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Land Investment by Japanese Firms during and after the Bubble Period*

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** Research and Statistics Department

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Abstract

This paper investigates (i) what has determined the land investment behavior of Japanese firms since the latter half of the 1980s; and (ii) how the current market prices of their land assets diverge from their shadow prices (marginal values of land investment). To do so, we estimate nonlinear land investment functions using micro panel corporate data, and calculate the partial q for land assets taking account of their collateral role.

The land investment functions reveal that firms, in particular those in the real estate related industries, have been net sellers of land in the 1990s, mainly in response to the decline in sales and the deterioration in financial conditions after the bursting of the bubble. Moreover, manufacturing firms have also sold land because of the hike in the overseas production ratio.

Partial q shows that the market price of land held by the real estate related industries has exceeded its shadow price since the latter half of the 1980s. For other industries, market land prices declined to the level of their shadow prices around the middle of the 1990s. However, since then market prices have once again found themselves above their shadow prices, in the face of pessimistic expectations revealed by distressed share prices after 1997.

JEL Classification Number: E22, G12, R30, C24

Keywords: land investment, multiple q, friction model

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1 Introduction

This paper investigates (i) what has determined the land investment behavior of Japanese firms since the latter half of the 1980s; and (ii) how the current market prices of their land assets diverge from their shadow prices (marginal values of land investment).

Asset price deflation has characterized the long-run stagnation of Japanese economy since the 1990s. After the bursting of bubble, both shares and land have lost much of their values. The average land price in 2002 was less than 30% level of its peak in 1990, while the average share price was less than 35% of its peak in 1989.

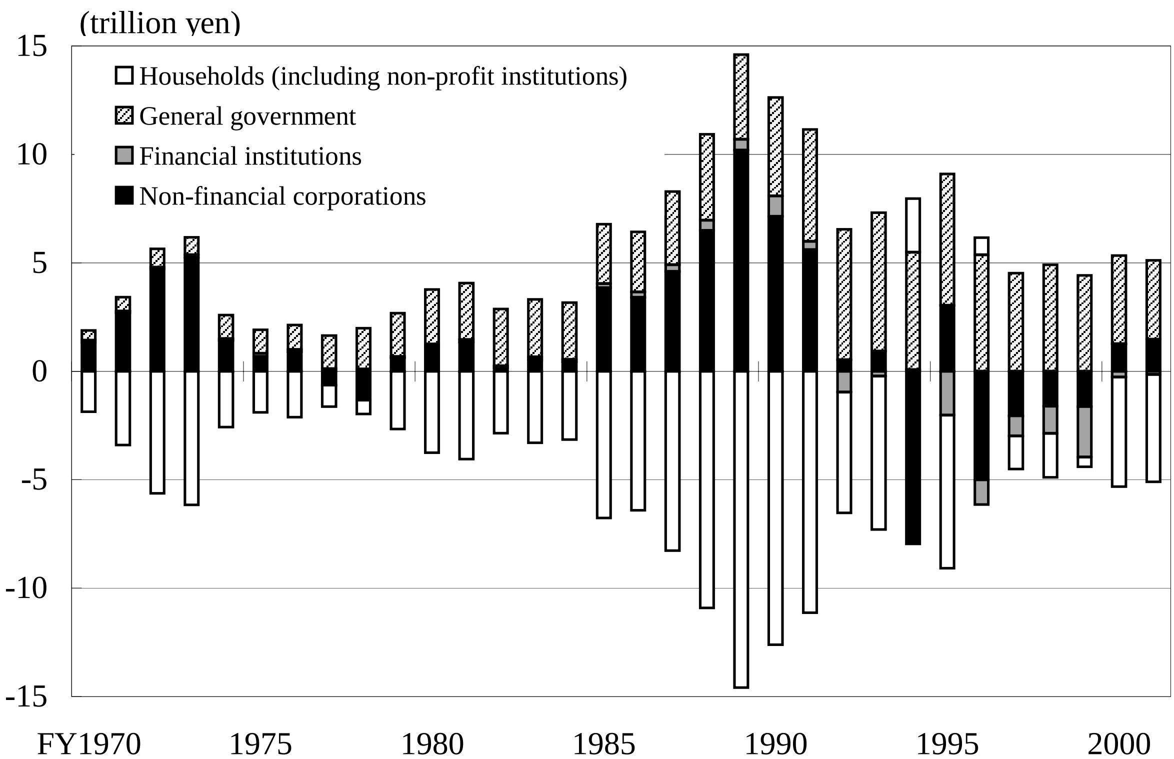
Of these two types of asset, this paper deals with land, paying particular attention to the role of the corporate sector in this regard. Our focus is articulated by Figure 1, which shows the net purchase of land assets by economic sector, based on the national accounting statistics. Since the 1980s, the corporate sector seems to have behaved rather like a swing voter. In the late 1980s, when land prices in Japan skyrocketed, the corporate sector loomed up as a big net purchaser of land assets. In the early 1990s, when land prices plummeted, it became a net seller of land assets. From these observations, one may suspect that the corporate sector has been behind the drastic land price fluctuations in Japan over the last two decades.

To the best of our awareness, however, there are few studies investigating the land investment behavior of Japanese firms since the 1980s. Asako et al. (1989, 1997) are notable exceptions, but they limit their scope to the manufacturing sector. In land investment, nonmanufacturing firms such as those in the construction and real estate industries are thought to play a more important role.

This paper tries to add to existing knowledge about the land investment activities of Japanese firms including those in the nonmanufacturing sector. For this purpose, we construct a large panel data set that covers all the listed firms in Japan. Based on this data set, we first estimate nonlinear land investment functions to uncover the determinants of the land investment decisions by these firms. Then, taking the role of land collateral into consideration, we calculate the partial q of firms' land assets so as to evaluate the discrepancies between their market prices and shadow prices.

This paper proceeds as follows. Section 2 goes through several statistical surveys to uncover the main features of Japanese firms' land investment behavior, and to make inferences about the factors underlying these. Section 3 discusses our empirical strategy and briefly describes our large panel data set. Section 4 estimates nonlinear land investment functions and statistically tests the inferences made in the previous sections. Section 5 estimates the partial q of land assets and examines its development over time. Section 6 concludes the paper.

Figure 1: Land Investment by Sector



(Source) Cabinet Office, "Annual Report on National Accounts."

2 Who Sold What Kind of Land, and for How Much?

In this section, we go through several statistical surveys in order to provide background information for the analysis that follow. The intention is to use this survey data to obtain clues about which kinds of firm sold what sort of land, and for what reasons, after the bubble burst in the early 1990s.

Table 1 sheds some light on *who* sold land. It summarizes firms' net purchases of land in the 1990s, in terms of area and with breakdowns by industry and by capital size. Hereafter, Real Estate Related Industries (RERIs) refer to construction, real estate, and general trading companies (*sogo shosha*), all of which are said to have been actively engaged in commercial and housing developments during the bubble era.

The most salient finding from Table 1 is that the RERIs have disposed of a huge area of land. The RERIs became net sellers of land assets in FY1994. They resumed the position of net purchasers in FY1995 and FY1996, but have been net sellers since then.[1] From FY1997 to FY2000, the RERIs accounted for about 60% of the total net land sales by corporate sector.

Figure 2 confirms the above finding by calculating net sales of land, in value terms, using another statistical source. Construction and real estate industries—general trading companies are not segmented in these statistics and only two of the RERI industries are considered here—were the dominant net sellers in the 1990s, after they purchased a huge amount of land in the latter half of the 1980s.

Table 2 summarizes *what* kind of land assets have been sold. Recently, the shares of "Properties for rent" and "Land for development" have increased sharply, partly reflecting, respectively, increased securitization of properties and the hike in sales of resort facilities. "Welfare facilities" and "Factories" have maintained high shares, consistent with anecdotal evidence that firms have sold their welfare facilities in the course of business restructuring and have also shut down domestic plants in favor of vigorous foreign direct investment. Meanwhile, the shares of "Parking lots and vacant properties" and "Branches and sales offices," which accounted for nearly half of total land sales in FY1996 and FY1997, have declined.

Table 3 deals with the question of *why* these land assets have been sold. Financial reasons such as "To repay business loans," "To raise working capital and to settle accounts at the end of business year," and "To reduce financial costs of holding land" are three of dominant reasons behind land sales in FY2000 and FY2001. This illustrates the straitened financial condition of firms: under the pressure of mounting debts, firms sold land assets to balance their books.

[1] The huge net purchase of land by the RERIs in FY1996 is an outlier due to the over 10,000 hectares net purchase by general trading companies—this represents an area larger than the central part of the Tokyo metropolitan area (Chiyoda-ku, Chuo-ku, Minato-ku, Shinjuku-ku and Bunkyo-ku). However, we cannot trace this transaction in the corporate panel data used in the following sections, so that the analysis therein appear to be free from the influence of this outlier.

Table 1: Net Land Purchases by Firm (In hectares)

FY	Total	Industries			Capital Size		
		Manufacturing	Real Estate Related Industries	Other Nonmanufacturing	Large	Medium	Small
1991	6,946	3,345	2,031	1,570	5,781	-450	1,613
1992	6,759	4,250	272	2,237	4,297	273	2,189
1993	3,748	1,107	1,508	1,133	1,681	-124	2,191
1994	1,190	1,698	-492	-16	1,309	373	-492
1995	3,684	-253	2,165	1,772	965	2,025	696
1996	13,518	1,724	9,706	2,088	10,795	2,495	224
1997	122	1,025	-843	-60	327	-5	-197
1998	-222	219	-812	371	-86	446	-586
1999	-1,700	-1,998	-308	606	-2,301	-749	1,354
2000	-2,353	-102	-553	-1,698	-722	-651	-980
1997-2000	-4,153	-856	-2,516	-781	-2,782	-959	-409

Notes:

1. Real Estate Related Industries (RERIs) consist of construction, real estate, and general trading companies (*sogo shosha*).
2. "Large" refers to firms with stockholders' equity of 10 billion yen or more, "Medium" refers to those with less than 10 billion but more than 1 billion yen of equity, and "Small" refers to those with less than 1 billion yen of equity.

(Source) Ministry of Land, Infrastructure and Transport, "Kigyo no Tochi Syutoku Joukyou tou ni kansuru Chosa (Survey on Land Purchases by Firms)."

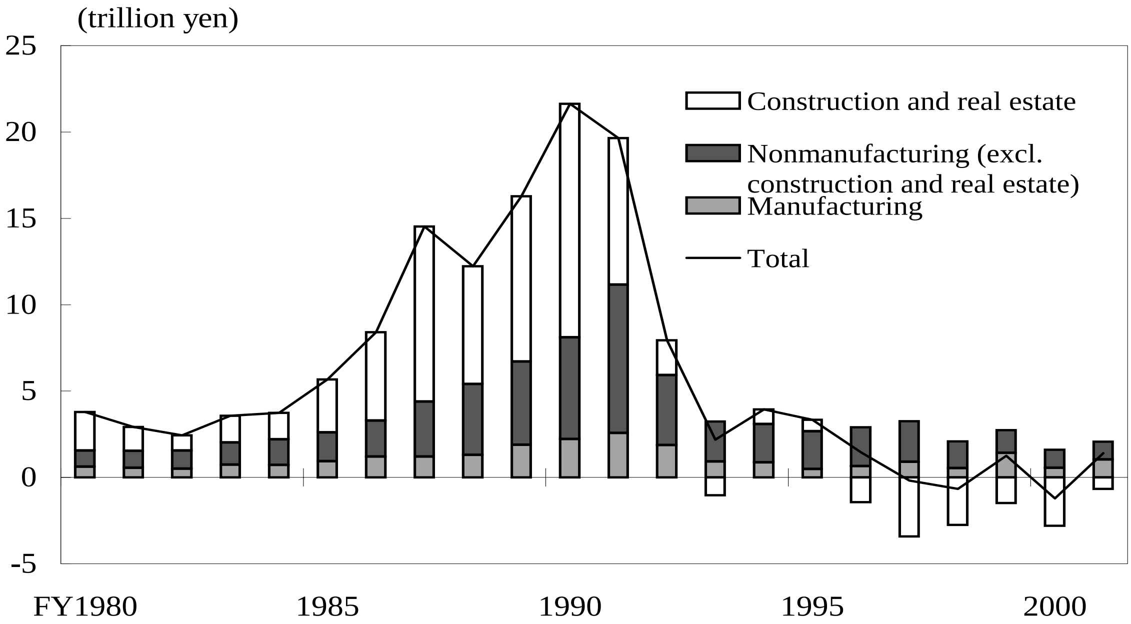
Table 2: Land Usages before Sale

FY	1996	1997	1998	1999	2000	2001
Properties for rent	3	8	20	20	19	23
Factories (including sites of former plants)	23	18	19	17	21	18
Welfare facilities	13	16	15	22	17	16
Land for development	4	4	5	6	9	13
Parking lots and vacant properties	19	21	13	11	9	11
Branches and sales offices	24	23	16	14	12	8
Warehouses	8	6	6	4	7	5
Headquarters buildings and others	6	4	6	5	7	5
Total	100	100	100	100	100	100

Note: In terms of the number of properties, expressed as a percentage.

(Source) Ministry of Land, Infrastructure and Transport, "Tochi Hakusho (White Paper on Land)," 2002, p.28.

Figure 2: Land Investment by Industry (1)



Note: 15% of special profits are assumed to arise from land sales. For construction (for real estate), 50% (90%) of inventory stock is assumed to be real estate properties for sale.

(Source) Ministry of Finance, "Corporate Statistics Annual."

Table 3: Purpose of Land Sales

Fiscal Year	1995	1996	1997	1998	1999	2000	2001
To repay business loans	44.8	44.1	43.5	37.6	32.4	32.3	35.7
To raise working capital and to settle accounts at the end of business year	22.3	21.7	24.9	24.5	21.9	23.0	24.1
To reduce financial costs of holding land	18.5	17.3	13.7	14.6	14.2	16.8	16.9
Completion of planned developments	19.9	16.1	18.9	16.4	13.7	14.3	14.4
For fear of a fall in land prices	11.0	15.6	13.2	11.3	10.0	8.9	12.8
To cut/close business activities	15.7	13.8	19.2	17.5	14.2	14.1	9.5

Note: Multiple choices are allowed. In percents.

(Source) Ministry of Land, Infrastructure and Transport, "Tochi Syoyu-Riyou Joukyou ni kansuru Kigyo Kodo Chosa (Survey on Land Ownership and Usages by Firms)."

Taken together, from these surveys, we make the following two inferences:

- *The RERIs have sold "Properties for rent" and "Land for development" to reduce their debt burdens.* Based on earlier surveys by the Ministry of Land, Yoshikawa (2002) shows that the RERIs purchased a huge area of land in the late 1980s (the bubble era) in order to develop then-lucrative resort areas such as golf courses, skiing pistes and camping fields. After the bursting of the bubble, increasing debt burdens and declining sales induced these firms to sell the land stocks build up during the 1980s.[2]
- *The hollowing of the manufacturing industry has had a substantial impact on the land market in Japan.* Although land sales by manufacturing firms have been much smaller than those by the RERIs, "Factories" accounted for a considerable share of such sales. If the impact of hollowing-out is substantial, the manufacturing sector's export of factories may be seen in terms of an import of land into Japan.

In the following sections, we statistically test these inferences, by estimating land investment functions based on a large panel data set.

3 Empirical Strategy and Data

3.1 Specification of Land Investment Function

For firms, their stock of land, just like their capital stock of machinery and buildings, is one of their inputs of production: $F(L_{it}, ...)$, where L_{it} is the real land stock for firm i in period t. Assuming $F(.)$ is a constant-elasticity-of-substitution (CES) production function and J_{it} is the user cost of the land stock, we can derive the following land investment function from the first-order condition of profit maximization, $\partial F / \partial L_{it} = J_{it}$.[3]

$$\left(\frac{I^L_{it}}{L_{i,t-1}} \right) = \alpha_0 + \alpha_1 \Delta y_{it} + \alpha_2 \Delta y_{i,t-1} + \alpha_3 (l - y)_{i,t-1} + \alpha_4 y_{i,t-1} + \alpha_5 J_{it} + u_{it}, \qquad (1)$$

where I^L_{it} indicates real land investment, i.e. real net purchases of land. l_{it} and y_{it} are natural logarithms of the real land stock and real output, respectively. u_{it} is a disturbance term. Δ denotes the first difference operator. For details, see Bond et al. (2003) and

[2] As of 1998, about a quarter of the land held by the RERIs was obtained during the bubble era. Out of their land assets, the share obtained from 1986-1992 is 22.6% for the RERIs, compared with 14.2% for manufacturing and 17.3% for other nonmanufacturing (percentages in terms of area, "Tochi Kihon Chosa (National Land Census)," Ministry of Land, Infrastructure and Transport.)

[3] This approach assumes that (i) the land stock serves solely as a production input, and (ii) the decision on land investment is independent of other capital investment decisions. These two assumptions will be relaxed in Section 5, where we estimate the q of land assets, explicitly taking into account the collateral role of the land stock and the simultaneity of land- and capital-investment.

Chatelain et al. (2001), where a capital investment function is derived from essentially the same set-up.

Equation (1) is an error correction specification of an accelerator-type capital investment model *à la* Jorgenson (1963). One difference from the capital investment function is that equation (1) does not include lagged dependent variables as independent variables. Investment in the depreciable capital stock depends on lagged dependent variables, because capital investment contains deprecation reflecting the past investment. The land stock, in contrast, does not depreciate, and hence, current land investment is unlikely to depend on its own lags.

In order to test the two inferences we put forward in the previous section, we add several variables to equation (1). First, we include variables that capture firms' financial conditions. Second, for the specification for manufacturing firms, we further add a variable that reflects their production in foreign countries.

For the financial variables, we add the interest coverage ratio ICR_{it} and the debt-to-asset ratio $(D/A)_{it}$. Both of these are said to be frequently used by Japanese commercial banks to establish credit ratings (Bank of Japan, 2001). In calculating $(D/A)_{it}$, we re-evaluate firms' assets at current prices by applying the perpetual inventory method. This is so that we can examine firms' balance-sheet problems under assets price deflation.

For overseas production, we add the overseas production ratio OPr_{it} of the industry to which firm i belongs. OPr_{it} is calculated as the ratio of local production in foreign countries to the total production of that industry ("Survey of Overseas Business Activities," Ministry of Economy, Trade and Industry.) By adding this variable, we test whether or not there is any tendency for firms which can more easily expand overseas production to be more severe in suppressing their domestic land investment. If this were to be the case, as popular accounts of the hollowing-out often suggest, foreign direct investment, which leads to a higher overseas production ratio, would be substituting for domestic investment.[4]

We suppose that the disturbance term u_{it} in equation (1) consists of time specific effects d_t, individual specific effects η_i, and idiosyncratic shocks ν_{it}. We drop the user cost of land J_{it}, assuming that d_t captures any effects from this source. Note that the financial conditions variables capture any possible variations in user costs between firms.

Specifically, the empirical equation we estimate is:

$$\left(\frac{I^L_{it}}{L_{i,t-1}}\right) = \alpha'_0 + \alpha'_1 \Delta y_{it} + \alpha'_2 \Delta y_{i,t-1} + \alpha'_3 (l-y)_{i,t-1} + \alpha'_4 y_{i,t-1}$$

[4]To the best of our awareness, this paper is the first attempt to statistically examine the effects of Japanese foreign direct investment on domestic land investment. In fact, to our surprise, there are little academic research that empirically explores the effects of overseas production on the Japanese economy. Fukao and Amano (1998), one of the few exceptions, conclude that until 1995, foreign direct investment by Japanese firms had a positive impacts on the real GDP growth rate in Japan by lowering energy costs. On the effects on capital investment, Miyagawa and Tokui (1994, Ch. 5) examine the case of foreign direct investment by the Japanese automobile industry, and allege that it may lower the domestic investment of the automobile industry.

$$+\alpha_5' ICR_{it} + \alpha_6' \left(\frac{D}{A}\right)_{i,t-1} + \alpha_7' OPr_{it} + d_t + \eta_i + \nu_{it}. \qquad (2)$$

3.2 Data

We estimate the land investment functions described in equation (2) using micro panel data. The use of micro panel data allows us to investigate the change in firms' land-investment behavior between the bubble and the post-bubble periods. With the short macro time-series data currently available, it is difficult to examine such a structural change. Panel data overcomes this lack of degrees of freedom in short time-series by adding a huge number of cross-sectional observations.

The building block of our panel data set is the financial-statements data compiled by the Development Bank of Japan (DBJ). The DBJ database contains consolidated and unconsolidated data on all the non-financial firms listed in (i) the first and the second sections of the Tokyo, Osaka and Nagoya stock exchanges, and (ii) the JASDAQ, the NASDAQ Japan (currently dubbed the Hercules) and the TSE Mothers—three stock exchange markets geared to small- and medium-sized companies. Since most consolidated data is available only for short-time periods (generally less than five years), we use unconsolidated data.

Although the database covers the relatively small firms listed in the JASDAQ/NASDAQ Japan/TSE Mothers, it does not include small unlisted firms. This prevents us from being able formally to test the validity of the claim made by Yoshikawa (2002) and Nishimura (1995): that the land-price bubble in the late 1980s was caused by the land-investment behavior of small firms, which were new entrants in land market. However, as the last column in Table 1 indicates, the role of small firms may not have been especially significant.

We construct the series capturing the land investment of individual firms in a somewhat different manner from existing studies. In fact, we believe this new method for constructing land investment data to be one of the contributions of this paper. Our method is as follows. From the accounting identity, nominal land investment NOL_{it} can be expressed as:

$$NOL_{it} = \Delta LB_{it} - DL_{it}\left(\frac{p_t^L}{p_{t-k}^L} - 1\right), \qquad (3)$$

where LB_{it} is the book-value of land assets; DL_{it} is the book value of land assets sold; p_t^L is the land price; and p_{t-k}^L is the land price that prevailed when the property being sold was initially purchased. Since p_{t-k}^L is not available in financial statements, most researchers follow Hoshi and Kashyap (1990) and assume the LIFO (Last-In-First-Out) principle can be applied to land assets: i.e. p_{t-k}^L is the land price current in the most recent period when ΔLB_{it} took a positive value—in other words, among their land properties, firms are supposed to sell the one which they purchased most recently. We believe this assumption is difficult to rationalize, and hence, instead of unrealistically assuming the LIFO principle, we propose to obtain $DL_{it}(p_t^L/p_{t-k}^L - 1)$ directly from the capital gains (losses) recorded under special profits (losses) on land sales. Since these items are not found in the DBJ database, we have to go back to the annotations of the original financial statements. See the Data Appendix for more details including adjustments resulting from revaluation.

The following sample selection rules are applied to all the records in the database.

1. We discard the observations for Nippon Telegraph and Telephone Corporation (NTT) and the three Japan Railway companies (JR East, JR West, and JR Central). Furthermore, we eliminate those for all the public utility enterprises (i.e., electricity, water or gas suppliers). In Japan, these companies are currently private, but are (or had been in the case of NTT and the JRs) quasi-public enterprises in nature. They may not fit well the simple framework of the profit maximization, because of, say, regional monopolistic behavior.

2. Due to complicated changes in accounting periods and procedures, we remove two firms from the sample: Cabin Industrial Co. LTD and Kokusai Kogyo Co. LTD.

3. We drop firms with zero entries in one or more of the following items: (i) land stock in the current or the previous accounting year; (ii) capital stock (machinery, non-residential buildings and structures) in the previous accounting year; or (iii) current production.

4. In order to exclude outliers, we eliminate firms (i) whose land investment rates ($I^L_{it}/L_{i,t-1}$) are in the upper or lower 2.5 percentiles; (ii) whose output growth rates Δy_{it}, stock adjustment terms $(l-y)_{it}$, or interest coverage ratios ICR_{it} are in the upper or lower 0.5 percentiles; or (iii) whose debt-to-asset ratios $(D/A)_{it}$ are in the upper one percentile.

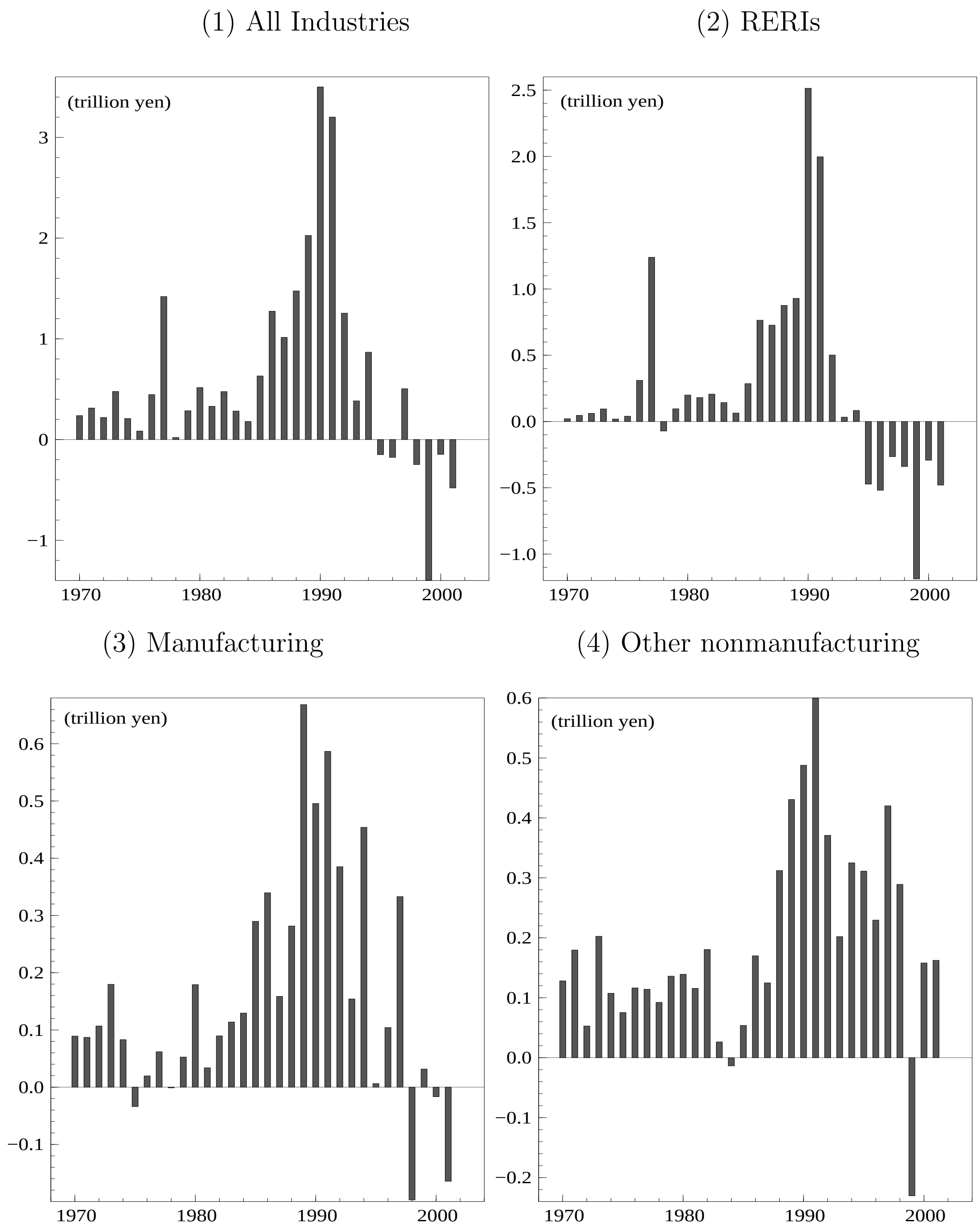
5. Finally, we select firms that continued to exist for at least three consecutive years during the bubble period (FY1985-FY1991) or the post-bubble period (FY1992-FY2001).

3.3 Development of Main Variables

Figure 3 shows the series we construct for aggregate land investment.[5] The corporate sector as a whole, which is shown in the upper-left panel, purchased a huge amount of land in the late 1980s, and started to sell its land stock around the middle of the 1990s. This development is broadly in line with that witnessed for non-financial corporations in Figure 1, where the data were constructed from the national accounting statistics. A minor difference between Figures 1 and 3 lies in the series development after 2000: in Figure 1, we see the corporate sector resuming its position as a net purchaser after 2000, while, in Figure 3, it remains as a net seller at that time.

[5]In Figure 3, we only apply criteria 1 and 2 of the above sample selection rule.

Figure 3: Land Investment by Industry (2)



Note: Authors' calculation from individual firm data. See the Data Appendix for details.

Table 4: Sample Properties: Means (Standard Deviations)

	All industries	Manufacturing	RERIs	Other nonmanufacturing
		(A) Sample Period: 1992-2001		
I^L/L_{-1}	0.000 (0.071)	-0.004 (0.073)	0.001 (0.080)	0.006 (0.064)
y	12.83 (1.401)	12.74 (1.390)	13.53 (1.581)	12.78 (1.298)
Δy	-0.006 (0.127)	-0.011 (0.126)	-0.019 (0.139)	0.009 (0.122)
ICR	0.868 (0.273)	0.849 (0.295)	0.913 (0.196)	0.889 (0.246)
D/A	0.442 (0.179)	0.414 (0.165)	0.583 (0.179)	0.450 (0.182)
OPr		0.105 (0.082)		
		(B) Sample Period: 1985-1991		
I^L/L_{-1}	0.009 (0.064)	0.004 (0.067)	0.027 (0.060)	0.015 (0.047)
y	13.06 (1.424)	12.90 (1.368)	13.90 (1.681)	13.17 (1.332)
Δy	0.050 (0.106)	0.049 (0.105)	0.063 (0.118)	0.049 (0.098)
ICR	0.915 (0.150)	0.912 (0.159)	0.939 (0.085)	0.915 (0.141)
D/A	0.409 (0.166)	0.398 (0.147)	0.531 (0.194)	0.390 (0.180)
OPr		0.051 (0.037)		

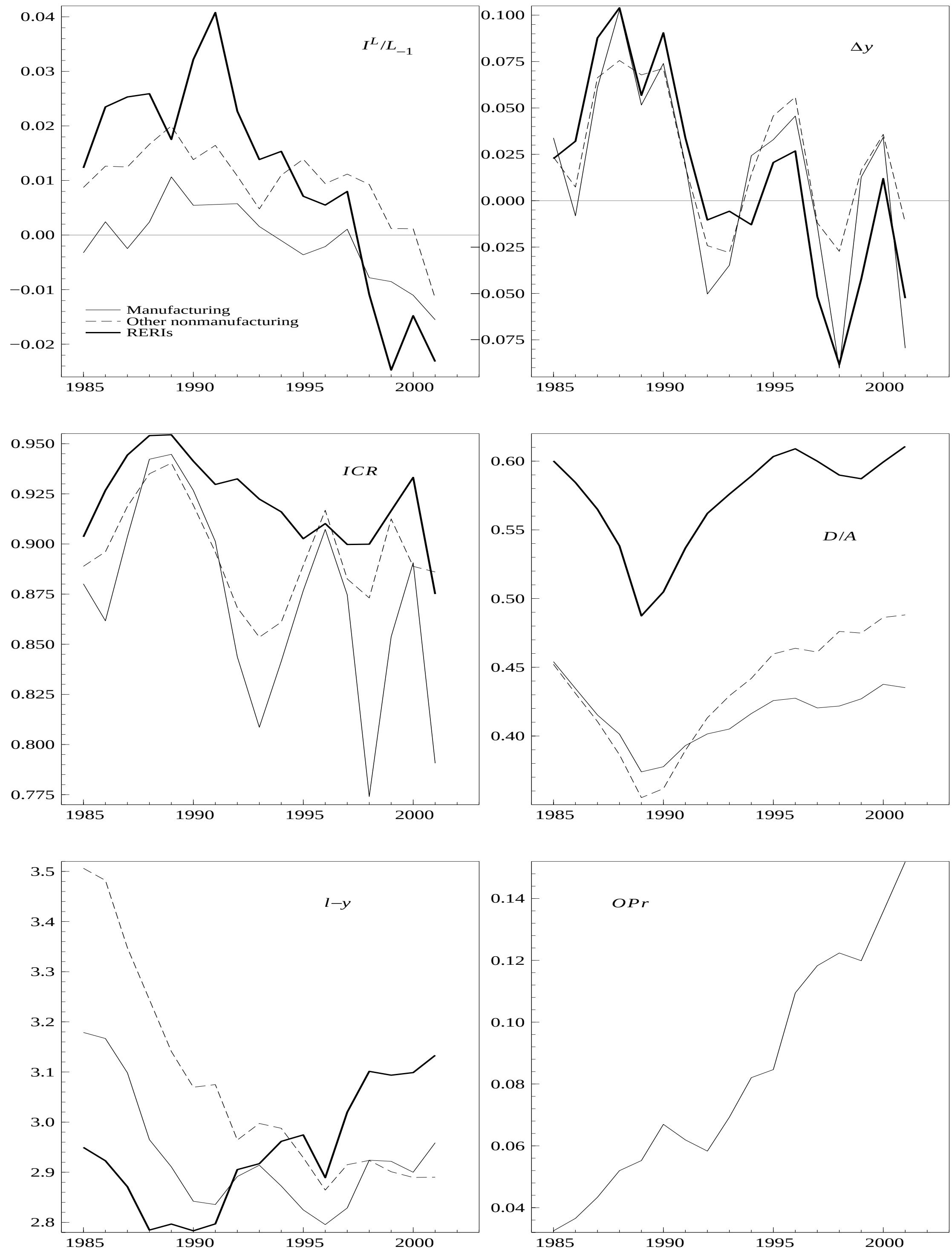
The industry breakdowns in Figure 3 confirm that the lion's share of land transactions are conducted by the RERIs. Purchases by these industries peaked at around 2.5 trillion yen, with a trough where sales exceeded one trillion yen. The corresponding figures for the manufacturing and the other nonmanufacturing industries are as small as 0.6 trillion yen and 0.2 trillion yen.

Table 4 summarizes the basic sample statistics of the variables used for estimating the land investment functions. Figure 4 depicts developments of the sample means of these variables. Several features stand out.

- The land investment rate I^L/L_{-1} of the RERIs exhibits a larger swing compared with the manufacturing and other nonmanufacturing firms (Figure 4, upper-left panel). The land investment rate of the manufacturing firms is not very high even in the late 1980s and it moves into negative territory as early as 1994. The land investment rate of the other nonmanufacturing firms hoovers around one percent until 1998, and then drops.

- The output growth rate Δy of the RERIs also exhibits a large swing (Figure 4, upper-right panel). The average growth rate declines from 6.3% during the 1985-1991 period to -1.9% during the 1992-2001 period (Table 4). Thus even with the huge net sales of land assets, the stock adjustment term $l-y$ for the RERIs increases

Figure 4: Main Indicators



in the 1990s (Figure 4, lower-left panel).

- The debt-to-asset ratio D/A for the RERIs is consistently higher than those for the other industries (Figure 4, middle-right panel). However, the interest coverage ratio ICR for the RERIs is generally higher (the burdens of interest payments is smaller). This reflects the fact that the RERIs, in particular construction companies, have paid lower interest rates.
- The overseas production ratio OPr for the manufacturing firms shows a steady increase throughout the sample period (Figure 4, lower-right panel).

Figure 5 depicts the distribution of the land investment rate. It reveals that for a considerable number of observations either no land investment is implemented, $I^L_{it}/L_{i,t-1} = 0$, or there is disinvestment (net sale), $I^L_{it}/L_{i,t-1} < 0$. Each year, the land investment rate is zero for about 20 to 30 percents of the samples, while a roughly equivalent proportion display a negative land investment rate.

The apparently high proportion of the sample implementing zero land investment is due to the fact discussed above, that land assets are not subject to depreciation and hence there is no replacement investment. As is usually the case with investment in fixed assets, irreversibility, uncertainty and fixed costs make new investment in land assets lumpy by generating an option value to waiting (Dixit and Pindyck, 1993). Such an option value results in long waiting periods before initiating new investment, and hence many observations where the land investment rate is zero.

4 Estimation of Land Investment Function

4.1 Estimation Issues

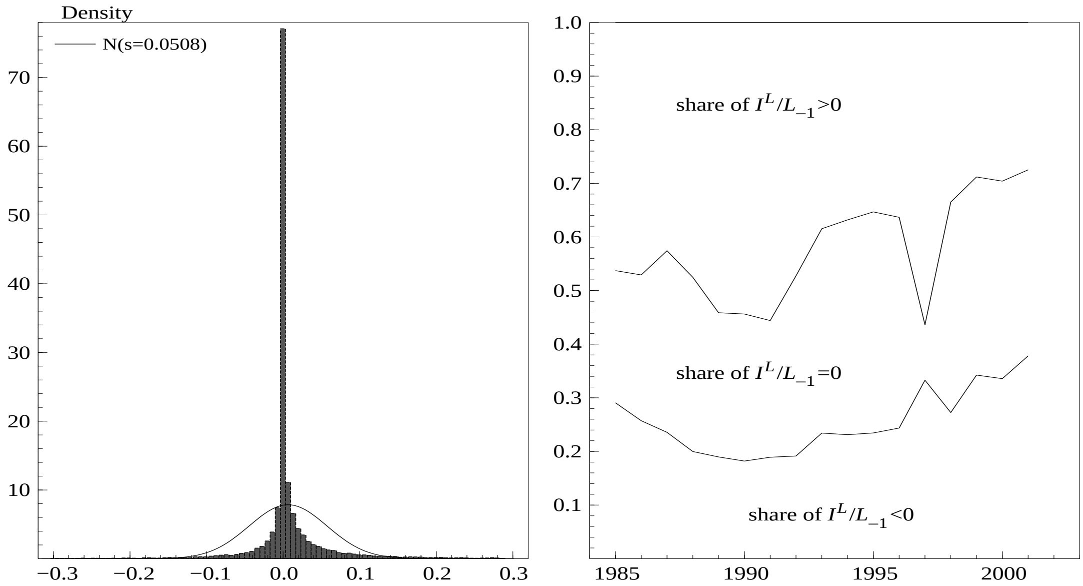
In order to capture this spike where the land investment rate is zero, we apply a friction model (Rosett, 1959) to the estimation of the land investment functions. The intuition behind the friction model is that, due to the frictions involved in trading, people only sell or purchase assets when there is a significant change in exogenous conditions. This results in the shape described in Figure 6. Such a friction model lends itself particularly well to the current case where firms refrain from purchasing or selling land assets until either their need is great enough, or their holding of such assets become sufficiently redundant.

Let the latent variables for land sales and purchases be respectively:

$$\left(\frac{I^L_{it}}{L_{i,t-1}}\right)^{s*} = \left(\frac{I^L_{it}}{L_{i,t-1}}\right)^{*} - \alpha'_0 + \alpha^s, \tag{4}$$

$$\left(\frac{I^L_{it}}{L_{i,t-1}}\right)^{b*} = \left(\frac{I^L_{it}}{L_{i,t-1}}\right)^{*} - \alpha'_0 + \alpha^b. \tag{5}$$

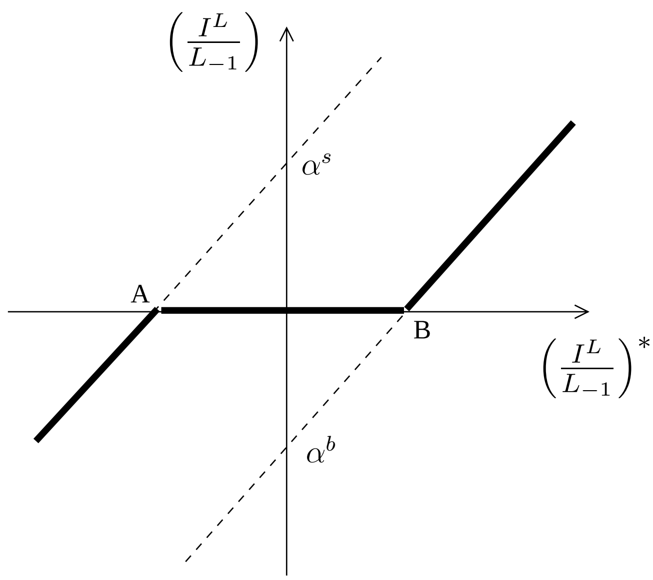
Figure 5: Distribution of Land-Investment Ratio, I^L/L_{-1}



Notes:

1. Left panel is a histogram of I^L/L_{-1}. The solid line describes the density of the normal distribution. Outliers, where $I^L/L_{-1} < -0.30$, are omitted.
2. Right panel plots the respective shares (1/100%) of positive/zero/negative land investments.

Figure 6: Friction Model



These two variables are defined by replacing the constant term in equation (2) by α^s in the case of land sales, and by α^b in the case of land purchases ($\alpha^s > \alpha^b$). The friction model expresses the relationship between these two latent variables and the observed land investment rate as:

$$\left(\frac{I_{it}^L}{L_{i,t-1}}\right) = \begin{cases} \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{s*}, & \text{if } \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{s*} < 0 \\ 0, & \text{if } \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{s*} > 0 \text{ and } \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{b*} < 0 \\ \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{b*}, & \text{if } \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{b*} > 0 \end{cases} \tag{6}$$

In Figure 6, if the latent demand for both land sales and land purchases lie between A and B, we will observe zero land investment.

The friction model is a combination of two Tobit models, as equation (6) can be transformed into the following:

$$\left(\frac{I_{it}^L}{L_{i,t-1}}\right) = \begin{cases} \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{s*}, & \text{if } \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{s*} < 0 \\ 0, & \text{if } \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{s*} > 0 \end{cases}$$

$$\left(\frac{I_{it}^L}{L_{i,t-1}}\right) = \begin{cases} \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{b*}, & \text{if } \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{b*} > 0 \\ 0, & \text{if } \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{b*} < 0 \end{cases}$$

The Tobit model has one threshold, whereas the friction model has two thresholds: a ceiling and a floor.

We estimate equation (6) by substituting $(I_{it}^L/L_{i,t-1})^*$ for the right-hand side of equation (2). We assume a random effects model, with an individual effect $\eta_i \sim N(0, \sigma_\eta^2)$, and an idiosyncratic shock $\nu_{it} \sim N(0, \sigma_\nu^2)$.[6] Due to the presence of an integral in the likelihood function, we adopt the simulated maximum likelihood method for estimation (Appendix A).[7]

4.2 Estimation Results

The estimation results of the land-investment regressions are summarized in Table 5.

Most of the estimated coefficients except those discussed below have the expected signs and are statistically significant at the conventional levels. The two intercepts, α^s and α^b,

[6] To estimate a fixed effects model with a discrete dependent variable, one needs fairly long time-series of observations for each unit (Greene (2003), p.697). The short sample periods in this paper discourage us from adopting the fixed effects model.

[7] We conduct most of the data processing and estimations in the paper using *Ox*, a matrix language developed by Doornik (2001). For some estimations, we also use a package in *Ox*: *DPD* for *Ox* by Doornik, Arellano, and Bond (2001).

Table 5: Land Investment Function

	Manufacturing	RERIs	Other nonmanufacturing
Dependent	I^L/L_{-1}	I^L/L_{-1}	I^L/L_{-1}
		(A) Sample Period: 1992-2001	
α^s	0.087 (0.013)***	0.096 (0.024)***	0.050 (0.016)***
α^b	-0.021 (0.013)*	0.055 (0.024)**	-0.040 (0.016)**
Δy	0.028 (0.008)***	0.123 (0.015)***	0.079 (0.010)***
Δy_{-1}	0.041 (0.008)***	0.078 (0.016)***	0.051 (0.011)***
$(l-y)_{-1}$	-0.004 (0.001)***	-0.005 (0.002)***	-0.001 (0.001)
y_{-1}	0.000 (0.001)	-0.003 (0.001)**	0.001 (0.001)
ICR	0.039 (0.003)***	0.042 (0.011)***	0.025 (0.005)***
$(D/A)_{-1}$	-0.096 (0.008)***	-0.049 (0.015)***	-0.047 (0.008)***
OPr	-0.032 (0.014)**		
σ_η	0.029 (0.001)***	0.005 (0.010)	0.025 (0.002)***
σ_ν	0.092 (0.009)***	0.087 (0.019)***	0.080 (0.013)***
Log Likelihood	1,648.4	1,203.5	1,585.9
Observations	12,624	2,060	6,009
Firms	1,589	281	904
		(B) Sample Period: 1986-1991	
α^s	-0.059 (0.018)***	-0.146 (0.060)**	-0.038 (0.024)
α^b	-0.146 (0.018)***	-0.177 (0.060)***	-0.083 (0.024)***
Δy	0.038 (0.012)***	0.061 (0.022)***	0.088 (0.015)***
Δy_{-1}	0.039 (0.012)***	0.066 (0.021)***	0.012 (0.014)
$(l-y)_{-1}$	-0.006 (0.002)***	0.010 (0.004)***	-0.002 (0.002)
y_{-1}	0.004 (0.001)***	0.007 (0.002)***	0.003 (0.001)**
ICR	0.125 (0.009)***	0.059 (0.037)	0.062 (0.012)***
$(D/A)_{-1}$	-0.048 (0.012)***	0.007 (0.024)	-0.008 (0.012)
OPr	0.001 (0.036)		
σ_η	0.023 (0.002)***	0.020 (0.004)***	0.019 (0.002)***
σ_ν	0.080 (0.013)**	0.064 (0.030)***	0.051 (0.021)***
Log Likekihood	1,841.8	706.8	1,469.3
Observations	5,485	803	1,849
Firms	1,122	170	401

Notes:

1. Maximum simulated likelihood estimation. 1,000 draws.
2. Numbers in parentheses are standard errors. "***", "**" and "*" denote statistical significance at the 1%, 5%, 10% levels, respectively.

satisfy the theoretical requirement of the friction model: $\alpha^s > \alpha^b$.[8] The estimated coefficients, for example, those on the stock adjustment term, tend in general to be smaller in magnitude than those obtained by Nagahata and Sekine (2002) who estimate investment functions for the capital and land stocks together. This is presumably due to the nonlinearity inherent in land investment that we explicitly take into account. Judging from the standard errors σ_η, the individual effects are substantial and statistically significant except for the RERIs in the post-bubble period. Thus the random effects model is more appropriate than simple pooled regressions.

In the RERIs estimation, a sharp contrast emerges between the bubble and the post-bubble periods. In the bubble period (1986-1991), the coefficients on the stock adjustment term $(l-y)_{i,t-1}$ and the debt-to-asset ratio $(D/A)_{i,t-1}$ are positive and contrary to prior expectation. Neither of the financial variables, the interest coverage ratio ICR_{it} or the debt-to-asset ratio $(D/A)_{i,t-1}$ has a statistically significant coefficient. What this means is that during the bubble period, the RERI firms implemented new land investment even when their holdings of land stocks were excessive compared to their sales and their financial conditions were deteriorating. In other words, their land investment behavior cannot be explained by standard economic theory.

During the post bubble period (1992-2001), the coefficient on the stock adjustment term becomes negative and significant, while those on the financial variables are also significant and signed as theory predicts. That is, after the bursting of the bubble, deterioration in the stock adjustment term and in their financial conditions induces RERI firms to sell their land assets. This finding is consistent with the survey results reported in Section 2. The bursting of the bubble notably altered the land investment behavior of the RERIs.

For the manufacturing sector, both in the bubble and the post-bubble periods, the coefficients on both the stock-adjustment term and the financial variables have the expected signs and are statistically significant. Thus the land-investment behavior of firms in the manufacturing sector has not been at odds with financial discipline since the middle of the 1980s. The coefficient on the overseas production ratio OPr becomes negative and significant in the latter sample period. This indicates that the main reason behind manufacturing firms' increasing sales of their land assets in the 1990s was the greater proportion of production being done by overseas.

For the other nonmanufacturing sector, somewhat similar to the RERIs, the coefficient on the debt-to-asset ratio turns out to be significant after the bubble burst. The stock adjustment term is statistically insignificant in both the bubble and the post-bubble periods.

Table 6: Cumulative Contribution from FY1992 to FY2001

	Manufacturing	RERIs	Other nonmanufacturing
Sales	–0.05	–1.19	–0.03
Stock-adjustment	0.00	–0.03	0.01
Interest payments	–0.27	–0.30	–0.05
Balance-sheet	–0.33	–0.46	–0.32
Overseas production	–0.18		

Notes:

1. Unit: % points.
2. Marginal effects are calculated from $\alpha'_1 \Delta y + \alpha'_2 \Delta y_{-1}$ (Sales); $\alpha'_3(l-y)_{-1} + \alpha'_4 y_{-1}$ (Stock-adjustment); $\alpha'_5 ICR$ (Interest payments); $\alpha'_6(D/A)_{-1}$ (Balance-sheet); and $\alpha'_7 OPr$ (Overseas production).

4.3 Comparing the Impacts on Land Investment

As Greene (2003, Ch.22) shows, for censored regression models including friction models, the marginal effect of an independent variable x_{it} is:

$$\frac{\partial E[(I^L_{it}/L_{i,t-1})]}{\partial x_{it}} = \Pr\left[\left(\frac{I^L_{it}}{L_{i,t-1}}\right) < 0\right]\alpha + \Pr\left[\left(\frac{I^L_{it}}{L_{i,t-1}}\right) > 0\right]\alpha, \tag{7}$$

where α is the coefficient on x_{it}, and $E[.]$ is the expectations operator.

Cumulative contributions in Table 6 are calculated in the following steps. First, using equation (7), the marginal effects of the relevant variables are derived for each firm. Then, by multiplying the above marginal effects by Δx_{it}, their annual contributions are calculated. Finally, cumulative contributions are obtained by adding up the sample averages of these annual contributions over the post-bubble period.

Table 6 indicates that: (i) depressed sales have a significant impact on the land investment of the RERIs; (ii) deteriorating financial conditions (i.e. a higher debt-to-asset ratio and a lower interest coverage ratio), have a sizable impact for all industries; (iii) for the manufacturing sector, an increase in the overseas production ratio has a larger negative impact than stagnating sales.

For all industries, the contribution of the debt-to-asset ratio is large and negative. This suggests that 'asset-price debt deflation' (Ueda, 2003) has been a real concern in Japan: declines in the land price caused the debt-to-asset ratio to deteriorate, inducing sales of land assets; these sales, in turn, exerted further downward pressure on the land price.

[8] The signs of α^s and α^b depend on the base year of the time dummy variable, and are not crucial. What the theory requires is that α^s is larger than α^b.

5 q for Land Assets

5.1 Analytical Framework

The previous sections show that: (i) Japanese firms, especially those in the RERIs, have undertaken substantial disinvestment in land assets since the 1990s; (ii) for the RERIs, this selling off of land assets has been induced by declining sales and the deterioration in their financial conditions; whereas (iii) for manufacturing firms, the increase in overseas production ratios has led them to sell their plant sites in Japan.

These findings, however, do not necessarily enable us to assess the current level of land prices in Japan: i.e. to examine whether or not land prices in Japan are still too high; and if so, how high they are compared with fundamental prices.

In order to obtain insight into this issue, we borrow another analytical framework from the existing firm investment literature: the q theory. In this section, by measuring the partial q of the land assets held by firms, we are able to compare the current price of such land with its shadow price.

The basic framework is the q theory with many capital goods, which is developed by Wildasin (1984). Consider a firm that consists of heterogeneous capital goods, say machinery/buildings (depreciable) and land (non-depreciable). Under appropriate conditions,

- The observed total q is the weighted sum of the partial q for machinery/buildings and the partial q for land. Here total q is defined as the ratio of the market value of the firm to the repurchase value of all its capital goods, a definition which is often referred as average q.
- The partial q for each capital good is related to its respective investment rate. That is, the partial q for machinery/buildings is related to the investment rate for machinery/buildings, and the partial q for land is related to the investment rate for land.

Using these relationships, if we can obtain both total q and the investment rates for both machinery/buildings and land, these enable us to calculate partial q for land assets, q^L.

We extend the model of Wildasin (1984) by explicitly taking into account the collateral role of land assets. When there are agency costs in financial markets, land assets may serve not only as a factor input but also as collateral. In a sense, this explicit incorporation of the collateral value of land assets allows us to provide a possible explanation for why we found the debt-to-asset ratio $(D/A)_{i,t-1}$ to be an important determinant of land investment in the previous section. The point is that the large shares of bank borrowings among total debts, and of land assets among total assets, mean that the debt-to-asset ratio is closely related to the inverse of the land collateral ratio (the market value of land assets over outstanding bank borrowings).

A caveat is in order here. Since we calculate total q from the stock price, if there is a bubble in the stock market it is difficult to argue that the derived q^L reflects the true marginal value of a firm's land assets.[9] In fact, Ogawa and Kitasaka (1998) and Chirinko and Schaller (2001) show that the sharp rise in Japanese stock prices in the late 1980s cannot be explained by the fundamental value of firms, and infer that there was indeed a bubble then. With this caveat in mind, this section tries to assess the current price of the land held by a firm by comparing it with the expectation of that firm's profitability represented in its stock price.

5.2 The Model

We adopt the basic framework of the multiple q models of Wildasin (1984), Asako et al. (1989, 1997), and Hayashi and Inoue (1991).

Consider a representative firm i with production function $F(K_{it}, L_{it}, N_{it})$, where K_{it} is the depreciable capital stocks such as machinery and buildings; L_{it} is the land stocks; and N_{it} is the labor inputs. To save on notation, we hereafter drop the firm subscript i when there is no room for confusion. We assume that the cash-flow of this firm in period t may be written as:

$$\begin{aligned}\Pi_t &= p_t F(K_t, L_t, N_t) + \left\{1 - \phi\left(\frac{p_t^L L_t}{B_t}\right)\right\} NB_t - w_t N_t - i_t B_t \\ &\quad - p_t^K \left\{I_t^K + G(I_t^K, K_t)\right\} - p_t^L \left\{I_t^L + C(I_t^L, L_t)\right\}. \qquad (8)\end{aligned}$$

Here p_t is the output price, p_t^K is the price of capital, p_t^L is the land price, w_t is the wage, i_t is the interest rate, NB_t is the amount of new debt finance, B_t is the outstanding debt, I_t^K is capital investment, I_t^L is land investment. $G(..)$ and $C(..)$ are the adjustment-cost functions of capital- and land-investment, respectively. Both $G(..)$ and $C(..)$ are assumed to satisfy the usual requirements for adjustment-cost functions, namely, to be twice continuously differentiable, linearly homogenous, and to have positive first and second derivatives.

The crux of this model is that new debt finance NB_t involves some agency cost, where the latter depends on the market value of land assets $p_t^L L_t$. Here the agency cost is modeled as a partial loss of NB_t: $\phi(.)NB_t$. A higher value of land assets relative to outstanding debt B_t reduces this loss rate $\phi(.)$ through providing safer collateral to financial institutions. Thus, in the model, the agency cost rate $\phi(.)$ is a decreasing function of the inverse of the land collateral ratio.[10]

[9] More generally, Baker et al. (2003) argue that the q potentially contains (i) mispricing of stock, (ii) information about the profitability of investment, and (iii) measurement error. The first and the third elements mar our analysis here.

[10] Bond and Meghir (1994) and Jaramillo, Schiantarelli, and Weiss (1996) make the same assumptions about the agency cost, when deriving the Euler equations for firm investment.

From the cash-flow Π_t, the current discounted value of this firm is:

$$V_t = \int_{s=t}^{\infty} \Pi_s \exp\left(-\int_{k=t}^{s} r(k)dk\right) ds,$$

where r is the discount rate. If the stock market is efficient, V_t is equal to the market value of outstanding shares.

The capital stock K_t, the land stock L_t, and the outstanding debt B_t changes over time in accordance with the following transition equations.

$$\dot{K}_t = I_t^K - \delta K_t, \tag{9}$$

$$\dot{L}_t = I_t^L, \tag{10}$$

$$\dot{B}_t = NB_t. \tag{11}$$

where δ denotes the depreciation rate.

The firm maximizes V_t subject to the constraints expressed in equations (9)-(11). From the first order conditions of this maximization problem, we can derive the following relationship between partial q and the current discounted value of firm V_t. Appendix B shows the details of this derivation.

$$p_t^K q_t^K K_t + p_t^L q_t^L L_t + q_t^B B_t = V_t. \tag{12}$$

Here q_t^K, q_t^L and q_t^B denote partial q for K_t, L_t and B_t, respectively. q_t^B is defined as $q_t^B = -(1-\phi(.))$, and if there is no agency cost, $q_t^B = -1$.

By dividing both sides of equation (12) by the market value of the firm's assets $p_t^K K_t + p_t^L L_t$, we obtain:

$$q_t^K s_t^K + q_t^L s_t^L + \phi\left(\frac{p_t^L L_t}{B_t}\right) s_t^B = q_t, \tag{13}$$

where $q_t = (V_t + B_t)/(p_t^K K_t + p_t^L L_t)$ is total q, $s_t^K = p_t^K K_t/(p_t^K K_t + p_t^L L_t)$ is the share of the capital stock, $s_t^L = 1 - s_t^K$ is the share of the land stock, and $s_t^B = B_t/(p_t^K K_t + p_t^L L_t)$ is the ratio of outstanding debt to the total value of assets.

When there is no agency cost, equation (13) reverts to the Multiple q equation in Asako et al. (1989, 1997).

$$q_t^K s_t^K + q_t^L s_t^L = q_t.$$

5.3 Empirical Specification

Theoretically, the partial q for each asset is equal to the marginal cost of investment (see equations (B.5) and (B.6) in Appendix B). Following Asako et al. (1989, 1997), we assume that appropriate forms for the cost functions $G(..)$ and $C(..)$ generate linear relationships between each partial q and its corresponding investment rate. That is,

$$q_{it}^K = a^K\left(\frac{I_{it}^K}{K_{i,t-1}}\right) + b^K, \tag{14}$$

$$q_{it}^L = a^L\left(\frac{I_{it}^L}{L_{i,t-1}}\right) + b^L, \tag{15}$$

where a^K, a^L, b^K and b^L are parameters from the cost functions. Expected signs of a^K and a^L are positive. Furthermore, we assume the agency cost function $\phi(.)$ can be expressed as follows:

$$\phi\left(\frac{p_t^L L_t}{B_t}\right) = \frac{c^B}{1+e^{x_{it}}},$$

where c^B is a parameter and x_{it} is the inverse of the land collateral ratio $p_t^L L_{it}/B_{it}$.

The empirical equation corresponding to equation (13) then becomes:

$$q_{it} = a^K\left(\frac{I_{it}^K}{K_{i,t-1}}\right)s_{it}^K + a^L\left(\frac{I_{it}^L}{L_{i,t-1}}\right)s_{it}^L + c^B AC_{it}s_{it}^B + b^K s_{it}^K + b^L s_{it}^L + u_{it}, \tag{16}$$

where $AC_{it} = 1/(1+e^{x_{it}})$ and u_{it} is a disturbance term.

Asako et al. (1989, 1997) estimate a^K, a^L, b^K, and b^L, in the absence of agency costs ($c^B = 0$), from cross-sectional regressions for each sample year: i.e. they essentially assume these coefficients are time-variant. Then, they substitute the estimated coefficients into equations (14) and (15) to obtain the partial q for each asset stock: q_{it}^K and q_{it}^L.

In the current analysis, on the other hand, we estimate equation (16) using panel regressions, which have the advantage of allowing us to control for individual effects. However, we adopt something of the spirit of Asako et al. (1989, 1997) by assuming time-variant b^K and b^L. More specifically, we assume the following empirical forms for equations (14) and (15):

$$q_{it}^K = a^K\left(\frac{I_{it}^K}{K_{i,t-1}}\right) + b^K + \omega_t^K, \tag{17}$$

$$q_{it}^L = a^L\left(\frac{I_{it}^L}{L_{i,t-1}}\right) + b^L + \omega_t^L, \tag{18}$$

where ω_t^K and ω_t^L are disturbance terms. We further assume that these disturbance terms consist of time effects, individual effects and idiosyncratic shocks: $\omega_t^K = d_t^K + \eta_i^K + \nu_{it}^K$ and $\omega_t^L = d_t^L + \eta_i^L + \nu_{it}^L$. Then, equation (16) can be expressed as:

$$\begin{aligned} q_{it} = {} & a^K\left(\frac{I_{it}^K}{K_{i,t-1}}\right)s_{it}^K + a^L\left(\frac{I_{it}^L}{L_{i,t-1}}\right)s_{it}^L + c^B AC_{it}s_{it}^B \\ & +(b^K - b^L)s_{it}^K + b^L + (\tilde{b}_t^K - \tilde{b}_t^L)s_{it}^K d_t + \tilde{b}_t^L d_t + \eta_i + \nu_{it}, \end{aligned} \tag{19}$$

where $d_t^K = \tilde{b}_t^K \cdot d_t$, $d_t^L = \tilde{b}_t^L \cdot d_t$, and d_t is a time dummy. $\eta_i = s_{it}^K\eta_i^K + s_{it}^L\eta_i^L$ and $\nu_{it} = s_{it}^K\nu_{it}^K + s_{it}^L\nu_{it}^L$ are assumed to follow stochastic processes such that $\eta_i \sim N(0,\sigma_\eta^2)$ and $\nu_{it} \sim N(0,\sigma_\nu^2)$.[11]

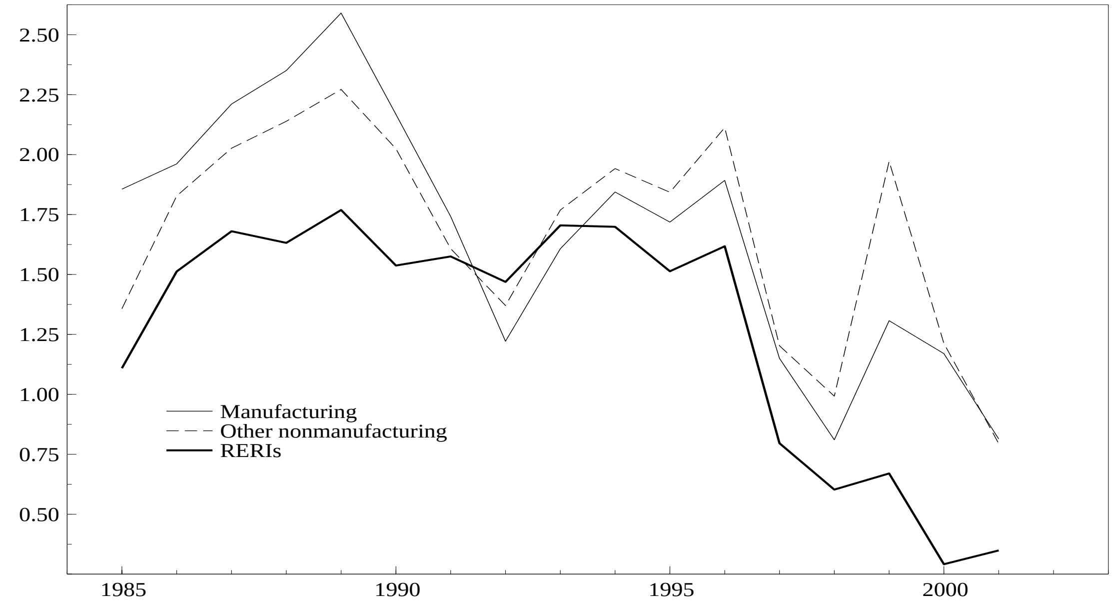
5.4 Results

For the estimations below, we also drop observations (i) whose $p_t^K K_{it} + p_t^L L_{it} = 0$; (ii) whose q_{it} or $I_{it}^K/K_{i,t-1}$ fall in the upper or lower 0.5 percentiles, or (iii) whose AC_{it} falls

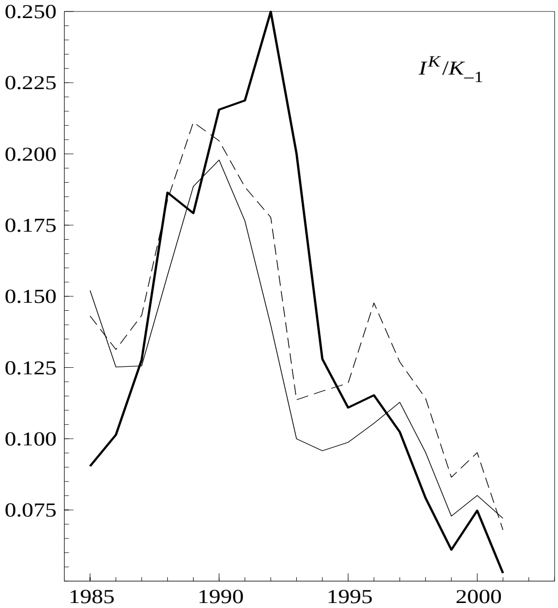
[11] We assume a random effects model instead of a fixed effects model, because the latter does not allow us to estimate the intercept terms b^K and b^L.

Figure 7: Total q and Investment Ratios

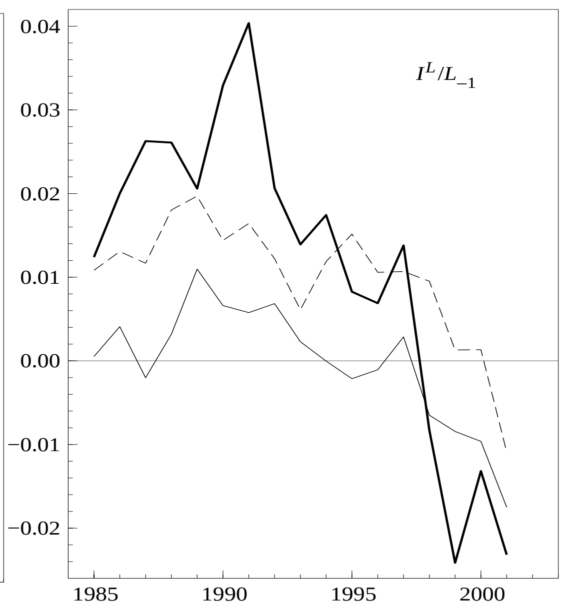
(1) Total q



(2) I^K/K_{-1}



(3) I^L/L_{-1}



in the upper one percentile.

Figure 7 depicts the sample means of total q and the capital- and land-investment rates. The bottom right panel is almost same as the upper left panel of Figure 4, although the two are subject to different sample selection rules.

Total q for the manufacturing and other nonmanufacturing sectors are broadly in line with business cycles in Japan (top panel of Figure 7): After peaking in 1989, they plunge as the bubble burst. In the 1990s, they recover somewhat on two occasions, but both recoveries are followed by sharp drops, reflecting first the banking crisis in 1997 and then the bursting of the IT bubble in 2000. Meanwhile, total q for the RERIs remains largely flat until 1996, after which it plummets.

Compared with land investment rates, capital investment rates evince wider swings—see the scales of the vertical axes in the two bottom panels of Figure 7. Even at their lowest level in 2001, capital investment rates remain positive because of replacement investment, while land investment rates fall into negative territory.

Table 7 reports estimation results for equation (19) during the 1986-1991 sample period.

For manufacturing firms, when the agency cost AC is included, all the coefficients are significant and have the expected signs. When AC is dropped from the equation, the coefficient on $s^K \cdot I^K/K_{-1}$ becomes insignificant, which might indicate the importance of controlling for agency costs.

For the RERIs and other nonmanufacturing sectors, coefficients on, respectively, $s^L \cdot I^L/L_{-1}$ and on $s^K \cdot I^K/K_{-1}$ turn out to be negative. These unexpected signs might reflect the fact that the behavior of these sectors during the bubble period ran counter to theoretical prediction—recall that in the error-correction type land investment functions in Table 5, the stock adjustment terms for these industries either do not have the expected sign or are insignificant.

Table 8 summarizes the estimation results for the same equation during the 1992-2001 sample period. While the coefficients on the capital investment rate $s^K \cdot I^K/K_{-1}$ and the agency cost $s^B \cdot AC$ are significant and have the expected positive signs, those on the land investment rate $s^L \cdot I^L/L_{-1}$ are insignificant for all industries.

In quest of significant coefficients on the land investment rate, we find that, for the manufacturing and other nonmanufacturing, they become positive and significant, once we include the agency cost and drop observations after 1999 (Table 9)—the latter implying that we get rid of any disturbances due to the IT bubble in 2000. For the RERIs, we need to further restrict our sample to those firms listed in the first section of the Tokyo stock exchange by excluding relatively heterogeneous small firms.

Figure 8 presents the sample means of partial q for the capital and land stocks of individual firms for each year. These partial q are calculated from equations (17) and (18) using the parameters in Tables 7-9.

The partial q for capital stocks q^K evince a wider swing than those for land stocks q^L,

Table 7: Multiple q Estimation (Sample period: 1986-1991)

Dependent	Manufacturing I^L/L_{-1}		RERIs I^L/L_{-1}		Other nonmanufacturing I^L/L_{-1}	
	with AC	without AC	with AC	without AC	with AC	without AC
$s^K \cdot I^K/K_{-1}$	0.53 (0.23)**	0.36 (0.23)	2.66 (0.85)***	2.14 (0.86)**	-1.00 (0.36)***	-1.00 (0.36)***
$s^L \cdot I^L/L_{-1}$	1.18 (0.59)**	1.06 (0.59)*	-0.80 (0.48)*	-1.02 (0.48)**	2.21 (0.75)***	1.94 (0.75)**
$s^B \cdot AC$	1.27 (0.10)***		0.26 (0.04)***		0.46 (0.04)***	
s^K	2.05 (0.30)***	2.83 (0.30)***	1.17 (0.54)**	1.24 (0.56)**	1.29 (0.50)**	0.84 (0.52)
s^KT1986	-0.13 (0.26)	-0.11 (0.26)	1.05 (0.63)	1.18 (0.63)*	2.15 (0.48)***	2.24 (0.48)***
s^KT1987	0.38 (0.25)	0.46 (0.25)*	2.00 (0.66)***	2.30 (0.65)***	2.47 (0.48)***	2.62 (0.48)***
s^KT1988	0.89 (0.25)***	0.98 (0.25)***	1.59 (0.64)**	1.93 (0.64)***	3.05 (0.47)***	3.14 (0.47)***
s^KT1989	1.31 (0.25)***	1.38 (0.25)***	2.40 (0.66)***	2.68 (0.66)***	3.47 (0.49)***	3.54 (0.49)***
s^KT1990	0.08 (0.25)	0.13 (0.25)	2.75 (0.66)***	2.99 (0.66)***	1.23 (0.49)**	1.34 (0.49)***
s^KT1991	-1.02 (0.25)***	-1.08 (0.25)***	2.54 (0.63)***	2.75 (0.63)***	0.01 (0.47)	0.08 (0.47)
Constant	0.43 (0.16)**	0.60 (0.17)***	0.38 (0.17)**	0.69 (0.16)***	0.95 (0.20)***	1.42 (0.20)***
T1986	0.30 (0.14)**	0.26 (0.14)*	0.29 (0.17)	0.21 (0.17)	-0.19 (0.18)	-0.27 (0.17)
T1987	0.35 (0.14)**	0.27 (0.14)*	0.38 (0.17)**	0.26 (0.17)	-0.04 (0.17)	-0.18 (0.17)
T1988	0.26 (0.13)*	0.18 (0.13)	0.52 (0.16)***	0.37 (0.16)**	-0.08 (0.16)	-0.23 (0.16)
T1989	0.41 (0.13)***	0.29 (0.13)**	0.64 (0.16)***	0.48 (0.15)***	0.06 (0.16)	-0.13 (0.16)
T1990	0.45 (0.14)***	0.35 (0.13)**	0.35 (0.16)**	0.20 (0.16)	0.35 (0.17)**	0.15 (0.16)
T1991	0.41 (0.14)***	0.35 (0.14)**	0.27 (0.16)	0.15 (0.16)	0.20 (0.17)	0.06 (0.17)
R^2	0.13	0.10	0.20	0.16	0.15	0.11
σ	1.09	1.09	0.67	0.66	1.01	1.01
σ_ν^2	1.15	1.16	0.42	0.42	0.94	0.96
σ_η^2	2.85	3.23	0.53	0.67	2.53	3.17
Observations	7,044	7,044	1,037	1,037	2,363	2,363
Firms	1,150	1,150	174	174	394	394

Notes:

1. Feasible GLS estimation.
2. Numbers in parentheses are standard errors. "***", "**" and "*" denote statistical significance at the 1%, 5%, 10% levels, respectively.

Table 8: Multiple q Estimation (Sample period: 1992-2001)

Dependent	Manufacturing I^L/L_{-1}		RERIs I^L/L_{-1}		Other nonmanufacturing I^L/L_{-1}	
	with AC	without AC	with AC	without AC	with AC	without AC
$s^K \cdot I^K/K_{-1}$	1.97 (0.18)***	1.85 (0.18)***	0.97 (0.39)**	0.80 (0.39)**	0.93 (0.30)***	0.90 (0.30)***
$s^L \cdot I^L/L_{-1}$	0.34 (0.56)	-0.13 (0.56)	0.36 (0.51)	-0.03 (0.51)	0.66 (0.73)	0.33 (0.72)
$s^B \cdot AC$	0.98 (0.06)***		0.37 (0.05)***		0.19 (0.05)***	
s^K	0.08 (0.26)	0.60 (0.26)**	3.51 (0.71)***	4.12 (0.72)***	2.51 (0.56)***	2.55 (0.56)***
s^KT1993	0.63 (0.26)**	0.60 (0.26)**	0.39 (0.74)	0.39 (0.74)	0.53 (0.57)	0.53 (0.57)
s^KT1994	0.62 (0.26)**	0.58 (0.26)**	-0.30 (0.70)	-0.41 (0.70)	0.03 (0.55)	-0.01 (0.55)
s^KT1995	0.22 (0.25)	0.16 (0.26)	-1.25 (0.68)*	-1.35 (0.68)*	-0.47 (0.54)	-0.52 (0.54)
s^KT1996	0.60 (0.25)**	0.52 (0.26)**	-1.84 (0.68)***	-1.97 (0.68)***	-0.10 (0.54)	-0.17 (0.54)
s^KT1997	0.47 (0.26)*	0.38 (0.26)	-3.06 (0.68)***	-3.26 (0.68)***	-1.60 (0.54)***	-1.67 (0.53)***
s^KT1998	-0.12 (0.26)	-0.23 (0.26)	-3.35 (0.68)***	-3.56 (0.68)***	-1.56 (0.53)***	-1.63 (0.53)***
s^KT1999	0.12 (0.26)	-0.02 (0.26)	-4.04 (0.69)***	-4.28 (0.69)***	0.22 (0.54)	0.11 (0.54)
s^KT2000	0.08 (0.27)	-0.03 (0.27)	-4.53 (0.70)***	-4.63 (0.70)***	-1.55 (0.55)***	-1.69 (0.55)***
s^KT2001	0.05 (0.28)	-0.11 (0.28)	-4.60 (0.70)***	-4.76 (0.70)***	-2.35 (0.57)***	-2.48 (0.56)***
Constant	0.82 (0.13)***	0.93 (0.14)***	0.43 (0.19)**	0.64 (0.19)***	0.88 (0.21)***	0.97 (0.21)***
T1993	0.04 (0.14)	0.06 (0.14)	0.02 (0.20)	0.02 (0.20)	0.13 (0.22)	0.14 (0.22)
T1994	0.21 (0.15)	0.26 (0.15)*	0.09 (0.20)	0.14 (0.20)	0.34 (0.22)	0.37 (0.22)*
T1995	0.23 (0.15)	0.32 (0.15)**	0.00 (0.20)	0.10 (0.20)	0.22 (0.21)	0.28 (0.21)
T1996	0.13 (0.15)	0.24 (0.15)	0.22 (0.21)	0.32 (0.20)	0.21 (0.22)	0.28 (0.22)
T1997	-0.57 (0.15)***	-0.46 (0.15)***	-0.17 (0.21)	-0.06 (0.21)	-0.13 (0.22)	-0.07 (0.22)
T1998	-0.53 (0.15)***	-0.42 (0.15)***	-0.30 (0.21)	-0.20 (0.21)	-0.44 (0.22)*	-0.38 (0.22)*
T1999	-0.16 (0.16)	-0.01 (0.16)	0.03 (0.22)	0.17 (0.22)	-0.22 (0.23)	-0.14 (0.23)
T2000	-0.33 (0.17)*	-0.15 (0.17)	-0.13 (0.23)	0.01 (0.23)	-0.20 (0.24)	-0.08 (0.24)
T2001	-0.61 (0.18)***	-0.41 (0.18)**	-0.01 (0.24)	0.14 (0.24)	-0.18 (0.25)	-0.07 (0.25)
R^2	0.10	0.09	0.23	0.21	0.09	0.09
σ	1.33	1.33	1.14	1.15	1.75	1.75
σ^2_ν	1.75	1.77	1.21	1.22	3.02	3.02
σ^2_η	2.72	2.88	2.26	2.49	6.61	6.74
Observations	13,859	13,859	2,343	2,343	7,008	7,008
Firms	1,604	1,604	290	290	888	888

Note: See notes for Table 7.

Table 9: Multiple q Estimation (Sample period: 1992-1999)

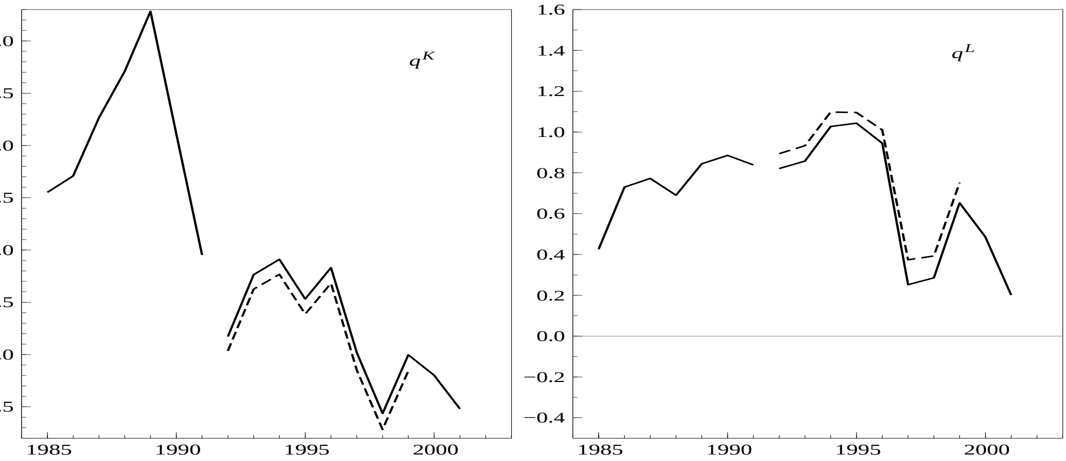
Dependent	Manufacturing I^L/L_{-1}		RERIs I^L/L_{-1}		Other nonmanufactuing I^L/L_{-1}	
	with AC	without AC	with AC	without AC	with AC	without AC
$s^K \cdot I^K/K_{-1}$	1.86 (0.18)***	1.70 (0.19)***	2.71 (0.81)***	2.21 (0.80)***	0.79 (0.30)**	0.73 (0.30)**
$s^L \cdot I^L/L_{-1}$	1.15 (0.59)*	0.67 (0.59)	2.33 (0.85)***	1.87 (0.84)**	1.55 (0.80)*	0.98 (0.8)
$s^B \cdot AC$	1.10 (0.07)***		0.43 (0.07)***		0.33 (0.05)***	
s^K	-0.11 (0.25)	0.48 (0.25)*	3.59 (1.01)***	4.12 (1.03)***	2.48 (0.56)***	2.56 (0.56)***
s^KT1993	0.62 (0.24)**	0.58 (0.24)**	0.76 (1.04)	0.80 (1.03)	0.54 (0.53)	0.54 (0.53)
s^KT1994	0.60 (0.24)**	0.56 (0.24)**	-0.41 (0.98)	-0.44 (0.97)	0.09 (0.51)	0.03 (0.51)
s^KT1995	0.22 (0.24)	0.15 (0.24)	-0.92 (0.97)	-1.02 (0.96)	-0.39 (0.50)	-0.49 (0.50)
s^KT1996	0.59 (0.24)**	0.49 (0.24)**	-0.53 (0.96)	-0.69 (0.95)	-0.03 (0.50)	-0.15 (0.50)
s^KT1997	0.38 (0.24)	0.27 (0.24)	-1.62 (0.97)*	-1.86 (0.96)*	-1.61 (0.50)***	-1.73 (0.50)***
s^KT1998	-0.18 (0.24)	-0.33 (0.24)	-2.08 (0.97)**	-2.30 (0.96)**	-1.64 (0.50)***	-1.76 (0.50)***
s^KT1999	0.06 (0.24)	-0.11 (0.25)	-2.95 (1.00)***	-3.12 (0.99)***	0.15 (0.51)	-0.04 (0.50)
Constant	0.89 (0.13)***	1.01 (0.13)***	0.12 (0.27)	0.46 (0.27)*	0.85 (0.20)***	1.01 (0.20)***
T1993	0.04 (0.13)	0.07 (0.13)	-0.06 (0.29)	-0.07 (0.28)	0.12 (0.20)	0.14 (0.20)
T1994	0.21 (0.13)	0.27 (0.14)*	0.11 (0.28)	0.15 (0.28)	0.30 (0.20)	0.35 (0.20)*
T1995	0.21 (0.14)	0.31 (0.14)**	-0.02 (0.28)	0.10 (0.28)	0.15 (0.20)	0.25 (0.20)
T1996	0.13 (0.14)	0.26 (0.14)*	-0.03 (0.29)	0.11 (0.29)	0.13 (0.20)	0.26 (0.20)
T1997	-0.52 (0.14)***	-0.39 (0.14)***	-0.38 (0.29)	-0.23 (0.29)	-0.18 (0.20)	-0.06 (0.20)
T1998	-0.49 (0.14)***	-0.36 (0.14)**	-0.48 (0.30)	-0.35 (0.30)	-0.48 (0.21)**	-0.36 (0.21)*
T1999	-0.12 (0.15)	0.05 (0.15)	-0.14 (0.32)	0.01 (0.32)	-0.28 (0.22)	-0.12 (0.21)
R^2	0.12	0.10	0.18	0.16	0.10	0.09
σ	1.23	1.24	1.18	1.17	1.62	1.62
σ^2_ν	1.50	1.52	1.06	1.11	2.56	2.56
σ^2_η	2.47	2.67	1.39	1.71	7.18	7.47
Observations	11,312	11,312	1,079	1,079	5,601	5,601
Firms	1,602	1,602	149	149	885	885

Notes:

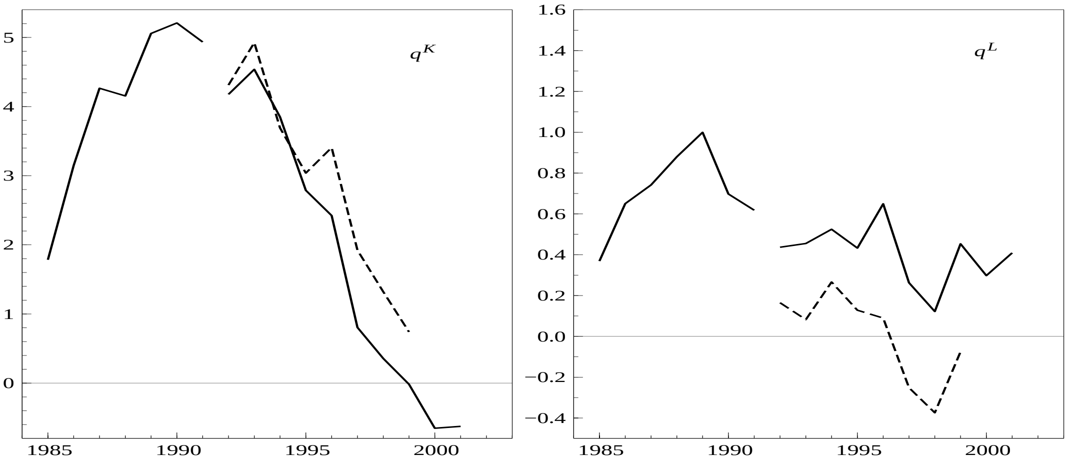
1. See notes for Table 7.
2. The RERIs are those listed in the first section of the Tokyo stock exchange.

Figure 8: q^K and q^L (with agency cost)

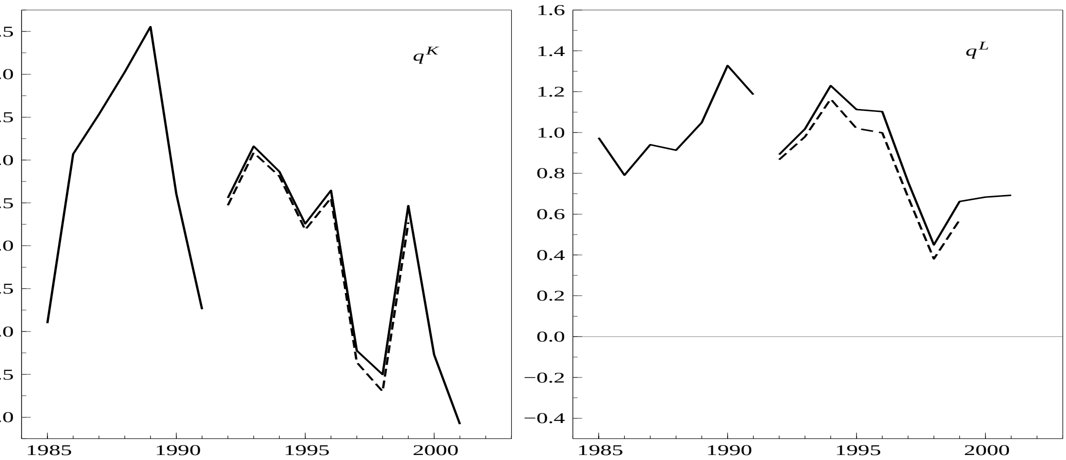
(1) Manufacturing



(2) RERIs



(3) Other nonmanufacturing



Note: Thick solid lines are obtained from parameters in Tables 7 and 8, while broken lines are obtained from those in Table 9. *AC* is included in the estimations.

reflecting the fact that capital investment rates swing more than land investment rates. We can look at this the other way around, and say that capital investment rates fall more sharply than land investment rates, because the partial q for capital stocks drop more than those for land stocks.

For both manufacturing and other nonmanufacturing sectors, the partial q for the land stock is around one in the middle of the 1990s, but then drops below one. Since partial q is defined as the ratio of the shadow price to the market price, this means that the market prices of the land assets of these firms attained a level consistent with their shadow prices in the middle of the 1990s. However, with expectations then turning pessimistic, as reflected in the decline in share prices, land prices subsequently exceeded their shadow prices once again.

For the RERIs, the partial q for the land stock is less than one throughout the sample period. In particular, the partial q for firms in the first section of the Tokyo exchange, for which we obtain sensible parameters, fall to a level around zero (dashed line). This indicates that market prices for the land assets of these firms continue to be higher than their shadow prices.

Figure 9 compares the partial q obtained from parameters estimated with and without the agency cost. In general, those without the agency cost (thin lines) are higher than those with the agency cost (thick lines). This indicates that the omission of AC_{it} in equation (19) causes upward biases in other parameters such as a^K, a^L, b^K and b^L.

6 Conclusion

In this paper, we investigate (i) what has determined the land investment behavior of Japanese firms since the latter half of the 1980s; and (ii) how the current market prices of their land assets diverges from their shadow prices (marginal values of land investment). For these purposes, we estimate nonlinear land investment functions using micro panel corporate data, and calculate the partial q for land assets taking account of their role as collateral.

The main findings of the paper can be summarized as below:

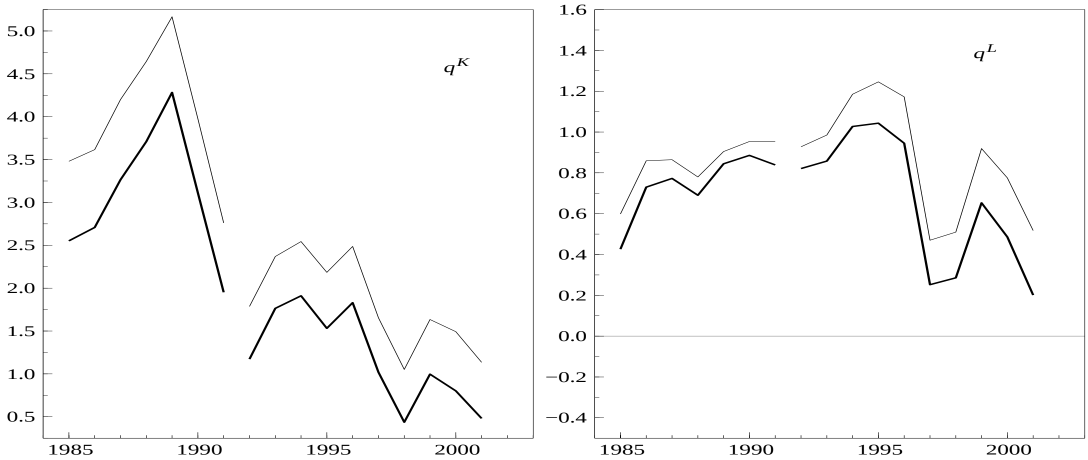
- In the early 1990s, driven by the real estate related industries (RERIs: construction, real estate, and general trading companies), the corporate sector as a whole turned out to be a net seller of land. Firms began to sell their land stocks mainly in response to the decline in sales and the deterioration in financial conditions after the bursting of the bubble.

- In addition, the hike in the overseas production ratio caused manufacturing firms to sell their land stocks, although the amount of land sales by these firms has been much smaller than that of the RERIs.

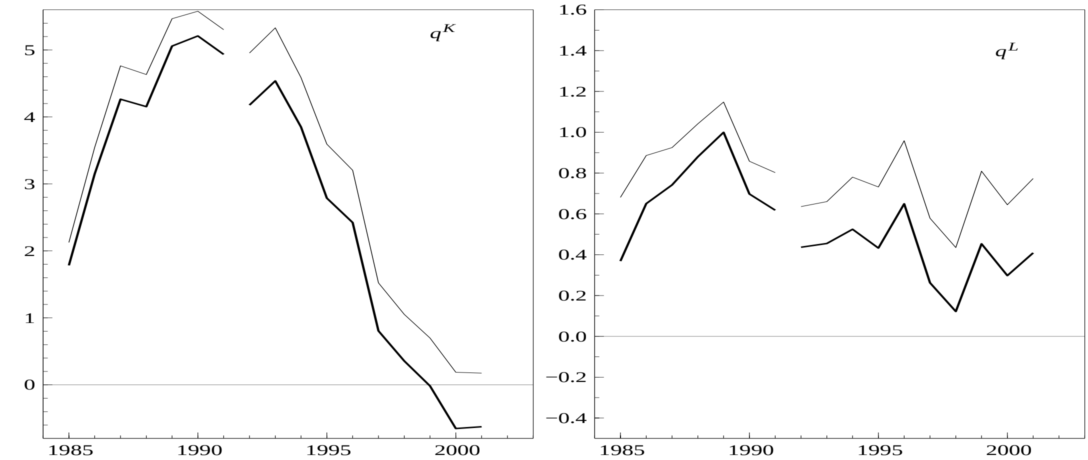
- The market prices of land held by the RERIs have exceeded their shadow prices

Figure 9: q^K and q^L (impacts of agency cost)

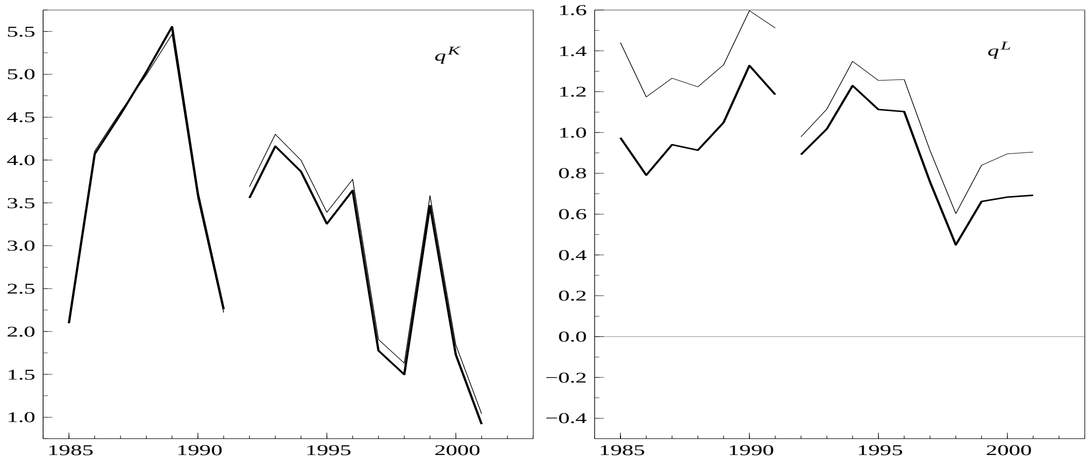
(1) Manufacturing



(2) RERIs



(3) Other nonmanufacturing



Note: Thick solid lines are obtained from parameters estimated with AC and thin solid lines are obtained from those without AC in Tables 7 and 8.

since the latter half of the 1980s. This implies that in spite of huge net sales from the early 1990s onward, the RERIs still hold excess land assets in terms of their marginal values of investment.

- For the other industries, market land prices declined to the level of their shadow prices around the middle of the 1990s. However, since then market prices have once again found themselves above their shadow prices, in the face of pessimistic expectations revealed by distressed share prices after 1997.

These findings suggest that downward pressure on land prices is likely to remain in evidence as long as the RERIs suffer from a debt-overhang problem and manufacturing firms continue to relocate their factories in overseas countries, although the impact of the latter is far smaller. Evaluation of the market prices of firms' land assets in relation to their shadow prices seems to reinforce this prediction given that market prices still exceed shadow prices. However, the fact that this evaluation process hinges crucially upon the expectations revealed in volatile share prices prevents us from deriving too strong a conclusion.

The above findings also imply that the non-performing loan problem has exerted significant downward pressure on land prices in Japan. This is because the debt-overhang problem for the RERIs and the non-performing loan problem for banks are different sides of the same coin. In fact, about 40 percent of risk management loans (as of March 2003) are those made to construction and real estate industries. See Ueda (2000) and Inaba et al. (2004) for the relationship between the non-performing loan problem and land prices.

Appendix A: Estimation of Friction Models by Simulated Maximum Likelihood

For the sake of notational simplicity, we change the notations from the main text so that y_{it} is a dependent variable and $\boldsymbol{x_{it}}$ is a vector of explanatory variables.

Let the two latent variables in a friction model be expressed as:

$$\begin{aligned} y_{1it}^* &= a_1 + \boldsymbol{x_{it} b} + \eta_i + \nu_{it}, \\ y_{2it}^* &= a_2 + \boldsymbol{x_{it} b} + \eta_i + \nu_{it}. \end{aligned}$$

We assume that the two intercepts satisfy $a_2 < a_1$, and that the individual effect η_i and idiosyncratic shock ν_{it} follow $\mathrm{IIN}(0, \sigma_\eta^2)$ and $\mathrm{IIN}(0, \sigma_\nu^2)$ processes, respectively.

In the friction model, an observed outcome y_{it} is related to the two latent variables y_{1it}^*, y_{2it}^* as follows:

$$y_{it} = \begin{cases} y_{1it}^*, & \text{if } y_{1it}^* < 0 \\ 0, & \text{if } y_{1it}^* > 0 \text{ and } y_{2it}^* < 0 \\ y_{2it}^*. & \text{if } y_{2it}^* > 0 \end{cases}$$

In general, the likelihood function $L_i(a_1, a_2, \boldsymbol{b}, \sigma_\eta, \sigma_\nu | y_{it}, \boldsymbol{x_{it}})$ for firm i can be expressed as the expected value of the likelihood $L_i(a_1, a_2, \boldsymbol{b}, \sigma_\nu | y_{it}, \boldsymbol{x_{it}}, \eta_i)$. That is,

$$L_i(a_1, a_2, \boldsymbol{b}, \sigma_\eta, \sigma_\nu | y_{it}, \boldsymbol{x_{it}}) = \int L_i(a_1, a_2, \boldsymbol{b}, \sigma_\nu | y_{it}, \boldsymbol{x_{it}}, \eta_i) \psi(\eta_i) d\eta_i, \tag{A.1}$$

where $\psi(.)$ is the standard normal density function.

Meanwhile, $L_i(a_1, a_2, \boldsymbol{b}, \sigma_\nu | y_{it}, \boldsymbol{x_{it}}, \eta_i)$ can be expressed as:

$$\begin{aligned} & L_i(a_1, a_2, \boldsymbol{b}, \sigma_\nu | y_{it}, \boldsymbol{x_{it}}, \eta_i) = \\ & \quad \prod_{it \in \jmath_0} \left\{ \frac{1}{s} \psi \left(\frac{y_{it} - a_1 - \boldsymbol{x_{it} b} - \eta_i}{s} \right) \right\} \\ & \quad \times \prod_{it \in \jmath_1} \left[\Psi \left(\frac{-a_2 - \boldsymbol{x_i b} - \eta_i}{s} \right) - \Psi \left(\frac{-a_1 - \boldsymbol{x_i b} - \eta_i}{s} \right) \right] \\ & \quad \times \prod_{it \in \jmath_2} \left\{ \frac{1}{s} \psi \left(\frac{y_{it} - a_2 - \boldsymbol{x_{it} b} - \eta_i}{s} \right) \right\}. \end{aligned} \tag{A.2}$$

Here, $s = \sigma_\nu$ and $\Psi(.)$ is the standard normal distribution function. $\jmath_0$, $\jmath_1$ and $\jmath_2$ are sets of observations that satisfy $y_{it} < 0$, $y_{it} = 0$ and $y_{it} > 0$, respectively.

Following Kuroda and Yamamoto (2003), Train (2003), and Gouriéroux and Monfort (1996), we conduct simulated maximum likelihood estimation using the algorithm below:

1. Draw a random number from the standard normal distribution.

2. Multiply the number obtained in Step 1 by σ_η, which is a parameter estimated later. Call this variable η_i^1. This variable is interpreted as the individual effect for firm i.

3. Calculate $L_i(a_1, a_2, \boldsymbol{b}, \sigma_\nu | y_{it}, \boldsymbol{x_{it}}, \eta_i)$ from equation (A.2).

4. Repeat Steps 1-3 R times and take an average:

$$L_i(a_1, a_2, \boldsymbol{b}, \sigma_\eta, \sigma_\nu | y_{it}, \boldsymbol{x_{it}}) \approx \frac{1}{R}\sum_{r=1}^{R} L_i(a_1, a_2, \boldsymbol{b}, \sigma_\nu | y_{it}, \boldsymbol{x_{it}}, \eta_i^r).$$

   This corresponds to equation (A.1).

5. Sum up the individual firm log likelihoods over all firms.

$$\log(L) = \sum_{i=1}^{n} \log(L_i).$$

   The parameters of interest $(a_1, a_2, \boldsymbol{b}, \sigma_\eta, \sigma_\nu)$ are obtained as the values that maximize the log-likelihood $\log(L)$.

We conduct simulations 1,000 times ($R = 1,000$) to obtain the parameters reported in Table 5.

For the purpose of comparison, we estimate the friction model without individual effects (Table A.1). In this case, we can estimate the model by ordinary maximum likelihood. The estimated coefficients are by and large similar to those in Table 5.

We also estimate equation (2) directly without assuming the non-linear relationship in the friction model (Table A.2). We obtain the coefficients as within-group estimators. In this latter case, the coefficients are quite different from those in Tables 5 and A.1. For instance, the coefficients on the stock adjustment terms become very large. This indicates the significant extent of possible biases, when we apply a linear model to censored data, such as the land investment rate with a number of zero observations.

Table A.1: Land Investment Function (Friction Model: No Individual Effect)

	Manufacturing	RERIs	Other nonmanufacturing
Dependent	I^L/L_{-1}	I^L/L_{-1}	I^L/L_{-1}
	(A) Sample Period: 1992-2001		
a_1	0.071 (0.010)***	0.095 (0.023)***	0.040 (0.013)***
a_2	-0.037 (0.010)***	0.054 (0.023)**	-0.048 (0.013)***
Δy	0.031 (0.007)***	0.124 (0.015)***	0.085 (0.010)***
Δy_{-1}	0.049 (0.008)***	0.078 (0.016)***	0.063 (0.010)***
$(l-y)_{-1}$	-0.002 (0.000)**	-0.005 (0.001)***	0.000 (0.000)
y_{-1}	0.000 (0.000)	-0.003 (0.001)**	0.001 (0.000)
ICR	0.045 (0.003)***	0.042 (0.010)***	0.028 (0.004)***
$(D/A)_{-1}$	-0.081 (0.006)***	-0.049 (0.014)***	-0.043 (0.006)***
OPr	-0.029 (0.011)***		
σ	0.095 (0.008)***	0.087 (0.017)***	0.083 (0.012)***
Observations	12,624	2,060	6,009
Firms	1,589	281	904
	(B) Sample Period: 1986-1991		
a_1	-0.074 (0.016)***	-0.148 (0.053)***	-0.045 (0.020)**
a_2	-0.160 (0.016)***	-0.179 (0.053)***	-0.091 (0.020)***
Δy	0.041 (0.012)***	0.066 (0.022)***	0.094 (0.014)***
Δy_{-1}	0.046 (0.011)***	0.070 (0.021)***	0.021 (0.014)
$(l-y)_{-1}$	-0.004 (0.001)***	0.011 (0.003)***	-0.001 (0.001)
y_{-1}	0.003 (0.000)***	0.007 (0.001)***	0.003 (0.001)***
ICR	0.130 (0.008)***	0.052 (0.033)	0.059 (0.010)***
$(D/A)_{-1}$	-0.037 (0.010)***	0.011 (0.021)	-0.004 (0.010)
OPr	0.001 (0.032)		
σ	0.083 (0.012)***	0.067 (0.028)***	0.055 (0.020)***
Observations	5,485	803	1,849
Firms	1,122	170	401

Note: See notes for Table 5. Maximum Likelihood Estimation.

Table A.2: Land Investment Function (Linear Model: Within-Group Estimation)

	Manufacturing	RERIs	Other nonmanufacturing
Dependent	I^L/L_{-1}	I^L/L_{-1}	I^L/L_{-1}
	(A) Sample Period: 1992-2001		
Δy	0.035 (0.009)***	0.118 (0.021)***	0.038 (0.011)***
Δy_{-1}	0.000 (0.008)	0.028 (0.018)	-0.005 (0.011)
$(l-y)_{-1}$	-0.067 (0.012)***	-0.103 (0.036)***	-0.070 (0.031)**
y_{-1}	-0.026 (0.013)**	-0.032 (0.031)	-0.049 (0.027)*
ICR	0.010 (0.004)**	0.038 (0.016)**	0.007 (0.004)
$(D/A)_{-1}$	-0.144 (0.022)***	-0.170 (0.051)***	-0.065 (0.017)***
OPr	-0.070 (0.030)**		
σ	0.068	0.075	0.059
R^2	0.058	0.140	0.056
Observations	12,831	2,089	6,098
Firms	1,584	278	897
	(B) Sample Period: 1986-1991		
Δy	0.055 (0.019)***	0.069 (0.026)***	0.073 (0.022)***
Δy_{-1}	-0.032 (0.013)**	-0.006 (0.025)	-0.035 (0.014)***
$(l-y)_{-1}$	-0.307 (0.067)***	-0.502 (0.059)***	-0.444 (0.048)***
y_{-1}	-0.208 (0.080)**	-0.378 (0.061)***	-0.377 (0.049)***
ICR	0.025 (0.012)**	-0.048 (0.064)	0.045 (0.016)***
$(D/A)_{-1}$	-0.122 (0.036)***	-0.070 (0.090)	0.004 (0.038)
OPr	-0.083 (0.062)		
σ	0.054	0.051	0.038
R^2	0.231	0.242	0.206
Observations	5,550	793	1,856
Firms	1,093	159	377

Note: See notes for Table 5. Within-Group Estimation.

Appendix B: q for Multiple Capital Goods with Agency Costs

This appendix derives q for the capital and land stocks. A distinguishing feature of this model is its explicit consideration of the agency costs involved in external funding.

To preserve notational simplicity, we consider the profit maximization problem of the representative firm in period 0. Henceforth the firm subscript i is suppressed.

$$
\begin{aligned}
V_0 &= \max \int_0^\infty \Pi_t \exp\left(\int_0^t -r(s)ds\right) dt, \\
&\quad \text{subject to equations (9), (10), (11) in the main text.}
\end{aligned}
$$

The current value Hamiltonian of this maximization problem is:

$$
\begin{aligned}
\mathcal{H} &= p_t F(K_t, L_t, N_t) + \left\{1 - \phi\left(\frac{p_t^L L_t}{B_t}\right)\right\} NB_t - w_t N_t - i_t B_t \\
&\quad - p_t^K \left\{I_t^K + G(I_t^K, K_t)\right\} - p_t^L \left\{I_t^L + C(I_t^L, L_t)\right\} \\
&\quad + \lambda_t^K \left\{I_t^K - \delta K_t\right\} + \lambda_t^L \left\{I_t^L\right\} + \lambda_t^B \left\{NB_t\right\}.
\end{aligned}
$$

Here, λ_t^K, λ_t^L and λ_t^B are the Lagrange multipliers showing the shadow prices of K_t, L_t and B_t in period t.

The first order conditions (FOCs) of this maximization problem can be summarized in the following ten equations.

$$
\begin{aligned}
\dot{K}_t &= I_t^K - \delta K_t, && \text{(B.1)} \\
\dot{L}_t &= I_t^L, && \text{(B.2)} \\
\dot{B}_t &= NB_t, && \text{(B.3)} \\
w_t &= p_t F(.)_{N_t}, && \text{(B.4)} \\
\lambda_t^K &= p_t^K \left\{1 + G_{I_t^K}\right\}, && \text{(B.5)} \\
\lambda_t^L &= p_t^L \left\{1 + C_{I_t^L}\right\}, && \text{(B.6)} \\
\lambda_t^B &= -\left\{1 - \phi\left(\frac{p_t^L L_t}{B_t}\right)\right\}, && \text{(B.7)} \\
\dot{\lambda}_t^K &= (r + \delta)\lambda_t^K + p_t^K G_{K_t} - p_t F_{K_t}, && \text{(B.8)} \\
\dot{\lambda}_t^L &= r\lambda_t^L + p_t^L C_{L_t} + \phi'(.)\frac{p_t^L}{B_t} NB_t - p_t F_{L_t}, && \text{(B.9)} \\
\dot{\lambda}_t^B &= r\lambda_t^B + i_t - \phi'(.)\frac{p_t^L L_t}{B_t^2} NB_t. && \text{(B.10)}
\end{aligned}
$$

In addition, the optimal path satisfies the following transversality conditions.

$$
\lim_{t \to \infty} \lambda_t^K K_t \exp\left(-\int_0^t r(s)ds\right) = 0,
$$

$$\lim_{t\to\infty} \lambda_t^L L_t \exp\left(-\int_0^t r(s)ds\right) = 0,$$
$$\lim_{t\to\infty} \lambda_t^B B_t \exp\left(-\int_0^t r(s)ds\right) = 0.$$

Following Hayashi (1982), the transversality conditions are tranformed as follows:

$$-\lambda_0^K K_0 = \int_0^\infty \frac{d}{dt}\left[\lambda_t^K K_t \exp\left(-\int_0^t r(s)ds\right)\right] dt,$$
$$-\lambda_0^L L_0 = \int_0^\infty \frac{d}{dt}\left[\lambda_t^L L_t \exp\left(-\int_0^t r(s)ds\right)\right] dt,$$
$$-\lambda_0^B B_0 = \int_0^\infty \frac{d}{dt}\left[\lambda_t^B B_t \exp\left(-\int_0^t r(s)ds\right)\right] dt.$$

Combining these conditions with the above FOCs, we obtain

$$\lambda_0^K K_0 + \lambda_0^L L_0 + \lambda_0^B B_0 = V_0.$$

Then substitution of equation (B.7) into the equation above generates

$$\lambda_0^K K_0 + \lambda_0^L L_0 + \phi(.)B_0 = V_0 + B_0.$$

Dividing both sides of this equation by $p_0^K K_0 + p_0^L L_0$, and defining $q^K = \lambda^K/p^K$, $q^L = \lambda^L/p^L$, we get equation (13). In this model, the q for each capital good is represented by the ratio of its shadow price to its market price.

Appendix C: Data Appendix

This appendix describes how we construct the two key variables in the paper: land investment and land assets. Definitions of the other variables are also provided. Below, figures in parentheses starting with the letter 'K' are code numbers corresponding to the relevant items in the Corporate Finance Data Set (the DBJ data set).

Land Variables

As mentioned in the main text, we propose a new method for coverting the book values of land investment and land assets to their market values, using special profits (losses) from land sales.

(1) Land Investment

When a firm i sells a land asset obtained k periods ago, land investment (net purchase) in period t, NOL_{it}, is expressed as:

$$NOL_{it} = NL_{it} - DL_{it} \cdot (p_t^L / p_{t-k}^L). \tag{C.1}$$

where NL_{it} is the purchase of land at book value, DL_{it} is the book value of land sales, and p_t^L is the land price. On the balance sheet, sales of land assets are recorded as DL_{it} which is the value of these land assets in period $t-k$. The market value of the land assets sold is derived by multiplying by p_t^L/p_{t-k}^L.

Since DL_{it} is not available in the Corporate Finance Data Set, sales of land assets are obtained via the following accounting identity:

$$LB_{it} = LB_{i,t-1} + NL_{it} - DL_{it}, \tag{C.2}$$

where LB_{it} is the book value of land assets. In our case, LB_{it} is the sum of land assets for operations (K1390) and land assets for sale (K1050). In the case of real estate firms, we also add expenses on unfinished construction works (K1090) and raw materials (K1100). These two items basically correspond to real-property for sale which remain under construction and vacant lots for future development.

(2) Profit and Loss from Land Sales

Since p_{t-k}^L is not available in the database, most existing studies follow Hoshi and Kashyap (1990) by assuming the LIFO principle: namely that p_{t-k}^L is the land price that was current in the most recent period when ΔLB_{it} took a positive value. There is, however, little rationale for assuming that the LIFO principle applies to the land investment behavior of Japanese firms.

Table C.1: Share of Profits and Losses from Land Sales

	Industry Code	Profit ϕ_h	Loss ψ_h
Manufacturing	000111-009199	59.41%	2.38%
Construction	030111-039199	55.32%	9.15%
General Trading Companies	040111	65.16%	6.63%
Other Wholesale Trade	040121-040199	46.32%	4.06%
Retailing	040311-040399	50.81%	4.35%
Real-estate	060111-060199	53.63%	12.70%
Railways	070111	91.59%	19.53%
Other Transportation, Communication	070311-071511	43.24%	2.21%
Service	090111-099199	43.43%	4.34%

Note: Calculated from financial statements of each company (FY1996-FY2001). Industry Codes are those of the DBJ data set.

To avoid assuming the LIFO, we exploit the information in profits (losses) from land-asset sales. Combining equations (C.1) and (C.2) yields:

$$NOL_{it} = \Delta LB_{it} - DL_{it} \cdot (p_t^L / p_{t-k}^L - 1). \tag{C.3}$$

Since the last term of this equation is the net profits from land-asset sales, if we have data on these profits, we can obtain precise estimates of land investment without making arbitrary assumptions about p_{t-k}^L.

Unfortunately, however, the DBJ data set contains only the profits (losses) from the sales of fixed assets in total. We thus go back to the original income statements of each listed company from FY1996 to FY2001, and collect information on the profits (losses) from land asset sales recorded in annotation or in special reports. For the RERIs (construction, real estate, and general trading companies) and the transportation and communication industry, we check all the listed companies. For the remaining companies, we randomly sample more than one-tenth of them. Then, for the sampled companies, we calculate the average ratios of profits (losses) from land asset sales to those from fixed asset sales for each industry (Table C.1). From FY1998, the RERIs and railway companies began to record losses from sales of "real-estate for sale." Since these are not available in the DBJ data set either, we also collect them from the original income statements.

Let

$$\phi_h = \frac{\text{Profit from land asset sales}}{\text{Profit from fixed asset sales}},$$

$$\psi_h = \frac{\text{Loss from land asset sales}}{\text{Loss from fixed asset sales}}.$$

Then, the net profits from land asset sales are estimated as follows:

$$DL_{it} \cdot (p_t^L / p_{t-k}^L - 1) =$$

$\phi_h \times$ (Profit from sales of fixed assets (K3400))
$-\psi_h \times$ (Loss from sales of fixed assets (K3550)
+Loss from sales of "real-estate for sale"),

An implicit assumption here is that the share of land in real-estate for sale, which records not only the value of land but also that of the buildings on it, is similar to that of land assets among total fixed assets.

In calculating land investment NOL_{it} via equation (C.3), we adopt a value of zero ($NOL_{it} = 0$) when there is no change in the book value of land assets ($\Delta LB_{it} = 0$).

(3) Revaluation of Land Assets

Land-asset revaluation, which was widely implemented by firms in the late 1990s, further complicates the calculation of land investment. Under the new law and accounting regulations, a firm can reevaluate its land assets at current market prices, and report capital gains or losses from this revaluation on its balance sheet.

Suppose a firm does not make any investment, but implements land revaluation and records a revaluation loss. In this case, the book value of land assets decreases ($\Delta LB_{it} < 0$). Thus even without any land transactions, we will obtain land disinvestment ($NOL_{it} < 0$) from equation (C.3). To avoid this complication, we need to further subtract the capital gains (losses) from land asset revaluation. If we do so, equation (C.3) becomes

$$c_{it} = \Delta LB_{it} - DL_{it} \cdot (p_t^L / p_{t-k}^L - 1) - REV_{it}, \tag{C.4}$$

where REV_{it} is the capital gain (loss) from land asset revaluation—$REV_{it} > 0$ indicates a capital gain and $REV_{it} < 0$ indicates a capital loss. In the above case of spurious land disinvestment, in equation (C.4) ΔLB_{it} and REV_{it} cancel out, and $NOL_{it} = 0$ as it should be.

Land asset revaluation is based on the following law and accounting regulation.

Land-Asset Revaluation Law (FY1998-FY2000)

Under this law, a firm can reevaluate its land assets for operations. The appraised value is reported on the debt side of the balance sheet. In the case when the revaluation results in a capital gain, this is divided into deferred tax liabilities and profit from revaluation on the credit side. When the revaluation results in a capital loss, this is divided into deferred tax assets on the debt side and loss from revaluation on the credit side. With the profit from revaluation, a firm can repurchase its own outstanding shares.

In response to this law, some firms implemented revaluation, while others did not. Among the firms implementing revaluation, some firms bought back their outstanding shares with the profit, but others did not. Interestingly, there were firms that implemented revaluation and posted capital losses. This is thought to have been mainly in order to lessen the shock from the expected introduction of asset-impairment accounting rules.

Deferred tax liabilities DTD_{it} and deferred tax assets DTA_{it} satisfy the following relationships:

$$\begin{aligned} DTD_{it} &= \tau_t(LB'_{it} - LB_{it}), \\ DTA_{it} &= -\tau_t(LB'_{it} - LB_{it}), \end{aligned}$$

where LB'_{it} is the book value of land assets after revaluation, LB_{it} is that before revaluation, and τ_t is the corporate tax rate.

Then, capital gains (losses) from land asset revaluation are calculated as:

$$REV_{it} = \max\left(\frac{\Delta DTD_{it}}{\tau_t}, 0\right) - \max\left(\frac{\Delta DTA_{it}}{\tau_t}, 0\right).$$

Both deferred tax liabilities DTD_{it} (K2504) and deferred tax assets DTA_{it} (K1724) come from the DBJ data set. Following Hayashi and Inoue (1991), the corporate tax rate is computed as:

$$\tau_t = \frac{(u_t + v_t)(1 + i_t)}{(1 + i_t + v_t)},$$

where u_t and v_t are the statutory rates of the corporate and enterprise taxes; and i_t is the yield on 10-year Japanese Government Bonds.[12]

On the Auditing Procedure for Depleted Real-estate for Sale (FY2001-)

This is a self-imposed regulation established by the Association of Certified Public Accountants in Japan (Report No. 69, issued in July 2000). It recommends the strict application of the mark-to-market valuation to depleted real-estate for sale for auditing purposes. Previously, there had already been a rule requiring that depletion be posted in real-estate for sale, however this had not been strictly implemented.

In Japan, the RERIs and the transportation and communication industries are responsible for most of the real-estate for sale. In preparation for this new auditing procedure, several firms in these industries had already reported appraisal losses in real-asset for sale as early as FY1999. Thus, for these industries, we further subtract appraisal losses in real-estate for sale (REV'_{it}) from the right-hand-side of equation (C.4).

The appraisal loss in land assets for sale is calculated as follows:

$$REV'_{it} = \psi_h \times \text{(Appraisal loss in real-estate for sale)}$$

Appraisal loss in real-estate for sale is collected from the original financial statements. We multiply it by ψ_h for the same reason that we multiply loss from sales of "real-estate for sale" by ψ_h.

[12] As for u_t, to take into account prefectural and municipal inhabitant taxes, we multiply the national corporate income tax rate by 1.173.

(4) Land Stocks at Market Price

Have derived land investment NOL_{it} above, we can now compute land stocks at market price LC_{it} using the perpetual inventory method.

$$LC_{it} = LC_{i,t-1} \cdot (p_t^L / p_{t-1}^L) + NOL_{it},$$

For the land price p_t^L, we use the Urban Land Price Index (in six major cities, all categories of land, appraised at the end of March) issued by the Japan Real Estate Institute.

The initial value of LC_{it} is obtained from LB_{it} at the earliest available year after FY1956. We adjust the initial market value by multiplying LB_{it} by the market-to-book ratio obtained from the SNA statistics ("Land" in "Tangible non-produced asset" held by the private non-financial corporations) and the Corporate Statistics Annual.[13]

We make the following adjustments, when we happen to encounter inconsistencies such as (i) firms having positive land stock at market value, but no land stock at book value; and (ii) firms having negative land stock at market value.

- In the case of (i), we infer a zero market value for land assets. Land investment is then calculated as $-LC_{i,t-1} \cdot (p_t^L / p_{t-1}^L)$.
- In the case of (ii), just as we did for the initial value of LC_{it}, we obtain the market value of land assets by multiplying its book value by the market-to-book ratio for the relevant year. Land investment is then calculated as $LC_{it} - LC_{i,t-1} \cdot (p_t^L / p_{t-1}^L)$.

We deflate LC_{it} with p_t^L so as to obtain the real stock of land assets at market price L_{it}.

Other Variables

Total q (Average q)

$$\text{Total } q \ (q_{it}) = \frac{V_{it} + D_{it} - S_{it} - OA_{it} - A_{it}}{(1 - \tau_t \mu_{it}) K_{it} + LC_{it}}.$$

V_{it} is firm value at market price obtained by multiplying the number of issued shares (K5440) by the relevant share prices, where the latter are obtained as the average of the highest (K0370) and the lowest (K0380) prices in each fiscal year. D_{it} is debt (K2630). S_{it} is the market value of inventory, and K_{it} is the market value of depreciable assets. See Nagahata and Sekine (2002) for how to obtain these series. LC_{it} is the market value of land stock derived as above. OA_{it} is other assets calculated as the difference between total assets (K1880) and the sum of the book values of inventory, depreciable assets and

[13] Since the SNA statistics are on an end-December basis, the Corporate Statistics Quarterly is used to transform the end-March figures from the Corporate Statistics Annual into their end-December equivalents.

land. τ_t is the corporate tax rate discussed above, μ_{it} is the depreciation allowance, and A_{it} is the present discounted value of the depreciation allowance that the firm can claim for any investment it has made in the past. See Hoshi and Kashyap (1990) and Sekine (1999).

Real Output

$$\text{Real output } (Y_{it}) = \frac{\text{Total sales (K2820) + Changes in inventories of finished goods}}{p_{it}}.$$

Changes in finished goods inventories refer to those in merchandise (K2820), real-estate for sale (K1050), and products (K1060). The output deflator p_{it} is obtained from the Input-Output Price Index and the SNA statistics for the industry to which firm i belongs.

Interest Coverage Ratio

$$c_{it} = \frac{\text{Operating profit (K3370)} + \text{Interest payments and fees for discounting bills (K3160)}}{\text{Interest payments and fees for discounting bills (K3160)}}.$$

For firms whose interest payments are negligibly small, c_{it} drastically swings from infinitesimal to infinity along with the signs on operating profits (losses are negative). We therefore standardize it between zero and one as follows:

$$\text{Interest coverage ratio } (ICR_{it}) = \frac{1}{1 + e^{-c_{it}}}.$$

Debt-to-Asset Ratio

$$\text{Debt-to-Asset Ratio } (D_{it}/A_{it}) = \frac{\text{Debt (K2630)}}{\text{Market value of Assets}}.$$

The market value of assets is obtained by substituting the market values of inventory S_{it}, land LC_{it}, and depreciable assets K_{it} for the corresponding items in total assets (K1880).

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