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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 Introduction

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 residential sector and housing-related industrial sectors resulting from the housing bubble were reported by Qiu and Wan (2021) and Wan and Qiu (2020), respectively. 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.

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] The

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

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).

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.

1.4 Structure of this research

The remainder of the paper 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.

2 Research question and hypotheses

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*.”

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.

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).

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 (2021) 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).

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

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.

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):

$$TVFA_{mt} = OVFA_{mt} - DFA_{mt} + Errors_{mt}, \quad (1)$$

where

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 nonsignificant 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 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 1. By year, the national value of the construction sector and the value by ownership are illustrated in Figures 4–6.

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 the approach in Wan and Qiu (2020), 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 before-tax total 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} = investment 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 of industrial sectors of *m* ownership at time *t*.

The estimated before-tax Marginal *q* values of the construction sector are summarized in Table 2, and the before-tax Marginal *q* values of ownership are illustrated in Figures 8 and 9.

4 Empirical specifications

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):

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

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* $_{mt}$ / *Total Assets* $_{mt-1}$ 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.

$\alpha_1, \alpha_2, \alpha_3$, are coefficients, and $\alpha_0, \tau_m, \rho_t, \varepsilon_{it}$ 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.

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 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).

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

where

a and τ are parameters of a quadratic function.

Formula 6 was applied to test hypothesis 2 using the structural form of the adjustment cost model for before-tax Marginal *q*.

4.3 Empirical results

Depreciation rate of construction sector obtained by DEAI

Figure 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 and 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 3 presents the summary statistics of the main variables, and Table 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 Wan's (2019) economic depreciation hypothesis.

Investment of the construction sector

Figure 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 8 and 9. Table 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). Comparing the before-tax Marginal q of each ownership, we 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 and 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 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).

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 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 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 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 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: 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.

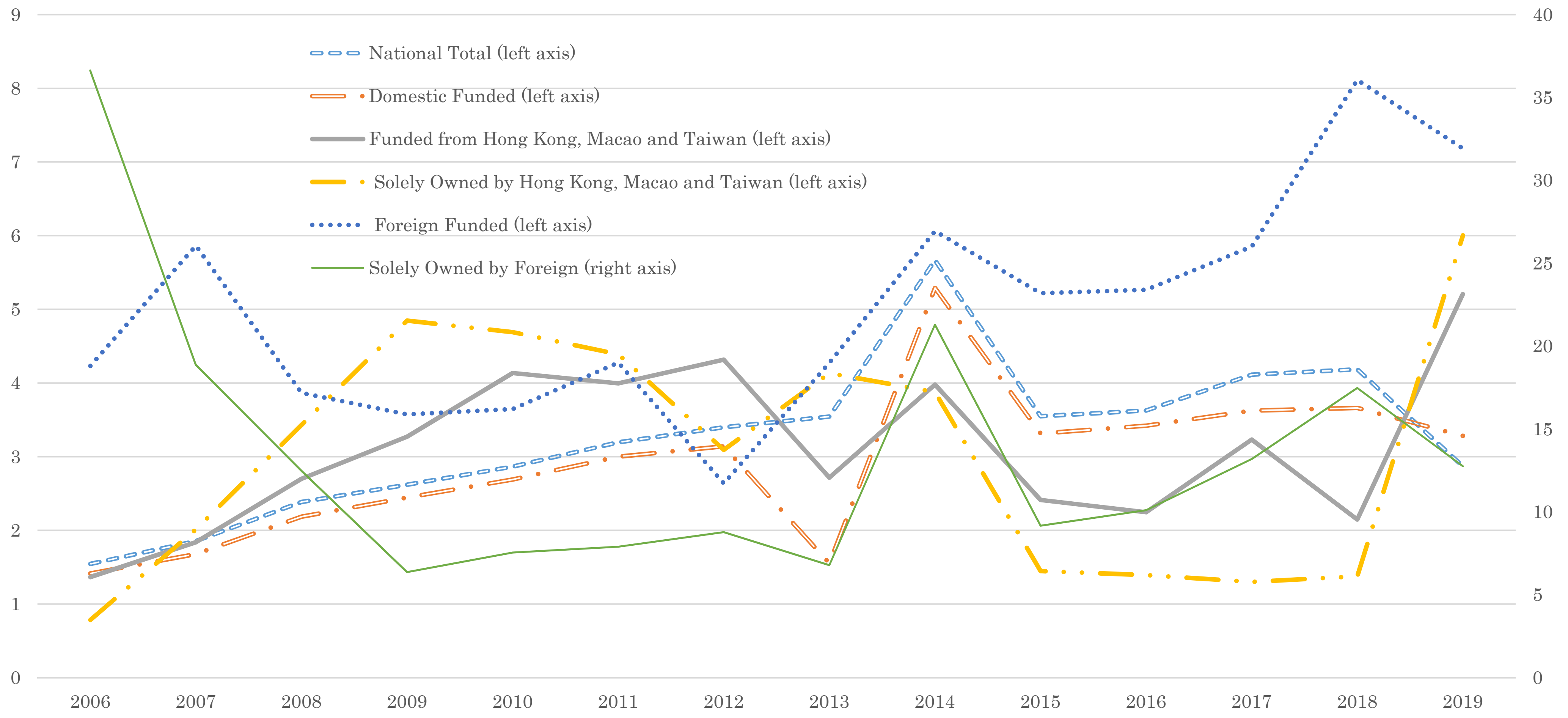
Table 6: Determinants of investments in construction sector (adjustment cost model), 2006-2019.

(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

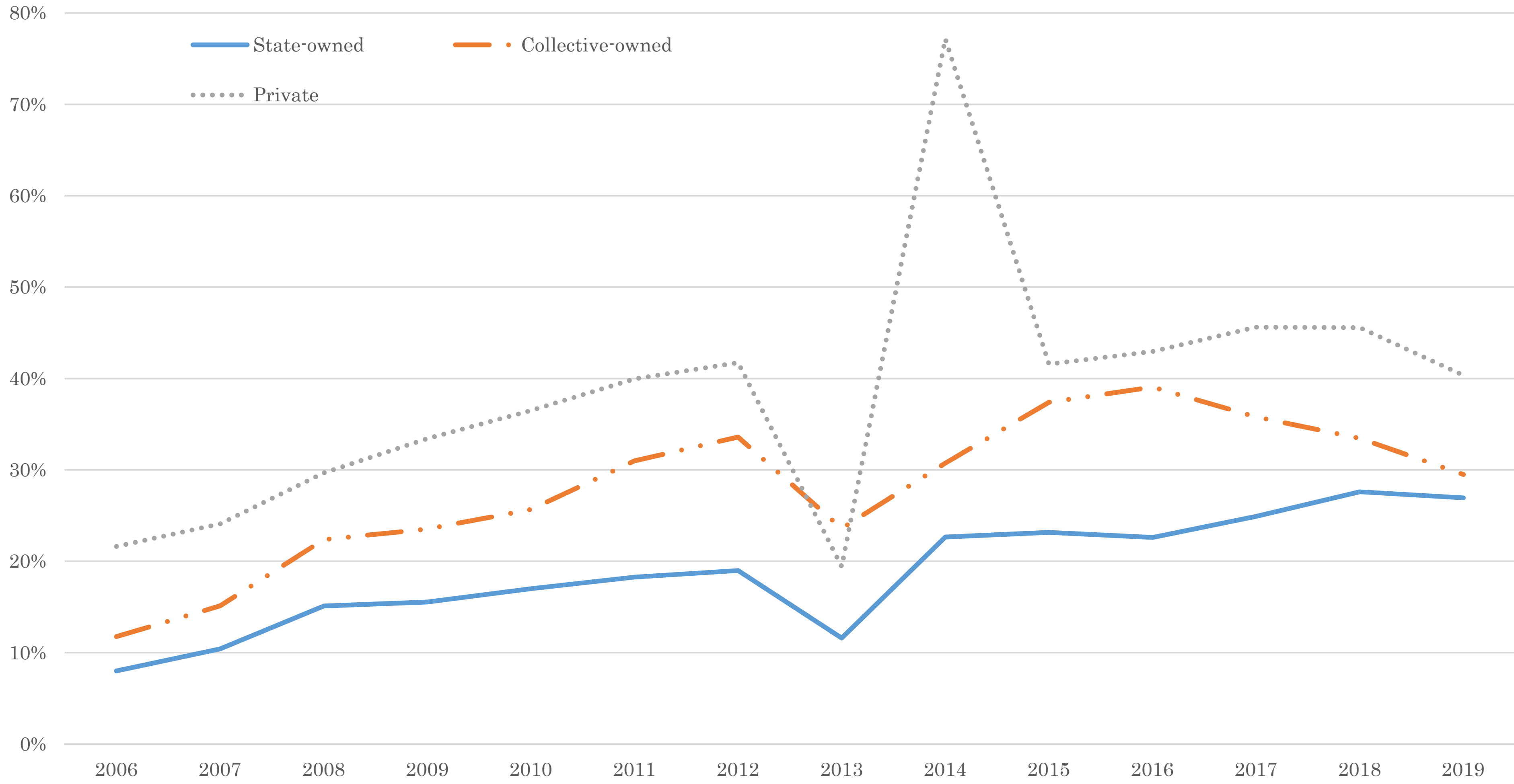
Note: Robust standard errors in parentheses (FE), *** p<0.01, ** p<0.05, * p<0.1.

Figure 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 2: Ratio of total profit to fixed asset of domestic funded construction sector by ownership during 2006-2019 (%).

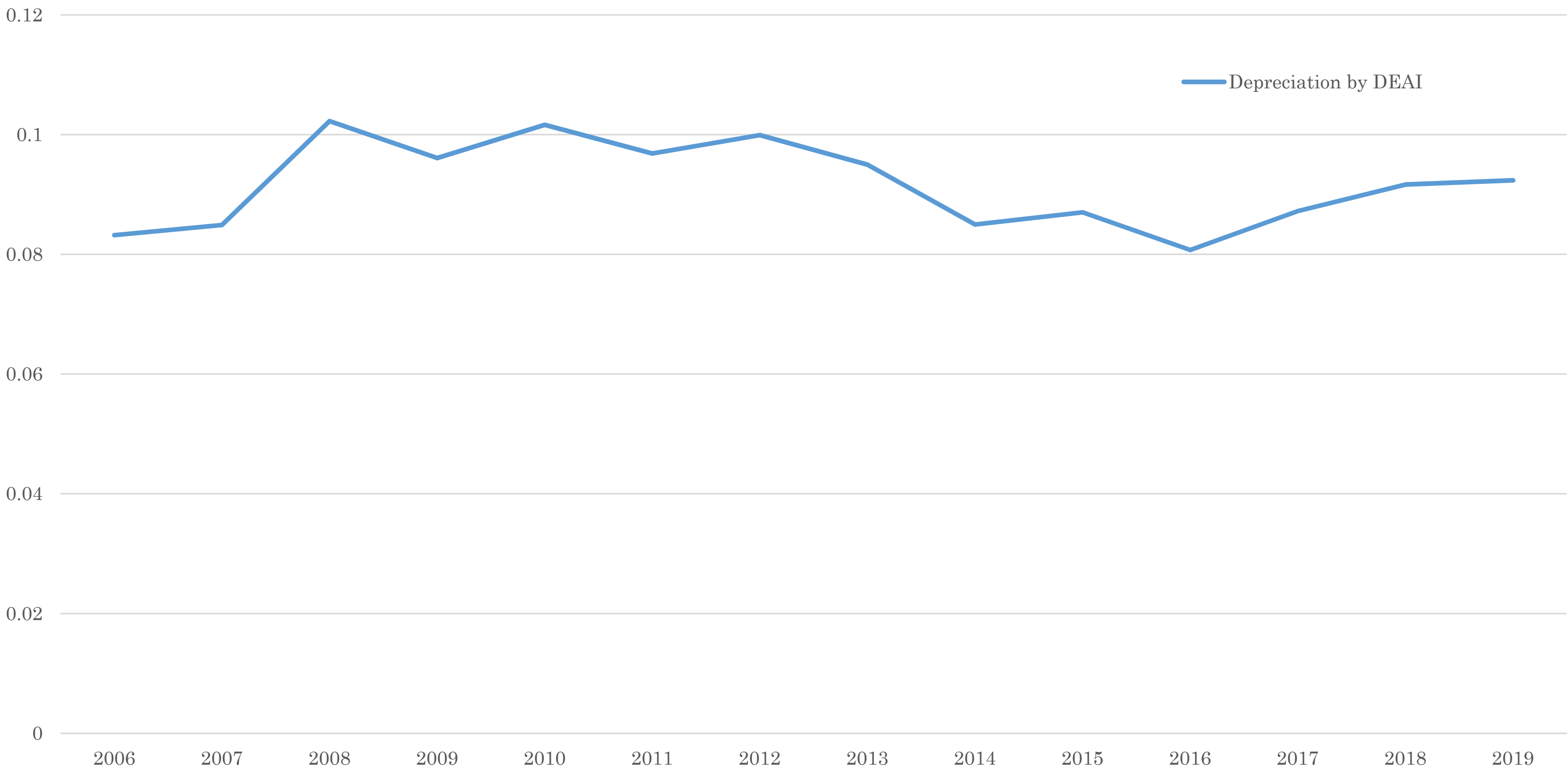


Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Figure 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.

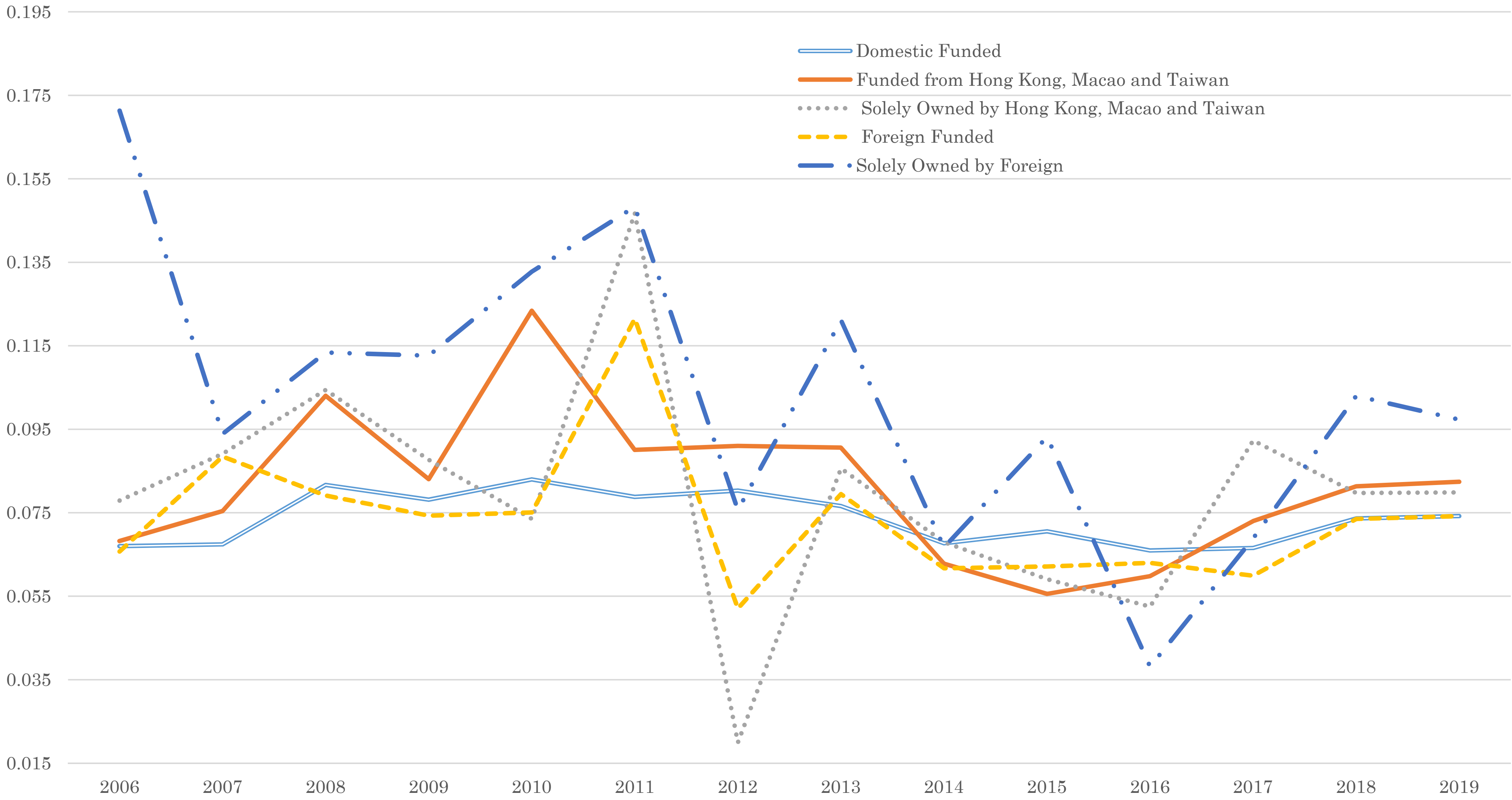
Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn

Figure 4: Deprecation rate of construction sector by Depreciation Expense as Accounting Item (DEAI) for the period 2006–2019.



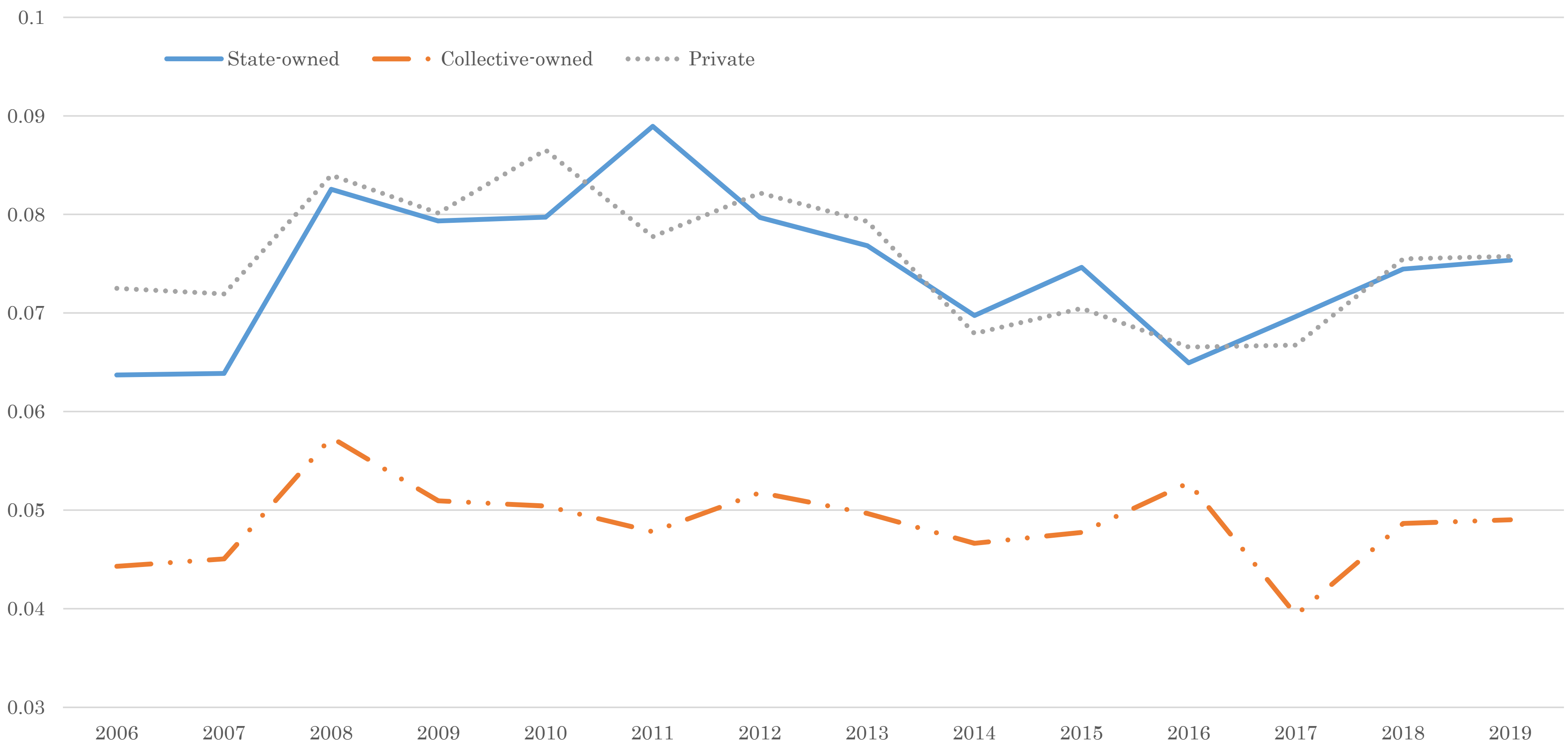
Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Figure 5: Deprecation rate of construction sector by Depreciation Expense as Accounting Item (DEAI) by ownership for the period 2006–2019.



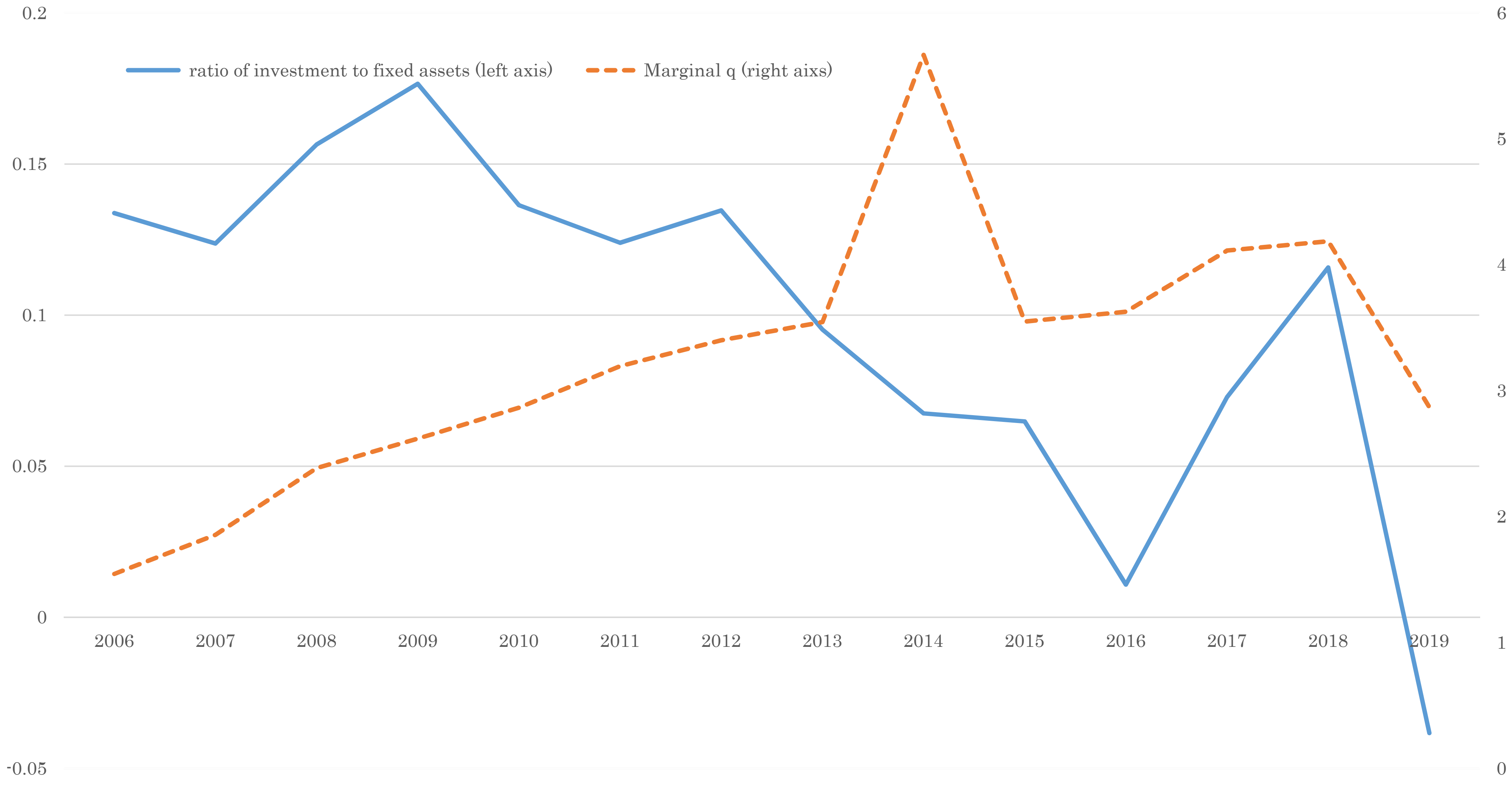
Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Figure 6: Deprecation rate of domestic funded construction sector by Depreciation Expense as Accounting Item (DEAI) by ownership for the period 2006–2019.



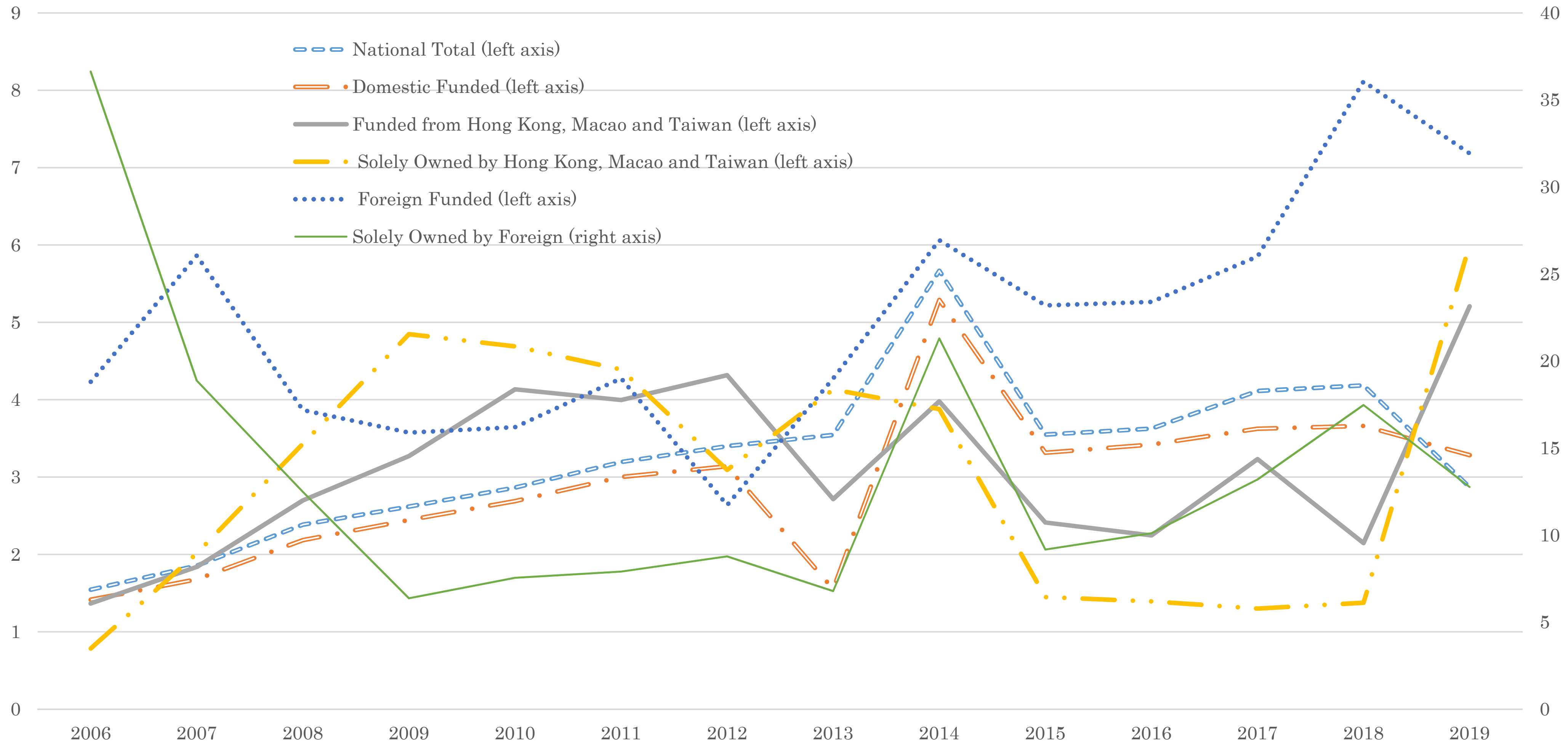
Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Figure 7: Before-tax Marginal *q* vs. ratio of investment to fixed assets of construction sector for the period 2006-2019.



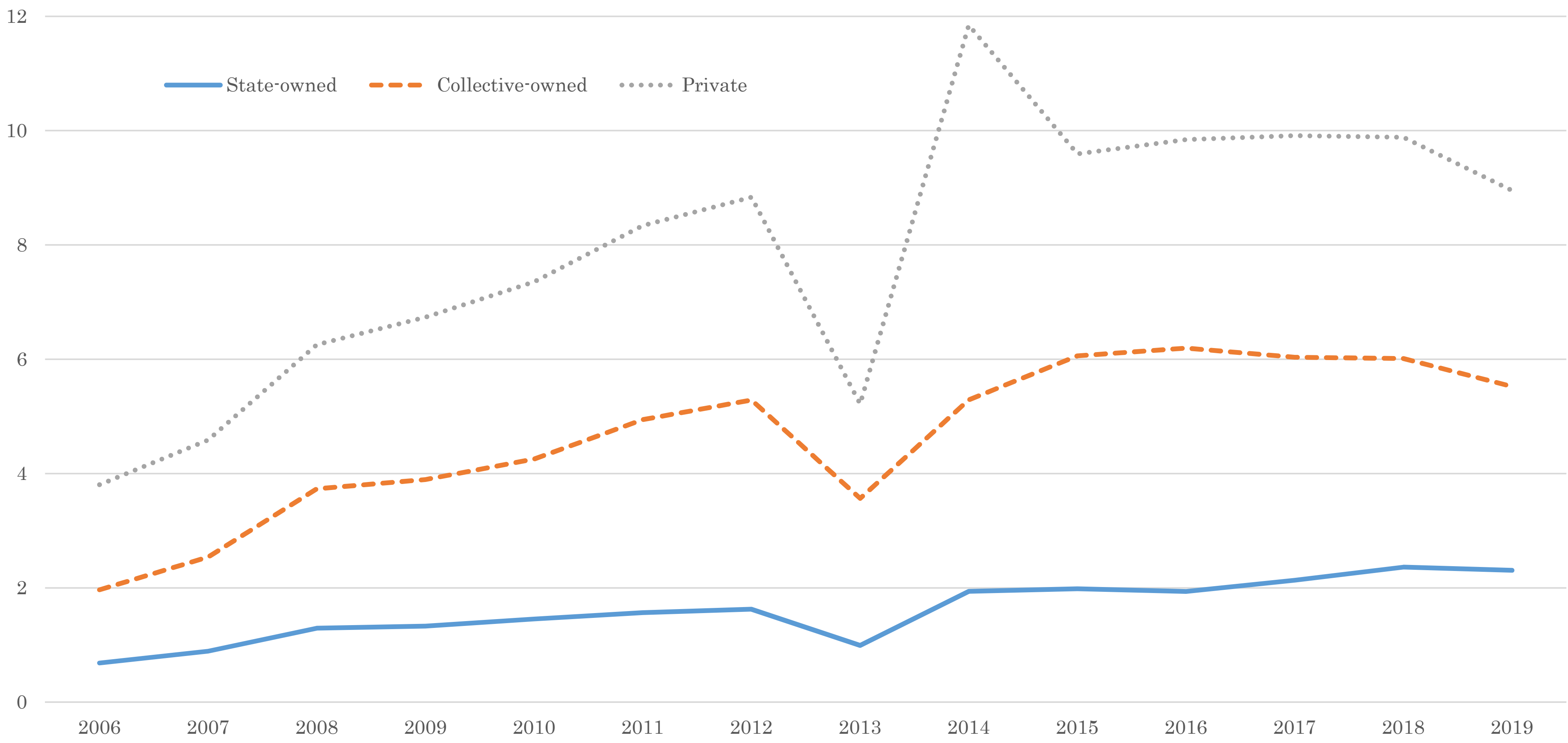
Source: Authors' estimations based on data from the National Data by National Bureau of Statistics of China. http://data.stats.gov.cn/

Figure 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 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/