Is Land a Production Input or a Financial Instrument?: Evidence from Japanese Panel Data

Toshitaka Sekine and Towa Tachibana *

June, 2004

Abstract

This paper investigates what has determined the land investment behavior of Japanese firms since the 1980s. Special attention is paid to the dual roles of land: production input and collateral. With a corporate panel data set, we estimate non-linear investment functions, and calculate the partial q for land assets. We confirm that firms invest in land not only as a production input but also as collateral. We also find that in the bubble period, the land-investment behavior of construction, real-estate and general trading companies was at odds with the conventional investment theories, even with considering the collateral role of land.

JEL Classification Number: E22, G12, R30, C24

Keywords: land investment, collateral value of land, friction model, multiple q

*Bank of Japan and Kobe University, respectively. Corresponding author: Towa Tachibana. Tel./Fax: +81-78-803-7154. E-mail: ttachi@kobe-u.ac.jp. This research was undertaken when the second author was an economist at Bank of Japan. We thank Jochi Nakajima for his resourceful research-assistant work. The view expressed in this paper is solely of authors' own, and not of Bank of Japan.

1 Introduction

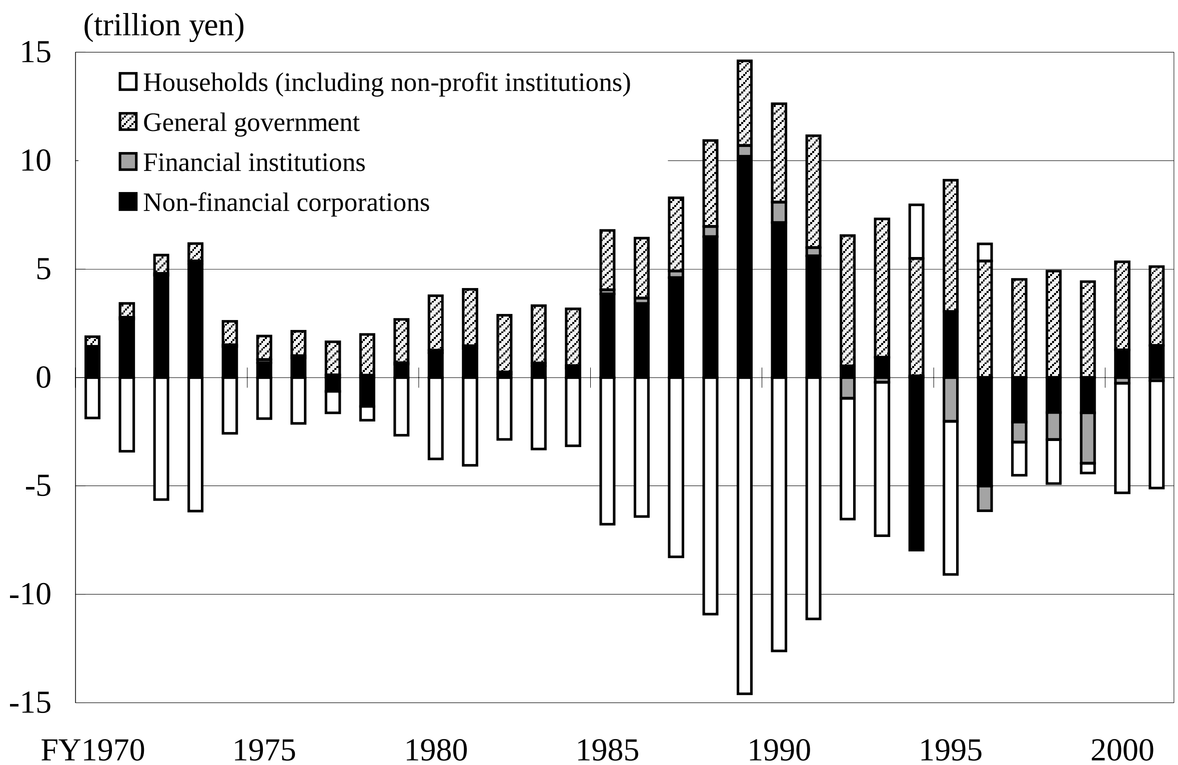
Since the 1990s, the link between asset-price fluctuation and real economic activity has received much attention both among academics and policy makers (See, among others, Bordo and Jeanne, 2002; Woodford, 2003). Such attention is particularly keen in Japan, where asset price deflation has characterized the long-run economic stagnation. In Japan, after the bursting of the bubble in 1991, both land and the stocks have lost much of their values. Average land price in 2003 was about 30% of its peak in 1990, while average stock price in 2003 was less than 35% of its peak in 1989. For a better policy design, it is indispensable to clarify the causes of this drastic fluctuation in asset prices, including its possible link to real economic activities. This paper deals with land, paying particular attention to the role of the corporate sector in this regard.[1]

Our focus on the corporate sector is highlighted by figure 1. Based on the national accounting statistics, it shows the net purchase of land assets by economic sector. Since the 1980s, the corporate sector (non-financial corporations) seems to have behaved 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. These observations render the corporate sector a prime suspect who brought Japan the drastic land price fluctuations in the last two decades.

The aim of this paper is to investigate the determinants of land investment behavior of the Japanese firms. In doing so, we pay special attention to the dual roles of land in the corporate sector. On one hand, land is a production input as well as labor and depreciable capital (machines/buildings). Land prices can go up following investment expansion, or a surge in land prices may restrain total investment expenditure. On the other hand, land is an asset and a major form of collateral in loan contracts. In Japan, in

[1] On the relationship between the stock prices and real economic activity in Japan, see Chirinko and Schaller (2001).

Figure 1: Land Investment by Sector



Note: Year is in Japanese fiscal year. For the definition, see footnote 7 in the text.
(Source) Cabinet Office, Japan, "Annual Report on National Accounts.", various issues.

particular, collateral tendered by land has been preferred to that tendered by the other assets. Consequently, land price deflation since 1991 has added the non-performing loans in the Japanese economy. In the past decade, the Japanese financial institutions have been struggling to establish a new business standard for extending their loans, which replaces the one depending on land collateral. Hence, investigating the balance of the dual roles of land in the Japanese corporate sector and its changes over the past decade, if any, is useful for gaining a broader understanding of the effects of the financial system on the link between asset prices and real economic activities.

To the best of our knowledge, however, there are few studies investigating the determinants of land investment behavior. On the cases in Japan, Asako et al. (1997) is a notable exception. But they limit their scope to the manufacturing sector. In land investment, nonmanufacturing firms such as those in the construction, real estate, and retail industry are thought to be vital players. In this paper, we construct a large panel data set that covers all the firms listed in the Japanese stock exchange markets. For the post bubble period, for example, it contains 20,693 annual observations of 2,774 firms, which obviously include nonmanufacturing firms. We estimate two types of empirical equations. The first one is the land investment functions with an error-correction specification. This empirical formation presumes land as a production input. By examining the fit of these investment functions over the industries and periods, we can evaluate how important land has been as a production input. The other approach estimates partial q of firms' land assets. In this specification, we explicitly separate the dual roles of land: production input and collateral in loan contracts. Theoretically, this approach is more consistent than the first one. But its empirical robustness largely depends on whether the stock prices correctly reveal the fundamental net present value of firms.

Besides the analysis on the dual roles of land asset, this study is of special interest for four reasons. First, we develop a new method to exploit market value of land investment from firms' financial statements. This is different from the methods adopted in the extant studies, which usually assume LIFO (Last-In-First-Out) mainly for convenience. Second, we estimate non-linear investment functions in order to capture the many observations of zero and negative land investment. More specifically, we applied a friction model *à la* Rosett (1959) to firms' land investment behavior. Third, we explicitly model the collateral role of land in the framework of q theory. In the estimation of partial q, we have avoided *ad hoc* inclusion of collateral value. Lastly, by calculating partial q of land assets, we evaluate the discrepancies between the market prices and the shadow prices of firms' land assets. These discrepancies will have many policy implications.

This paper proceeds as follows. Section 2 discusses our empirical strategy. We derive an error-correction type land-investment function and partial q of land assets. Section 3 describes our large panel data set. Section 4 estimates non-linear land investment functions, while section 5 estimates partial q of land assets with collateral value. Section 6 concludes the paper.

2 Empirical Strategy

2.1 Specification of Land Investment Function

In the first approach, we assume 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. Let $F(L_{it}, ...)$ be a constant-elasticity-of-substitution (CES) production function, where L_{it} is the real land stock for firm i in period t. We can derive the following land investment function from the first-order condition of profit maximization, $\partial F/\partial L_{it} = J_{it}$, where J_{it} is the user cost of land stock.

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

In equation (1), I_{it}^L 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 Chatelain et al. (2002), where a capital investment function is derived from essentially the same set-up.

Equation (1) is an error-correction specification of an accelerator-type 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. Hence, current land investment is unlikely to depend on its own lags.

Based on the survey results and anecdotal evidences collected by Sekine and Tachibana (2004), we add several variables to equation (1). First, we include variables that capture firms' financial conditions. Anecdotal evidence suggests that in the 1990s, firms under the mounting debts often sold land assets to balance their books. Second, to the specification for manufacturing firms, we further add a variable that reflects their production in foreign countries. A survey result collected in Sekine and Tachibana (2004) shows that "factories" accounted for a considerable share of land sales. This mirrors the fact that in the 1990s, many manufacturing firms transferred their domestic factories into foreign countries. If the impact of hollowing-out is substantial, the manufacturing sector's export of factories may be seen as an import of land, which results in a lower land price in Japan.

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 (Nagahata and Sekine, 2002). 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 asset 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. 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 would be substituting for domestic investment.

In the panel-data analysis, 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:

$$\begin{aligned}\left(\frac{I_{it}^L}{L_{i,t-1}}\right) &= \alpha_0' + \alpha_1'\Delta y_{it} + \alpha_2'\Delta y_{i,t-1} + \alpha_3'(l-y)_{i,t-1} + \alpha_4' y_{i,t-1} \\ &\quad + \alpha_5' ICR_{it} + \alpha_6'\left(\frac{D}{A}\right)_{i,t-1} + \alpha_7' OPr_{it} + d_t + \eta_i + \nu_{it}. \qquad (2)\end{aligned}$$

2.2 Partial q for Land Assets

The second approach is based on a dynamic optimization model with adjustment costs in investment. In this approach, we model simultaneous decisions of land investment and other capital investment. The specific framework we utilize is the q theory with many capital goods, which was developed by Wildasin (1984). Consider a firm that consists of heterogeneous capital goods, say machinery/buildings (depreciable) and land (non-depreciable). Under appropriate conditions, Wildasin (1984) shows that: (a) The observed total q, which is often referred as average q, is the weighted sum of the partial q for machinery/buildings and the partial q for land. (b) 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. Thus, with total q and the investment rates for both machinery/buildings and land, we can calculate partial q for land assets: q^L. Asako et al. (1997) applied this specification to the land-investment behavior of the Japanese firms.

An innovation in this paper is to explicitly include the collateral value of land in the framework of multiple q. When there are agency costs in financial markets, land assets may serve not only as a factor input but also as collateral.[2] 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 is written as:

$$\begin{aligned} \Pi_t &= p_t F(K_t, L_t, N_t) + \left\{1 - \phi\left(\frac{p_t^L L_t}{D_t}\right)\right\} ND_t - w_t N_t - i_t D_t \\ &\quad - p_t^K \left\{I_t^K + G(I_t^K, K_t)\right\} - p_t^L \left\{I_t^L + C(I_t^L, L_t)\right\}. \end{aligned} \tag{3}$$

Here p_t is the output price, p_t^K is the price of depreciable capital, p_t^L is the price of land, w_t is the wage, i_t is the interest rate, ND_t is the amount of new debt finance or repayment, D_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, they are twice continuously differentiable, linearly homogenous, and have positive first and second derivatives.

The crux of this model is that new debt finance $ND_t > 0$ involves some agency cost,

[2] There is a body of theoretical literature on this issue: refer to Kiyotaki and Moore (1997) and the references therein. Ogawa and Suzuki (1998) show that in Japan, firms' credit conditions are affected by the value of land asset they hold.

which depends on the market value of land assets $p_t^L L_t$. Here the agency cost is modeled as a partial loss of new debt finance $\phi(.)ND_t$, where

$$\begin{aligned} 1 > \phi(.) &> 0 \quad \text{when } ND_t > 0 \\ &= 0 \quad \text{when } ND_t \leq 0. \end{aligned}$$

A higher value of land assets relative to outstanding debt D_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, where the land collateral ratio is defined as $D_t/(p_t^L L_t)$.[3]

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 D_t changes over time in accordance with the following transition equations.

$$\dot{K}_t = I_t^K - \delta K_t, \tag{4}$$

$$\dot{L}_t = I_t^L, \tag{5}$$

$$\dot{D}_t = ND_t. \tag{6}$$

where δ denotes the depreciation rate.

The firm maximizes V_t subject to equations (4)-(6). From the first order conditions of this maximization problem, we can derive the following relationship between partial q and

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

the current discounted value of firm V_t. Appendix A shows the details of this derivation.

$$p_t^K q_t^K K_t + p_t^L q_t^L L_t + q_t^D D_t = V_t. \tag{7}$$

Here q_t^K, q_t^L and q_t^D denote partial q for K_t, L_t and D_t, respectively. q_t^D is defined as $q_t^D = -(1 - \phi(.))$, and if there is no agency cost, $q_t^D = -1$. By dividing both sides of equation (7) by the market value of the firm's tangible assets $p_t^K K_t + p_t^L L_t$, we obtain:

$$q_t^K s_t^K + q_t^L s_t^L + \phi\left(\frac{p_t^L L_t}{D_t}\right) s_t^D = q_t, \tag{8}$$

where $q_t = (V_t + D_t)/(p_t^K K_t + p_t^L L_t)$ 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 $s_t^D = D_t/(p_t^K K_t + p_t^L L_t)$ is the ratio of outstanding debt to the total value of assets.

Following Asako et al. (1997), we assume appropriate forms for the adjustment cost functions $G(.)$ and $C(.)$ that generate linear relationships between each partial q and its corresponding investment rate. That is,

$$q_t^K = a^K \cdot \frac{I_t^K}{K_{t-1}} + b^K, \tag{9}$$

$$q_t^L = a^L \cdot \frac{I_t^L}{L_{t-1}} + b^L, \tag{10}$$

where a^K, a^L, b^K and b^L are parameters from the adjustment-cost functions. Expected signs of a^K and a^L are positive. The empirical equation corresponding to equation (8) then becomes:

$$q_t = a^K \frac{I_t^K}{K_{t-1}} s_t^K + a^L \frac{I_t^L}{L_{t-1}} s_t^L + \phi\left(\frac{p_t^L L_t}{D_t}\right) s_t^D + b^K s_t^K + b^L s_t^L + u_t, \tag{11}$$

where u_t is a disturbance term. Intuitively, this specification divides total q into the partial q for depreciable capital (K_t) and that for land asset (L_t) in proportion to the volatility in investment rate in K_t and L_t.

This model is more general and theoretically consistent than the error-correction type investment function in the first approach. A caveat is, however, in order here. We calculate total q from the stock prices. Thus, the empirical robustness of the current approach largely depends on whether the stock prices correctly reveal the fundamental net present value of firms. If there is a bubble in the stock market, for example, it is difficult to argue that the derived q^L reflects the true marginal value of a firm's land assets.[4] In fact, 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. Even with the bubble in stock prices, however, q^L provides information about the shadow price of firms' land stock given the market evaluation (although it may be out of economic reasoning) of the firms: stock price. Comparisons with such a shadow price and market price of land will provide important policy implications.

3 Data

3.1 Construction

Firm-level panel data is crucial to test the possible structural change in the roles of land assets between the bubble and the post-bubble periods. 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 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—

[4] More generally, Baker et al. (2003) argue that 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.

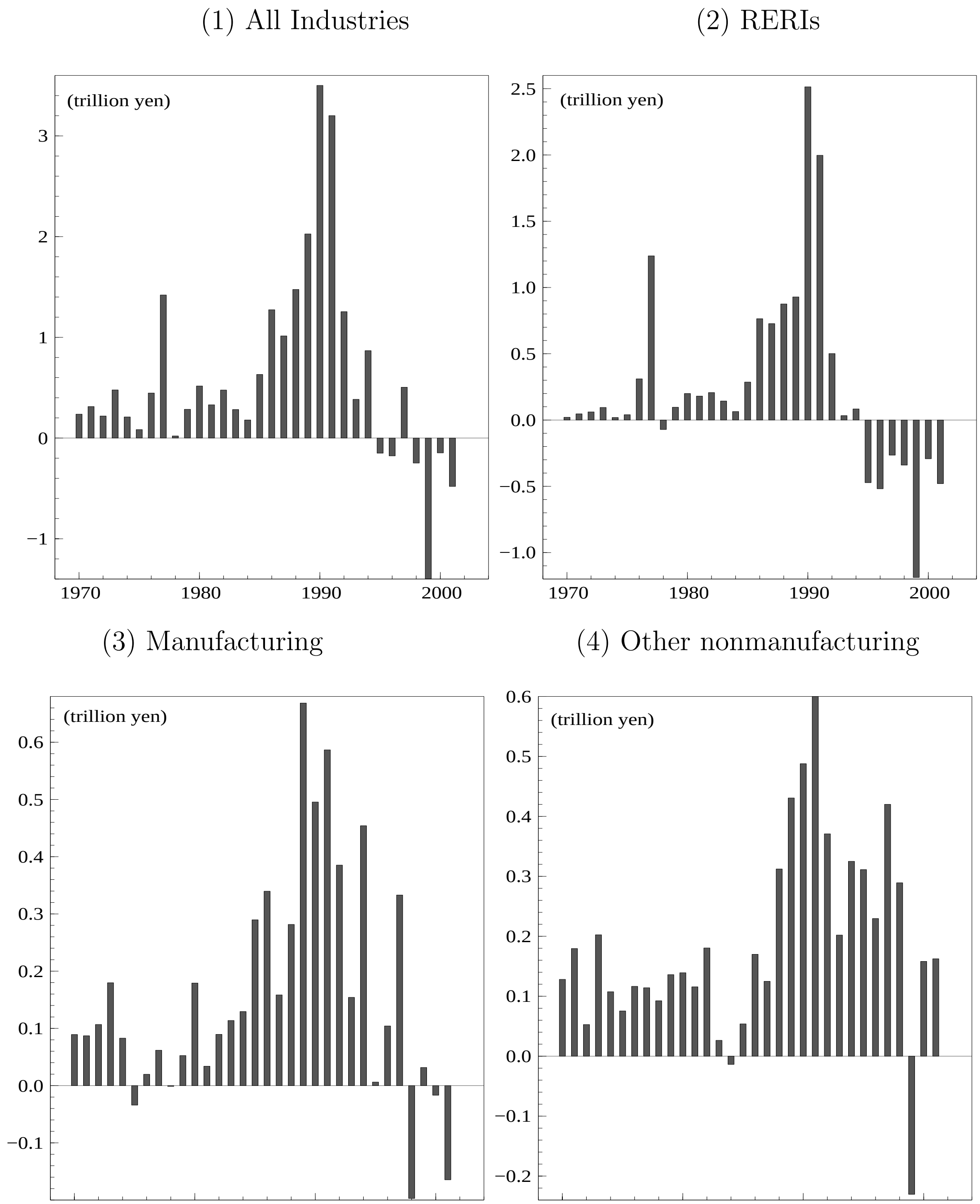
three stock exchange markets geared to small- and medium-sized companies.[5]

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

$$NOL_{it} = \Delta LD_{it} - DL_{it}\left(\frac{p_t^L}{p_{t-k}^L} - 1\right), \tag{12}$$

where LD_{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 purchased. Since p_{t-k}^L is not available in financial statements, most researchers assume the LIFO (Last-In-First-Out) principle following Hoshi and Kashyap (1990). In other words, among their land properties, firms are supposed to sell the one which they purchased most recently. We are afraid that this assumption is difficult to rationalize. Instead of 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 to pick them up. Further details of the calculation, including the adjustment for land-asset revaluation on the balance-sheets, are available from the authors upon request.

Figure 2: Land Investment by Industry



Notes:

1. Authors' calculation from individual firm data.
2. Real Estate Related Industries (RERIs) consist of construction, real estate and general trading companies.

3.2 Development of Main Variables

3.2.1 Land Investment Rate

Figure 2 aggregates the series we construct for land investment over industries. Refer to Appendix B for the rules for excluding outliers.[6] In making breakdowns by industry, we closely examine the construction, real estate, and general trading companies. Hereafter, we refer to these three industries as Real Estate Related Industries (RERIs). The popular accounts suggest that many firms in the RERIs were actively engaged in commercial and resort developments during the bubble era (the late 1980s), and have been suffering from accumulating debt in the course of land-price deflation in the 1990s (Sekine and Tachibana, 2004).

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 2 lies in the series development after the year of 2000.[7] In figure 1, we see the corporate sector resuming its position as a net purchaser after 2000. In figure 2, however, it remains as a net seller at that time.

The industry breakdowns in figure 2 confirm that the lion's share of land transactions is conducted by the RERIs. Purchases by these industries peaked at around 2.5 trillion yen, with a trough where sales exceeded one trillion yen.[8] The corresponding figures for the manufacturing and the other nonmanufacturing industries are as small as 0.6 trillion yen and 0.2 trillion yen.

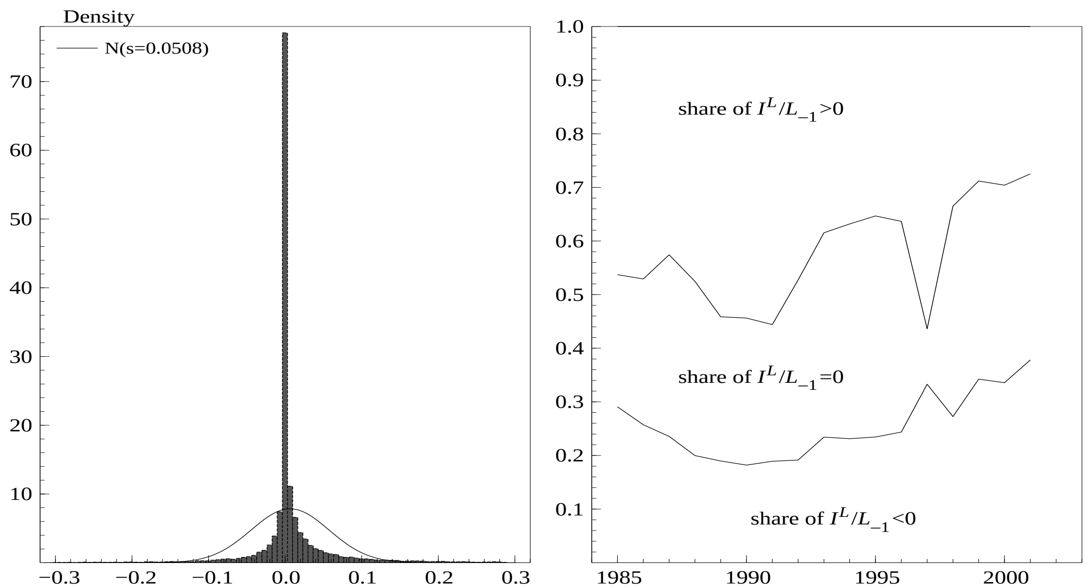
[5]The DBJ database contains both the consolidated and unconsolidated financial statements. Since most consolidated data is available only for short-time periods (generally less than five years), we use unconsolidated data.

[6]In figure 2, we only apply criteria 1 and 2 of excluding outliers in Appendix B.

[7] In most of the data sets in the paper, year indicates the Japanese fiscal year, which starts on April 1 and ends on March 31.

[8]2.5 trillion yen is about 0.6% of the Japanese GDP in 1989.

Figure 3: 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 3 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 high proportion of samples with zero land investment is due to the fact discussed above. That is, land assets are not subject to depreciation and hence there is no replacement investment. As is usually the case with investment in fixed assets, considerable transaction cost, irreversibility, and uncertainty make new investment in land assets lumpy by generating an option value (Dixit and Pindyck, 1994). Such an option value results in long waiting periods before initiating new investment, and hence we have many observations of zero land investment rate.

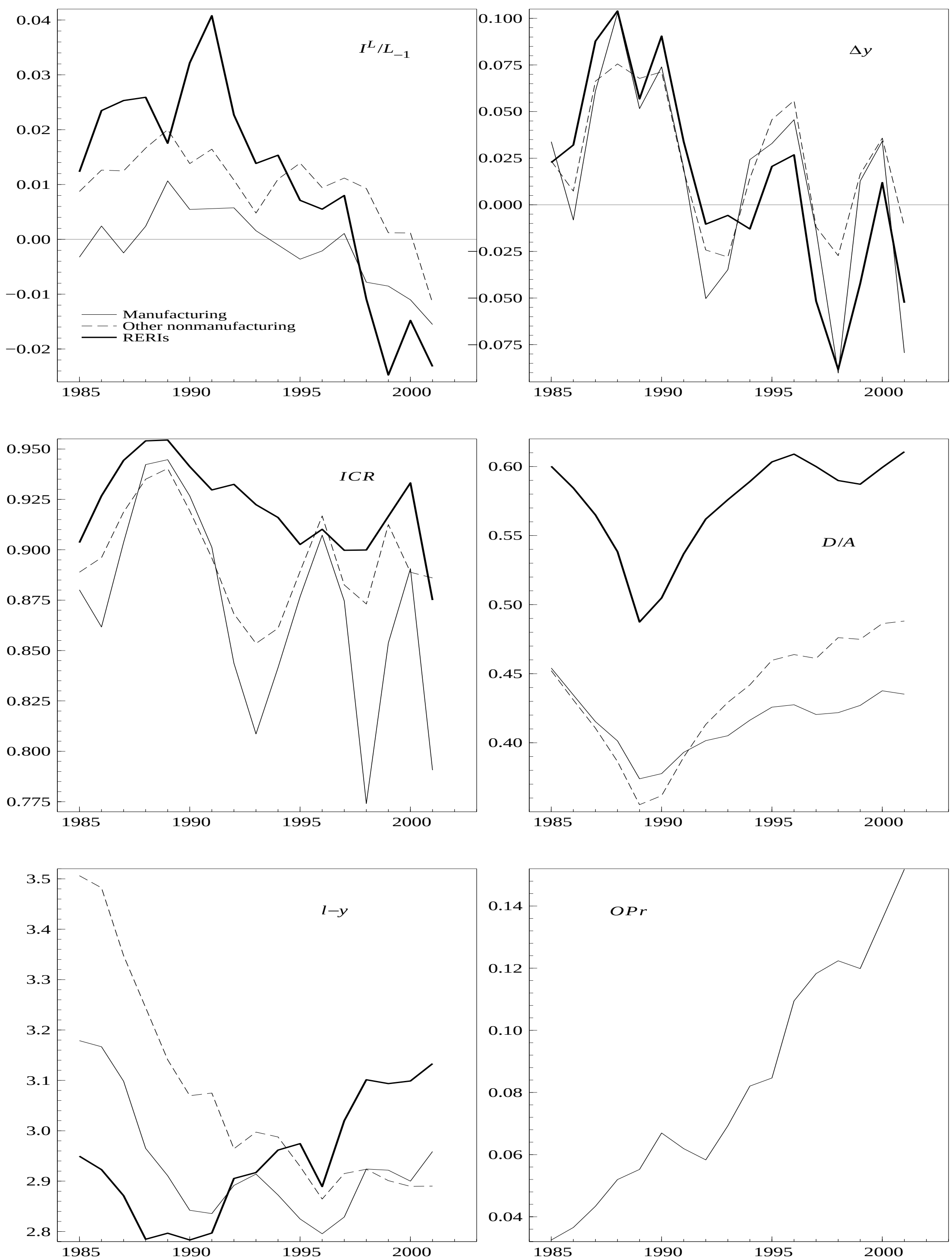
3.2.2 Variables for Land Investment Function

Table 1 summarizes the basic sample statistics of the variables used for estimating the land investment functions (2). Figure 4 depicts developments of the sample means of these variables. Several features stand out. First, 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 hovers around one percent until 1998, and then drops. Second, the output growth rate Δy of the RERIs also exhibits a large swing (figure 4, upper-right panel). As table 1 shows, the average growth rate declines from 6.3% during the 1985-1991 period to –1.9% during the 1992-2001 period. Thus even with the huge net sales of land assets, the stock adjustment term $l - y$ for the RERIs *increases* in the 1990s (figure 4, lower-left panel). Third, 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

Table 1: Sample Properties: Means (Standard Deviations)

	All industries	Manufacturing	RERIs	Other nonmanufacturing
		(A) 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)		
		(B) 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)		

Figure 4: Main Indicators



higher (the burdens of interest payments is smaller). This reflects the fact that the RERIs, in particular construction companies, have paid lower interest rates. Lastly, the overseas production ratio OPr for the manufacturing firms shows a steady increase throughout the sample period (figure 4, lower-right panel).

3.2.3 Variables for Partial q Analysis

Figure 5 depicts the variables for the second approach: partial q analysis in equation (11). Total q for the manufacturing and other nonmanufacturing sectors are broadly in line with business cycles in Japan (top panel of figure 5). 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 5. Even at their lowest level in 2001, capital investment rates remain positive because of replacement investment, while land investment rates fall into negative territory.

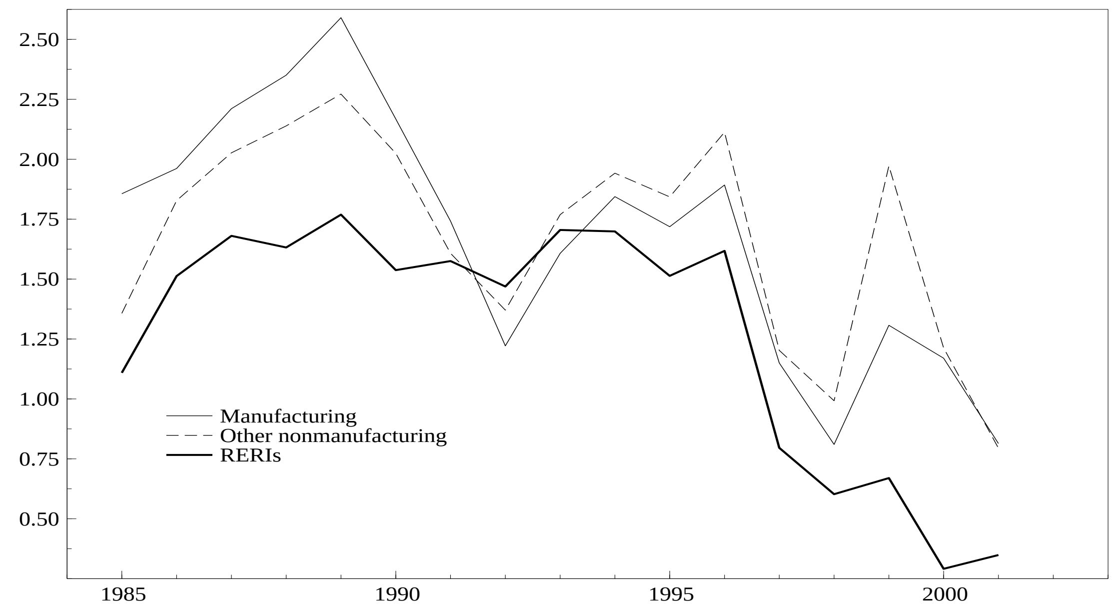
4 Estimation of Land Investment Function

4.1 Friction Model

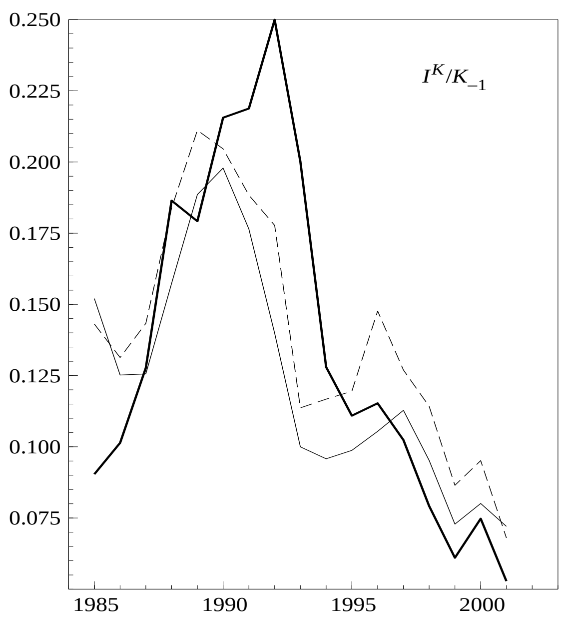
The estimations of the land-investment function 2 should consider the spike at zero investment and the substantial number of negative investment positions shown in figure 3. We apply the friction model proposed by Rosett (1959). The intuition behind the friction model is that, due to the frictions involved in trading, people sell or purchase assets only when there is a significant change in exogenous conditions. This results in the shape

Figure 5: Total q and Investment Ratios

(1) Total q



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



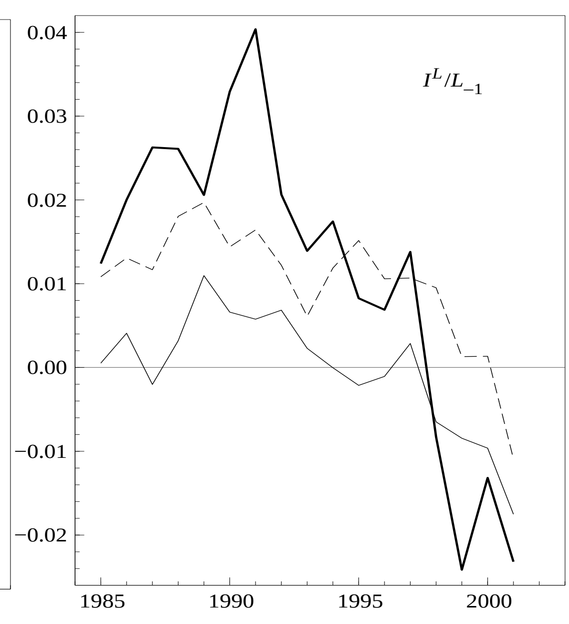
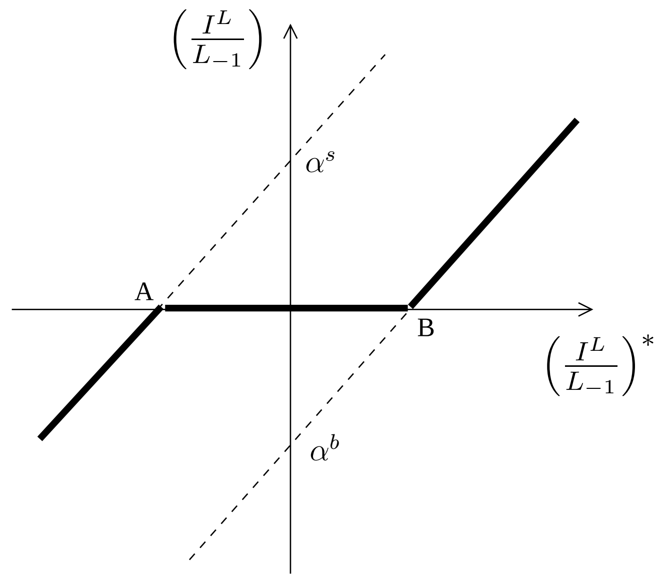


Figure 6: Friction Model



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:

$$\left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{s*} = \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{*} - \alpha_0' + \alpha^s, \tag{13}$$

$$\left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{b*} = \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{*} - \alpha_0' + \alpha^b. \tag{14}$$

respectively. 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:

$$\left(\frac{I_{it}^L}{L_{i,t-1}}\right) = \begin{cases} \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{s*}, & \text{if } \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{s*} < 0 \\ 0, & \text{if } \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{s*} > 0 \text{ and } \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{b*} < 0 \\ \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{b*}, & \text{if } \left(\frac{I_{it}^L}{L_{i,t-1}}\right)^{b*} > 0 \end{cases} \tag{15}$$

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. Intuitively, the friction model is a combination of two Tobit models. The Tobit model has one threshold, whereas the friction model has two thresholds: a ceiling and a floor.

We finalize the land-investment function by substituting $(I_{it}^L/L_{i,t-1})^*$ in equation (15) 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 $\nu_{it} \sim N(0, \sigma_\nu^2)$.[9] Due to the presence of an integral in the likelihood function, we adopt the simulated maximum likelihood method for estimation (Train, 2003).[10]

4.2 Estimation Results of Land-investment Function

Table 2 summarizes the estimation results of the land-investment regressions. 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, satisfy the theoretical requirement of the friction model: $\alpha^s > \alpha^b$.[11] Judging from the standard errors σ_η, the individual effects η_i are substantial and statistically significant except for the RERIs in the post-bubble period. Thus the random effects model is more appropriate

[9]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.

[10]The details of simulation algorithm are available from the authors upon request. We conduct most of the data processing and estimations 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).

[11]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.

Table 2: Land Investment Function

	Dependent Variable: Land-Investment Rate I^L/L_{-1}		
	Manufacturing	RERIs	Other nonmanufacturing
Independent Variable	**(A) 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)		
$\sigma_\eta{}^{a)}$	0.023 (0.002)***	0.020 (0.004)***	0.019 (0.002)***
$\sigma_\nu{}^{b)}$	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
Independent Variable	**(B) 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)**		
$\sigma_\eta^{a)}$	0.029 (0.001)***	0.005 (0.010)	0.025 (0.002)***
$\sigma_\nu^{b)}$	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

Notes:

1. a), b) Standard error of individual specific effect η, and idiosyncratic effect ν, respectively.
2. Maximum simulated likelihood estimation. 1,000 draws.
3. Numbers in parentheses are standard errors. "***", "**" and "*" denote statistical significance at the 1%, 5%, 10% levels, respectively.

than simple pooled regressions.

In the RERIs (construction, real-estate, and general trading companies) estimation, a sharp contrast emerges between the bubble and the post-bubble period. The most interesting finding is that, in the bubble period (1986-1991), the coefficient on the stock adjustment term $(l-y)_{i,t-1}$ is *positive* and statistically significant. This means that during the bubble period, the RERI firms implemented new land investment even when their land stock holdings were excessive compared to their sales. This is contrary to the prediction of the error-correction type investment function (2). In other words, the land-investment behavior of the RERIs in the period of surging land price cannot be explained by the standard investment theory which considers land solely as a production input. There is one more unexpected result. 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. The debt-to-asset ratio has the wrong sign: positive. What this means is that during the bubble period, the RERI firms implemented new land investment irrespective of their financial conditions. The bursting of the bubble notably altered the land investment behavior of the RERIs. The coefficient on the stock adjustment term becomes negative and statistically significant. Furthermore the financial variables also have significant coefficients with expected signs. 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, particularly that on the stock adjustment term, is consistent with the theories which focus on the role of land assets as a production input.

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 standard investment theory and financial disciplines since the middle of the 1980s. The important finding here is that the coefficient on the industry-wise overseas production ratio OPr becomes negative and significant in the latter sample period. This indicates that in the 1990s, the main reason behind manufacturing firms' increasing sales of their land assets was the re-allocation of domestic factories to 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, however, statistically insignificant in both the bubble and the post-bubble periods. This is at odds with the predictions of conventional investment theory which considers land as a production input.

4.2.1 Comparing the Impacts of Individual Variables

As is well known, in the censored regression models such as friction models, the estimated coefficients do not necessarily reveal the influence of independent variables. We thus calculate the cumulative contribution of each independent variable on variations in the land-investment rate as follows. First, for each firm, marginal effects of the relevant variables are derived from the following equation.

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

where α is the coefficient on independent variable x_{it}, and $E[.]$ is the expectations operator. Then, by multiplying the above marginal effects by Δx_{it}, their annual contributions are calculated for each firm. Finally, cumulative contributions are obtained by adding up the sample averages of these annual contributions over the post-bubble period.

Table 3 reports the result for the post-bubble period: 1992 to 2001. Three salient features stand out there: (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.

Table 3: Cumulative Contribution of Independent Variables: 1992 to 2001

	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).

For all industries, the contribution of the debt-to-asset ratio is large and negative. This suggests that 'asset-price debt deflation' 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.

In the estimation of partial q that follows, we address the question whether the unexpected land-investment behavior of the RERIs in the bubble period can be explained by the financial role of land.

5 Estimation of Partial q

5.1 Setting for Panel Estimation

We estimate equation (11) using panel regressions to control for individual effects. To avoid imposing overly restrictive conditions on the coefficients, however, we adopt time-variant intercepts: b_t^K and b_t^L.[12] More specifically, we assume the following empirical

[12] Asako et al. (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. Thus, they essentially assume that both the coefficients of slopes and intercepts are time-variant. This estimation method without controlling for individual effects

forms for equations (9) and (10):

$$q_{it}^K = a^K\left(\frac{I_{it}^K}{K_{i,t-1}}\right) + b_t^K + \omega_{it}^K, \quad (16)$$

$$q_{it}^L = a^L\left(\frac{I_{it}^L}{L_{i,t-1}}\right) + b_t^L + \omega_{it}^L, \quad (17)$$

where $b_t^K = b^K + d_t^K$ and $b_t^L = b^L + d_t^L$. The time-varying part of intercepts, d_t^K and d_t^L, can be regarded as the time specific effects. Disturbance terms ω_{it}^K and ω_{it}^L consist of individual effects and idiosyncratic shocks: $\omega_{it}^K = \eta_i^K + \nu_{it}^K$ and $\omega_{it}^L = \eta_i^L + \nu_{it}^L$. Furthermore, we assume the agency cost function $\phi(.)$ takes the following form:

$$\phi\left(\frac{p_t^L L_{it}}{D_{it}}\right) = \frac{c^B}{1+exp(x_{it})},$$

where c^B is a parameter and x_{it} is $p_t^L L_{it}/D_{it}$, which is the inverse of the land collateral ratio. This specification smoothes drastic swings in x_{it} along with small values of D_{it}.

With these formulations, equation (11) becomes:

$$\begin{aligned} q_{it} = {} & a^K\left(\frac{I_{it}^K}{K_{i,t-1}}\right)s_{it}^K + a^L\left(\frac{I_{it}^L}{L_{i,t-1}}\right)s_{it}^L + c^B AC_{it}s_{it}^D \\ & +(b^K - b^L)s_{it}^K + b^L + (\tilde{b}_t^K - \tilde{b}_t^L)s_{it}^K d_t + \tilde{b}_t^L d_t + \eta_i + \nu_{it}. \end{aligned} \quad (18)$$

where $AC_{it} = 1/(1+exp(x_{it}))$. Here time effects d_t^K, d_t^L are further decomposed into the effects specific to depreciable capital ($\tilde{b}_t^K$) and land ($\tilde{b}_t^L$), and the common macro shock summarized in time dummy (d_t): $d_t^K = \tilde{b}_t^K \cdot d_t$, $d_t^L = \tilde{b}_t^L \cdot d_t$. The individual specific effect $\eta_i = s_{it}^K\eta_i^K + s_{it}^L\eta_i^L$ and the idiosyncratic shock $\nu_{it} = s_{it}^K\nu_{it}^K + s_{it}^L\nu_{it}^L$ are assumed to follow stochastic processes such that $\eta_i \sim N(0, \sigma_\eta^2)$ and $\nu_{it} \sim N(0, \sigma_\nu^2)$. Since we need to estimate the intercepts b^K and b^L, we apply a random effects model to equation (18).

in micro data set might have brought unstable estimates in Asako et al. (1997).

5.2 Estimation Results of partial q

For the estimations of partial q of equation (18), in addition to the observations excluded from the previous analysis, we further 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 in the upper one percentile (refer to Appendix B).

Table 4 reports estimation results during the 1986-1991 sample period: the bubble era. For manufacturing firms, when the agency cost AC is included, all the coefficients on partial qs have the expected signs, and are statistically significant. When AC is dropped from the equation, the coefficient on partial q for depreciable capital ($s^K \cdot I^K / K_{-1}$) becomes insignificant. This result suggests that controlling for AC is important. In other words, in the bubble era, the manufacturing firms invest in land not only for enhancing their production input but also for obtaining the collateral value of land in loan contracts.

For the RERIs (construction, real-estate, and general trading companies), the coefficients on partial q for land assets ($s^L \cdot I^L / L_{-1}$) turn out to be negative. Even with AC, the negative coefficient is statistically significant at the marginal 10% level. This result is consistent with the estimate of the land investment functions. Recall that in table 2, the stock adjustment term for the RERIs has the unexpected sign and is statistically significant. For the other nonmanufacturing firms, the coefficients on partial q for depreciable capital assets have unexpected negative signs and are statistically significant with or without AC. As in the case of RERIs, this is consistent with the estimate of the land investment function in table 2, and inconsistent with the theoretical predictions. Even with considering the collateral value of land, during the bubble period, the investment behavior of RERIs and other nonmanufacturing firms ran counter to profit maximization behavior.

Table 5 to 7 summarize the estimation results of the post bubble era: since 1992. In each table, columns (1) and (2) show the estimation results of the sample period from

Table 4: Multiple q Estimation (Sample period: 1986-1991)

	Manufacturing		RERIs		Other nonmanufacturing	
	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^2_ν	1.15	1.16	0.42	0.42	0.94	0.96
σ^2_η	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 5: Multiple q Estimation: Manufacturing Sector (1992-)

Sample	All Manufacturing		All Manufacturing		In the First Section	
Period	1992-2001		1992-1999		1992-1999	
	(1)	(2)	(3)	(4)	(5)	(6)
	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)***	1.86 (0.19)***	1.70 (0.19)***	1.79 (0.29)***	1.63 (0.29)***
$s^L \cdot I^L/L_{-1}$	0.34 (0.56)	-0.13 (0.57)	1.15 (0.59)*	0.67 (0.59)	2.57 (0.97)***	2.21 (0.96)**
$s^B \cdot AC$	0.98 (0.07)***		1.10 (0.07)***		0.77 (0.11)***	
s^K	0.08 (0.26)	0.60 (0.26)**	-0.11 (0.25)	0.48 (0.25)*	0.34 (0.34)	0.73 (0.35)**
s^KT1993	0.63 (0.27)**	0.60 (0.27)**	0.62 (0.25)**	0.58 (0.25)**	0.73 (0.33)**	0.71 (0.33)**
s^KT1994	0.62 (0.26)**	0.58 (0.26)**	0.60 (0.24)**	0.56 (0.25)**	0.96 (0.33)***	0.95 (0.33)***
s^KT1995	0.22 (0.26)	0.16 (0.26)	0.22 (0.24)	0.15 (0.24)	0.73 (0.33)**	0.71 (0.33)**
s^KT1996	0.60 (0.26)**	0.52 (0.26)**	0.59 (0.24)**	0.49 (0.24)**	0.90 (0.34)***	0.91 (0.33)***
s^KT1997	0.47 (0.26)*	0.38 (0.26)	0.38 (0.24)	0.27 (0.24)	0.61 (0.34)*	0.59 (0.34)*
s^KT1998	-0.12 (0.26)	-0.23 (0.26)	-0.18 (0.24)	-0.33 (0.25)	0.09 (0.34)	0.04 (0.34)
s^KT1999	0.12 (0.27)	-0.02 (0.27)	0.06 (0.25)	-0.11 (0.25)	0.45 (0.35)	0.38 (0.35)
s^KT2000	0.08 (0.28)	-0.03 (0.28)				
s^KT2001	0.05 (0.29)	-0.11 (0.29)				
Constant	0.82 (0.14)***	0.93 (0.14)***	0.89 (0.13)***	1.01 (0.14)***	0.82 (0.19)***	0.90 (0.19)***
T1993	0.04 (0.15)	0.06 (0.15)	0.04 (0.14)	0.07 (0.14)	-0.01 (0.19)	0.00 (0.19)
T1994	0.21 (0.15)	0.26 (0.15)*	0.21 (0.14)	0.27 (0.14)*	-0.14 (0.20)	-0.12 (0.20)
T1995	0.23 (0.15)	0.32 (0.15)**	0.21 (0.14)	0.31 (0.14)**	-0.19 (0.20)	-0.14 (0.20)
T1996	0.13 (0.15)	0.24 (0.15)	0.13 (0.14)	0.26 (0.14)*	-0.06 (0.21)	-0.03 (0.21)
T1997	-0.57 (0.16)***	-0.46 (0.16)***	-0.52 (0.14)***	-0.39 (0.15)***	-0.50 (0.21)**	-0.45 (0.21)**
T1998	-0.53 (0.16)***	-0.42 (0.16)***	-0.49 (0.15)***	-0.36 (0.15)**	-0.43 (0.22)*	-0.37 (0.22)*
T1999	-0.16 (0.16)	-0.01 (0.16)	-0.12 (0.15)	0.05 (0.15)	-0.13 (0.23)	-0.04 (0.23)
T2000	-0.33 (0.17)*	-0.15 (0.17)				
T2001	-0.61 (0.18)***	-0.41 (0.18)**				
R^2	0.10	0.09	0.12	0.10	0.08	0.07
σ	1.33	1.33	1.23	1.24	1.16	1.16
σ_ν^2	1.75	1.77	1.50	1.52	1.32	1.33
σ_η^2	2.72	2.88	2.47	2.67	2.03	2.20
Observations	13,859	13,859	11,312	11,312	5,789	5,789
Firms	1,604	1,604	1,602	1,602	770	770

Note: See notes for table 4.

Table 6: Multiple q Estimation: RERIs (1992-)

Sample	All RERIs		All RERIs		In the First Section	
Period	1992-2001		1992-1999		1992-1999	
	(1) with AC	(2) without AC	(3) with AC	(4) without AC	(5) with AC	(6) without AC
$s^K \cdot I^K/K_{-1}$	0.97 (0.40)**	0.80 (0.40)**	1.25 (0.48)***	1.07 (0.48)**	2.71 (0.81)***	2.21 (0.81)***
$s^L \cdot I^L/L_{-1}$	0.36 (0.52)	-0.03 (0.52)	0.83 (0.61)	0.26 (0.61)	2.33 (0.86)***	1.87 (0.84)**
$s^B \cdot AC$	0.37 (0.05)***		0.49 (0.06)***		0.43 (0.08)***	
s^K	3.51 (0.72)***	4.12 (0.72)***	3.15 (0.77)***	3.79 (0.78)***	3.59 (1.02)***	4.12 (1.04)***
s^KT1993	0.39 (0.74)	0.39 (0.74)	0.38 (0.75)	0.40 (0.75)	0.76 (1.05)	0.80 (1.04)
s^KT1994	-0.30 (0.70)	-0.41 (0.70)	-0.31 (0.71)	-0.44 (0.71)	-0.41 (0.98)	-0.44 (0.97)
s^KT1995	-1.25 (0.69)*	-1.35 (0.69)*	-1.32 (0.69)*	-1.41 (0.70)**	-0.92 (0.98)	-1.02 (0.96)
s^KT1996	-1.84 (0.69)***	-1.97 (0.69)***	-1.96 (0.70)***	-2.09 (0.70)***	-0.53 (0.97)	-0.69 (0.96)
s^KT1997	-3.06 (0.69)***	-3.26 (0.69)***	-3.10 (0.70)***	-3.33 (0.70)***	-1.62 (0.97)*	-1.86 (0.96)*
s^KT1998	-3.35 (0.68)***	-3.56 (0.68)***	-3.38 (0.70)***	-3.61 (0.70)***	-2.08 (0.97)**	-2.30 (0.96)**
s^KT1999	-4.04 (0.70)***	-4.28 (0.70)***	-4.03 (0.71)***	-4.28 (0.71)***	-2.95 (1.01)***	-3.12 (1.00)***
s^KT2000	-4.53 (0.70)***	-4.63 (0.70)***				
s^KT2001	-4.60 (0.71)***	-4.76 (0.71)***				
Constant	0.43 (0.20)**	0.64 (0.20)***	0.38 (0.21)*	0.69 (0.21)***	0.12 (0.28)	0.46 (0.27)*
T1993	0.02 (0.21)	0.02 (0.21)	0.03 (0.21)	0.04 (0.21)	-0.06 (0.29)	-0.07 (0.29)
T1994	0.09 (0.20)	0.14 (0.20)	0.10 (0.21)	0.17 (0.21)	0.11 (0.29)	0.15 (0.28)
T1995	0.00 (0.20)	0.10 (0.20)	0.01 (0.21)	0.14 (0.21)	-0.02 (0.29)	0.10 (0.29)
T1996	0.22 (0.21)	0.32 (0.21)	0.25 (0.21)	0.39 (0.21)*	-0.03 (0.30)	0.11 (0.29)
T1997	-0.17 (0.21)	-0.06 (0.21)	-0.15 (0.22)	0.00 (0.22)	-0.38 (0.30)	-0.23 (0.29)
T1998	-0.30 (0.21)	-0.20 (0.21)	-0.28 (0.22)	-0.14 (0.22)	-0.48 (0.31)	-0.35 (0.30)
T1999	0.03 (0.22)	0.17 (0.22)	0.05 (0.23)	0.23 (0.23)	-0.14 (0.33)	0.01 (0.32)
T2000	-0.13 (0.23)	0.01 (0.23)				
T2001	-0.01 (0.24)	0.14 (0.24)				
R^2	0.23	0.22	0.20	0.18	0.18	0.16
σ	1.14	1.15	1.15	1.15	1.18	1.17
σ^2_ν	1.21	1.22	1.23	1.25	1.06	1.11
σ^2_η	2.26	2.49	2.60	3.02	1.39	1.71
Observations	2,343	2,343	1,897	1,897	1,079	1,079
Firms	290	290	289	289	149	149

Notes:

1. See notes for table 4.

Table 7: Multiple q Estimation: Other Nonmanufacturing (1992-)

Sample	All Nonmanu		All Nonmanuring		In the First Section	
Period	1992-2001		1992-1999		1992-1999	
	(1)	(2)	(3)	(4)	(5)	(6)
	with AC	without AC	with AC	without AC	with AC	without AC
$s^K \cdot I^K/K_{-1}$	0.93 (0.30)***	0.90 (0.30)***	0.79 (0.31)**	0.73 (0.31)**	1.67 (0.53)***	1.53 (0.53)***
$s^L \cdot I^L/L_{-1}$	0.66 (0.73)	0.33 (0.72)	1.55 (0.81)*	0.98 (0.80)	1.69 (1.48)	0.48 (1.47)
$s^B \cdot AC$	0.19 (0.05)***		0.33 (0.06)***		0.54 (0.10)***	
s^K	2.51 (0.56)***	2.55 (0.57)***	2.48 (0.56)***	2.56 (0.57)***	0.33 (0.97)	0.34 (0.98)
s^KT1993	0.53 (0.58)	0.53 (0.58)	0.54 (0.53)	0.54 (0.53)	1.14 (0.93)	1.13 (0.93)
s^KT1994	0.03 (0.56)	-0.01 (0.56)	0.09 (0.52)	0.03 (0.52)	1.23 (0.91)	1.19 (0.91)
s^KT1995	-0.47 (0.55)	-0.52 (0.55)	-0.39 (0.51)	-0.49 (0.51)	1.87 (0.89)**	1.75 (0.89)*
s^KT1996	-0.10 (0.54)	-0.17 (0.54)	-0.03 (0.51)	-0.15 (0.51)	2.48 (0.89)***	2.32 (0.89)***
s^KT1997	-1.60 (0.54)***	-1.67 (0.54)***	-1.61 (0.50)***	-1.73 (0.50)***	0.10 (0.89)	-0.06 (0.88)
s^KT1998	-1.56 (0.54)***	-1.63 (0.54)***	-1.64 (0.50)***	-1.76 (0.50)***	0.91 (0.90)	0.81 (0.90)
s^KT1999	0.22 (0.55)	0.11 (0.54)	0.15 (0.51)	-0.04 (0.51)	3.35 (0.91)***	3.10 (0.91)***
s^KT2000	-1.55 (0.55)***	-1.69 (0.55)***				
s^KT2001	-2.35 (0.57)***	-2.48 (0.57)***				
Constant	0.88 (0.21)***	0.97 (0.21)***	0.85 (0.21)***	1.01 (0.21)***	1.37 (0.36)***	1.69 (0.37)***
T1993	0.13 (0.22)	0.14 (0.22)	0.12 (0.21)	0.14 (0.20)	0.08 (0.35)	0.10 0.35
T1994	0.34 (0.22)	0.37 (0.22)*	0.30 (0.20)	0.35 (0.20)*	-0.06 (0.36)	0.00 (0.36)
T1995	0.22 (0.22)	0.28 (0.22)	0.15 (0.20)	0.25 (0.20)	-0.50 (0.36)	-0.37 (0.36)
T1996	0.21 (0.22)	0.28 (0.22)	0.13 (0.21)	0.26 (0.21)	-0.57 (0.37)	-0.40 (0.37)
T1997	-0.13 (0.22)	-0.07 (0.22)	-0.18 (0.21)	-0.06 (0.21)	-0.47 (0.38)	-0.30 (0.37)
T1998	-0.44 (0.23)*	-0.38 (0.23)*	-0.48 (0.21)**	-0.36 (0.21)*	-1.00 (0.39)**	-0.85 (0.39)**
T1999	-0.22 (0.23)	-0.14 (0.23)	-0.28 (0.22)	-0.12 (0.22)	-0.95 (0.40)**	-0.74 (0.40)*
T2000	-0.20 (0.24)	-0.08 (0.24)				
T2001	-0.18 (0.26)	-0.07 (0.26)				
R^2	0.09	0.09	0.10	0.09	0.10	0.09
σ	1.75	1.75	1.62	1.62	1.74	1.74
σ^2_ν	3.02	3.02	2.56	2.56	2.84	2.84
σ^2_η	6.61	6.74	7.18	7.47	6.71	7.18
Observations	7,008	7,008	5,601	5,601	2,291	2,291
Firms	888	888	885	885	327	327

Notes:

1. See notes for table 4.

1992 to 2001, the full sample available in our data set. While the coefficients on the capital investment rate ($s^K \cdot I^K/K_{-1}$) and the agency cost ($s^B \cdot AC$) have the expected positive signs and are statistically significant, those on the land investment rate ($s^L \cdot I^L/L_{-1}$) are insignificant for all the industries. Columns (3) and (4) of table 5 to 7 show the estimation results with the sample period from 1992 to 1999. This sample period means that we drop the observations in 2000, when the stock prices fluctuate vastly due to the IT bubble. Once we include the agency cost, for the manufacturing and other nonmanufacturing industry, the coefficients on partial qs become positive and statistically significant. These estimates imply that at least before 2000, land assets still functioned as a financial instrument in the manufacturing and nonmanufacturing sector.

The statistical support for these positive coefficients on land investment rate is weak, however. They are significant at the marginal 10% level. Furthermore, even including AC and dropping the observations with IT bubble, the coefficient on the RERIs' land-investment rate is statistically insignificant. These ambiguous results disappear when we take the size of the firms into consideration. Columns (5) and (6) of table 5 to 7 restrict the sample of firms to the ones listed in the first section of the stock exchange markets.[13] With this sub-sample, the coefficient on land investment rate of RERIs is positive and becomes statistically significant at the 1% level. More interestingly, the coefficient is much larger than the one with the full-sample RERIs. This result leads to two important findings. First, in the post bubble period, the RERIs listed in the first section implement their land investment following profit maximization behavior, while the other RERIs do not. It seems that it is the large RERIs that altered their land investment behavior after the bursting of the bubble in 1991. Recall the estimates of the land investment function in table 2. It revealed that land investment behavior of the RERIs changed drastically after the bursting of the bubble. Second, without arguing the causality, this estimate

[13]In our data set, the information about the listed exchange markets for each firm is available only at the end of the sample period: year of 2001. In the bubble era, many firms upgraded to the first section of the exchange markets. We thus cannot utilize this information to the estimation for the bubble era.

implies that there is negative feedback in the stock prices and land prices. The large positive coefficient on land investment rate implies that the large RERIs sell much of their land assets when the market evaluation on them declines, that is, when their stock price declines.

A similar argument applies to the manufacturing firms. With the sub-sample of the firms listed in the first section of exchange markets, the estimated coefficient on land investment rate becomes larger and statistically more significant than the one with the full sample. We can argue that, in implementing land investment, large manufacturing firms follow the profit maximization principle, while the other smaller manufacturing firms do not. Except for the large firms, the land assets of manufacturing firms may be more like a fixed cost, and cannot be reduced even in the face of recession. In the case of other nonmanufacturing firms, the coefficient on land investment rate becomes insignificant when we use the sub-sample of the large firms. In fact, in the case of other nonmanufacturing firms, it is the coefficient on capital investment rate that becomes larger with the sub-sample of large firms. This observation may suggest that the large nonmanufacturing firms reduced much of capital investment to cope with their declining stock prices, while the smaller nonmanufacturing firms sold their land assets.

An important finding here is that even after the bursting of the bubble, the land assets continue to play a role of a financial instrument. From table 5 to 7, all the coefficients on agency cost ($s^B \cdot AC$) are positive and statistically significant. For the manufacturing sector, the coefficient on the agency cost of larger firms (column 5 of table 5) is smaller than that of the industry average (column 3 of table 5). From this observation, one might argue that the larger manufacturing firms are getting away from the loan contracts based on the land collateral. We, however, need further examination to confirm such an argument. The smaller coefficient may be due to the significant reduction of debt by larger manufacturing firms in the post bubble era. For the RERIs, between larger firms and smaller firms, there are no significant differences in the size of the coefficient on agency cost. In this industry, land might be the prevailing collateral regardless of the size of the firms. For the other nonmanufacturing firms, the coefficient on agency cost is larger for the larger firms listed in the first section of exchange market. This may reflect the fact that after the bursting of the bubble, many of the large retail and whole sale stores have suffered from the financial distress, and have received many forbearance loans.

5.3 Value of Partial q

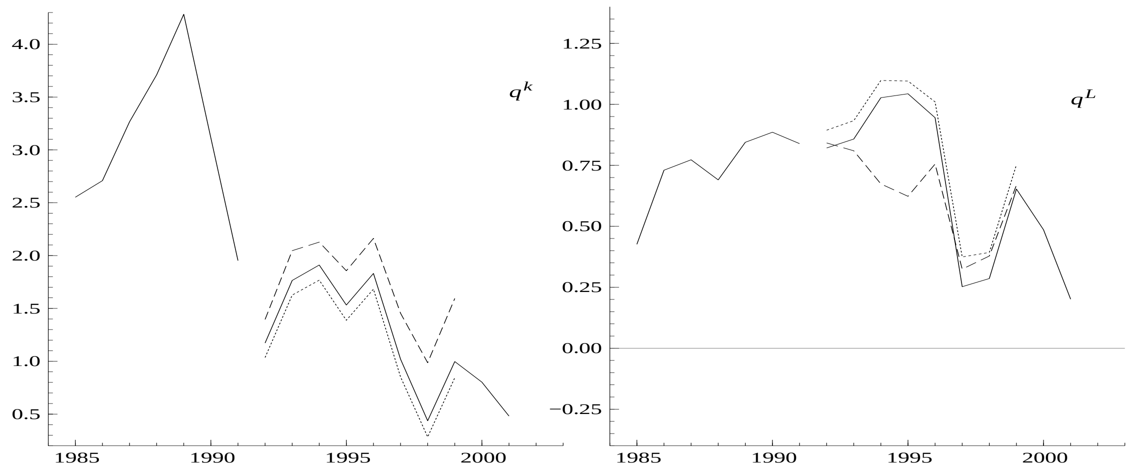
Figure 7 presents the sample means of partial q for the capital and land stocks of individual firms for each year. These partial q estimates are calculated from equations (16) and (17) using the parameters in tables 4–7. The partial q for capital stocks q^K evince a wider swing than those for land stocks q^L, 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 drops more than those for land stocks.

For the manufacturing sector, the partial q for the land stock is around one in the middle of the 1990s, but then drops below one. Since q^L is defined as the ratio of the shadow price to the market price of land assets, 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 stock prices, market prices subsequently exceeded their shadow prices once again. The q^L of larger manufacturing firms listed in the first section show the different development from the industry average. It is below one in the middle of the 1990s.

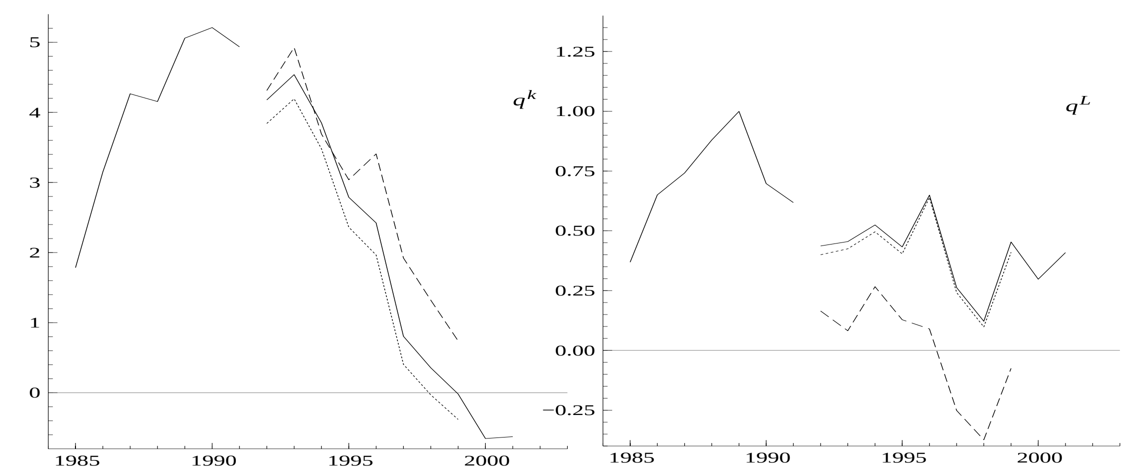
For the RERIs, the partial q for the land stock is less than one throughout the sample period. In particular, the partial q for firms in the first section, for which we obtain statistically sensible parameters, fall to a level around zero (dashed line). This indicates that marginal values (shadow prices)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

Figure 7: q^K and q^L

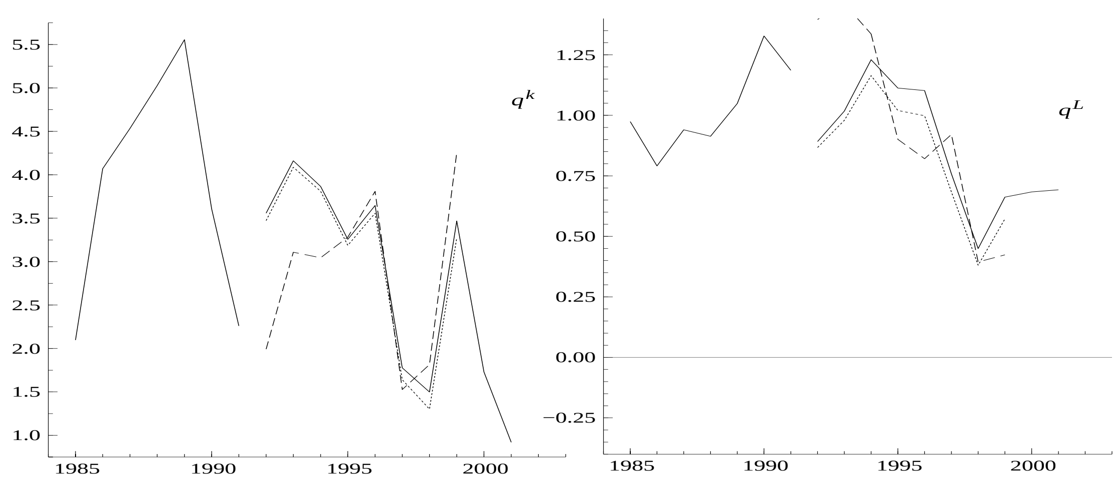
(1) Manufacturing



(2) RERIs



(3) Other nonmanufacturing



Note: Thick solid lines are obtained from parameters in table 4 and columns (1) and (2) of table 5 to 7. Broken lines and dashed lines are obtained from columns (3) and (4), and (5) and (6) in the corresponding tables.

be lower than the market land prices. The q^L of the other nonmanufacturing firms show the similar movement as that of the manufacturing sector. One difference is that in the other nonmanufacturing sector, there is not much difference between q^L of large firms and that of smaller firms.

6 Summary and 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 diverge from their shadow prices (marginal values of land investment). In the analysis, we pay special attention to distinguish the dual roles of land assets: production input and financial instrument as collateral. 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 explicitly.

The main findings of the paper can be summarized as follows. First, 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 their sales and the deterioration in financial conditions after the bursting of the bubble.

Second, in the 1990s, the hike in the overseas production ratio caused manufacturing firms to sell their land stocks. The amount of land sales by the manufacturing firms has been, however, much smaller than that of the RERIs.

Third, the marginal value (shadow price) of land held by the RERIs has been lower than the market land prices 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. For the manufacturing and other nonmanufacturing industries, market land prices declined to the level of their shadow prices around the middle of the 1990s. However, in the face of pessimistic expectations revealed by distressed stock prices after 1997, market land prices have once again found themselves above their shadow prices.

Fourth, there seem to be significant differences between the large firms and small firms in their land investment behavior. In the case of RERIs, the large firms listed in the first section of stock exchange markets seem to have altered their land-investment behavior after the bursting of bubble. Their land investment behavior becomes in line with the conventional investment theory. Whereas the land investment behavior of the smaller RERIs are still at odds with the conventional investment theory.

Lastly, contrary to our expectation, the land assets continue to play a role of financial instrument after the bursting of the bubble. In the estimation of partial q, all the coefficient on agency cost are positive and statistically significant. Estimation result suggests that the large manufacturing firms may have been getting out of the loan contracts based on land collateral. But in general, we confirm that the attempts of Japanese financial institutions to replace their loan contract system relying on land collateral is *not* progressing.

These findings suggest that downward pressure on land prices in Japan 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. The impact of the latter is, however, far smaller. 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, as of March 2003, about 40 percent of risk management loans are those made to construction and real estate industries. To further clarify the link between asset prices and real economic activities, it is necessary to make an explicit analysis on the interactions between financial institutions and asset prices. For such an analysis, the experiences of the Japanese economy will provide an important source of information.

References

ASAKO, K., M. KUNINORI, T. INOUE, AND H. MURASE (1997): "Setsubi Toshi to Tochi Toshi: 1977-1994 [Capital Investment and Land Investment: 1977-1994]," in *Gendai Makro Keizai Dougaku [Contemporry Dynamic Macroeconomics]*, ed. by K. Asako, and M. Ootaki, chap. 9, pp. 323–349. Tokyo Daigaku Shutspankai [University of Tokyo Press], Tokyo.

BAKER, M., J. C. STEIN, AND J. WURGLER (2003): "When Does the Market Matter?: Stock Prices and the Investment of Equity-Dependent Firms," *Quarterly Journal of Economics*, 118(3), 969–1005.

BOND, S., J. A. ELSTON, J. MAIRESSE, AND B. MULKAY (2003): "Financial Factors and Investment in Belgium, France, Germany, and the United Kingdom: A Comparison Using Company Panel Data," *Review of Economics and Statistics*, 85(1), 153–165.

BOND, S., AND C. MEGHIR (1994): "Dynamic Investment Models and the Firm's Financial Policy," *Review of Economics Studies*, 61, 197–222.

BORDO, M. D., AND O. JEANNE (2002): "Boom-Busts in Asset Prices, Economic Instability, and Monetary Policy," NBER Working Paper 8966, National Bureau of Economic Research.

CHATELAIN, J. B., A. GENERALE, I. HERNANDO, U. VOL KALCKREUTH, AND P. VERMEULEN (2002): "Firm Investment and Monetary Policy Transmission in the Euro Area," Paper presented at 10th International Conference on Panel Data, Berlin, July 5-6, 2002.

CHIRINKO, R. S., AND H. SCHALLER (2001): "Business Fixed Investment and "Bubbles": The Japanese Case," *American Economic Review*, 91(3), 663–680.

DIXIT, A. K., AND R. S. PINDYCK (1994): *Investment Under Uncertainty*. Princeton University Press, Princeton, New Jersey.

DOORNIK, J. A. (2001): *Ox 3.0: Object-oriented Matrix Programming Language*. Timberlake Consultants Press, London, 4th ed. edn.

DOORNIK, J. A., M. ARELLANO, AND S. BOND (2001): "Panel Data Estimation Using DPD for Ox," available from http://www.nuff.ox.ac.uk/users/doornik/.

GREENE, W. H. (2003): *Econometric Anaysis*. Prentice Hall, New Jersey, 5th ed. edn.

HAYASHI, F. (1982): "Tobin's Marginal q and Average q: A Neoclassical Interpretation," *Econometrica*, 50(1), 213–224.

HOSHI, T., AND A. KASHYAP (1990): "Evidence on q and Investment for Japanese Firms," *Journal of the Japanese and International Economies*, 4, 371–400.

JARAMILLO, F., F. SCHIANTARELLI, AND A. WEISS (1996): "Capital Market Imperfections before and after Financial Liberalization: An Euler Equation Approach to Panel Data for Ecuadorian Firms," *Journal of Development Economics*, 51(2), 367–386.

JORGENSON, D. W. (1963): "Capital Theory and Investment Behavior," *American Economic Review*, 53(2), 247–259.

KIYOTAKI, N., AND J. MOORE (1997): "Credit Cycles," *Journal of Political Economy*, 105(2), 211–248.

NAGAHATA, T., AND T. SEKINE (2002): "The Effects of Monetary Policy on Firm Investment after the Collapse of the Asset Price Bubble: An Investigation Using Japanese Micro Data," *Research and Statistics Department, Bank of Japan, Working Paper*, No. 02-03.

OGAWA, K., AND K. SUZUKI (1998): "Land Value and Corporate Investment: Evidence from Japanese Panel Data," *Journal of the Japanese and International Economies*, 12(3), 232–249.

ROSETT, R. N. (1959): "A Statistical Model of Friction in Economics," *Econometrica*, 27(2), 263–267.

SEKINE, T. (1999): "Firm Investment and Balance-Sheet Problems in Japan," IMF Working Paper, WP/99/111, International Monetary Fund: Washington D.C.

SEKINE, T., AND T. TACHIBANA (2004): "Land Investment by Japanese Firms during and after the Bubble Period," Bank of Japan Working Paper Series, No.04-E-2, Bank of Japan: Tokyo.

TRAIN, K. E. (2003): *Discrete Choice Methods with Simulation.* Cambridge University Press, Cambridge.

WILDASIN, D. E. (1984): "The q Theory of Investment with Many Capital Goods," *American Economic Review*, 74(1), 203–210.

WOODFORD, M. (2003): *Interest & Prices.* Princeton University Press, Princeton, New Jersey.

Appendix A: Multiple q with Agency Costs

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

$$\begin{aligned} V_0 &= \max \int_0^\infty \Pi_t \exp\left(\int_0^t -r(s)ds\right) dt, \\ &\quad \text{subject to equations (4), (5), (6) in the main text.} \end{aligned}$$

The current value Hamiltonian of this maximization problem is:

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

Here, λ_t^K, λ_t^L and λ_t^D are the Lagrange multipliers showing the shadow prices of K_t, L_t and D_t in period t. In this specification, we consider the firms which make new borrowing.

The first order conditions (FOCs) of this maximization problem can be summarized in the following seven equations and the equations (4), (5), (6) in the main text.

$$w_t = p_t F(.)_{N_t}, \tag{A.1}$$

$$\lambda_t^K = p_t^K \left\{1 + G_{I_t^K}\right\}, \tag{A.2}$$

$$\lambda_t^L = p_t^L \left\{1 + C_{I_t^L}\right\}, \tag{A.3}$$

$$\lambda_t^D = -\left\{1 - \phi\left(\frac{p_t^L L_t}{D_t}\right)\right\}, \tag{A.4}$$

$$\dot{\lambda}_t^K = (r+\delta)\lambda_t^K + p_t^K G_{K_t} - p_t F_{K_t}, \tag{A.5}$$

$$\dot{\lambda}_t^L = r\lambda_t^L + p_t^L C_{L_t} + \phi'(.)\frac{p_t^L}{D_t} ND_t - p_t F_{L_t}, \tag{A.6}$$

$$\dot{\lambda}_t^D = r\lambda_t^D + i_t - \phi'(.)\frac{p_t^L L_t}{{D_t}^2} ND_t. \tag{A.7}$$

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

$$\begin{aligned} \lim_{t\to\infty} \lambda_t^K K_t \exp\left(-\int_0^t r(s)ds\right) &= 0, \\ \lim_{t\to\infty} \lambda_t^L L_t \exp\left(-\int_0^t r(s)ds\right) &= 0, \\ \lim_{t\to\infty} \lambda_t^D D_t \exp\left(-\int_0^t r(s)ds\right) &= 0. \end{aligned}$$

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

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

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 (A.4) into the equation above generates

$$\lambda_0^K K_0 + \lambda_0^L L_0 + \phi(.) B_0 = V_0 + B_0. \tag{A.8}$$

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 (8). In this model, the q for each capital good is represented by the ratio of its shadow price to its market price. For the firms that reducing the outstanding debt, the equation(A.8) degenerate to the traditional form of multiple q.

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

Appendix B: Data Appendix

This appendix describes how we construct some variables in the paper. About the two important variables, land investment and land assets, the details of construction are available on request. Then we explain the criteria for excluding outliers in the land investment variable. 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).

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 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).

Criteria to Exclude Outliers in Land Investment

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, we remove two firms from the sample.

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 (1985-1991) or the post-bubble period (1992-2001).