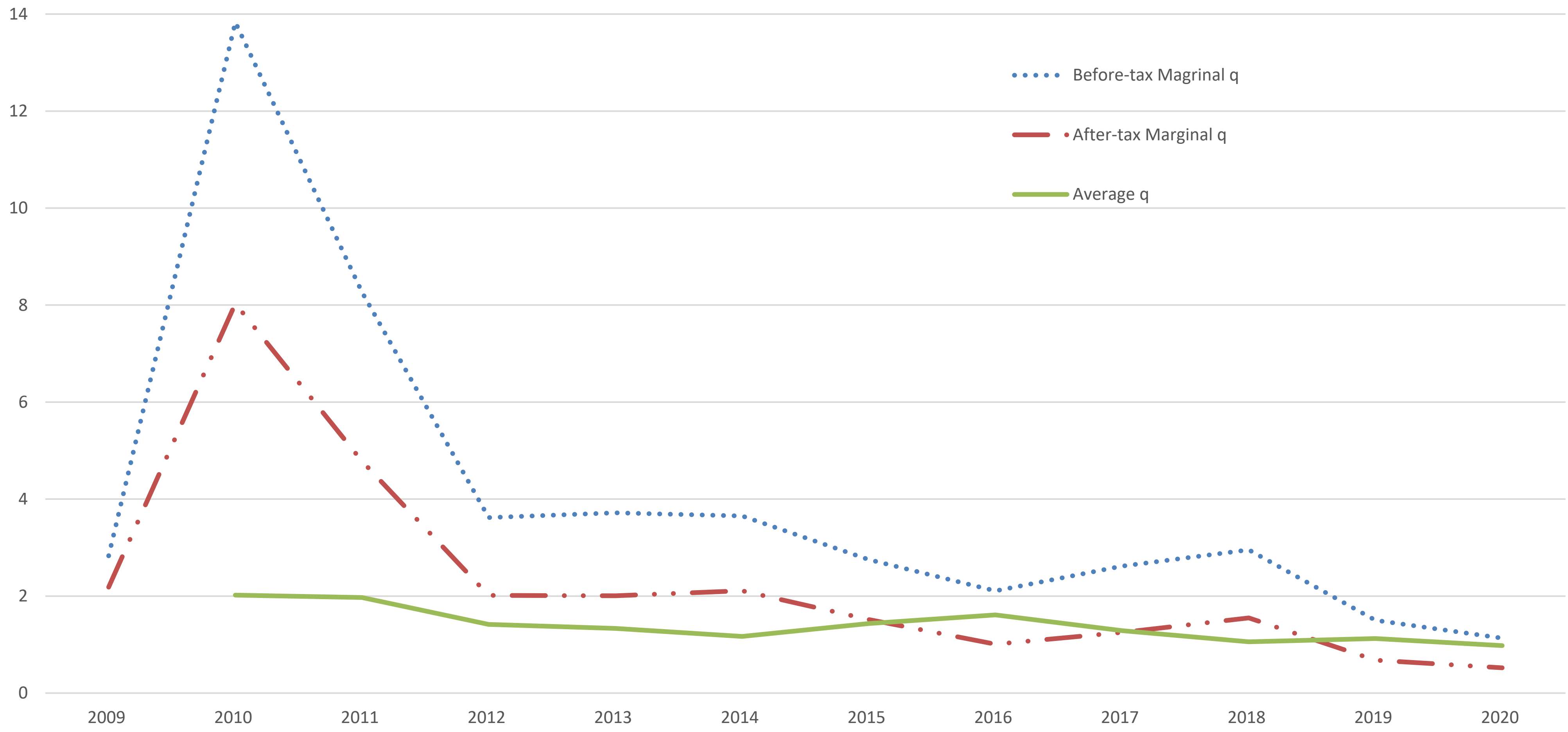
Source: Authors' estimations based on data from the balance sheets.

Figure 3.2: Average value of before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of the 19 listed real estate firms by year.



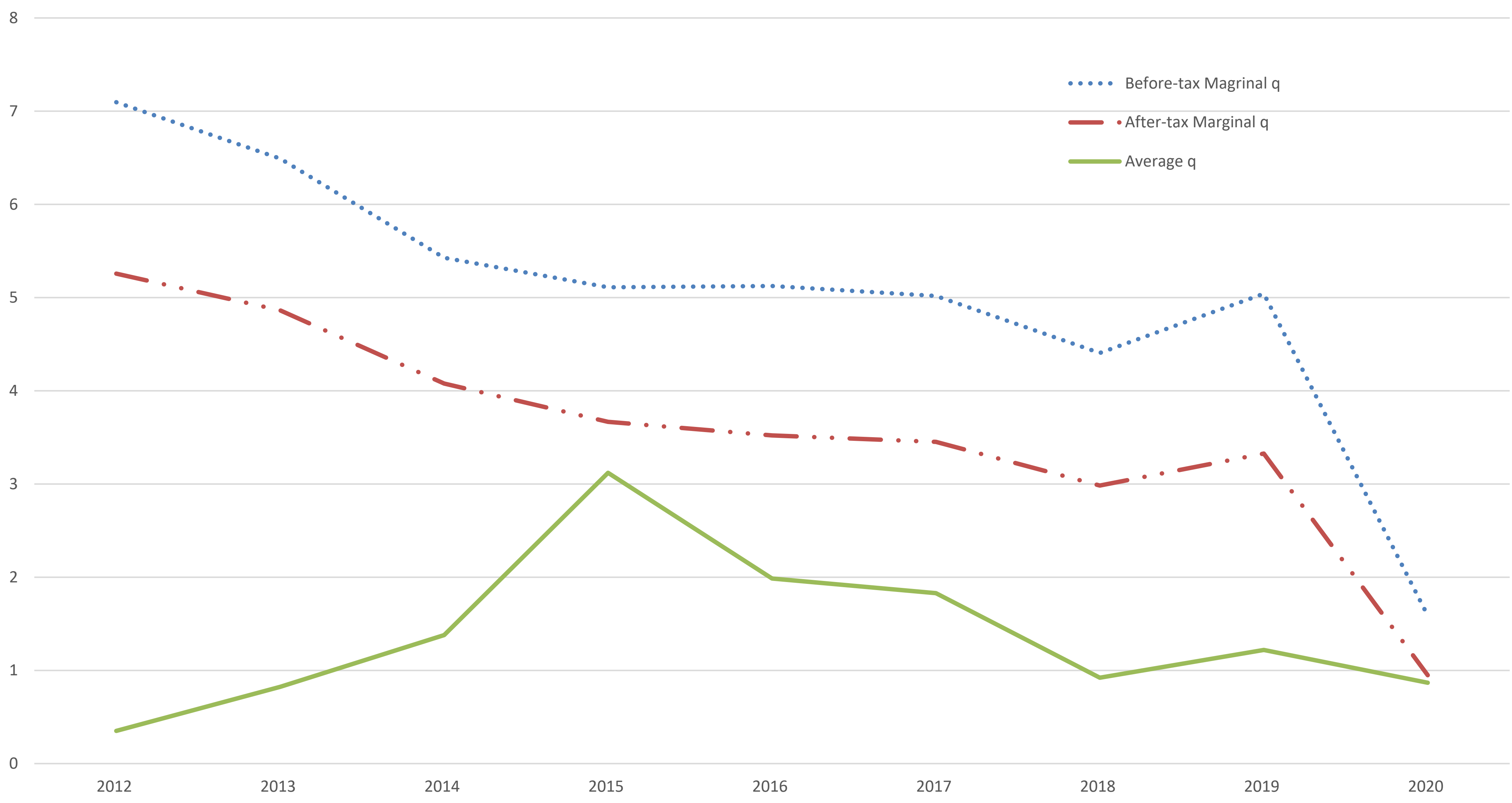
Source: Authors' estimations based on data from the balance sheets.

Figure 3.3: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of Evergrande Group for the period 2009–2020.



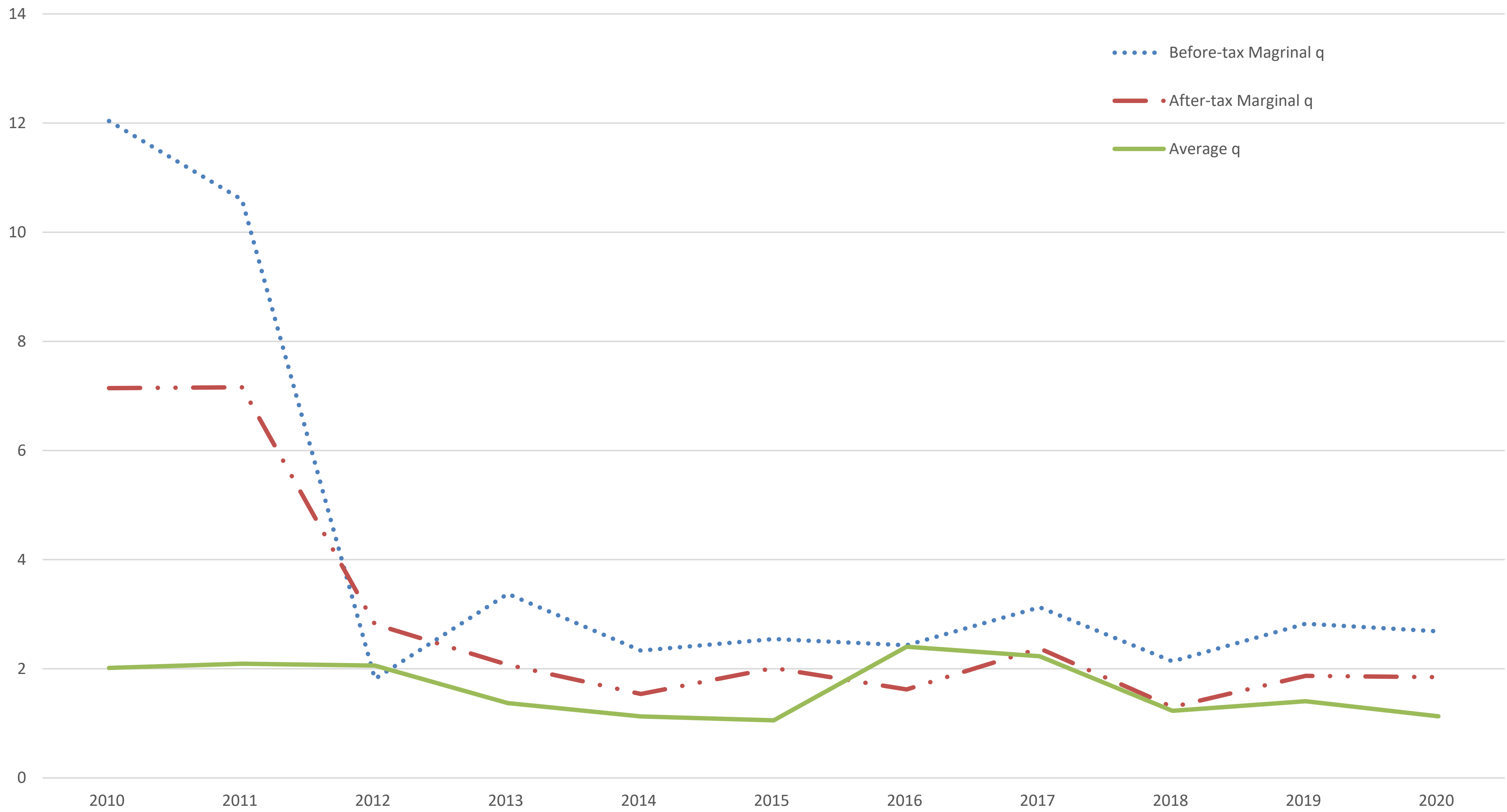
Source: Authors' estimations based on data from the balance sheet of Evergrande Group.

Figure 3.4: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of China Fortune Land Development Co., Ltd. for the period 2012–2020.



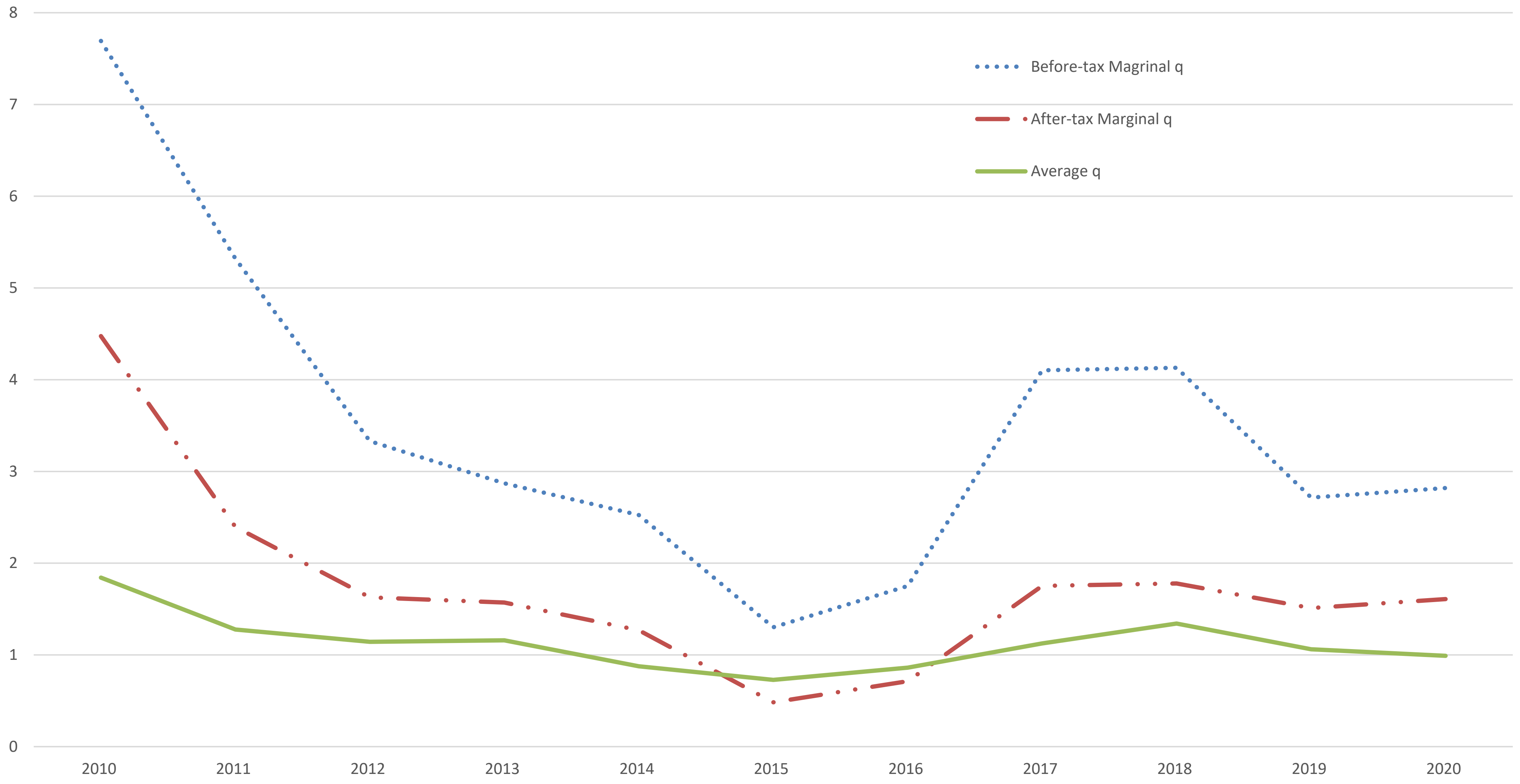
Source: Authors' estimations based on data from the balance sheet of Fortune Land Development Co., Ltd.

Figure 3.5: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of Sunac China Holdings Limited for the period 2010–2020.



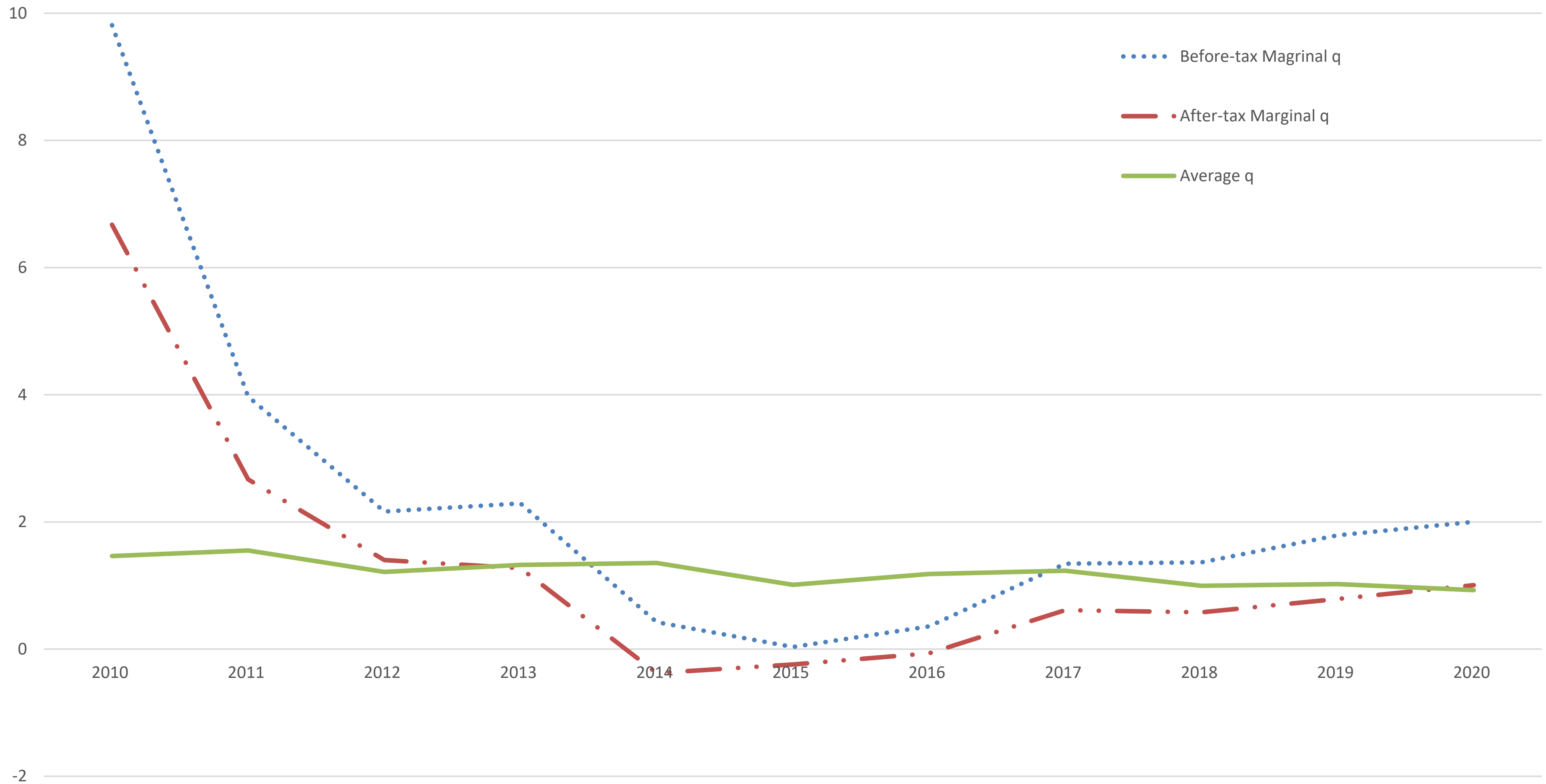
Source: Authors' estimations based on data from the balance sheet of Sunac China Holdings Limited.

Figure 3.6: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of Agile for the period 2010–2020.



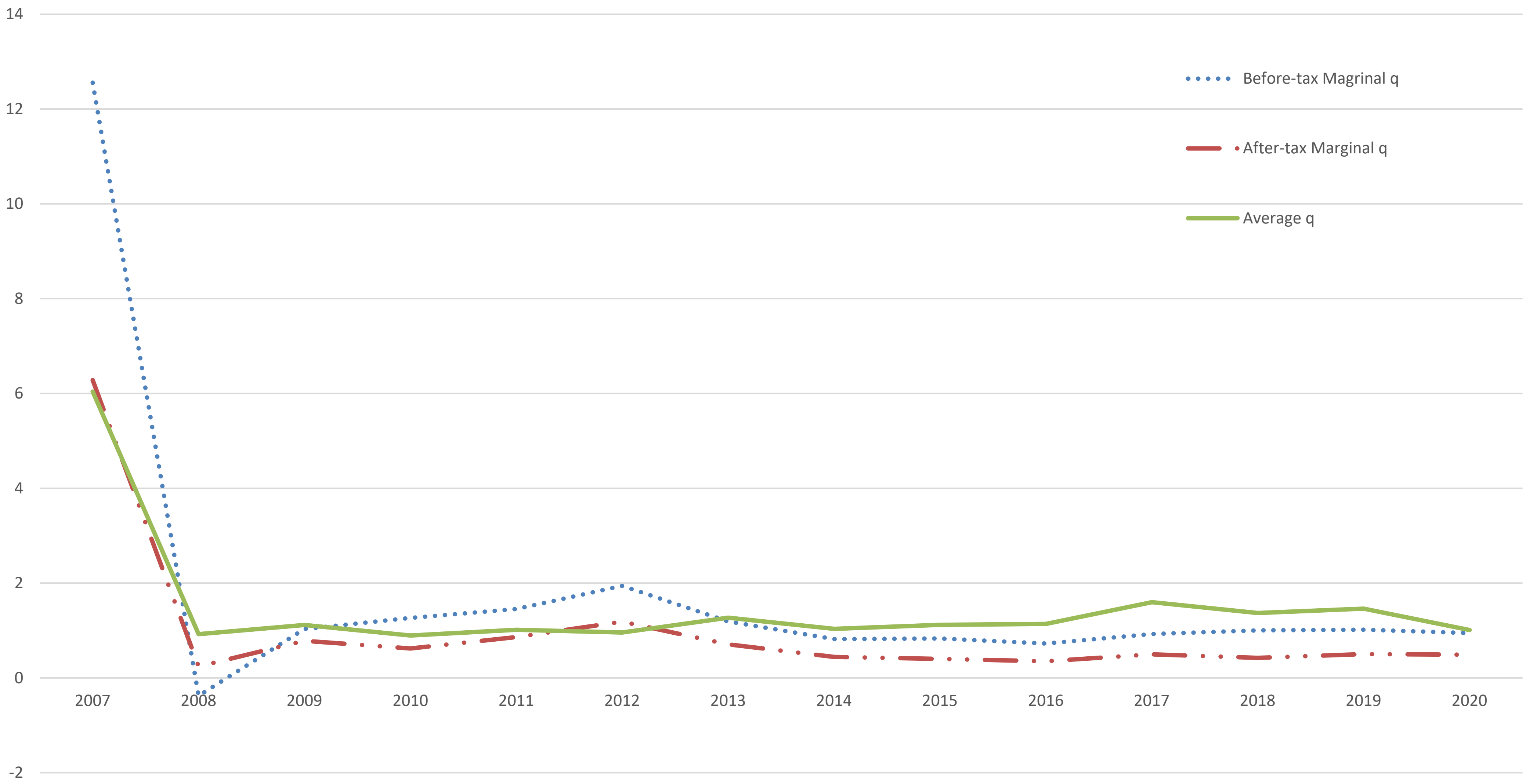
Source: Authors' estimations based on data from the balance sheet of Agile.

Figure 3.7: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of Kaisa Group Holdings Ltd. for the period 2010–2020.



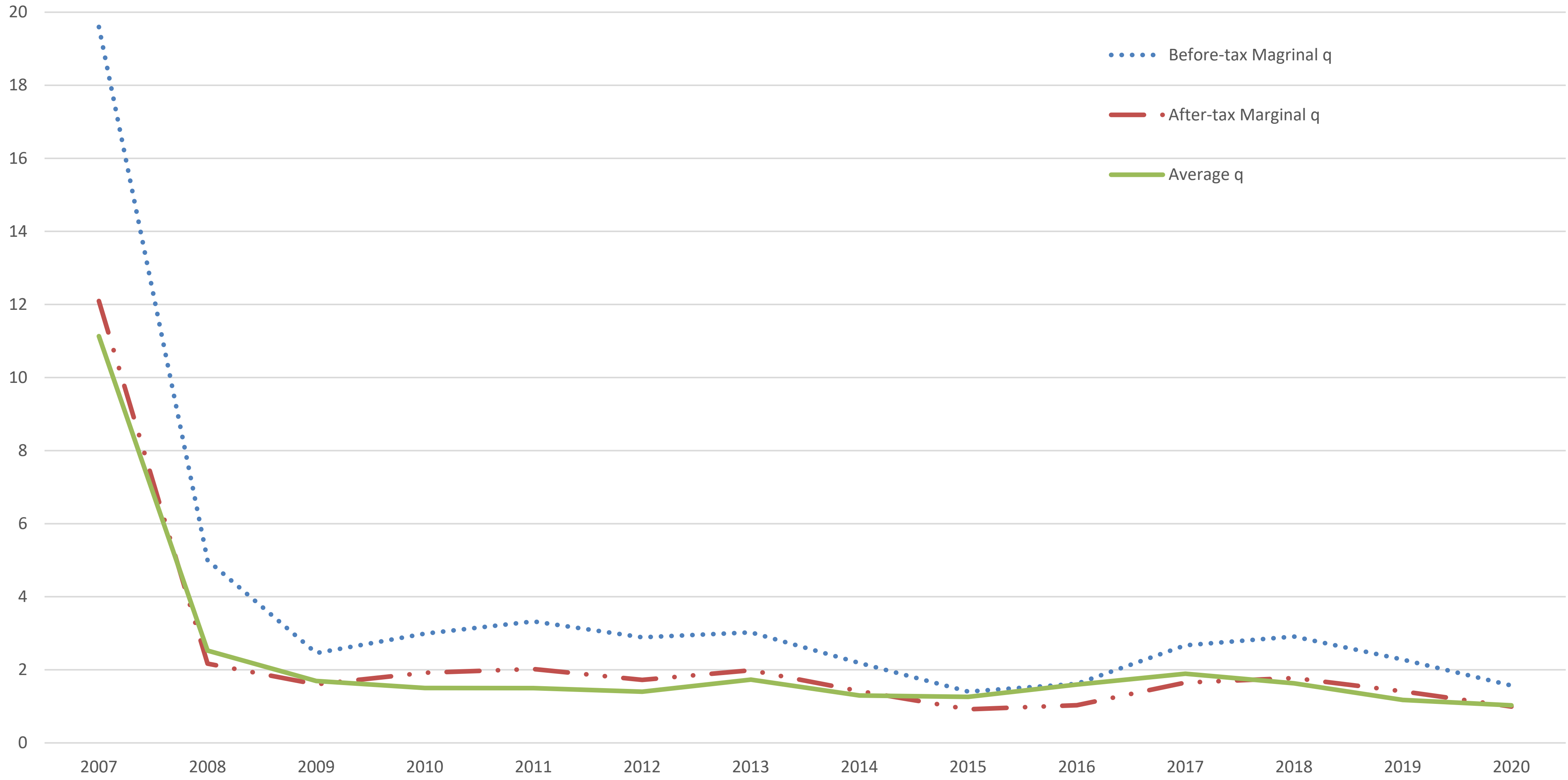
Source: Authors' estimations based on data from the balance sheet of Kaisa Group Holdings Ltd.

Figure 3.8: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of China Aoyuan Property Group Limited for the period 2007–2020.



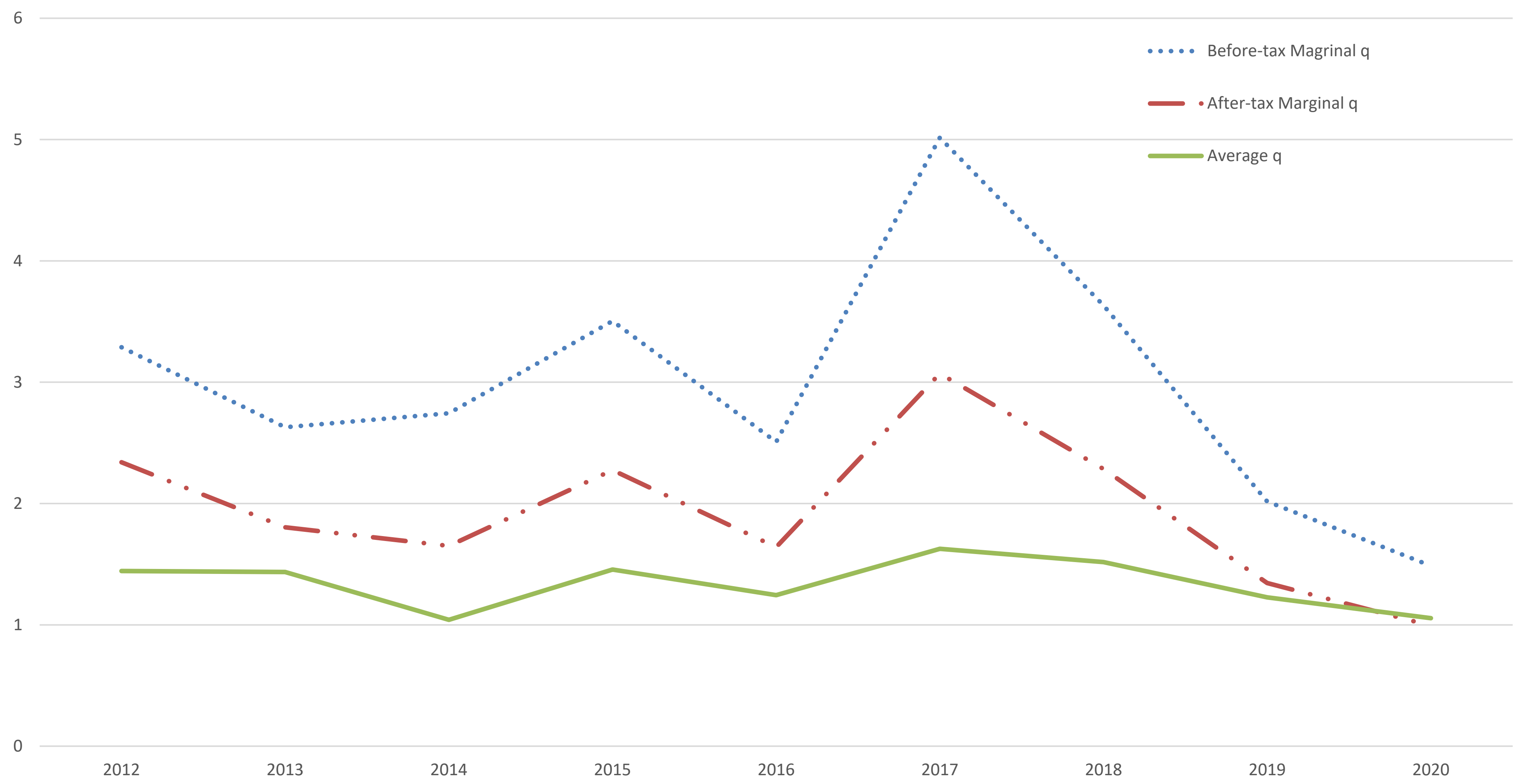
Source: Authors' estimations based on data from the balance sheet of China Aoyuan Property Group Limited.

Figure 3.9: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of Country Garden for the period 2007–2020.



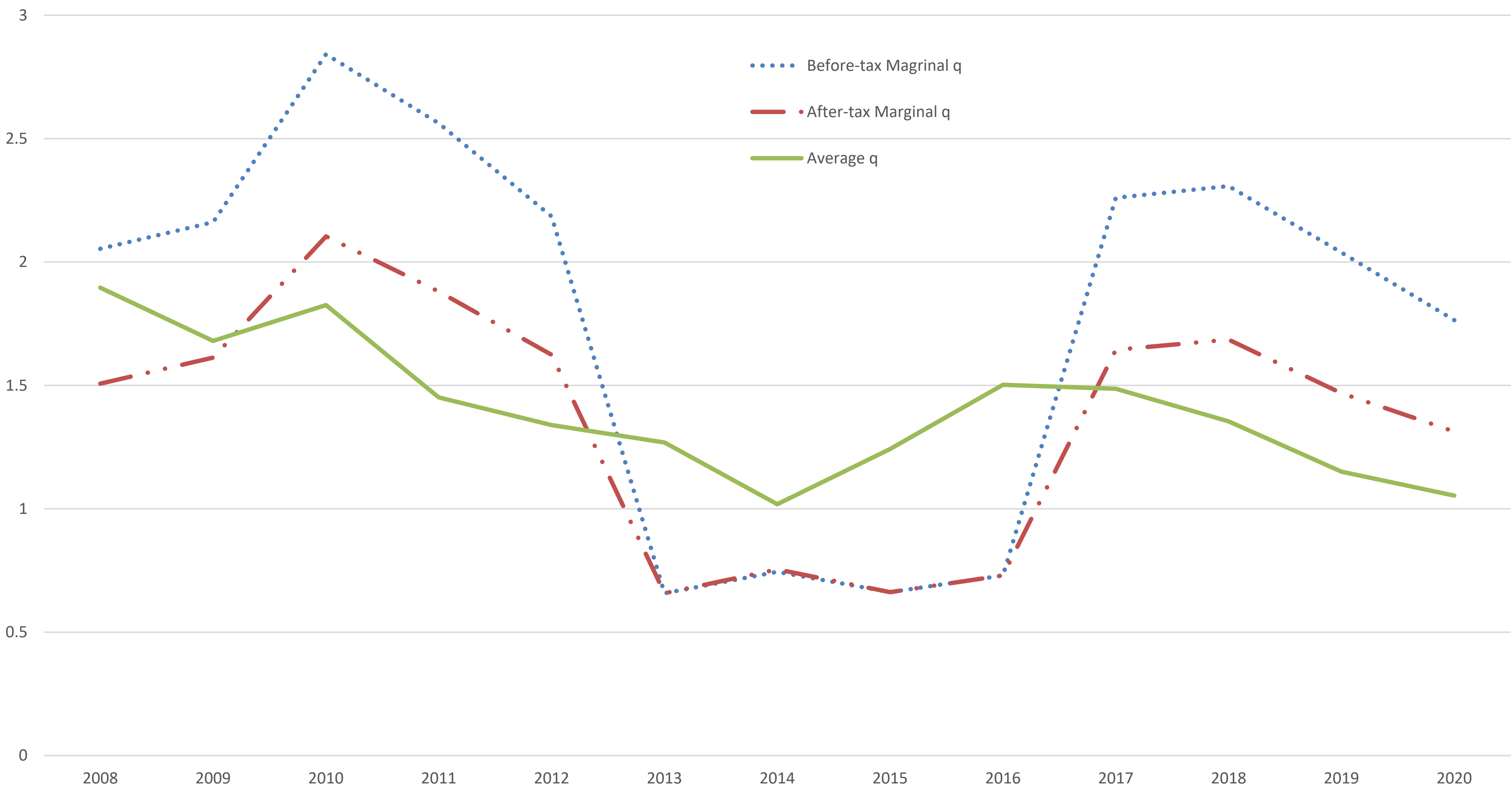
Source: Authors' estimations based on data from the balance sheet of Country Garden.

Figure 3.10: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of Cifi Group for the period 2012–2020.



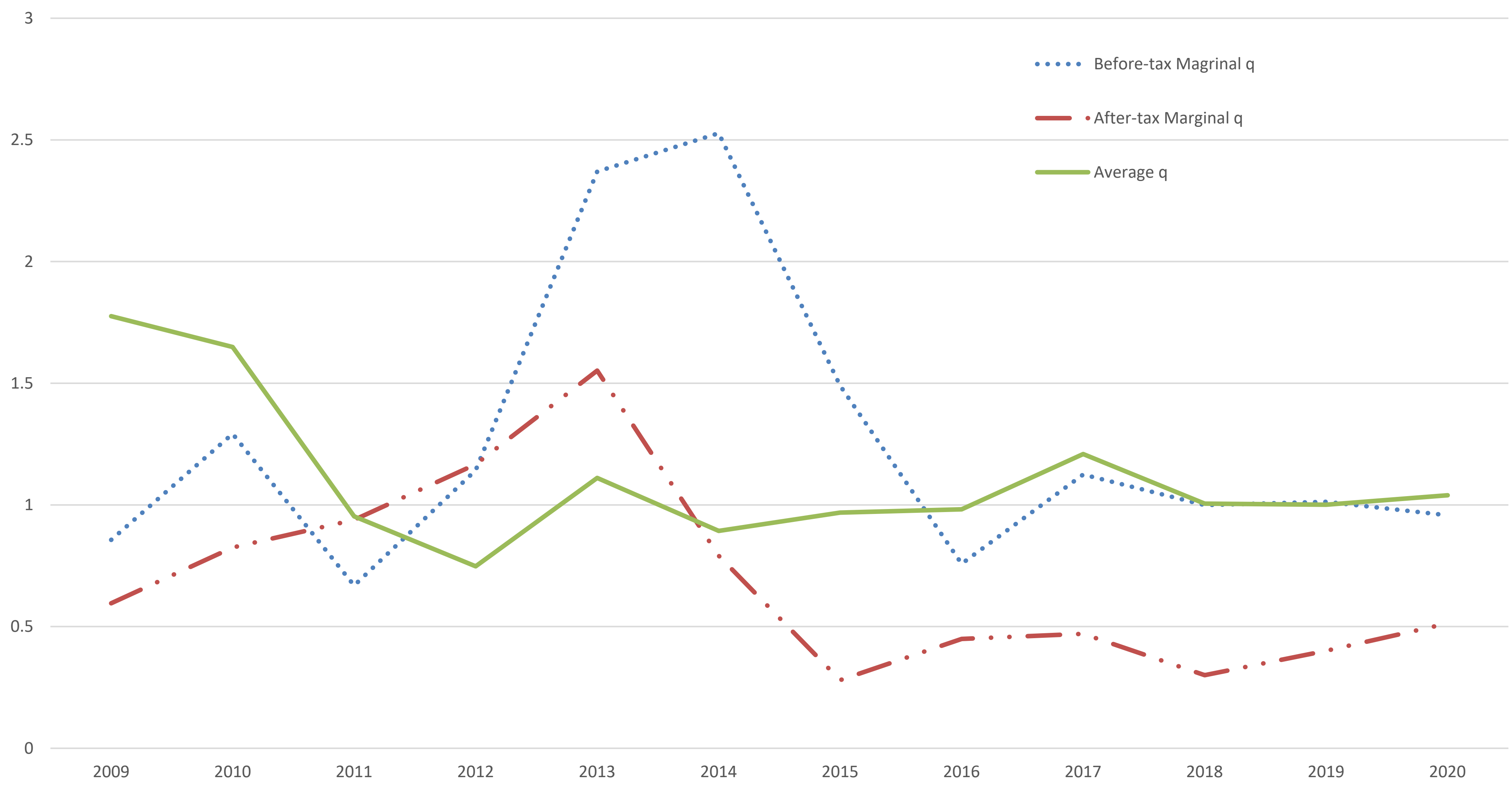
Source: Authors' estimations based on data from the balance sheet of Cifi Group.

Figure 3.11: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of China Vanke Co., Ltd. for the period 2008–2020.



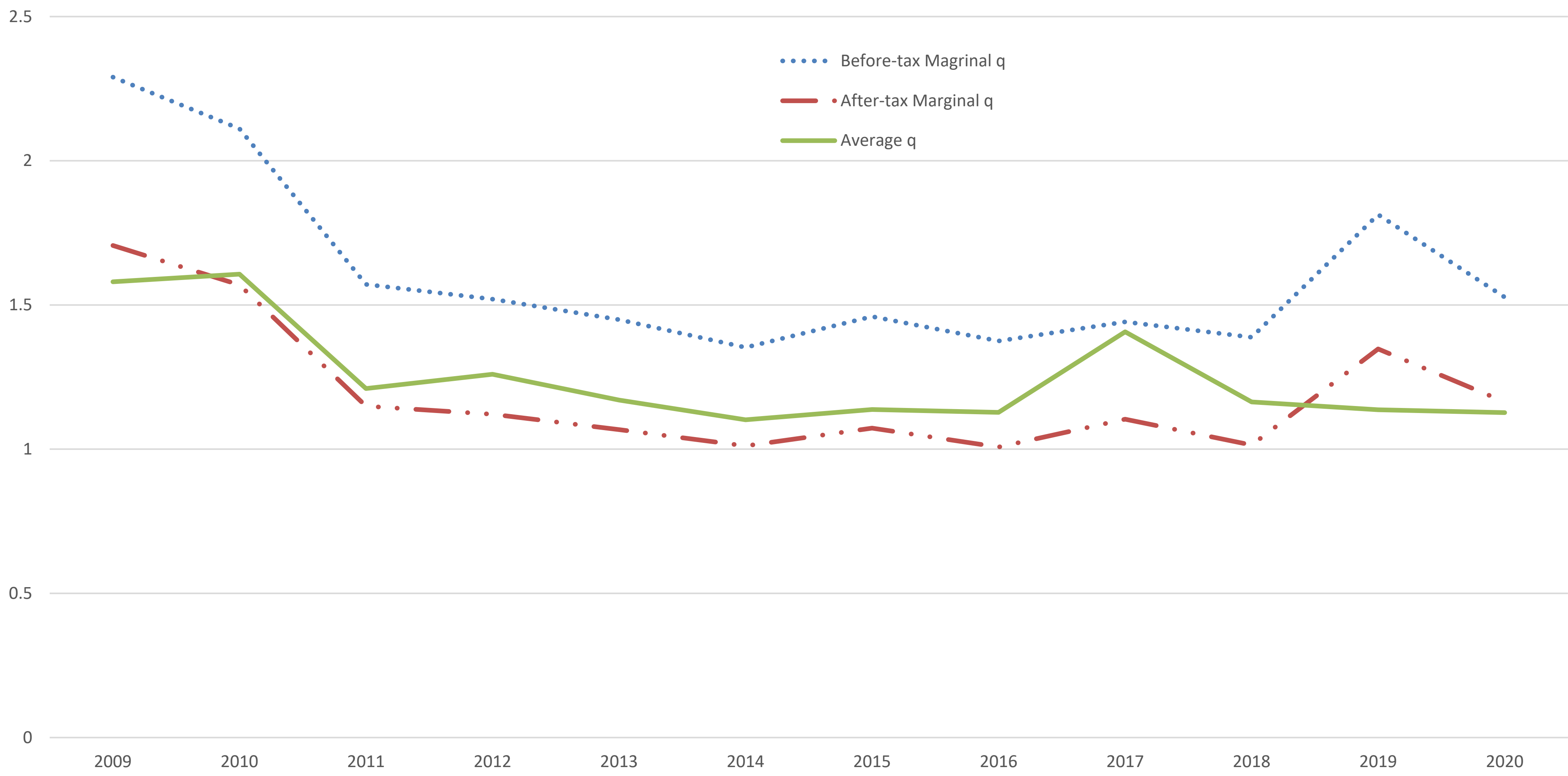
Source: Authors' estimations based on data from the balance sheet of China Vanke Co., Ltd.

Figure 3.12: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of Green Town for the period 2009–2020.



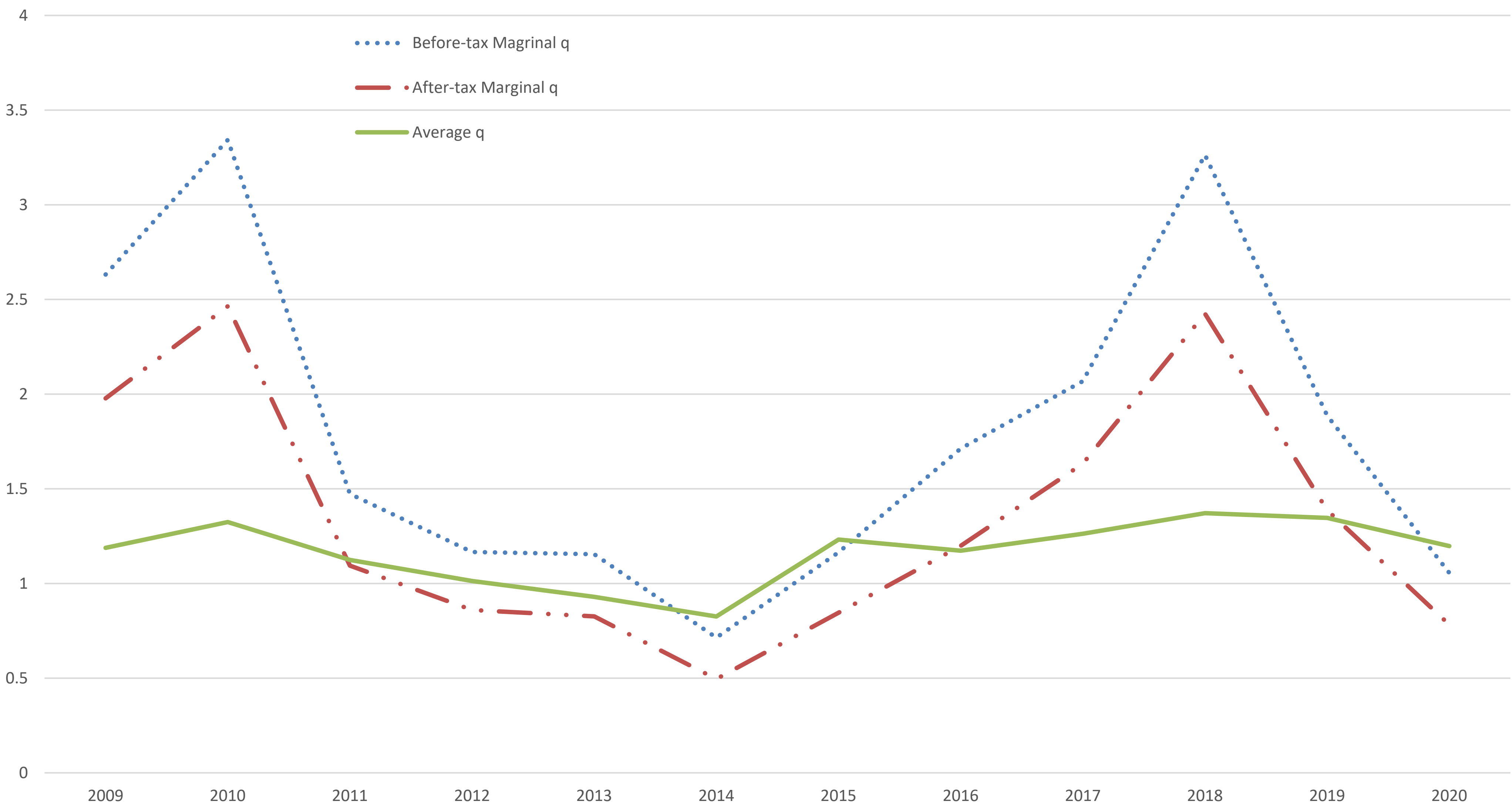
Source: Authors' estimations based on data from the balance sheet of Green Town.

Figure 3.13: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of Poly Development Holding Group Co., Ltd. for the period 2009–2020.



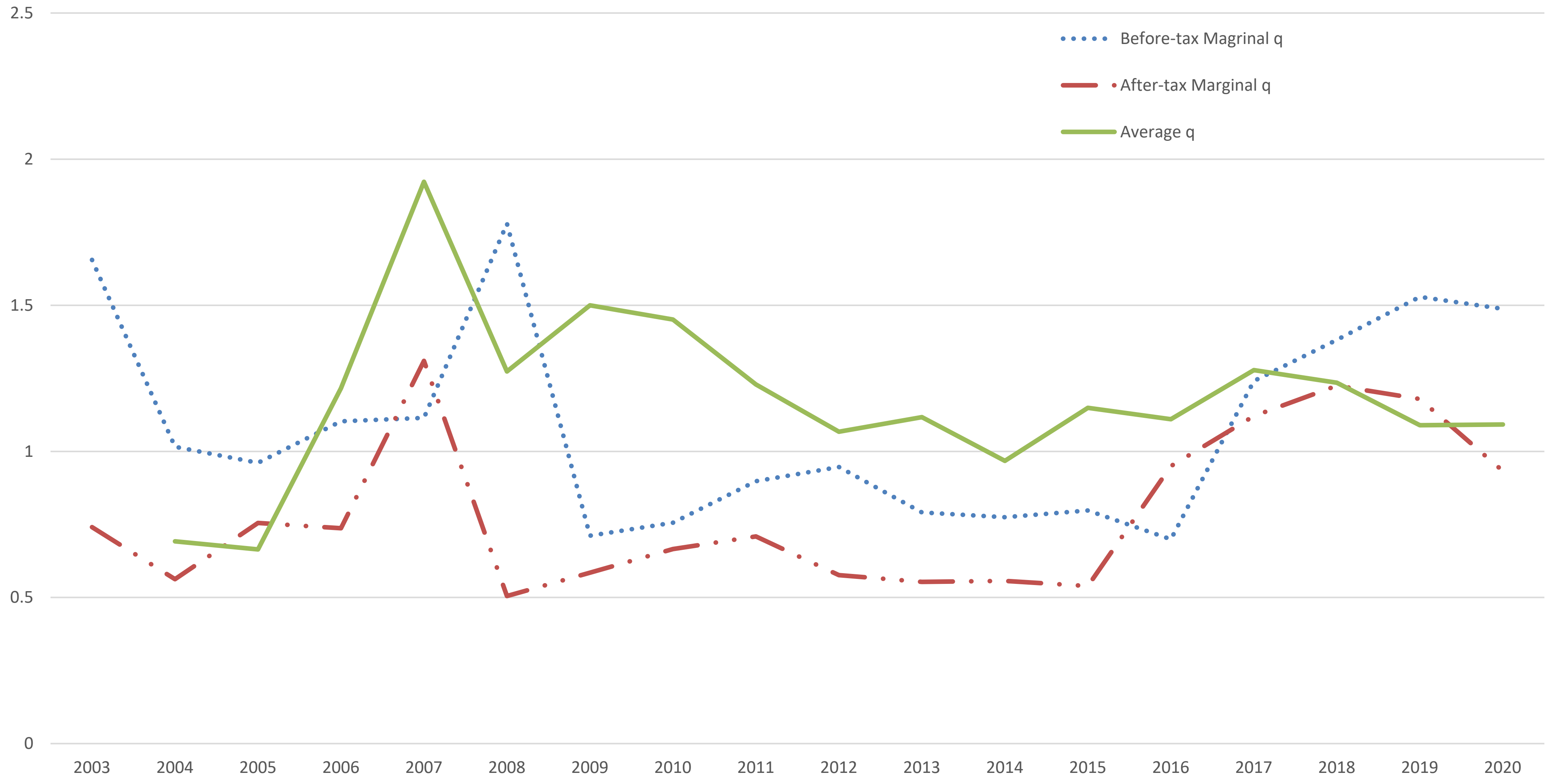
Source: Authors' estimations based on data from the balance sheet of Poly Development Holding Group Co., Ltd.

Figure 3.14: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of Hangzhou Binjiang Real Estate Group Co., Ltd. for the period 2009–2020.



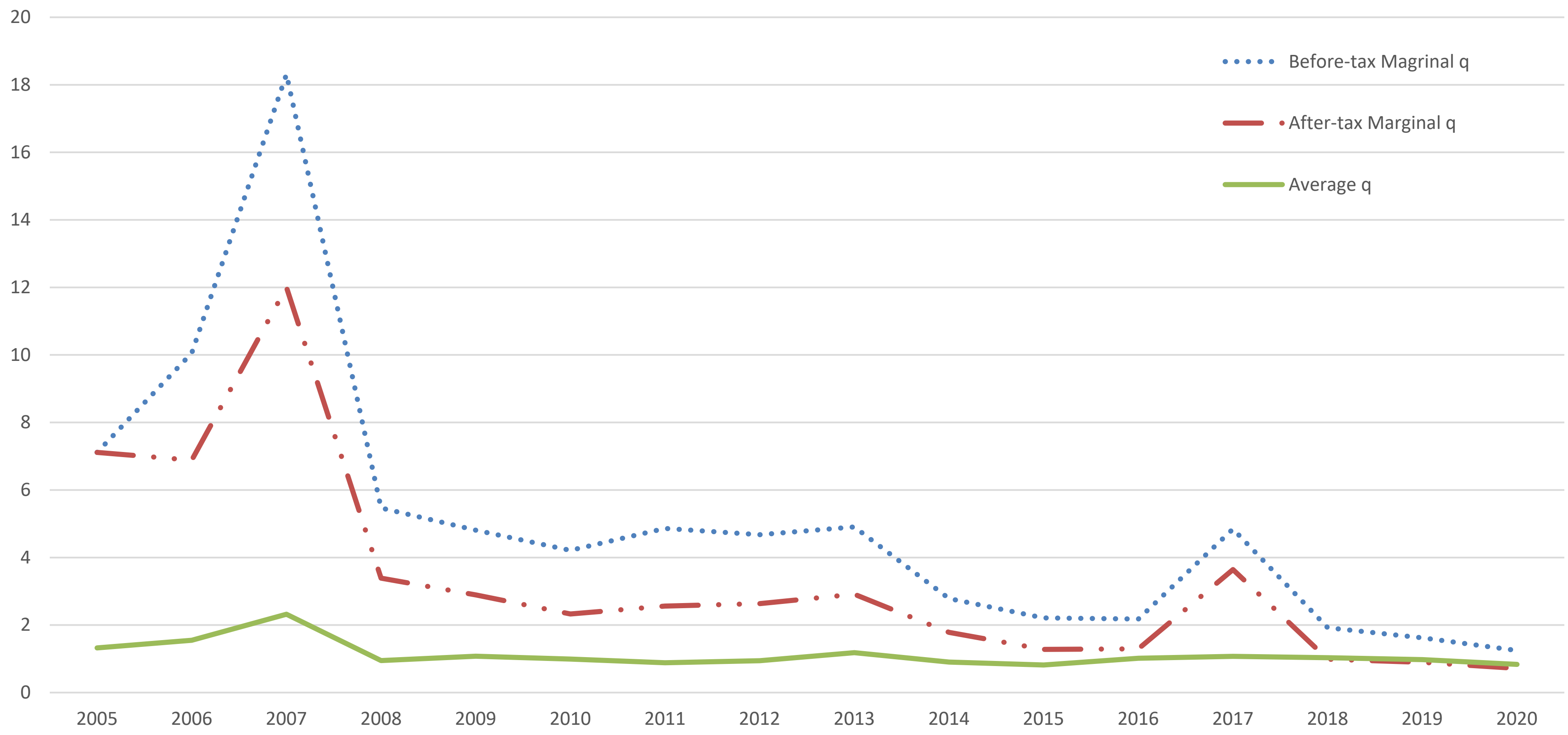
Source: Authors' estimations based on data from the balance sheet of Hangzhou Binjiang Real Estate Group Co., Ltd.

Figure 3.15: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of Gemdale Group for the period 2003–2020.



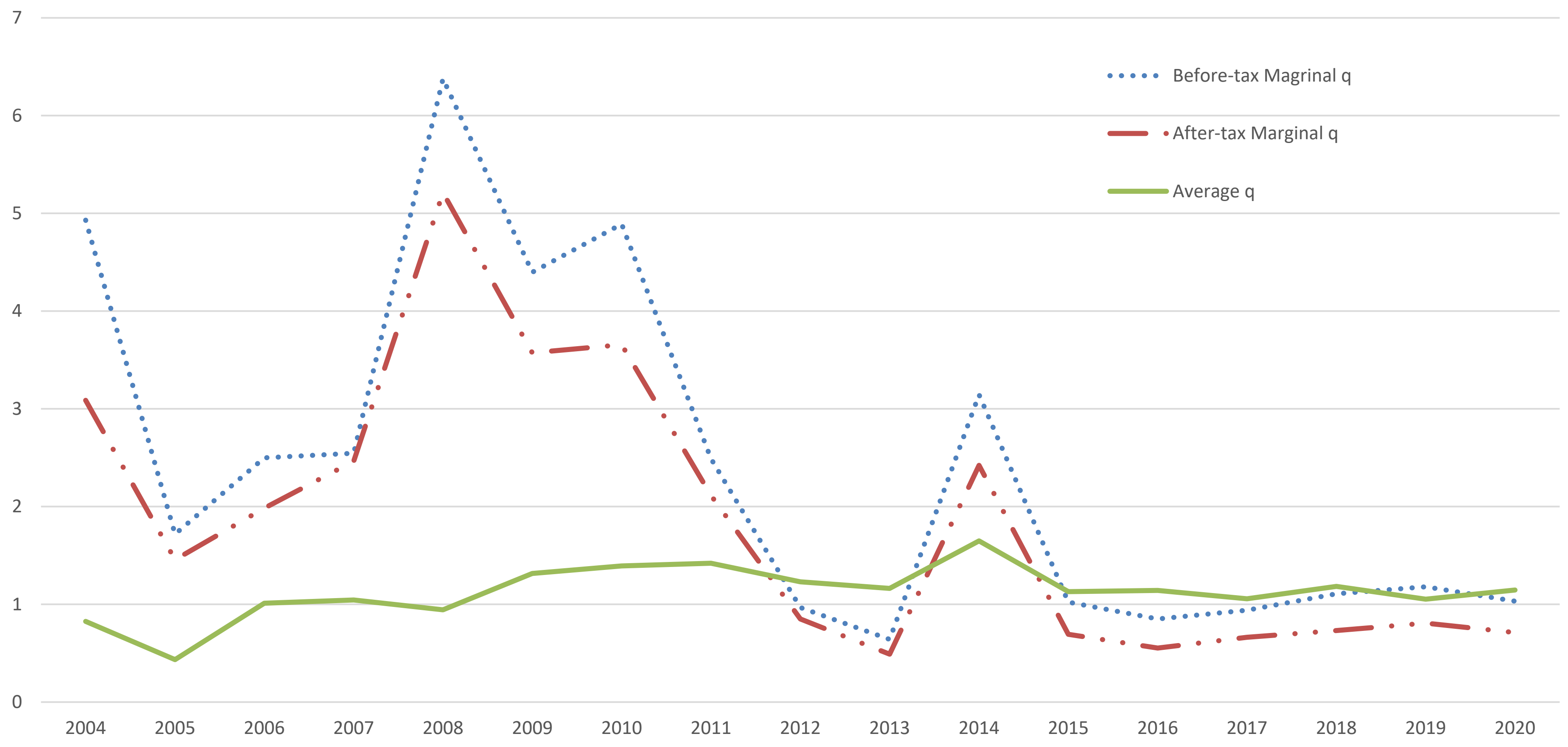
Source: Authors' estimations based on data from the balance sheet of Gemdale Group.

Figure 3.16: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of R&F Group for the period 2005–2020.



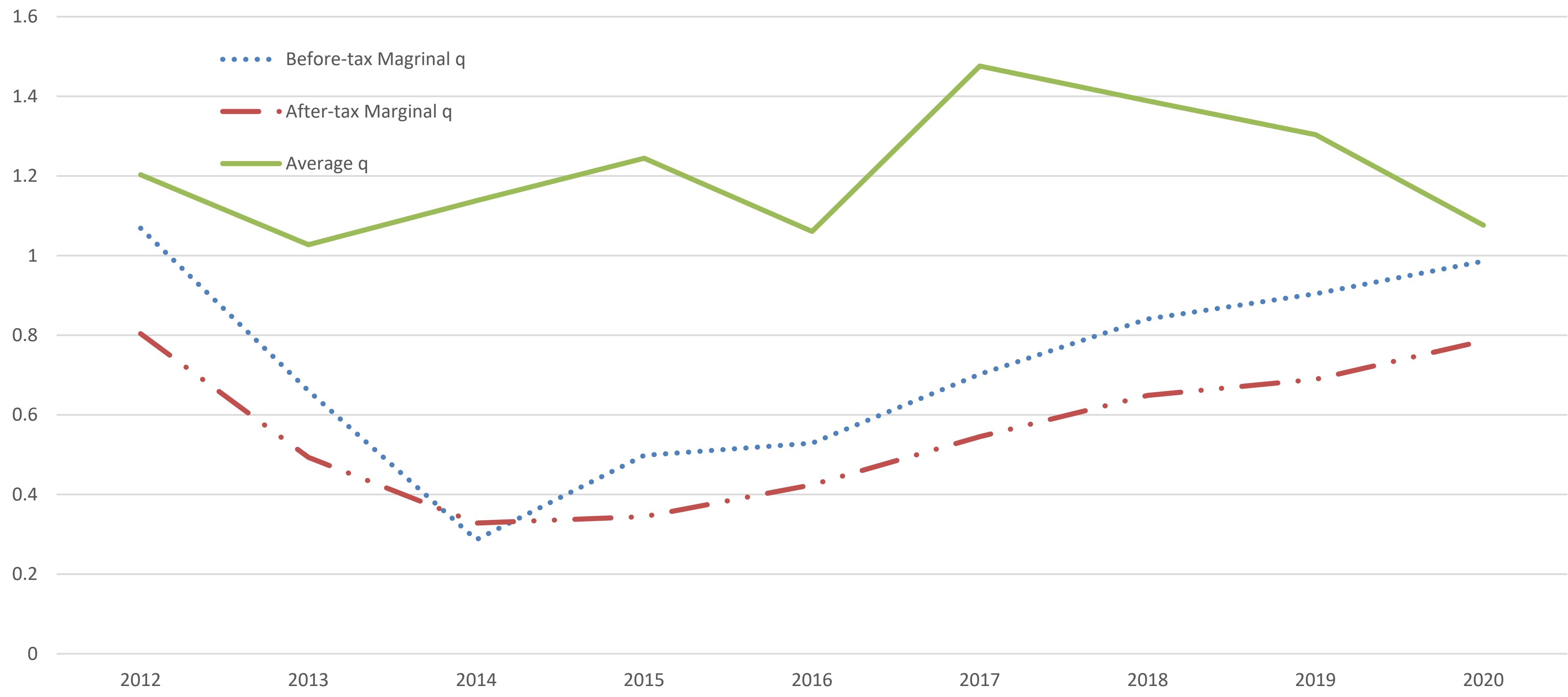
Source: Authors' estimations based on data from the balance sheet of R&F Group.

Figure 3.17: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of Green Land for the period 2004–2020.



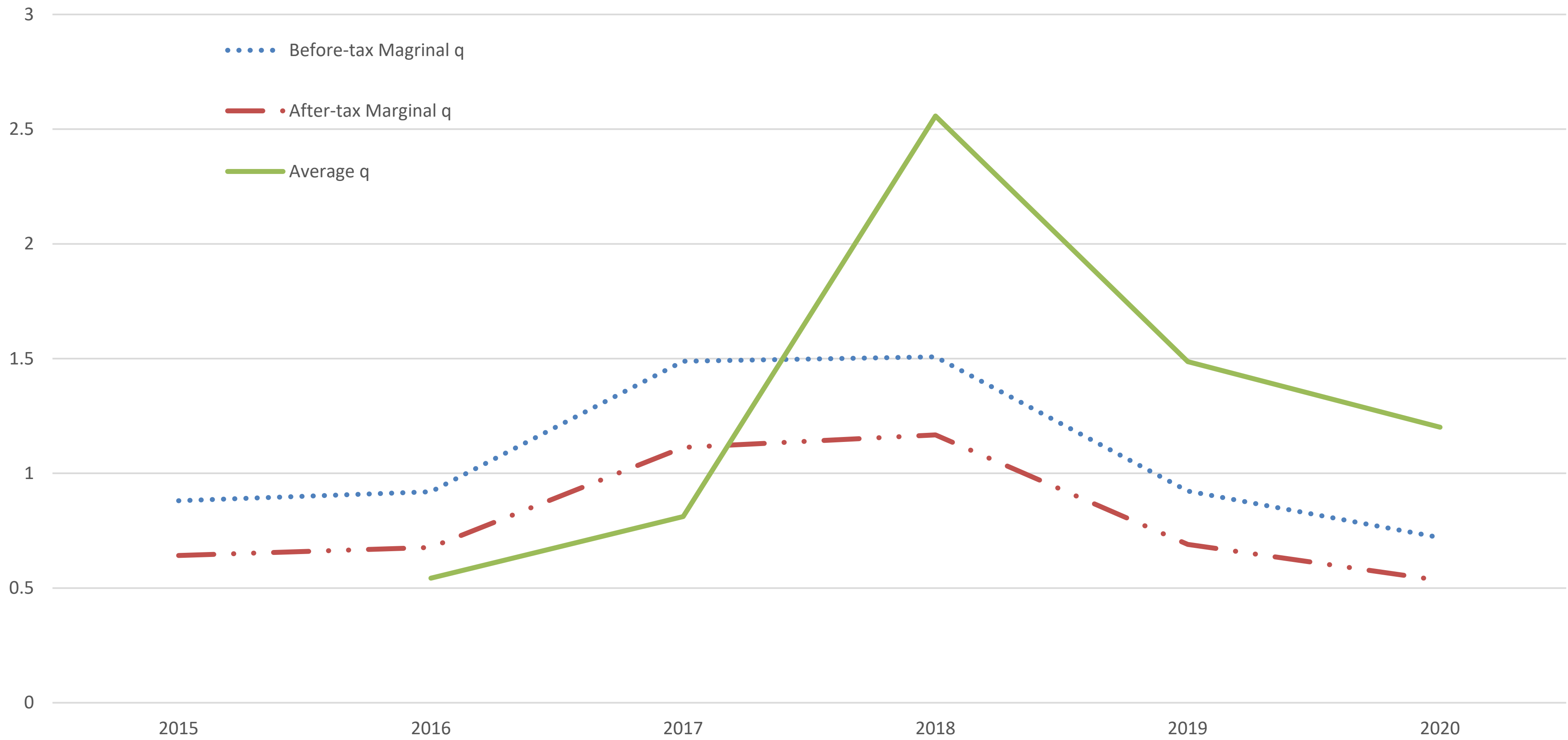
Source: Authors' estimations based on data from the balance sheet of Green Land.

Figure 3.18: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of Jinke Property Group Co., Ltd. for the period 2012–2020.



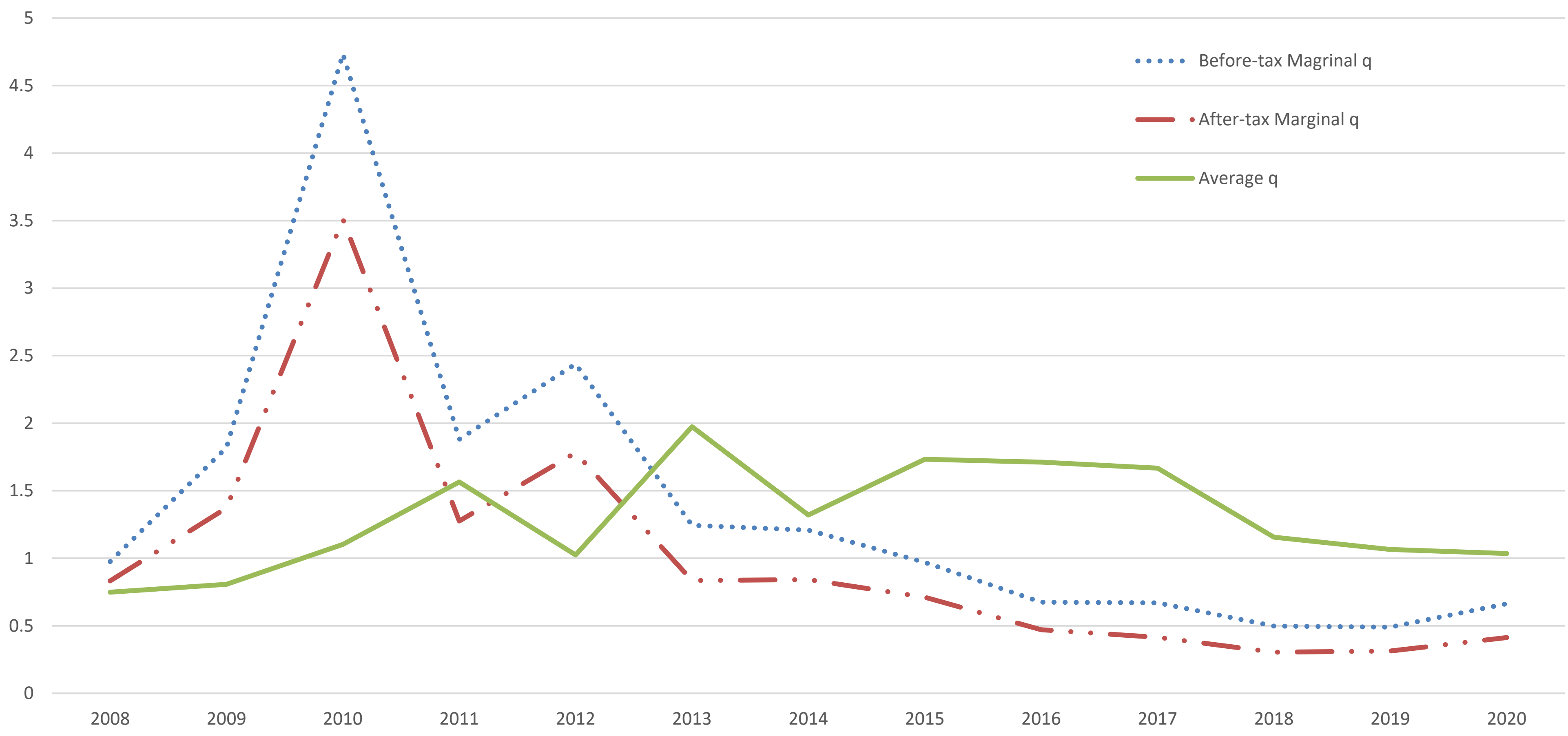
Source: Authors' estimations based on data from the balance sheet of Jinke Property Group Co., Ltd.

Figure 3.19: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of Seazen Holdings Co., Ltd. for the period 2015–2020.



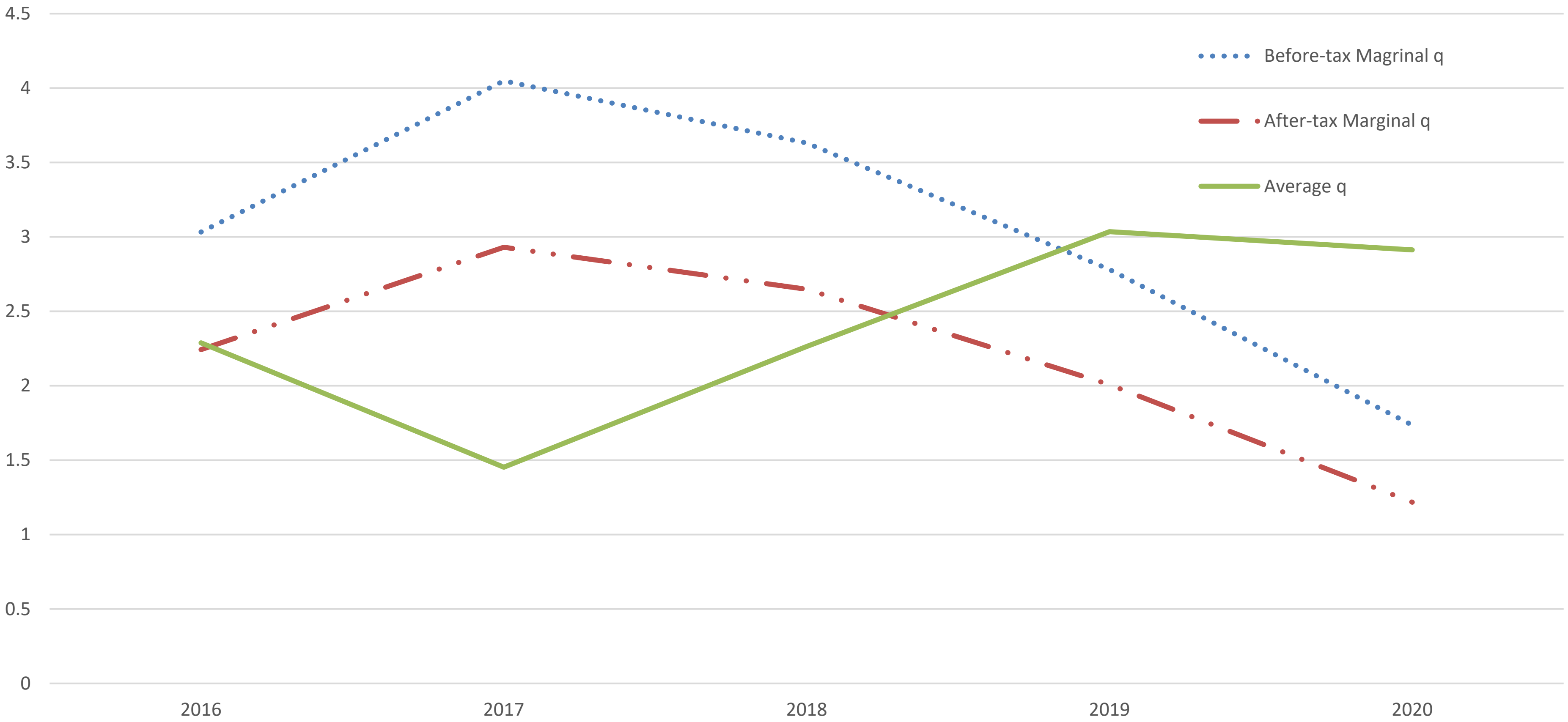
Source: Authors' estimations based on data from the balance sheet of Seazen Holdings Co., Ltd.

Figure 3.20: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of Yango Group for the period 2008–2020.



Source: Authors' estimations based on data from the balance sheet of Yango Group.

Figure 3.21: Before-tax Marginal *q*, after-tax Marginal *q*, and Average *q* of China Merchants Shekou Industrial Zone Holdings Co., Ltd. for the period 2016–2020.



Source: Authors' estimations based on data from the balance sheet of China Merchants Shekou Industrial Zone Holdings Co., Ltd.

Chapter 4

Investment in Construction Sector and Housing Prices: A Review[1]

Abstract

This chapter summarizes and analyzes the literature regarding construction sector investment and housing prices in China. First, we compare the literature from China, Japan, the U.S., and other countries in terms of how construction sector activity affects housing prices, investment, and depreciation. We analyze the effects of housing prices on the construction sector using an input-output table combined with the neoclassical theoretical framework established by Wan (2021). We found it useful to employ Marginal *q* theory to analyze real investment, although few studies have used this approach; an exception is Wan and Qiu (2020). When estimating the Marginal *q*, the depreciation rate must be derived using the method established by Wan (2019), as employed by Wan and Qiu (2021). It is necessary to closely study the relationship between Chinese construction sector activity and housing prices because that country is experiencing a major housing bubble.

JEL classification: E13, E22, D24

Keywords: Bubble, China, construction sector, transmission, depreciation rate, investment, housing price

[1] This chapter is from Qiu (2021a).

4.1 Introduction

4.1.1 Construction sector investment and housing prices

In recent years, housing prices have increased in China. Wan (2018) and Wan and Qiu (2020) subjected housing prices to bubble testing; bubbles were evident in 36 large Chinese cities. Wan and Qiu (2020) analyzed the relationship between housing prices and industrial sector activity in China; they found that 13 housing-related sectors may have engaged in overinvestment. This emphasizes the need to closely examine the construction sector, which is intimately associated with the housing sector. Rogoff and Yang (2021) found that the construction sector comprised approximately 28.7% of Chinese Gross Domestic Product (GDP); this is a remarkably high figure. Housing prices and the construction sector would be expected to affect each other; this relationship was not analyzed in detail by Rogoff and Yang (2021). Here, we study the impact of housing prices on construction sector investment in China. We use various approaches for this assessment. Wan and Qiu (2020) analyzed the relationship between industrial sector investment and housing prices in China using the Marginal q; they examined the effects of housing prices on the industrial sector, as well as the depreciation rate.

Before analyzing how housing prices affect construction sector investment, it is necessary to determine how housing prices are transmitted to that sector. Cook et al. (2018) and Rogoff and Yang (2021) used input-output tables when studying transmission; Liu and Xiong (2018) and Hau and Ouyang (2018) employed a neoclassical framework. Wan (2021) presented a new theoretical framework that combined an input-output table with neoclassical theory to identify transmission from a housing bubble to all industrial sectors.

In the construction sector investment literature, Ogawa (1994) used q theory and the Marginal q to analyze Japanese construction enterprises. Wan and Qiu (2020) employed the same method to analyze industrial sectoral investment. Some studies have explored the financial interrelationships between construction sector investment and land prices; an example is Thomas et al. (2012). However, no detailed analysis of the relationship between construction sector investment and housing prices has been published, and housing bubbles have received little attention.

The use of Marginal q theory absolutely requires information regarding depreciation rates. Wan and Qiu (2021) conducted a thorough literature analysis and estimated the economic depreciation rates among industry sectors in China. Wan (2020) developed a new theory regarding economic depreciation.

However, it remains unclear (both theoretically and empirically) how housing prices or bubbles affect construction sector investment in China. Here, we survey the literature regarding transmission of housing prices to construction sector investment as revealed by the Marginal q, as well as the construction sector depreciation rate. We examine existing theories and empirical results. This chapter clarifies how housing prices affect construction sector investment in China, then identifies an optimal methodology for empirical research.

4.1.2 Contributions of this work

We summarize the literature regarding the relationship between construction sector investment and housing prices or bubbles. We found few relevant studies. Use of the approach proposed by Wan and Qiu (2020) revealed how Chinese housing prices affected the construction sector. In the work by Wan and Qiu (2020), the transmission, investment, and depreciation rates were simultaneously analyzed. The only existing structural model of transmission theory combines a neoclassical framework with the input-output table established by Wan (2021). In terms of real investment, Ogawa (1994) and Wan and Qiu (2020) used Marginal q theory to analyze Japanese enterprises and Chinese industrial sectors, respectively. Both methods mentioned above could be used in future research regarding the Chinese construction sector. The depreciation rate estimators established by Wan and Qiu (2021) and Wan (2020) can be employed to estimate the construction sector depreciation rate in China.

4.1.3 Structure of this chapter

Section 2 summarizes the theoretical and empirical research regarding transmission of housing prices to the construction sector. Section 3 summarizes the theoretical and empirical research regarding construction sector investment. Section 4 summarizes studies of depreciation rates, and Section 5 contains the conclusions.

4.2 Transmission of housing prices to the construction sector and other sectors

When studying the links between construction sector investment and housing prices in China, it is important to know how construction sector investment is affected by housing prices. Wan and Qiu (2020) used an input-output table to identify specific industrial sectors as housing-related in China. Compared with industry sectors in general, the correlations between the housing and construction sectors should be higher. Here, we study the transmission of housing prices to the construction sector and other sectors.

4.2.1 Transmission of housing prices to the construction sector and other sectors in China

Cook et al. (2018) used input-output tables to analyze the statuses of various industries when excess demand for housing in China was falling. Input-output data from 2002, 2007, and 2012 were employed to comparatively analyze the relationships among the manufacturing, construction, finance, and housing sectors. A decline in demand for the products of a single industry was found to trigger similar declines in other industries. Liu and Xiong (2018) explored Chinese housing sector development and the relationships among housing booms, family circumstances, land prices, government regulation, individual enterprise, and the financial system. The relationship between the enterprise and housing sectors was analyzed by exploring the banking and financial systems. Housing booms reduced business investment and discouraged entrepreneurship. Hau and Ouyang (2018) used data from 172 Chinese cities to model the housing, business, waged, and manufacturing sectors. During housing booms, household savings were invested in the housing sector, increasing local manufacturing costs and reducing local investment. These results were consistent with the findings by Qiu and Wan (2018) and Wan and Qiu (2020);

housing bubbles triggered overinvestment in 13 housing-related industries. Similarly, Wan and Yin (2018) found that housing bubbles reduced investment in service sectors such as education and health.

Rogoff and Yang (2021) used data from a Chinese input-output table to analyze the impact of the housing sector on construction sector investment in equipment and activities that enhanced housing values. The values added by housing-related industries, construction sector investment, and housing-related equipment investment in 2016 were tabulated (page 23, Table 1, Rogoff and Yang 2021).

Wan (2021) combined economic neoclassicism with an input-output table to develop a new theoretical framework that explains the transmission of housing prices to the household, business, and intermediate sectors. The framework showed that when housing-related sectors attract higher investment, housing product prices rise; conversely, investments and product prices both decline in industrial sectors unrelated to housing.

The studies cited above are the most important in terms of transmission from the Chinese housing sector to the industrial sector and other sectors. Cook et al. (2018) and Rogoff and Yang (2021) used the input-output table approach, while Liu and Xiong (2018) and Hau and Ouyang (2018) employed a neoclassical model to construct theoretical frameworks; only Wan (2021) combined the two approaches. In an empirical analysis, Hau and Ouyang (2018) found that housing booms clearly affected manufacturing investment. Cook et al. (2018) and Liu and Xiong (2018) analyzed the relationships among multiple industries (including manufacturing) and the housing sector; they found that housing booms affected manufacturing investment. Rogoff and Yang (2021) mentioned the construction sector but did not perform in-depth analysis. Rogoff and Yang (2021) explored only the added-values afforded by the housing and related construction sectors, as well as equipment investment, as proportions of GDP.

The only detailed theoretical analysis of the relationship between the housing and construction sectors was performed by Wan (2021). No detailed empirical work has explored the relationship between housing prices and construction sector investment in China.

4.2.2 Transmission of housing prices to the construction sector and other sectors in Europe and other countries

Araghi (2005) employed the housing sector as a transmission center when analyzing relationships upstream and downstream of that center in Iran. Thus, the housing sector served as both the demand and the supply side of many industries. Prices, labor requirements, and salary demands upstream and downstream from the housing sector (and other industries) were amenable to macro-economic study. Liu and London (2011) analyzed the relationship between the housing sector and monetary policy in Australia, using the Granger causality test to show that two distinct transmission mechanisms connected the housing sector to monetary policy, housing prices, and the construction sector. The study focused on monetary policy when analyzing the transmission mode of housing prices. An expansionary monetary policy inhibited housing supply.

Martin et al. (2021) used Spanish data to explore transmission of housing prices through the financial system. In both theoretical and empirical analyses, housing booms increased the levels of housing loans and the levels of other loans. The cited authors presumed that this was undesirable in Spain, but it might be appropriate in the U.S. Furthermore, analyses based on financial systems might be possible in other countries.

Martin et al. (2021) and Liu and London (2011) used the financial system and monetary policy, respectively, to analyze the impacts of the housing sector on other industries. Martin et al. (2021) constructed theoretical models but did not perform detailed analyses at the industry level. Liu and London (2011) did not construct a theoretical model that provided insights regarding the construction sector. The work by Araghi (2005) is similar to works by Cook et al. (2018) and Rogoff and Yang (2021); all used the input-output table approach. Araghi (2005) analyzed the transmission and impact of the housing sector to/on other sectors, but that study did not explore how housing price fluctuations affected the construction sector.

Thus, there have been insufficient detailed reports regarding the relationship between the housing and construction sectors in Europe and other countries. The theoretical approach established by Wan (2021) could be used to perform empirical studies.

4.3 Construction sector investment and housing prices

Above, we have summarized the literature regarding housing price transmission to the construction sector and other sectors. Here, we will summarize and analyze the literature regarding the relationship between investment and housing prices. Housing prices in China have grown rapidly in recent years, leading to overinvestment in various housing-related industries accompanied by non-performing loans (NPLs) and other problems.

Wan (2018) used banking data to analyze the relationship between NPLs and housing prices in China. Examination of housing prices in 36 major Chinese cities from 2004 to 2015 revealed housing bubbles. Furthermore, data regarding 19 industries, various banks, and a study of the “Restriction of Speculative Housing Purchase Policy (RSHPP)” of China revealed that RSHPP increased NPLs. Grange causality tests confirmed an impact of housing prices on NPLs.

Wan and Qiu (2020) used macro data concerning Chinese industry sectors to explore the correlation between housing bubbles and industrial investment. Employing an input-output table, they found that 13 of the 36 Chinese industrial sectors closely linked to housing were affected by the bubbles. The Marginal *q* values of the 36 sectors were estimated. The 13 industries with close links to housing exhibited higher investment elasticity of their Marginal *q* values than did the other 23 industries. The Grange causality test was used to verify overinvestment in 13 industries; the housing bubble increased the Producer Price Index (PPI), which reflects the price of industrial outputs. Qiu (2021b) examined transmission from the housing bubble to the PPI, using both theoretical and empirical approaches.

The research cited above was conducted from the perspectives of the Chinese industrial sectors and financial system. Housing bubbles trigger overinvestment in certain industrial sectors, as well as bank NPLs. Industrial sectors and financial firms are less affected by housing bubbles, compared with the construction sector. A detailed systematic study is required.

4.3.1 Construction sector investment and housing prices in China

Zheng and Liu (2004) used the Grange causality test and vector autoregression (VAR) to analyze the effects of investments in the construction sector and other sectors on Chinese GDP from 1981 to 2001. After 1998, a causal relationship was evident between construction sector investment and GDP. Rong et al. (2016) employed Chinese manufacturing data from 1999 to 2007 to analyze the effects of housing prices on innovation. The rapid growth in housing prices encouraged manufacturing enterprises to invest in housing, thus reducing investment in research and development. Notably, the funds of enterprises not involved in housing were used to invest in housing, rather than to enhance production.

He and Meng (2021) used a Dynamic Stochastic General Equilibrium (DSGE) model to simulate and analyze whether bank credit was "crowded-out" as Chinese housing prices rose. Indeed, more bank credit then flowed into housing, while less bank credit flowed into enterprises.

Few reports have appeared regarding the relationship between Chinese construction sector investment and housing prices.   focused only on the empirical relationship between construction sector investment and GDP, while Rong et al. (2016) focused on the relationship between manufacturing investment and housing prices. The relationship between construction sector investment and housing prices has not been studied in depth. He and Meng (2021) used a DSGE model for simulation; no theoretical model was constructed.

4.3.2 Construction sector investment and housing prices in Japan

Some studies concerning construction sector investment in Japan have appeared, including works by Ogawa et al. (1994) and Ogawa (2003). Ogawa et al. (1994) estimated the Marginal q and Average q values for the industrial, construction, and other sectors in the 1980s, using a macro perspective. Ogawa et al. (1994) used the Marginal *q* and Average *q* values to reveal positive effects of land held by companies (i.e., as mortgage assets) on real investment via collateral channels in the 1980s. The Marginal *q* of the construction sector was different from the Average *q*; notably, the Average *q* did not have any significant negative impact on construction sector investment. However, increases in both land prices and cash flow encouraged land purchases by the construction sector.

Ogawa (2003) used enterprise-level data to analyze corporate investment and financial difficulties after the land price crash of the 1990s. The Marginal *q* was employed to explore the effects of financing difficulties on investment by the manufacturing, construction, and other sectors. The unemployment rate was highest in the construction sector. If the 1996 attitudes of banks toward lending had continued, construction sector investment should have increased in 1998. However, the construction sector was not analyzed in detail.

The analysis of the Japanese construction sector by Ogawa et al. (1993) serves as an important basis for research concerning construction sector investment in China; use of the Marginal *q* would be appropriate. The VAR model was employed to estimate discount factors and profits. This method differs from the approach used by Wan and Qiu (2020). Research regarding construction sector investment and housing prices in China should employ the VAR model to determine discounts and profits. A better method is required to estimate the Marginal *q* of the Chinese construction sector. In terms of the relationships among the Marginal *q*, Average *q*, and investment, data concerning the Chinese construction sector is lacking, although the construction sector is large.

4.3.3 Construction sector investment and housing prices in the U.S. and Europe

Many theoretical and empirical papers concerning enterprise investment in the U.S. and Europe have appeared; two focused on construction sector investment. Wigren and Wilhelmsson (2007) analyzed the relationship between such investment and economic development in Western Europe using the construction value-added data for residential buildings, infrastructure, and other buildings, as well as the GDPs, of 14 European countries from 1990 to 2004. The ratio of the construction value added to GDP was calculated. Thomas et al. (2012) used micro data regarding 83,719 companies collected from 1993 to 2007 to analyze the effects of housing prices on corporate investment in western Europe. Investments by enterprises that were credit-restricted were more affected by housing prices, compared with investments by other enterprises. Importantly, the macro impacts of housing prices on corporate investment in the U.S. required further study.

Ahmadi and Shahandashti (2017) were the first to study the relationship between U.S. construction sector investment and GDP growth, using the method established by Wigren and Wilhelmsson (2007). The construction value added and GDP data of 36 states were collected. The Grange causality test revealed leading and/or lagging relationships between construction sector investment and the GDPs of 23 states.

Thus, a detailed analysis of the links between construction investment and housing prices in the U.S. and Europe is lacking. The methods used by Ahmadi and Shahandashti (2017) and Wigren and Wilhelmsson (2007) are similar to the approach used by Zheng and Liu (2004), although Zheng and Liu did not analyze the relationship between construction investment and housing prices. Thomas et al. (2012) evaluated the impact of housing prices on enterprise investment from the financial perspective; housing was viewed as collateral. The U.S. and Europe require relevant in-depth studies; housing prices are increasing rapidly and bubbles may be present.

When the literature concerning construction investment in China, the U.S., Japan, and Europe was compared, we found that only Ogawa et al. (1994) and Ogawa (2003) estimated the Marginal q values of construction enterprises (specifically, in Japan). Use of the Marginal q theory would facilitate analysis of the effects of housing prices on construction sector investment in a simple and intuitive manner. The Marginal q is a meaningful parameter, but it has never been estimated in the Chinese context. The Marginal q would better reveal the impact of housing prices on construction investment because the Average q cannot be estimated for non-listed firms (i.e., most firms).

4.4 Depreciation rates among construction sectors

To enable the use of Marginal *q* theory in investment analysis, depreciation rates are required. In this section, we summarize the theoretical and empirical literature concerning construction industry depreciation rates.

4.4.1 Depreciation rates among construction sectors in China

Wan (2019) used *q* theory to construct a new economic depreciation rate. A relationship was evident among profit, investment, and the depreciation rate; it was possible to use book values to estimate economic depreciation rates. The Perpetual Inventory Method (PIM) robustly estimated the imputed values of capital stock by reference to the book values and inflation rates of investment goods. The economic depreciation rates for all Chinese industrial and service sectors were estimated; these rates were similar to rates in the U.S.

Wan and Qiu (2021) used the PIM and the Depreciation Expense as Accounting Item (DEAI) approach to estimate the depreciation rates of 37 Chinese industries from 2001 to 2016. The relevant literature was analyzed; the findings were problematic because the capital stock choices and estimations were controversial. Wan and Qiu (2021) used existing data to estimate the market values of capital stock, then derived the upper limit of the depreciation rate for the Chinese macro economy. The depreciation rates estimated by the two methods were consistent with the economic depreciation rates determined by Wan (2019).

Wan and Qiu (2021) empirically studied Chinese depreciation rates, effectively summarizing the rates of the literature. Wan (2019) theoretically studied the economic depreciation rate; this is a new form of depreciation applicable to both developing and developed countries. The economic depreciation rate of the Chinese construction sector is unknown; relevant research is required.

4.4.2 Depreciation rates by construction sector in other countries

Steven (2008) summarized the accounting methods used to determine depreciation rates. Construction sector economic depreciation rates are lacking, especially for the Chinese construction sector. The methods established by Wan and Qiu (2021) and Wan (2019) could be used to estimate economic depreciation rates.

4.5 Conclusion

We surveyed the literature concerning the relationships between the construction sector and housing prices from the perspectives of transmission, investment, and depreciation rate. Few relevant reports have appeared.

First, we analyzed the transmission of housing prices to the construction sector. The literature employed input-output tables that focused on the real economy; it also used neoclassical, economic theoretical frameworks that focused on the financial economy. Future Chinese research should implement both approaches.

Second, we analyzed the connection between construction sector investment and housing prices. In Japan alone, Marginal q theory has been employed for this analysis, but such macro work lacks detail. In the U.S., the relationship between construction sector investment and bank lending has been analyzed from the financial perspective. Thus, the Marginal q theory should be used for future detailed economic research that is focused on China.

Finally, based on analysis of the construction sector and its economic depreciation rate, we reviewed the literature estimates of that rate. Few reports have appeared regarding the links between construction sector investment and housing prices, especially with respect to China. Such work is essential; China is experiencing a major housing bubble.

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Chapter 5

Construction Investments and Housing Prices: Marginal *q* Analysis by Panel Macro Data in China[1]

Abstract

The development of the construction machinery leasing industry means that the depreciation rate cannot be estimated using the perpetual inventory method (PIM). We estimated the depreciation rate using depreciation expense as accounting item (DEAI) and before-tax Marginal *q* of the construction sector for the period 2006–2019 in China. The depreciation rate is close to those in the U.S. and Japan, and the before-tax Marginal *q* is close to that in Japan during the 1980s. High before-tax Marginal *q* may result from housing bubbles and the compression of fixed assets may be caused by the development of the leasing industry. The depreciation rate and investment can be explained by before-tax profit and before-tax Marginal *q*, respectively. This suggests that economic depreciation theory and Marginal *q* theory can be applied to the analysis of replacement and new investment in construction. Hence, resolution of the housing bubble issue may reduce overinvestment in construction caused by what we term here "bubbly Marginal *q*".

JEL classification: E13, E22, D24

Keywords: China, construction sector, depreciation rate, Marginal *q,* investment

1 This chapter is from Qiu and Wan (2021), and the author thanks Professor Junmin Wan for the permission of use of manuscript.

5.1 Introduction

5.1.1 Transmission of housing bubbles in China

A housing bubble was observed in China and it induced speculative (excessive) household savings (Wan 2015). It was found that China's housing bubble Granger caused changes in the producer price index (PPI) in Qiu and Wan (2018). Overinvestment and overcapacity in housing-related industrial sectors resulting from the housing bubble were reported by Wan and Qiu (2020). The housing bubble has significantly increased non-performing loans (NPLs) in China (Wan 2018b). The housing bubble has emerged as a significant issue in China by virtue of its considerable impact on the economy as a whole (Wan 2021). However, little is known about the construction sector, which supplies housing in China, since few studies have focused on this topic. Moreover, no satisfactory approach to studying the construction sector has yet been proposed. Herein, we analyze the housing bubble's impact on construction investment in China.

A recent study surveyed transmission from housing prices and bubbles to the real economy (Qiu 2021b). Input-output table approaches have been used—for example, by Cook et al. (2018) and Rogoff and Yang (2021)—as well as neoclassical model approaches—for example, by Liu and Xiong (2018) and Hau and Ouyang (2018). Another recent study conducted comprehensive analysis by combining an input-output table with a neoclassical model to clarify the housing bubble's impacts on all sectors, in an approach called demand-side driving theory (Wan 2021). This study here is the first to analyze the impact of the housing bubble on construction sector investment within the framework of demand-side driving theory.

5.1.2 Housing bubble and construction sector investment in China

In 2019 and 2020, the number of employees in the construction sector was 53.669 million and 54.271 million in China, respectively. In 2019, the number of employees in the construction sector accounted for 6.69% of China's total working population.[2]

2 Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

The ratio of housing-related construction's gross domestic product (GDP) to total GDP was 28.7% (Rogoff and Yang 2021). Compared with the industrial sector, the housing bubble may have a more profound impact on the construction sector. Qiu (2021a) summarized and compared the literature on investment in the construction sector and housing prices, and found that the research in this field is lacking. Ogawa et al. (1994) estimated the before-tax Marginal q of Japan's construction sector in the 1980s and analyzed investment in accordance with q theory, but not from the perspective of overinvestment. Therefore, this study will fill the gap in this field by providing evidence of the housing bubble's impact on the construction sector within the framework developed by Wan (2021).

5.1.3 Contributions

First, we find that the depreciation rate in China's construction sector cannot be estimated by perpetual inventory method (PIM) because the development of the construction machinery and equipment leasing industry has reduced investment in fixed assets. Data pertaining to the equipment leasing industry are not included in the construction sector data.

Next, we used construction sector ownership data for the period 2006–2019 to estimate the depreciation rate based on DEAI and before-tax Marginal q in China. The average depreciation rate value of the construction sector is close to the values of heavy construction equipment in the U.S. and of the 36 industrial sectors in China. The before-tax Marginal q in China's construction sector is close to the value in Japan, and the high before-tax Marginal q in China may be attributable to the housing bubble and development of the leasing industry.

Third, depreciation rate and investment are significantly increased by before-tax profit and Tobin's before-tax Marginal q value via panel estimations, respectively. This indicates that the replacement and new investment behavior of the construction sector can be explained by economic depreciation theory and Tobin Marginal q theory. Since housing bubbles may generate additional profit in the construction sector via demand-side driving theory, the empirical result may constitute evidence for overinvestment in the construction sector in association with housing bubbles.

5.1.4 Structure of this chapter

The remainder of this chapter is organized as follows. The research question and hypotheses are presented in Section 2. Section 3 describes the data sources and the estimations. The empirical specifications are summarized in Section 4, and Section 5 summarizes the conclusions.

5.2 Research question and hypotheses

5.2.1 Housing bubble, investment, and before-tax Marginal *q* in the construction sector in China

Housing bubbles have occurred in 36 major cities in China (Wan 2018, Wan and Qiu 2020). Overinvestment and overcapacity of 13 housing-related industrial sectors in China were detected by Wan and Qiu (2020). Qiu (2021a) conducted a literature review on overinvestment in the construction sector associated with the housing bubble and asserted that there is a need to study the relationship between the housing bubble and investment in the construction sector in China, after summarizing and comparing existing research results worldwide and the methodology from theoretical and empirical views. Wan and Qiu (2020) proposed that a high Marginal *q* value may derive from the high profit generated by the housing bubble, which may be designated as a new concept called "bubbly Marginal *q*."

5.2.2 Transmission from the housing bubble to the construction sector in China

Although the high correlation between the housing bubble and construction sector is obvious, empirical analysis is necessary to clarify the specific relationship between the two. Qiu (2021b) found that the input-output table approach and neoclassical theory can be used, individually or in combination, to analyze financial transmission from the housing bubble to construction sector. It was reported that the average ratio of the total output value of housing construction to the total output value of construction for the period 2001–2019 was 62%.[3] Hence, the construction sector is mainly derived from the housing sector.

5.2.3 Depreciation rate of the construction sector in China

Before analyzing investment behavior, it is necessary to estimate the depreciation rate, which is the basic parameter for estimation of Marginal *q*. We estimated the construction sector following Wan and Qiu (2021). Qiu (2021a) summarized and analyzed the existing literature on depreciation and noted that Wan (2019) had proposed a new economic depreciation theory, and proved the relationship between profit and the economic depreciation rate. Wan and Qiu (2021) defined the total value of fixed assets (TVFA) as the imputed value according to economic depreciation theory (Wan 2019), and estimated the depreciation rate of China's 37 industrial sectors using the PIM and depreciation expense as accounting item (DEAI).

5.2.4 Hypotheses

The theory of economic depreciation rate of Wan (2019) holds that the corporate depreciation rate should be significantly positively correlated with profit before tax. Wan and Qiu (2021) confirmed that the theory of the economic depreciation rate applied across China's 37 industrial sectors using PIM and DEAI. On this basis, we propose the following hypothesis:

Hypothesis 1*:* The depreciation rate of the construction sector in China is increased by profit before tax.

It is generally believed that high profits accelerate investment and thereby also depreciation. This phenomenon also implies that the high profit generated by the bubble will increase the depreciation rate. Since the construction sector in China has a high profit ratio, we will investigate whether the depreciation rate can be explained by economic depreciation theory.

3 Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Following Jorgenson (1963), Tobin (1969), and Hayashi (1982), firms' investment should be positively and significantly correlated with Marginal q in accordance with investment theory. Wan and Qiu (2020) confirmed that the theory of investment applied across 36 industrial sectors in China using reduced and structural forms of the adjustment cost model. We offer the following hypothesis:

Hypothesis 2: Investment behavior in the construction sector can be explained by Marginal q theory.

If the empirical results support Hypothesis 2, they will represent new evidence that China's construction industry is oriented by market mechanisms (Wan and Qiu 2020).

5.3 Depreciation rate, before-tax Marginal q, and investment in the construction sector

5.3.1 Panel data on the construction sector

We collected panel data from the National Bureau of Statistics of China (NBSC, http://data.stats.gov.cn/). The principal economic indicators of the construction sector by ownership were downloaded. Owing to data availability, we used only data for the period 2006–2019.

5.3.2 Estimations of depreciation rates by DEAI and before-tax Marginal q

Estimation of total value of fixed assets

We found no ownership data pertaining to TVFA beyond the national level, but TVFA must be used in the estimation of depreciation rate and before-tax Marginal q. Therefore, we applied the following formula to estimate TVFA, following Wan and Qiu (2021):

$$TVFA_{mt} = OVFA_{mt} - DFA_{mt} + Errors_{mt}, \tag{1}$$

where

$OVFA_{mt}$: original value of fixed assets of m ownership at time t.

DFA_{mt} : depreciation of fixed assets of m ownership at time t.

$Errors_{mt}$: includes, for example, impairment of fixed assets, disposal of fixed assets, and construction in progress for ownership *m* at time *t*, which are omitted.

We also followed Wan and Qiu (2021) to confirm the gap between TVFA and the imputed value of fixed assets. The TVFA will be lower than the imputed value of fixed assets (5%).

Why can the depreciation rate not be estimated using PIM?

Wan and Qiu (2021) estimated the depreciation rate using PIM in 36 industrial sectors, but we found that the depreciation rate cannot be estimated using PIM in China's construction sector for the period 2006–2019 because PIM requires more information on prior original value of fixed assets (OVFA) and TVFA in the construction sector, which shows a non-significant upward trend or even a downward trend in China. The number of employed persons and gross output value show significant upward trends; the corresponding investment of fixed assets (OVFA and TVFA) should also show an upward trend, particularly in the construction sector. Figure 5.3 shows that the growth ratio of the gross output value and number of employed persons is higher than that of investment in fixed assets (TVFA), and the amount of machinery and equipment owned by the construction sector. We also calculated the average growth rates of the investment to fixed asset ratio, the number of pieces of machinery and equipment owned by the construction sector, gross output value, and the number of employed persons per firm for 2006–2019. These values were -0.30%, 1.20%, 5.18%, and 14.99%, respectively. The ratio of investment in fixed assets was negative and significantly lower than the other two values, suggesting a gradual decline in fixed asset investment.

These findings may be attributable to the development of the construction machinery and equipment leasing industry. Since 2010, the construction machinery and equipment leasing market has expanded rapidly, from 350 billion yuan in 2014 to 700 billion yuan in 2019, and the market penetration rate has increased from 13.7% in 2010 to 55% in 2019, as noted by Huaon (2020). This industry's rapid development may explain the downturn in the construction sector's investment in fixed assets. This means that construction enterprises can lease construction machinery at a lower cost, to reduce the cost of fixed assets and improve the enterprise's profit margin, as reported by the U.S. Department of Commerce (1976). The development of the machinery and equipment leasing industry may also be one of the reasons for the high Marginal q estimated in the next section. For the construction sector, the machinery and equipment leasing industry can reduce the necessary fixed assets under the excess construction demand caused by temporary housing bubbles. Hence, the lease industry may protect construction firms against bankruptcy after the collapse of the housing bubble.

The data from the construction machinery and equipment leasing industry are not included in the construction sector data. Moreover, we were unable to locate these data on the official website of the NBSC. Therefore, the OFVA and TVFA values of the construction industry do not satisfactorily reflect the capital stock of the depreciation rate obtained using PIM. The depreciation rates obtained by DEAI require less past information compared with PIM, and the DFA value is also available. Therefore, we will only estimate the depreciation rate in China's construction sector for 2006–2019 using DEAI.

Estimation of depreciation rate by DEAI

We followed Wan and Qiu (2021) to estimate the depreciation rate using DEAI. We used the average price index for investment in fixed assets (PIIFA) for 2006–2019 to control inflation. We estimated DEAI using the following formula:

$$\delta_{deai-mt} = \frac{DFA_{mt}/PIIFA}{TVFA_{mt-1}}, \tag{2}$$

where

$\delta_{deai-mt}$: the depreciation rate obtained by DEAI of m ownership at time t.

Since we obtained the data on the annual depreciation expense of fixed assets, the value of DEAI in the construction sector is not negative, while Wan and Qiu (2021) reported a negative value because the depreciation expense per year is estimated by stock information for accumulated depreciation. The values of the depreciation rate based on DEAI by ownership are summarized in Table 5.1. By year, the national value of the construction sector and the value by ownership are illustrated in Figures 5.4–5.6.

Data issues and solutions

Because the DFA data for 2013, 2018, and 2019 were not reported, the depreciation rates in 2013, 2014, 2018, and 2019 cannot be estimated. Therefore, we used the average value of the estimated results during the periods 2006–2012, 2015–2017, 2006–2017 and 2006–2018 to replace the estimated results in 2013, 2014, and 2018 and 2019, respectively.

Estimation of investment and before-tax Marginal q

We estimate the before-tax Marginal q of China's construction sector using macro data. As the number of observations is limited, we prefer a simple specification based on Wan and Qiu (2020)'s approach, which follows Ogawa (2003). We used the OVFA data to estimate the investment, following Wan and Qiu (2021). We also used the average depreciation rate value obtained by DEAI in the construction sector, and the average value of interest payments of industrial sectors to estimate the before-tax Marginal q using the following formula in Wan and Qiu (2020):

$$Mq_{mt} = \frac{\pi_{mt}}{P^{I}_{mt}} \frac{1+r_{industrial\ sector-t}}{r_{industrial\ sector-t}+\delta_{deai-mt}}, \quad (3)$$

where

π_{mt} : ratio of total before-tax profit of *m* ownership at time *t.* Data on after-tax total profit is not available, thus only the before-tax Marginal q can be estimated.

P^{I}_{mt} : ratio of investment price of *m* ownership at time *t.*

$\delta_{deai-mt}$: average value of depreciation rate by DEAI of *m* ownership at time *t.*

$r_{industrial\ sector-t}$: average value of interest payments ratio of industrial sectors of *m* ownership at time *t.*

The estimated before-tax Marginal q values of the construction sector are summarized in Table 5.2, and the before-tax Marginal q values of ownership are illustrated in Figures 5.8 and 5.9.

5.4 Empirical specifications

5.4.1 Depreciation rate and profit before tax

To analyze whether economic depreciation hypothesis (Hypothesis 1) by Wan (2019) can explain the relationship between the construction sector's depreciation and profit rates, we consider the following empirical specification by Wan and Qiu (2021):

$$\frac{DEAI_{mt}}{TVFA_{mt-1}} = \alpha_0 + \alpha_1 RTPBT_{mt} + \alpha_2 RTVFA_{mt} + \alpha_3 RNEPC_{mt} + \tau_m + \rho_t + \varepsilon_{it}, \quad (4)$$

where

$RTPBT_{mt}$: *Total Profits before Tax* $_{mt}$ / *TVFA* $_{mt-1}$ of m ownership at time t. We anticipate that *RTPBT* will have a significant positive impact on the depreciation rate obtained by *DEAI* to confirm the economic depreciation hypothesis.

$RTVFA_{mt}$: *TVFA* $_{mt}$ / *TVFA* $_{mt-1}$ of m ownership at time t. We anticipate that different types of ownership will have different fixed asset sizes, and thus that *RTFA* can capture the impact of the fixed asset sizes of different types of ownership on the depreciation rate.

$RNEPC_{mt}$: *Number of Employed Persons on Construction Enterprises mt / Number of Construction mt* of m ownership at time t. We assume that different types of ownership have different numbers of employees per enterprise, and that *RNEPC* can capture the impact of employee numbers per enterprise for different types of ownership on the depreciation rate.

α_1 , α_2 , α_3 , are coefficients, and α_0 , τ_m , ρ_t , ε_{it} are a constant term, sector-specific effect, time effects (time trend or dummy by year), and random errors, respectively. We obtain the parameters using the panel estimation method with fixed effects and robust standard errors.

5.4.2 Investment and before-tax Marginal *q*

Following the empirical investment function based on Abel (1980), Chirinko (1993), Ogawa et al. (1994, 2019), and Wan and Qiu (2019), we consider the following empirical specification:

$$\frac{I_{mt}}{K_{mt-1}} = \beta_0 + \beta_1 Mq_{mt} + \beta_2 RTVFA_{mt} + \beta_3 RNEPC_{mt} + \mu_m + \gamma_t + \varepsilon_{mt}, \qquad (5)$$

where

$\frac{I_{mt}}{K_{mt-1}}$: investment ratio (investment/*TVFA*) of m ownership at time *t.*

Mq_{mt} : before-tax Marginal q of m ownership at time *t.*

β_1, β_2 and β_3 are coefficients, and β_0, μ_m, γ_t, and ε_{mt} are the constant term, industry-specific effects, time effects (time trend or dummy by year), and random errors, respectively.

We obtain the parameters using the panel estimation method with fixed effects and robust standard errors. Hypothesis 2 can be tested by Eq. (5). We also consider the structural form of the adjustment cost model for before-tax Marginal q proposed by Chirinko (1993, Eq. (17)) and Wan and Qiu (2020).

$$\frac{I_{mt}}{K_{mt-1}} = \tau + \frac{1}{a}(Mq_{mt} - 1)P^I_{mt} + \beta_2 RTVFA_{mt} + \beta_3 RNEPC_{mt} + \mu_m + \gamma_t + \varepsilon_{mt}, (6)$$

where

a and τ are parameters of a quadratic function.

Formula 5.6 was applied to test hypothesis 2 using the structural form of the adjustment cost model for before-tax Marginal q.

5.4.3 Empirical results

Depreciation rate of construction sector obtained by DEAI

Figure 5.4 shows the national depreciation rate level of the construction sector obtained by DEAI for 2006–2019. The depreciation rate of the construction sector by ownership obtained by DEAI from 2006 to 2019 is shown in Figures 5.5 and 5.6. The depreciation rate values for the construction sector obtained by DEAI during the period 2006–2019 are presented in Table 1. The average value of the national level of construction sector (0.0092) is close to that of China's industrial sector (0.0799), as reported by Wan and Qiu (2021).

The depreciation rate of heavy construction equipment in the U.S. in 2013 was 0.0990, as reported by Suga and Nomura (2018). The depreciation rate of construction machinery (except tractors) for 1949–1974, according to the U.S. Bureau of Economic Analysis (BEA), was around 0.20, and the rate of economic depreciation of construction machinery was 0.17 (Hulten and Wykoff 1981). The results of the present study are close to the depreciation rate of heavy construction equipment in the U.S., as observed by Suga and Nomura (2018).

Table 5.3 presents the summary statistics of the main variables, and Table 5.4 details the empirical results. We found that the depreciation rate obtained by DEAI is significantly affected by the enterprise profits before tax, regardless of whether the size of the fixed assets, average employees per firm, time trend, and year dummies are controlled for. This finding supports economic depreciation hypothesis by Wan (2019).

Investment of the construction sector

Figure 5.7 shows the change of investment and before-tax Marginal q of the construction sector during the period 2006–2019. The before-tax Marginal q of the construction sector by ownership from 2006 to 2019 is shown in Figures 5.8 and 5.9. Table 5.2 presents the before-tax Marginal q values of the construction sector during 2006–2019. The mean before-tax Marginal q value of the construction sector in China (3.2448) is close to the value in Japan (3.8475), as reported by Ogawa et al. (1994). Following Wan (2021c), we compared the before-tax Marginal q of each ownership, and found that the before-tax Marginal q values of each ownership are high, which may imply overinvestment caused by the housing bubble according to demand-side driving theory, as well as compression of fixed assets through the development of China's equipment leasing industry.

Tables 5.5 and 5.6 present the empirical results for the reduced form and structural investment equations with adjustment cost, respectively. We found that investment was significantly affected by before-tax Marginal q, regardless of whether the size of fixed assets, average employees per firm, time trend, and year dummies are controlled for. These results support Hypothesis 2, suggesting that investment behavior can be explained by Tobin's Marginal *q* theory.

5.5 Conclusion

We found that OVFA and TVFA values in the construction sector have decreased in China, making the depreciation rate impossible to estimate using PIM. This may be attributable to the low growth rate of fixed asset investment in the construction industry sector, as well as to the development of the construction machinery and equipment leasing industry. Hence, we were obliged to estimate the depreciation rate using the DEAI approach. We estimated the depreciation rate using DEAI in the construction sector by ownership in China for 2006–2019. The national average deprecation rate of the construction sector is 0.0917, which is close to the 0.0799 of China's 36 industrial sectors, as reported by Wan and Qiu (2020), and to the 0.099 of heavy construction equipment in the U.S., as reported by Suga and Nomura (2018). Using panel estimation, we found that the depreciation rates may be explained by economic depreciation theory, as proposed by Wan (2019).

We further estimated before-tax Marginal *q* in the construction sector according to ownership in China for 2006–2019. The mean value of before-tax Marginal *q* in China's construction sector (3.2448) is close to the value (3.8475) of Japan's construction sector during the 1980s, as reported by Ogawa et al. (1994). The high before-tax Marginal *q* value may derive from the "bubbly demand" for housing construction as well as the development of China's construction machinery and equipment leasing industry. The fixed assets owned by construction firms may be considerably diminished by leasing, and the Marginal return of the fixed assets may be increased by the lease. Furthermore, bubbly demand may be temporary, so leasing could be considered as a precautionary behavior of construction sector. The investment in the construction sector in China can be explained by Tobin's Marginal *q* theory.

The implications of our findings are as follows. Marginal *q* theory is among the main economic theories applicable to the analysis of enterprise investment. When a housing bubble occurs in China, Marginal q theory can explain the investment behavior of the industrial sector and construction industry via demand-side driving theory, as per Wan (2021a). Although investment in the construction sector may be regarded as reasonable and rational behavior, if the industrial profits are derived from the bubble by demand-side driving, high profits will lead to overinvestment and overcapacity. This study provides key evidence regarding the problem of overinvestment and overcapacity due to the housing bubble, which links the housing market with industrial sectors, as in Wan (2018b) and Wan and Qiu (2020). Therefore, to resolve the overinvestment and overcapacity issue of the construction and industrial sectors, the housing bubble must to be resolved in accordance with the soft landing proposals of Wan (2018a, 2021b,2021c).

In future studies, we will apply the micro-level data of listed firms to analyze the impact of housing bubbles on housing firms in accordance with demand-side driving theory.

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Table 5.1: Depreciation rates of the construction sector by Depreciation Expense as Accounting Item (DEAI) by ownership, 2006-2019.

Year	National Total	Domestic Funded	State-owned	Collective-owned	Private	Funded from Hong Kong, Macao and Taiwan	Solely Owned by Hong Kong, Macao and Taiwan	Foreign Funded	Solely Owned by Foreign
2006	0.0832	0.0670	0.0637	0.0443	0.0725	0.0682	0.0779	0.0657	0.1713
2007	0.0849	0.0674	0.0639	0.0451	0.0719	0.0754	0.0891	0.0885	0.0939
2008	0.1022	0.0817	0.0825	0.0574	0.0840	0.1030	0.1044	0.0791	0.1134
2009	0.0961	0.0781	0.0793	0.0509	0.0801	0.0830	0.0877	0.0743	0.1126
2010	0.1016	0.0830	0.0797	0.0504	0.0865	0.1234	0.0735	0.0751	0.1328
2011	0.0968	0.0788	0.0889	0.0478	0.0778	0.0900	0.1467	0.1215	0.1483
2012	0.0999	0.0803	0.0797	0.0518	0.0822	0.0910	0.0200	0.0521	0.0757
2013	0.0950	0.0766	0.0768	0.0497	0.0793	0.0906	0.0856	0.0795	0.1211
2014	0.0850	0.0677	0.0697	0.0466	0.0679	0.0628	0.0680	0.0617	0.0667
2015	0.0870	0.0705	0.0746	0.0478	0.0705	0.0556	0.0591	0.0621	0.0932
2016	0.0807	0.0659	0.0649	0.0528	0.0665	0.0598	0.0525	0.0630	0.0381
2017	0.0872	0.0666	0.0696	0.0394	0.0667	0.0730	0.0923	0.0599	0.0689
2018	0.0916	0.0736	0.0745	0.0487	0.0755	0.0813	0.0797	0.0735	0.1030
2019	0.0923	0.0742	0.0754	0.0490	0.0757	0.0824	0.0799	0.0742	0.0973
Avg.	0.0917	0.0737	0.0745	0.0487	0.0755	0.0814	0.0798	0.0736	0.1026

Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Table 5.2: Before-tax Marginal q of construction sector by ownership, 2006-2019.

Year	National Total	Domestic Funded	State-owned	Collective-owned	Private	Funded from Hong Kong, Macao and Taiwan	Solely Owned by Hong Kong, Macao and Taiwan	Foreign Funded	Solely Owned by Foreign
2006	1.5451	1.4156	0.6850	1.2828	1.8381	1.3656	0.7846	4.2320	36.6304
2007	1.8555	1.6796	0.8921	1.6493	2.0472	1.8384	2.0141	5.8638	18.8726
2008	2.3861	2.1869	1.2936	2.4411	2.5208	2.6986	3.4315	3.8662	12.4809
2009	2.6196	2.4461	1.3305	2.5666	2.8392	3.2719	4.8480	3.5754	6.3714
2010	2.8652	2.6904	1.4554	2.8001	3.1008	4.1347	4.6902	3.6468	7.5470
2011	3.1959	3.0015	1.5651	3.3795	3.3951	3.9959	4.3914	4.2764	7.9017
2012	3.4006	3.1408	1.6257	3.6634	3.5457	4.3174	3.0939	2.6384	8.7801
2013	3.5458	1.5525	0.9934	2.5738	1.6508	2.7156	4.1334	4.2757	6.7843
2014	5.6669	5.2902	1.9393	3.3521	6.5553	3.9779	3.8786	6.0626	21.2980
2015	3.5498	3.3155	1.9825	4.0784	3.5327	2.4130	1.4486	5.2199	9.1714
2016	3.6272	3.4208	1.9359	4.2599	3.6490	2.2466	1.3937	5.2657	10.1060
2017	4.1139	3.6254	2.1334	3.9034	3.8759	3.2322	1.3015	5.8524	13.1941
2018	4.1866	3.6624	2.3633	3.6493	3.8711	2.1469	1.3770	8.1141	17.4746
2019	2.8695	3.2832	2.3068	3.2169	3.4278	5.2070	6.0047	7.1830	12.7585
Avg.	3.2448	2.9079	1.6073	3.0583	3.2750	3.1116	3.0565	5.0052	13.5265

Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Table 5.3: Summary statistics of construction sector, 2006-2019.

Variable	Obs	Median	Mean	Std. Dev.	Min	Max
Depreciation Expense as Accounting Item $_{(t)}$ / Total Value of Fixed Assets$_{(t-1)}$	126	0.0762	0.0779	0.0022	0.0200	0.1713
Before-tax Marginal $q_{(t)}$	126	3.3873	4.3103	4.3996	0.6850	36.6304
[Before-tax Marginal $q_{(t)}$ - 1]*Price Index for Investment in Fixed Assets	126	2.4214	3.3576	4.4623	-0.3195	36.1387
Investment$_{(t)}$/ Total Value of Fixed Assets$_{(t-1)}$	126	0.0644	0.0631	0.2353	-0.8191	1.1352
Total Profits Before Tax$_{(t)}$ / Total Value of Fixed Assets$_{(t-1)}$	126	0.3836	0.5453	0.6451	0.0800	5.2743
Total Value of Fixed Assets$_{(t)}$ / Total Assets$_{(t)}$	126	0.1214	0.1234	0.0572	0.0174	0.2791
Number of Employed Persons on Construction Enterprises$_{(t)}$ / Number of Construction Enterprises$_{(t)}$	126	483.0210	497.1806	246.4666	137.7778	1305.8670
Year	126	2012.5	2012.5	4.0472	2006	2019

Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Table 5.4: Determinants of depreciation rate by Depreciation Expense as Accounting Item (DEAI) of construction sector, 2006-2019.
(Panel estimation with fixed effect and robust standard errors (FE))

Independent Variables	Dependent variable = depreciation expense as accounting item$_{(t)}$ / Total value of fixed assets$_{(t-1)}$			
Total Profits Before Tax$_{(t)}$ / Total Value of Fixed Assets$_{(t-1)}$	0.0092 ***	0.0088 ***	0.0092 ***	0.0123 ***
	(0.0021)	(0.0024)	(0.0024)	(0.0016)
Total Value of Fixed Assets$_{(t)}$ / Total Assets$_{(t)}$		-0.0256	-0.0314	-0.0313
		(0.0569)	(0.0540)	(0.0804)
Number of Employed Persons on Construction Enterprises$_{(t)}$ / Number of Construction			0.2705	0.3683
			(0.2761)	(0.2609)
Constant	2.4781 **	2.8835 **	3.8239 *	0.0614 **
	(0.7885)	(1.2465)	(1.8165)	(0.0204)
Year (Trend)	-0.0012 **	-0.0014 *	-0.0019 *	
	(0.0004)	(0.0006)	(0.0009)	
Year 2006 (Dropped)				
Year 2007				-0.0026
				(0.0079)
Year 2008				0.0127 *
				(0.0066)
Year 2009				0.0045
				(0.0040)
Year 2010				0.0088
				(0.0069)
Year 2011				0.0189
				(0.0107)
Year 2012				-0.0113
				(0.0112)
Year 2013				0.0033
				(0.0055)
Year 2014				-0.0196
				(0.0128)
Year 2015				-0.0167
				(0.0091)
Year 2016				-0.0251
				(0.0157)
Year 2017				-0.0180
				(0.0147)
Year 2018				-0.0111
				(0.0124)
Year 2019				-0.0094
				(0.0115)
Observations	126	126	126	126
R-squared	0.1187	0.1199	0.1306	0.4521
Number of id	9	9	9	9

Note: Robust standard errors in parentheses (FE), *** p<0.01, ** p<0.05, * p<0.1.

Table 5.5: Determinants of investments in construction sector (reduced form), 2006-2019.

(Panel estimation with fixed effect and robust standard errors (FE))

Independent Variables	Dependent variable = $Investment_{(t)}$ / Total Value of $Fixed Assets_{(t-1)}$			
Before-tax Marginal $q_{(t)}$	0.0254 ***	0.0311 ***	0.0324 ***	0.0367 ***
	(0.0026)	(0.0053)	(0.0061)	(0.0061)
Total Value of $Fixed Assets_{(t)}$ / $Total Assets_{(t)}$		2.5873 ***	2.4807 ***	2.5088 ***
		(0.6547)	(0.5311)	(0.4212)
Number of Employed Persons on Construction $Enterprises_{(t)}$ / Number of Construction $Enterprises_{(t)}$			5.3532	4.6985
			(4.6402)	(4.5086)
Constant	29.8943 ***	-10.6997	7.8517	-0.6951 ***
	(5.4740)	(7.0821)	(21.1854)	(0.1905)
Year (Trend)	-0.0149 ***	0.0051	-0.0042	
	(0.0027)	(0.0035)	(0.0106)	
Year 2006 (Dropped)				
Year 2007				0.0368
				(0.0744)
Year 2008				0.1415 ***
				(0.0403)
Year 2009				0.145 **
				(0.0468)
Year 2010				0.0217
				(0.0712)
Year 2011				0.2629 *
				(0.1146)
Year 2012				-0.0346
				(0.0981)
Year 2013				0.0346
				(0.0522)
Year 2014				-0.0876
				(0.1318)
Year 2015				0.1122
				(0.0923)
Year 2016				-0.0411
				(0.1215)
Year 2017				0.1709
				(0.1057)
Year 2018				-0.0259
				(0.1622)
Year 2019				0.0604
				(0.0922)
Observations	126	126	126	126
R-squared	0.1556	0.2231	0.2471	0.4147
Number of id	9	9	9	9

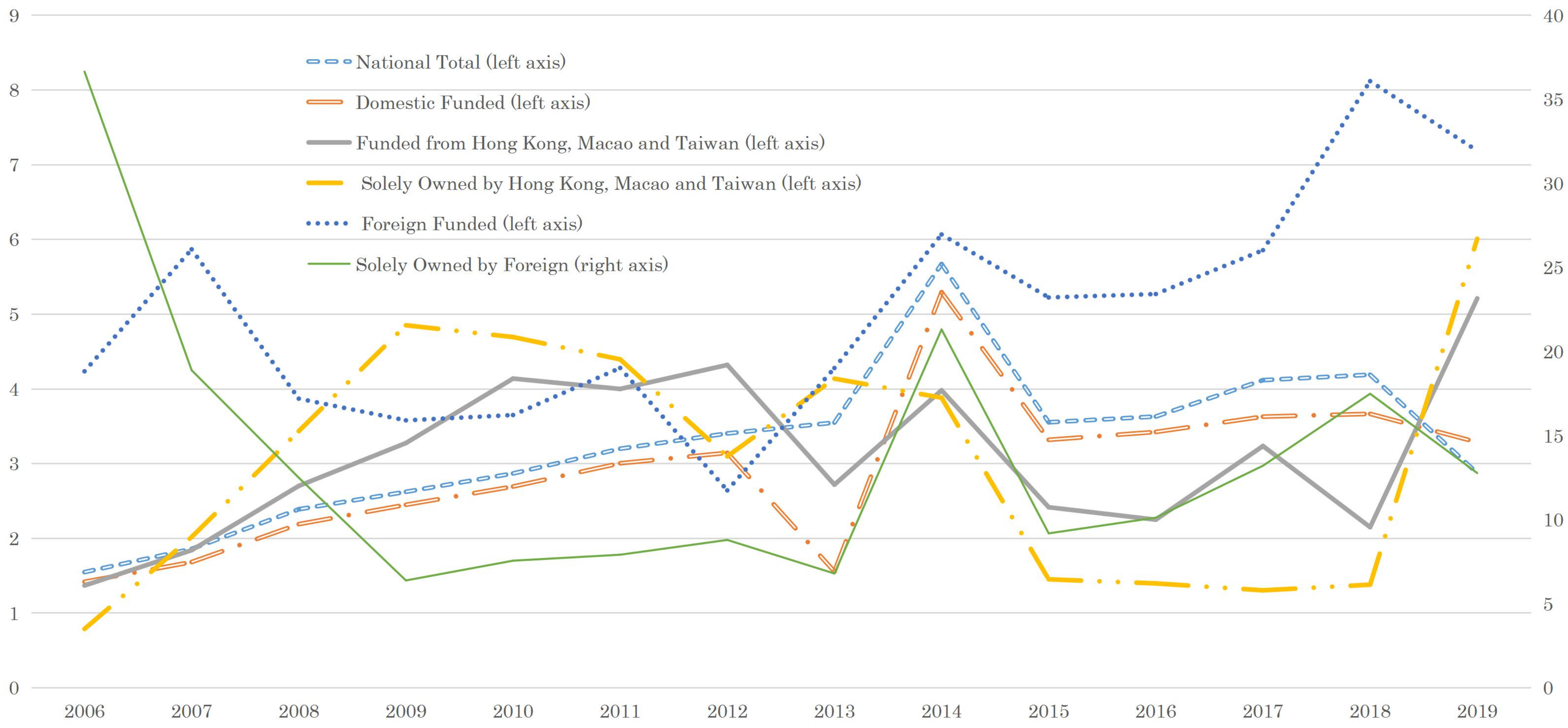
Note: Robust standard errors in parentheses (FE), *** p<0.01, ** p<0.05, * p<0.1.

Table 5.6: Determinants of investments in construction sector (adjustment cost model), 2006-2019.
(Panel estimation with fixed effect and robust standard errors (FE))

Independent Variables	Dependent variable = Investment$_{(t)}$ / Total Value of Fixed Assets$_{(t-1)}$			
[Before-tax Marginal $q_{(t)}$ - 1]*Price Index for Investment in Fixed Assets	0.025 ***	0.0307 ***	0.0319 ***	0.0362 ***
	(0.0026)	(0.0052)	(0.0060)	(0.0060)
Total Value of Fixed Assets$_{(t)}$ / Total Assets$_{(t)}$		2.5873 ***	2.4807 ***	2.5088 ***
		(0.6547)	(0.5311)	(0.4212)
Number of Employed Persons on Construction Enterprises$_{(t)}$ / Number of Construction Enterprises$_{(t)}$			5.3532	4.6985
			(4.6402)	(4.5086)
Constant	29.9196 ***	-10.6686	7.8841	-0.6584 ***
	(5.4730)	(7.0798)	(21.1864)	(0.1877)
Year (Trend)	-0.0149 ***	0.0051	-0.0042	
	(0.0027)	(0.0035)	(0.0106)	
Year 2006 (Dropped)				
Year 2007				0.0368
				(0.0744)
Year 2008				0.1415 ***
				(0.0403)
Year 2009				0.145 **
				(0.0468)
Year 2010				0.0217
				(0.0712)
Year 2011				0.2629 *
				(0.1146)
Year 2012				-0.0346
				(0.0981)
Year 2013				0.0346
				(0.0522)
Year 2014				-0.0876
				(0.1318)
Year 2015				0.1122
				(0.0923)
Year 2016				-0.0411
				(0.1215)
Year 2017				0.1709
				(0.1057)
Year 2018				-0.0259
				(0.1622)
Year 2019				0.0604
				(0.0922)
Observations	126	126	126	126
R-squared	0.1556	0.2231	0.2471	0.4147
Number of id	9	9	9	9

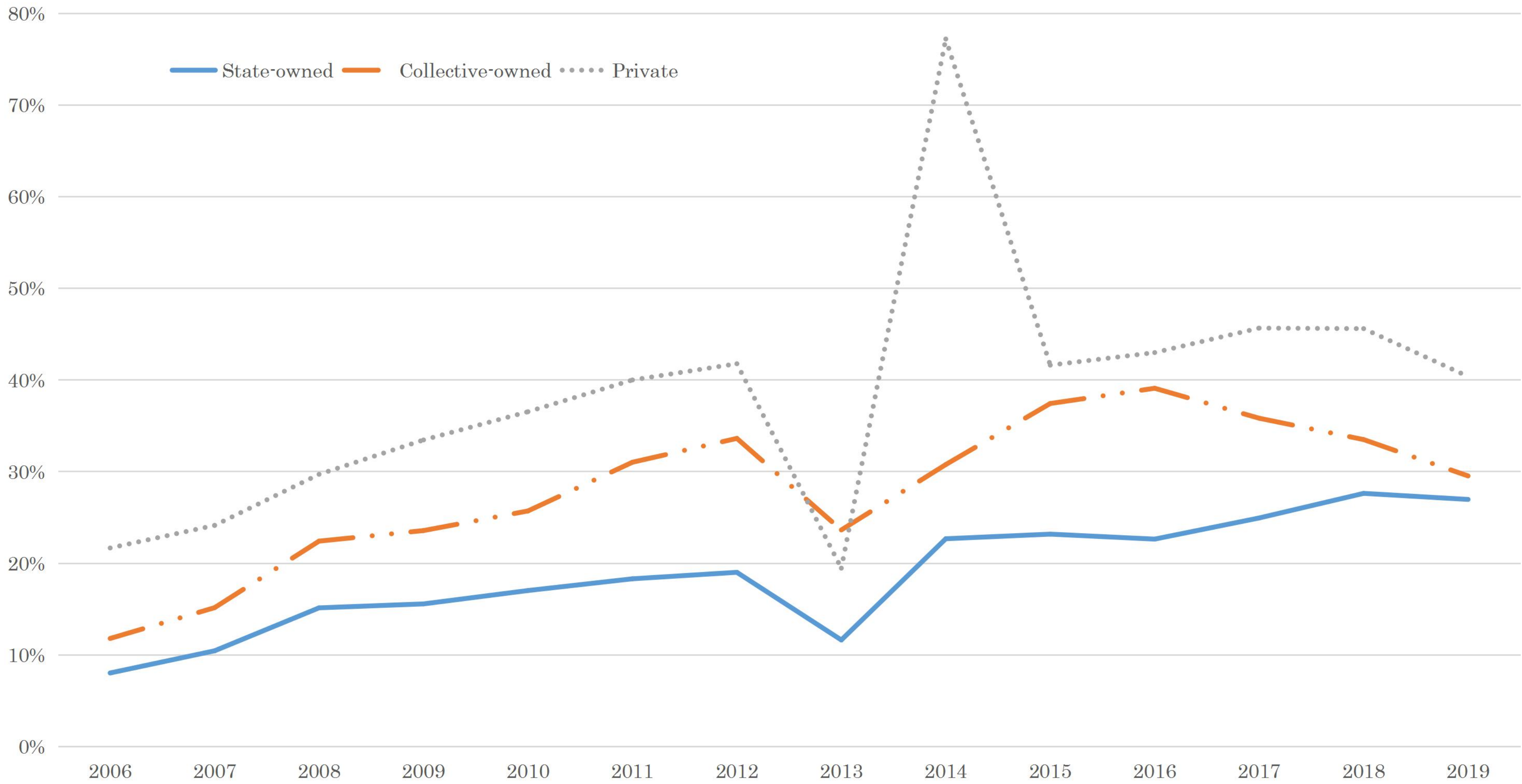
Note: Robust standard errors in parentheses (FE), *** p<0.01, ** p<0.05, * p<0.1.

Figure 5.1: Ratio of total profit to fixed asset of construction sector by ownership during 2006-2019 (%).



Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Figure 5.2: Ratio of total profit to fixed asset of domestic funded construction sector by ownership during 2006-2019 (%).

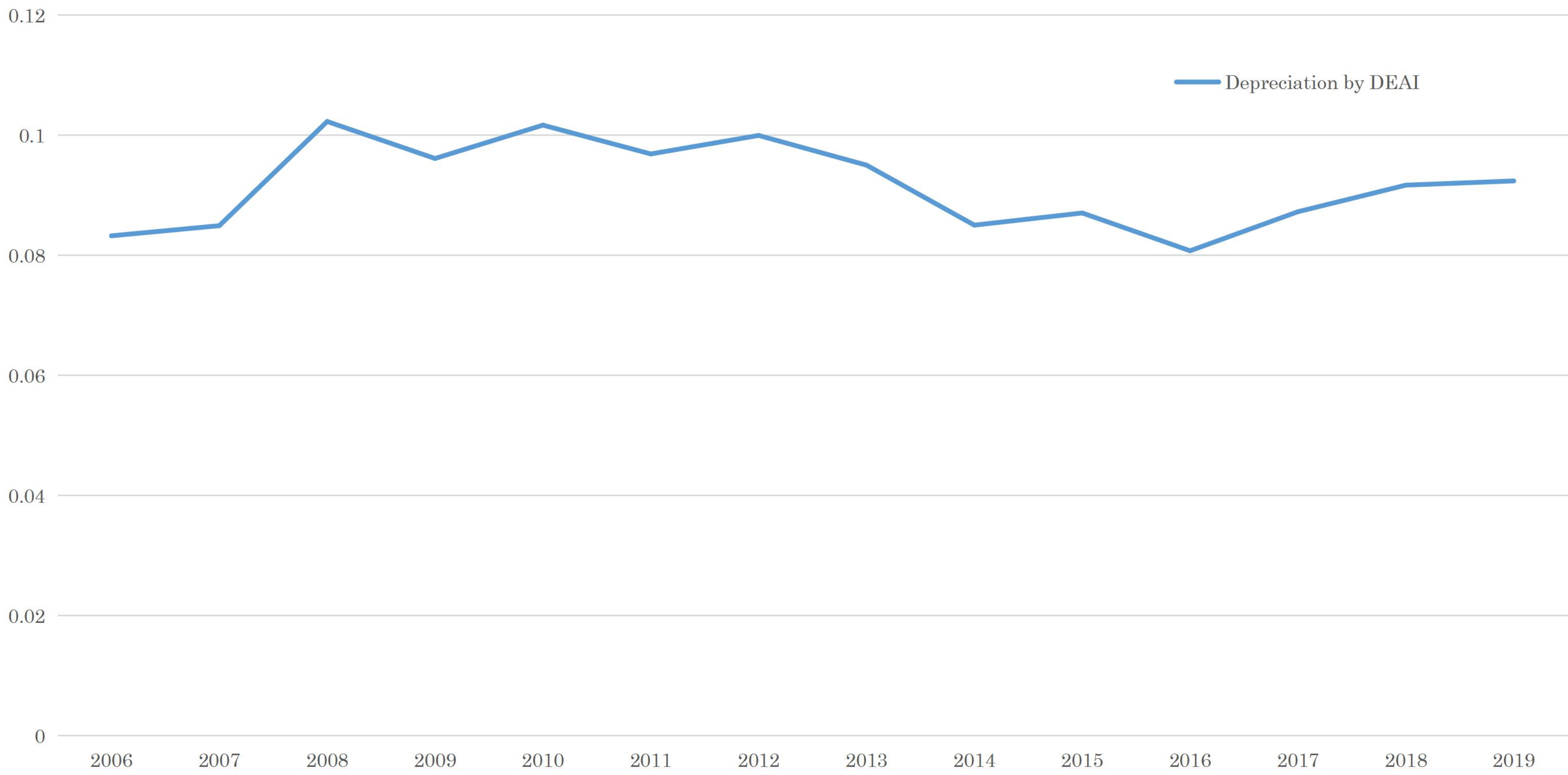


Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Figure 5.3: The growth rates of Ratio of Investment to Real Capital Stock, Number of Machinery and Equipment Owned of Construction Enterprises Year-end, Number of Employed Persons on Construction Enterprises, Gross Output Value of Construction Enterprises during 2007-2019.

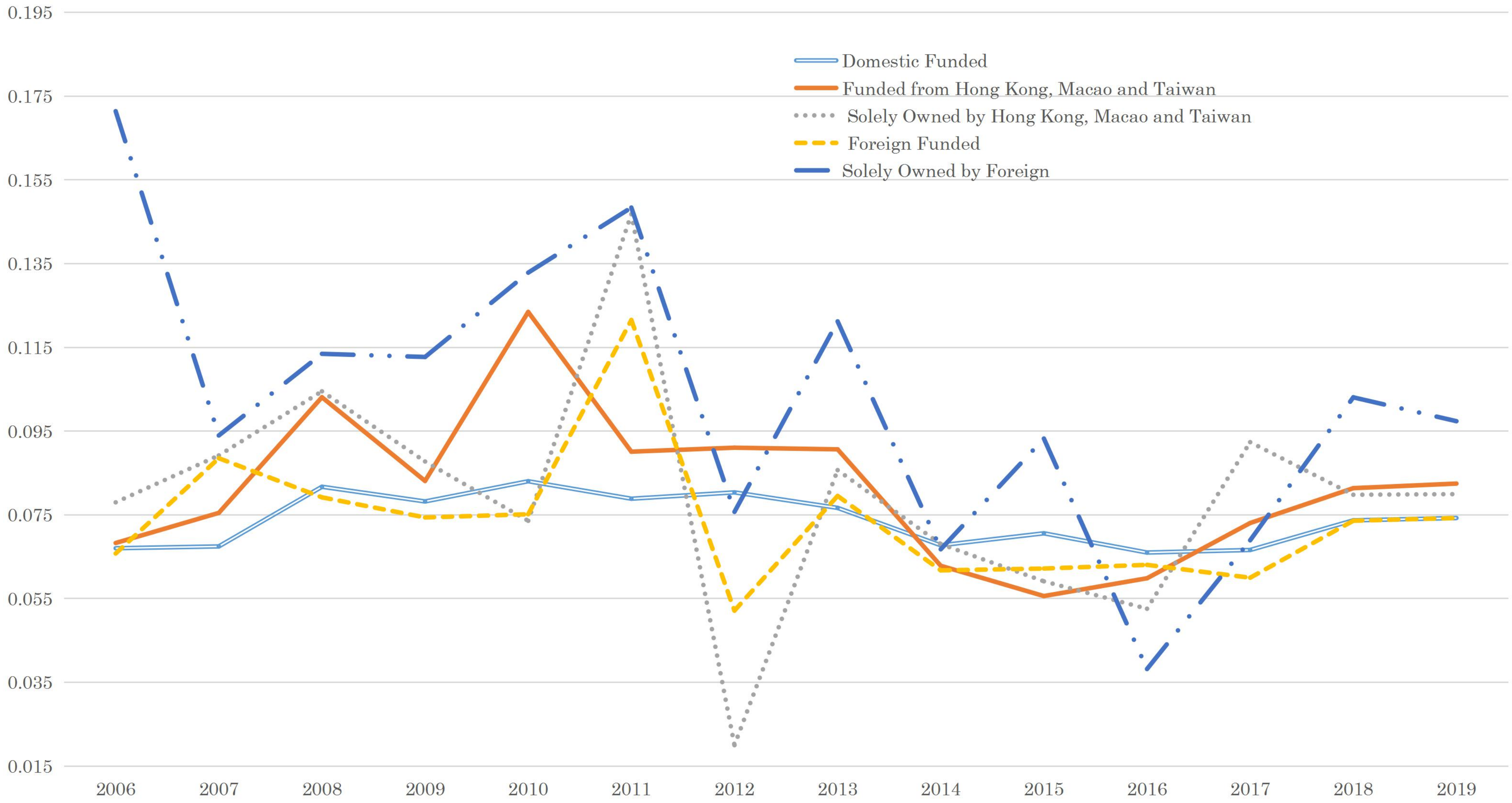
Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn

Figure 5.4: Deprecation rate of national construction sector by Depreciation Expense as Accounting Item (DEAI) for the period 2006–2019.



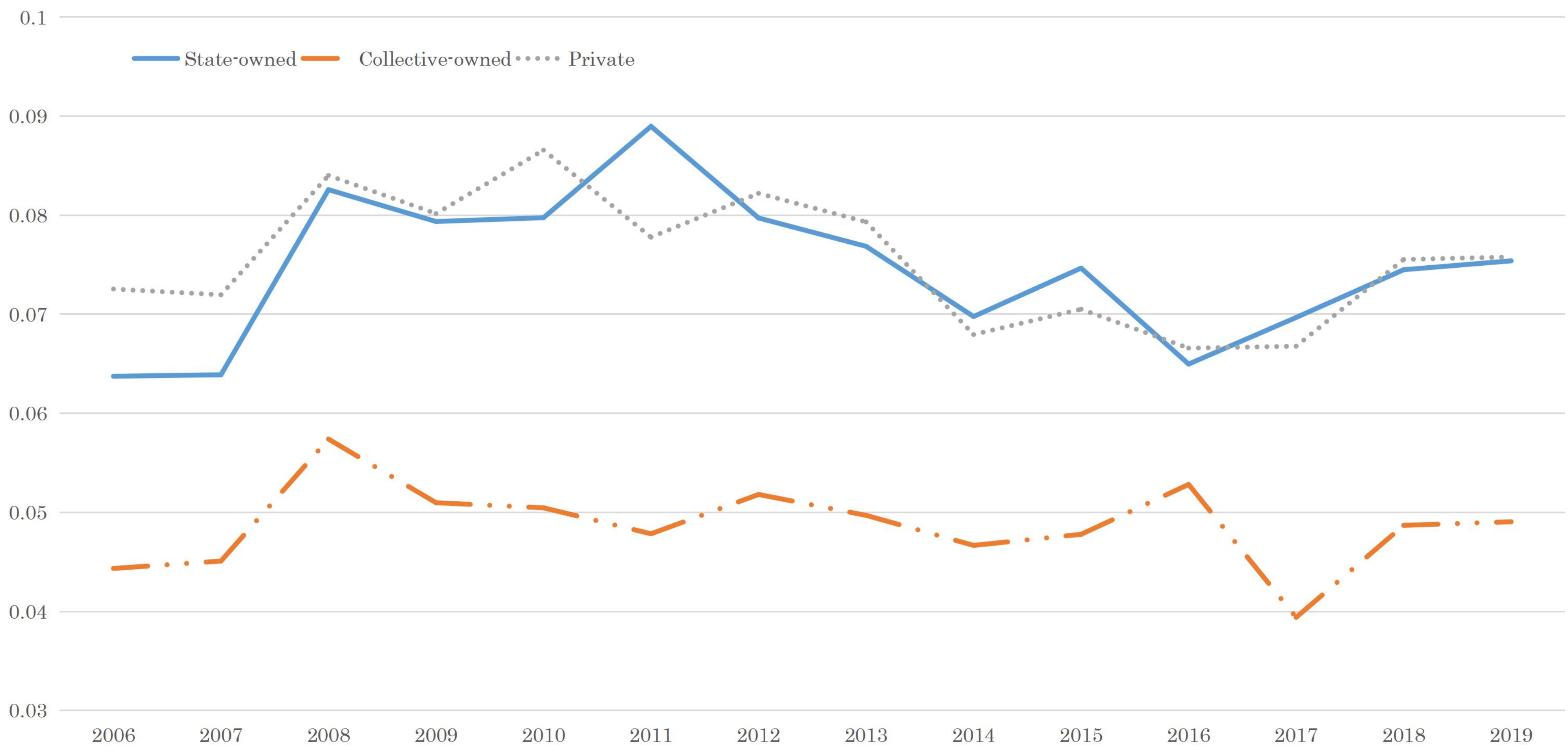
Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Figure 5.5: Deprecation rate of construction sector by Depreciation Expense as Accounting Item (DEAI) by ownership for the period 2006–2019.



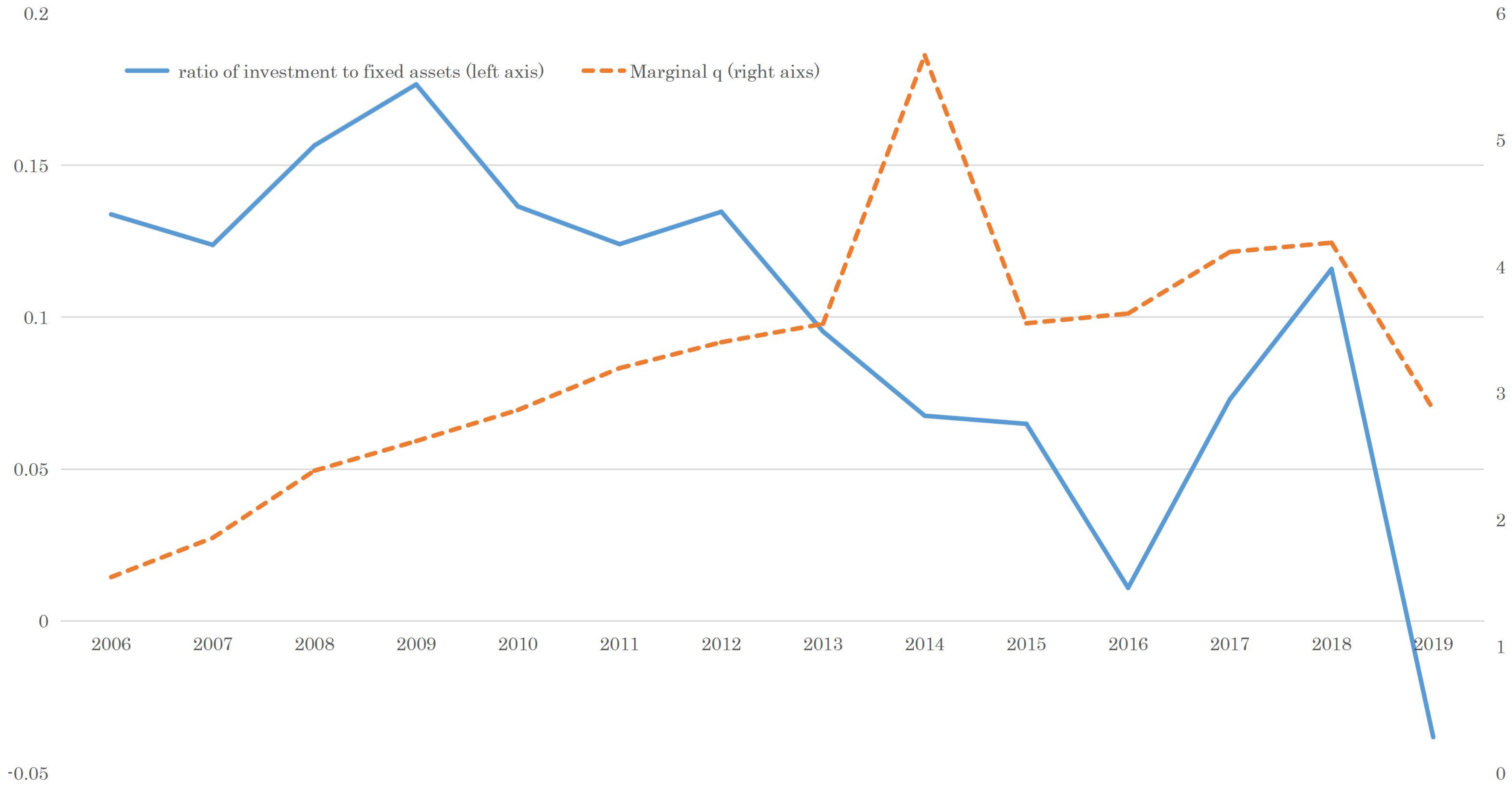
Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Figure 5.6: Deprecation rate of domestic funded construction sector by Depreciation Expense as Accounting Item (DEAI) by ownership for the period 2006–2019.



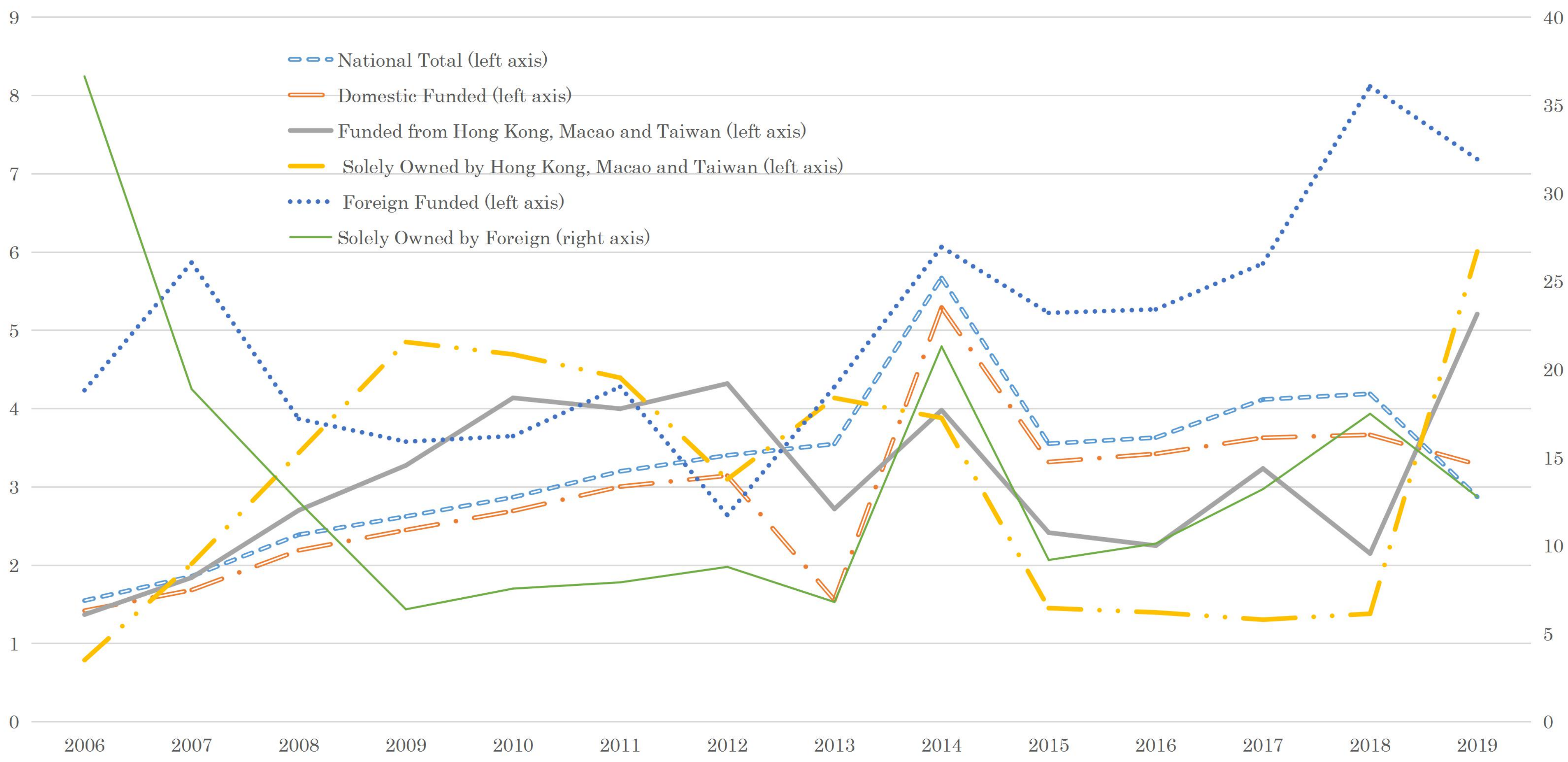
Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Figure 5.7: Before-tax Marginal *q* vs. ratio of investment to fixed assets of construction sector during 2006-2019.



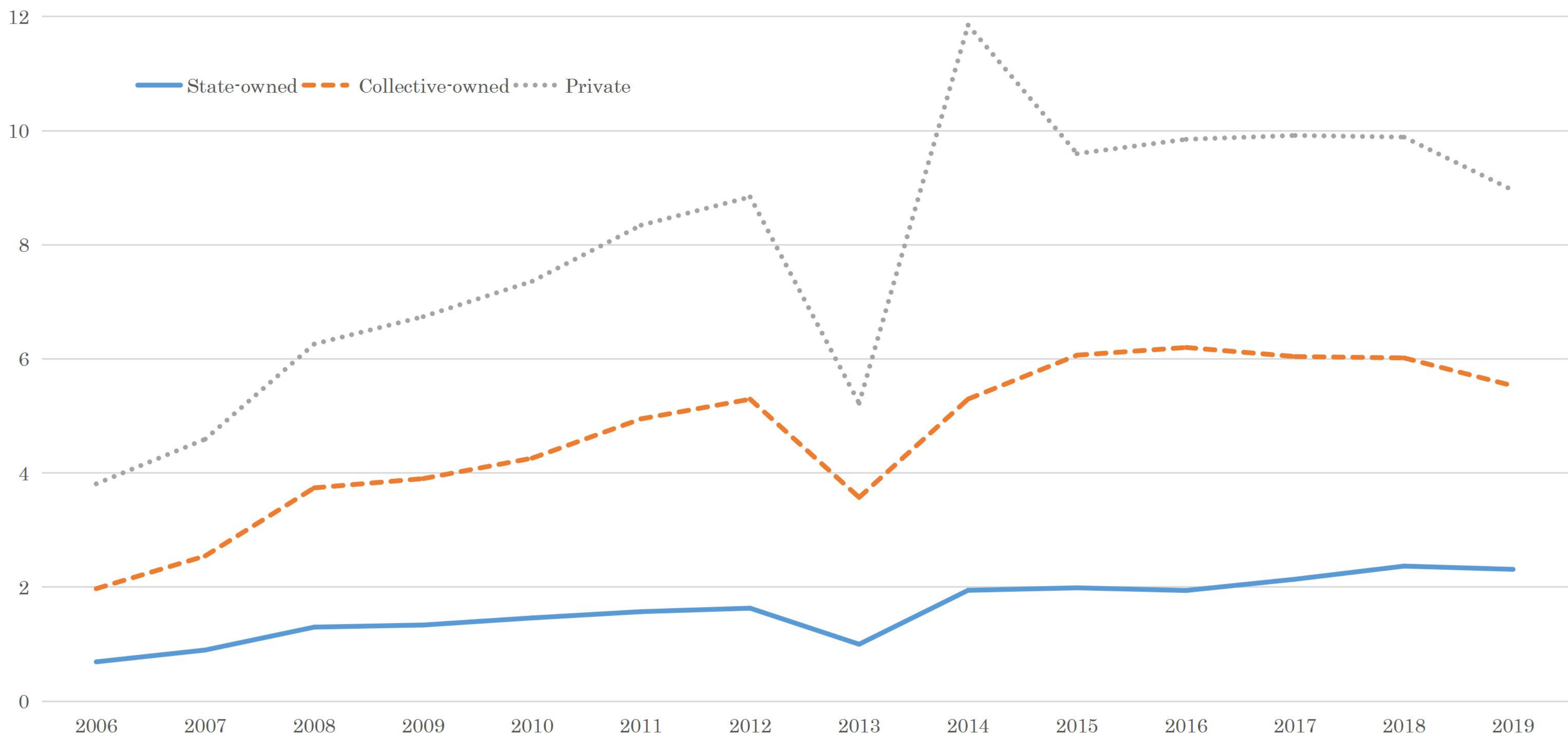
Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Figure 5.8: Before-tax Marginal q of construction sector by ownership for the period 2006–2019.



Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Figure 5.9: Before-tax Marginal q of domestic funded construction sector by ownership for the period 2006–2019.



Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Chapter 6
Conclusion

6.1 Summary and implications

We analyzed transmission from the housing bubble to housing-related industrial sectors and firms via the *q* approach. The main conclusion is that overinvestment in the real estate and construction sectors in China has been caused by housing bubbles. A soft landing policy could help resolve the current housing bubble in China (Wan, 2018, 2021b). Here, we summarize the findings by chapter.

Chapter 2 summarized and compared the literature on transmission from house prices to the Producer Price Index (PPI) in China. We found that transmission can be divided into supply and demand-side. Analysis approaches include use of an input-output table and the application of neoclassic economic theory; both of these approaches are incorporated into the demand-side theory of Wan (2021). Granger causality test results showed housing prices may affect the PPI, in accordance with demand-side theory (Qiu and Wan, 2018; Wan, 2021). When there is a housing bubble in China, house prices can also affect housing-related industries and firms, according to the transmission hypothesis (Wan, 2021). A housing bubble may lead to overinvestment in housing-related industries and firms.

Chapter 3 presents an analysis of data for 19 real estate firms in China, to quantify overinvestment in the residential sector via the *q* approach. We estimated the depreciation rate by Depreciation Expense as Accounting Item (DEAI) with and without inventory fellow Wan and Qiu (2021), and the before- and after-tax Marginal and Average *q* values of the real estate firms fellow Wan and Qiu (2020). The before-tax Marginal and Average *q* values calculated herein were close to those obtained by Ogawa et al. (1994) for Japan in the 1980s. However, the higher Marginal than Average *q* in this study is in opposition to the trend for Japan in the 1980s calculated by Chrinko and Schaller (2001). High before- and after-tax Marginal *q* values imply profit in association with the housing bubble, as well as overinvestment in the real estate sector in China (including by the Evergrande Group) in accordance with demand-side theory (Wan 2021), where investment is informed by Marginal *q*. The before- and after-tax Marginal *q* and Average *q* of the China Evergrande Group drastically decreased from 13.8307, 8.0304, 2.0198 in 2010 to 1.1330, 0.5213, 0.9791 in 2020, respectively. Based on the Tobin *q* theory, the China China Evergrande Group and the other similar firms have been overinvestment. The economic depreciation theory and Tobin *q* theory can explain the depreciation rate by DEAI and investment behavior of the 19 real estate firms. Analysis of panel data indicated overinvestment in the real estate sector in China, which may be linked to factors such as iron or cement quantities (Wan and Qiu 2020).

Chapter 4 summarizes and compares the literature on construction investment and housing prices for various countries. We found that the demand-side theory of Wan (2021) can be used to analyze construction sector investment according to house prices in China. The Marginal *q* approach is the main method to analyze investment in the construction sector in China; this approach has also been used to analyze overinvestment in 13 housing-related industry sectors in China (Wan and Qiu 2020).

Chapter 5 demonstrates that construction machinery leasing prompted the construction sector to reduce investment in fixed assets, such that the perpetual inventory method (PIM) cannot be used to estimate the rate of depreciation. We estimated the depreciation rate by DEAI and before-tax Marginal *q* for the construction sector in China by macro data for the period 2006–2019. The mean value of depreciation rate by DEAI was close to those calculated previously for Japan and the U.S. A high before-tax Marginal *q* implies profit from the housing bubble and some degree of overinvestment in the construction sector. The rate of depreciation and investment in the construction sector can be explained by economic depreciation theory and Marginal *q* theory, respectively.

Finally, Chapter 6 summarizes the conclusions of this work. We used the *q* approach to show that the housing bubble affected real estate firms and the construction sector in China. The high Marginal *q* implies overinvestment in the 19 real estate firms of interest in this study, and in the construction sector overall. We also observed transmission from the housing bubble to real estate firms, and from real estate firms to the construction sector, in line with the demand-side theory of Wan (2021). This study supplements Wan and Qiu (2020) by showing the need for iron, cement, and other materials for housing construction.

6.2 Directions for future research

In Chapter 2, we summarized and compared the literature on transmission from the housing bubble to the PPI, but did not assess transmission from the housing bubble to each individual housing-related sector, nor the influence of the housing bubble on the link between material quantity and price for each sector. An input-output table, panel data and the Granger causality test can be used to identify the transmission mechanism in a structural model.

In Chapter 3, we found that, for 19 real estate firms in China, the Marginal q was higher than the Average q, which is the opposite trend to that reported for Japan in the 1980s by Chrinko and Schaller (2001). More authoritative data are needed to confirm the results presented in this Chapter, using both our approach and that of Chrinko and Schaller (2001). Analysis of macro- and micro-level data is also needed to more accurately determine how housing firms are affected by housing bubbles.

In Chapter 5, we used macro data and the q approach to analyze the relationship between construction sector investments and the housing bubble in China, and connected these results to those provided in Chapter 4. Analysis of micro data based on the q approach is needed to fully characterize the relationship between investment in construction firms and the housing bubble in China.

Further study is needed to resolve these issues; to that end, we look forward to making more contributions to this research field.

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