The Study of Swiss Investment Expenditures using Tobin's q Model 1948-1995

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Abstract

The purpose of this paper is to explain, using Tobin's q investment model, the Swiss investment movements from 1948 to 1995. This paper adds to previous work in two ways: firstly, it puts forward how to adjust the model so as to take into account some possible stock exchange disturbances, and secondly, it provides evidence that cash flow is a key determinant of the investment behavior. The results reveal that Tobin's q model is relevant in explaining the Swiss investment movements only after controlling for the disturbances which begun in 1985.

Keywords: Investment, Tobin's q model, Cash flow.

1. Introduction

Investment is arguably the most important economic variable. Its wide fluctuations reinforce the business cycle. Also, current capital expenditures condition the level and the composition of the future capital stock and therefore influence the potential growth of the economy.

There exists a large theoretical and empirical literature on investment, trying to detect and model the factors that help explain and predict its movements, both in the short run and in the long run. This literature is mainly dominated by two theories of investment: the neoclassical theory originated by Jorgenson (1963) and later developed in his work (1972, 1996a, and 1996b) and the q theory suggested by Tobin in 1969. The neoclassical theory starts from a firm's optimization behavior, wherein the present discounted of firm's net cash flow is maximized subject to its production and capital stock functions. The flows of investment are function of adjustment costs in changing capital stock. While, the q theory suggests that the rate of investment is function of marginal q, the ratio of the firm market value of new additional investment goods to their replacement cost. This theory draws inspiration from neoclassic fundaments, in that first, it is derived from the firm's optimization and second, the adjustment costs reflected by the marginal Tobin's q are important in determining the flow of investment. The marginal q includes all information needed for taking an investment decision, unfortunately, this is

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an unobservable variable. To solve this problem, Tobin suggests an observable variable as a proxy for marginal q. This variable, called Tobin's q or average q, can be defined as the ratio of the market value of the firm to the replacement cost of its capital stock.

Among empirical applications of Tobin's q model are Hayashi (1982) and Zarin-Nejadan (1989) who found evidence for Tobin's q in explaining respectively the US investment behavior from 1952 to 1978 and Swiss investment behavior from 1948 to 1986.

The aim of the present study is to analyze the determinants of investment in Switzerland. In particular, I examine the importance of the variable "marginal q" in determining the flow of investment. In this paper, a theoretical model is developed along these lines. It is then tested empirically using Swiss data over the period 1948-1995.

This paper is organized as follows. In the next section, I develop the basic theoretical framework of Tobin's q model used in this study to explain the Swiss investment behavior. In section 3, I discuss the empirical implementation of the model. In section 4, I introduce and describe the data. In section 5, I present the empirical results. Finally, the main results are summarized in the conclusion.

2. Development of Theoretical Framework of Tobin's q model

This section aims at developing the investment model suggested by James Tobin in 1969 and formalized by Hayashi (1982). Based on such a model, investments is shown to be a function of marginal q. Tobin's q model is the result of the maximization of the firm's present value under the capital accumulation constraint. The firm's present value is given by

$$\varpi = \int_0^{\infty} R(t)\exp\left[-\int_0^{t} r(s)ds\right]dt \qquad (2.\ 1)$$

where r is the discount rate and R is the firm's profit less its investment expenditures. I assume that cash flow is the only source which firms use to finance their investment projects and for the sake of simplicity I don't take into account taxation. Then, $R(t)$ is given by

$$R(t)=\pi(t)-p(t)\mathrm{I}(t) \qquad (2.\ 2)$$

where p is the price of output as well as investment goods, I is the gross investment, and π is the profit, given by

$$\pi(t)=p(t)[F(\mathrm{K}(t),\mathrm{N}(t))-\phi[\mathrm{I}(t),\mathrm{K}(t)]]-\gamma(t)\mathrm{N}(t) \qquad (2.\ 3)$$

where K is the stock of capital, N is the labor force, γ is the wage rate, and F is the production function. In addition, equation (2. 3) integrates the adjustment costs ϕ which are an increasing and convex function of I [1].

Y is the real output, related to capital and labor as follows

[1] Further explanations are given in Ben Hamida, L. (2002).

$$\mathrm{Y}(t) = F[\mathrm{K}(t), \mathrm{N}(t)] \tag{2. 4}$$

Hence, the problem of maximization can be written as follows

$$Max\ \omega = \int_0^{\infty} [\pi(t) - p(t)\mathrm{I}(t)] \exp\left[-\int_0^t r(s)ds\right] dt \tag{2. 5}$$
$$\text{under the constraint : } \dot{\mathrm{K}}(t) = \mathrm{I}(t) - d\mathrm{K}(t)$$

where d is the depreciation rate of capital.
The first condition equations are the following

$$F_{\mathrm{N}} = \frac{\gamma}{p} \tag{2. 6a}$$

$$p(1 + \phi_I) = \lambda \tag{2. 6b}$$

$$\dot{\lambda} = (r + d)\lambda - p(F_{\mathrm{K}} - \phi_{\mathrm{K}}) \tag{2. 6c}$$

where λ is the shadow price related to the capital accumulation constraint and the dot over indicates its time derivative.
Equation (2.6a) describes the neoclassical marginal condition. Equation (2.6c) interprets the shadow price λ as the present value of the future extra profits resulting from the installation of one further unit of investment. And equation (2.6b) shows that the marginal revenue of the installation of an additional unit of investment goods is equal to its cost.

By resolving the first order condition equations, under the assumption that ϕ is homogeneous of degree 1 in I and K, I derive the investment function which relates the capital accumulation ratio to the marginal q variable

$$\frac{\mathrm{I}}{\mathrm{K}} = \beta(q_m) \quad \text{with } \beta > 0\text{, and } q_m = \frac{\lambda}{p} \tag{2. 7}$$

where $\frac{\mathrm{I}}{\mathrm{K}}$ is the capital accumulation rate and q_m is the marginal q.

Therefore, according to this model, the marginal q variable represents the main determinant of investment. This variable is defined as the ratio of the increase of firm's value resulting from the installation of one further unit of investment to the cost of this unit.

3. Empirical Implementation of Tobin's q model

In this section, I discuss the empirical application of the Tobin's q model developed in section 2. As previously noted the marginal q variable is unobservable and can be substituted by the Tobin's q variable or the average q. This variable can be defined as the ratio of the market value of the firm to the replacement cost of its capital stock. If this ratio is less than or equal to unity, then there is no incentives for the firm to invest in plant and equipment. In this case, the firm's shareholders could earn a higher return elsewhere. If the value of Tobin's q is grater than unity, then the firm should invest in capital goods in order to maximize the return to its shareholders. From a macroeconomic point of view, Tobin's q is presented as the ratio of the firms' stock market capitalization to the replacement cost of their physical capital

$$q = \frac{V}{p\mathrm{K}} \tag{2. 8}$$

where V is the stock market capitalization of private firms and pK is the replacement cost of their physical capital.

Hence, Tobin's q investment model becomes

$$\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_t = \alpha + \beta_1 q_t + \beta_2 \left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{t-1} + \xi_t \tag{2. 9}$$

where $\frac{\mathrm{I}}{\mathrm{K}}$ is the rate of capital accumulation, $\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{t-1}$ is the lagged rate of capital accumulation and refers to the investment process lags, q_t is Tobin's q, and α is an intercept . The residual ξ is initially assumed to be identically and independently distributed.

A further variable that can play an important role in explaining investment behavior is the cash flow. This variable, first suggested by Meyer and Kuh (1957), represents the firm's self-financing capacity and is supposed to facilitate investment by procuring low-cost and less constrained financing. I propose to include in the equation (2.9) the cash flow variable (caf) as follows

$$\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_t = \alpha + \beta_1 q_t + \beta_2 \left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{t-1} + \beta_3 \left(\frac{caf}{\mathrm{K}}\right)_t + \xi_t \tag{2.10}$$

I note that the Tobin's q can also be (arithmetically) defined as a ratio of the expected rate of return on capital (Ra) to the expected cost of capital (Ca) (Zarin-Nejadan, 1989). The expected rate of return on capital is defined as the ratio of the expected profits (π_a) to the nominal value of the capital stock. While, the expected cost of capital is defined as the ratio of the expected profits to the stock market value of the firm. Tobin's q variable can then be rewritten in the following way

$$q_t = \frac{V}{p\mathrm{K}} = \frac{\pi_a / p\mathrm{K}}{\pi_a / V} = \frac{Ra}{Ca} \tag{2.11}$$

Since expected profits (π_a) are unobservable, they can be replaced by the ex post realized profits.
In order to compare the separate impacts of these variables (Ra and Ca) with that of Tobin's q presented in model (2.9), I can rewrite this equation differently

$$\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_t = \alpha + \beta_2\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{t-1} + \beta_3\left(\frac{caf}{\mathrm{K}}\right)_t + \beta_4 Ra_t + \beta_5 Ca_t + \xi_t \quad (2.12)$$

I use the ordinary least squares method to estimate the models (2.9), (2.10) and (2.12).

4. Description and interpretation of the data

In the present study I am interested in flows of fixed capital formation by Swiss private firms. These flows are defined as the sum of private expenditures in equipment and nonresidential structures. I applied these data to explain the behavior of Swiss private investment from 1948 to 1995[2].

Figure 1 shows the profiles of Swiss Tobin's q for structures, equipment, and both (respectively q_s, q_e, and q). These profiles have the same trend and present overestimated values of Tobin's q from 1987 to 1995. This overestimation can be attributed to the widening gap between the real investment decisions of the firms and the financial market fluctuations since mid-1980s. In fact, this separation is explained by the strong growth of stock market capitalization since 1985[3]. This growth might be the result of speculative movements.

Furthermore, figures 3, 4 and 5 depict the profiles of Tobin's q and the capital accumulation rate respectively for q, q_e, and q_s. In these three figures, the trends of Tobin's q and the capital accumulation rate have a quasi-perfect match, with a certain time lag, from 1948 to 1985 but they diverge since 1986. This divergence could be the consequence of the financial market boom that started in mid-1980s. To solve this problem and yet to bring out the relevance of Tobin's q variable in explaining Swiss investment movements from 1948 to 1995, I propose to integrate in the model an additional explanatory variable that includes information about this boom.

In addition, Tobin's q can be written as the ratio of the expected rate of return on capital (Ra) to the expected cost of capital (Ca). Figure 6 shows the profile of the expected rate of return on capital from 1948 to 1995. It has an increasing trend from 1948 to 1972 and then decreases from 1973 to 1995. This trend is similar to the profile of the share of profits in gross domestic product (GDP)[4]. Thus, I can assert that Ra's behavior is the result of the trend of profit share in GDP.

Figure 8 presents the profile of the expected cost of capital from 1948 to 1995. It has an increasing trend from 1963 to 1982 and decreases from 1982 to 1995. The Ca's trend is negatively correlated to the evolution of capital accumulation rate from 1948 to

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[2] The data definitions and sources are given in appendix.
[3] Figure 2 depicts the evolution of Swiss stock market capitalization.
[4] Figure 7 shows the profile of profit share in GDP.

1995[5]. The investment rate has a decreasing trend from 1963 to 1984 and then an increasing trend for the remaining period.

5. Estimation Results and Analysis

The estimation results of the Tobin's q investment model (2.9) for the period 1948-1986 confirms those realized by Zarin-Nejadan (1989) for the same period. In addition, these results remain valid even when investment is composed into equipment and nonresidential structures. The coefficients take their theoretically expected signs and are significant. The Chow tests of the inter-temporal stability of investment equations corroborate the model for all three investment specifications (structures, equipment and aggregate). Therefore, variables q_s, q_e and q can be considered as relevant leading indicators of Swiss private investments from 1948 to 1986.

Nonetheless, model (2.9) performs less well when I extend the period of observation to 1995. The coefficients of variables q_s, q_e and q take their theoretically expected signs but are not significant[6]. Thus, these variables seem not to be appropriate leading indicators of Swiss private investment for the entire period from 1948 to 1995. Still, I obtain a good fit ($\overline{R}^2$) in equations (1), (9) and (14). Therefore, I can assume that q_s, q_e and q explain a fair amount of variance of the capital accumulation rate during the extended period, despite their weak significance.

To solve the problem of variables insignificance, I propose to add a dummy variable noted k in equations (1), (9) and (14). k is a binary variable (1 or 0) defined in accordance with the presence or not of the presumed speculative movements on the stock market. Indeed, I have assumed that the stock market "bubble", which dates back to mid-1980s, is the main source of insignificance of the variables q_s, q_e and q in explaining the Swiss investment behavior. The dummy variable is defined as follows: in the equations (2) and (15), it takes the value 0 from 1948 to 1990 and the value 1 from 1991 to 1995; in equation (10), it takes the value 0 from 1948 to 1989 and the value 1 from 1990 to 1995. My choice is based on two statistical criteria: $\overline{R}^2$ and the standard error of regression. I vary the period in which k takes the value 1 and then choose the equation that has the maximum $\overline{R}^2$ and the minimum standard error of regression. The dummy variable k takes the theoretically expected sign and is significant[7]. Finally, the equations (1), (9) and (14) are re-specified as follows:

- for the private equipment:

$$\left(\frac{\mathrm{I}_e}{\mathrm{K}_e}\right)_t = \alpha + \beta_1 q_{e,t-1} + \beta_2\left(\frac{\mathrm{I}_e}{\mathrm{K}_e}\right)_{t-1} + \beta_3\left(\frac{caf}{\mathrm{K}}\right)_t + \beta_4 k_t + \xi_t \qquad (3.\ 1)$$

- for the private nonresidential structures :

[5] Figure 3 analyzes the profile of the capital accumulation rate.
[6] Eq. 1, 9, and 14.
[7] Eq. 2, 10, and 15.

$$\left(\frac{\mathrm{I}_s}{\mathrm{K}_s}\right)_t = \alpha + \beta_1 q_{s,t} + \beta_2 \left(\frac{\mathrm{I}_s}{\mathrm{K}_s}\right)_{t-1} + \beta_3 \left(\frac{caf}{\mathrm{K}}\right)_t + \beta_4 k_t + \xi_t \qquad (3.\ 2)$$

- for private aggregate investment :

$$\left(\frac{\mathrm{I}}{\mathrm{K}}\right)_t = \alpha + \beta_1 q_t + \beta_2 \left(\frac{\mathrm{I}}{\mathrm{K}}\right)_{t-1} + \beta_3 \left(\frac{caf}{\mathrm{K}}\right)_t + \beta_4 k_t + \xi_t \qquad (3.\ 3)$$

Using these new versions of the models, all coefficients take their theoretically expected signs and are significant[8]. $\overline{R}^2$ remains relevant in equations (2), (10) and (15) . Therefore, I can conclude that q_s, q_e and q have significant impacts on Swiss investments. Furthermore, the Chow tests of inter-temporal stability of investment functions confirm the robustness of the results for the three investment specifications (structures, equipment and aggregate)[9].

As shown above, Tobin's q can be written as the ratio of the expected rate of return on capital (Ra) to the expected cost of capital (Ca). This modelisation shows as good a fit as the model (2.9). Although the coefficient of Ra is significant, that of Ca is not, these two variables takes their theoretically expected signs[10]. In addition, the F statistic rejects the hypothesis of equality between the coefficients of variables Ra and Ca [11]. Therefore, the expected cost of capital is dominated by the expected rate of return on capital because (Ra) is significant while (Ca) is not. Hence, Ra reflects by itself the whole information embodied by Tobin's q.

Finally, the coefficient of the cash flow variable takes its theoretically expected sign and is significant[12]. Therefore, I conclude that financial liquidity has a positive impact on Swiss investment movements.

6. Conclusion

Tobin's q investment model turns out to be a powerful tool for explaining the Swiss investment behavior from 1948 to 1986. It can be applied either to equipment or to nonresidential structures or to aggregate investment. However, the model becomes less irrelevant when the period of observations is extended to 1995. This decrease in the performance of the model can a priori be explained by the stock market disturbances, which intensified since mid-1980s. To solve this problem and check the "bubble" hypothesis, I have introduced a dummy variable which takes the value 1 for the occurrence of the speculative movements on the stock market and 0 otherwise. In the presence of this variable, all regression coefficients take their theoretically expected signs and become significant. Therefore Tobin's q remains a relevant leading indicator of Swiss private investment even during the extended period, when the "bubble"

[8] Eq. 2, 10 and 15.
[9] Eq. 6, 7, 11, 12, 16 and 17.
[10] Eq. 3
[11] Eq. 4 and 5.
[12] Eq. 8, 13 and 18.

phenomenon is taken into account. Financial liquidity also plays a significant role in explaining the investment flows.

Future studies should focus on including other variables such as taxes[13] and technological changes, which may determine the behavior of investment.

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[13] In this respect, one could see Jorgenson (1996), Hall and Jorgenson (1967), and Poterba et al. (1982) for further discussions.

Figures:

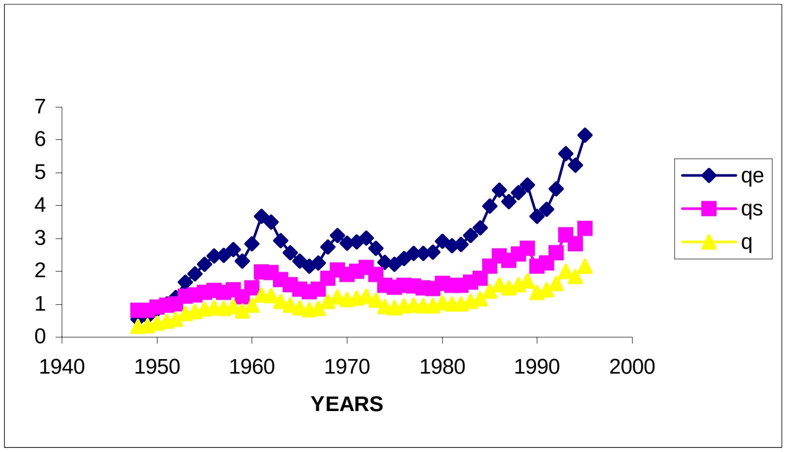

Figure 1 q, qe, qs

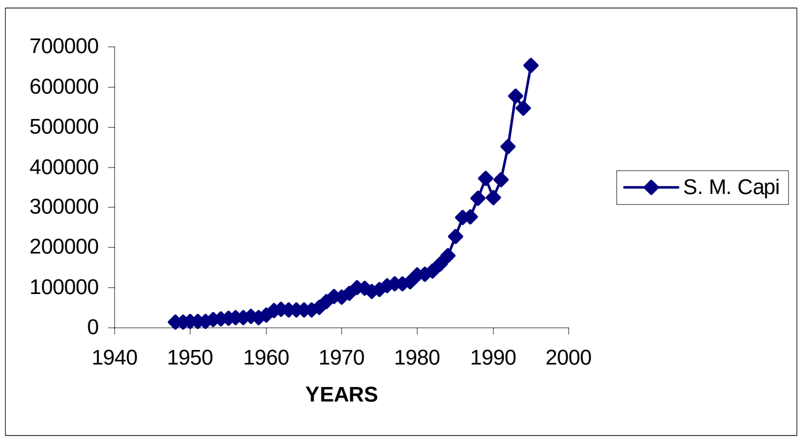

Figure 2 The Swiss stock market capitalization (CHF m)

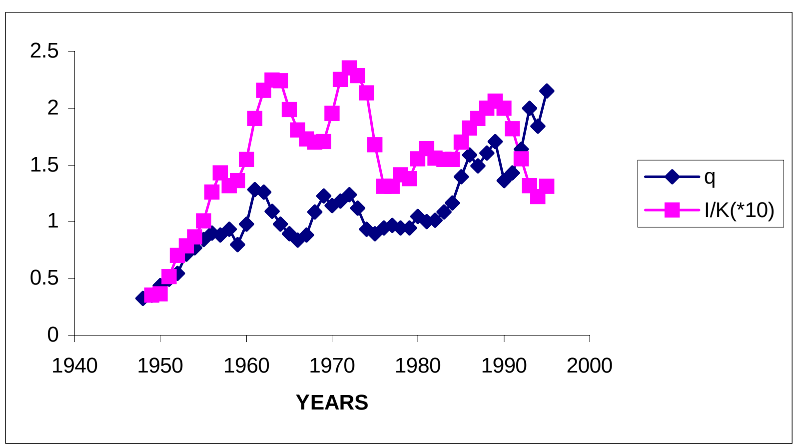

Figure 3 q, I/K(*10)

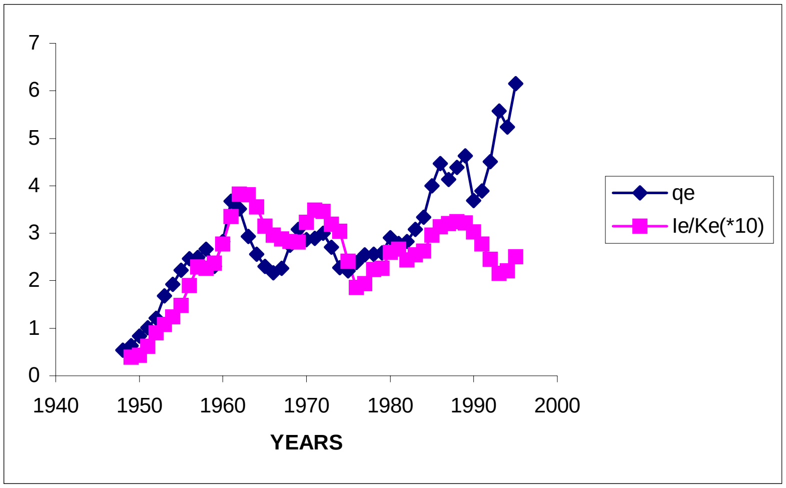

Figure 4 qe, Ie/Ke (*10)

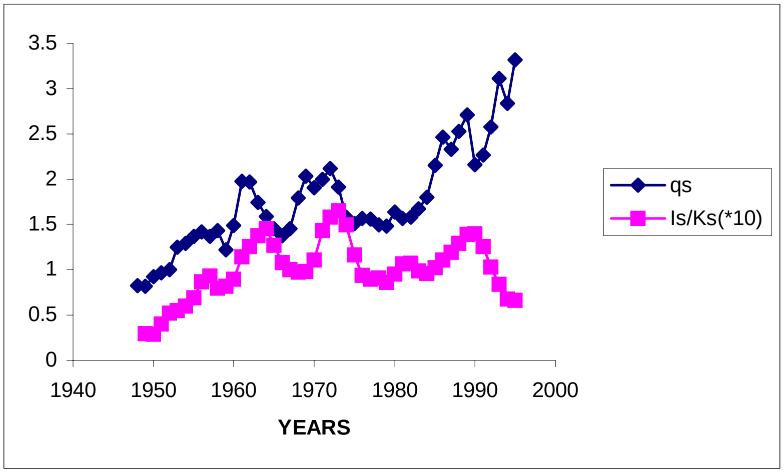

Figure 5 qs, Is/Ks (*10)

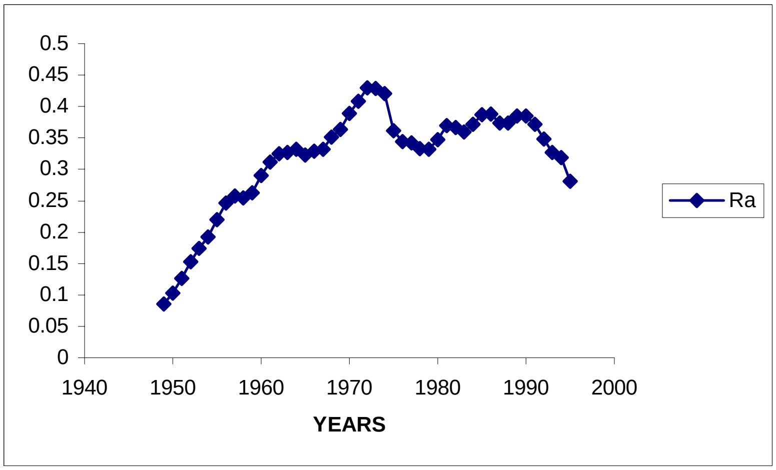

Figure 6 The expected rate of return on capital (%)

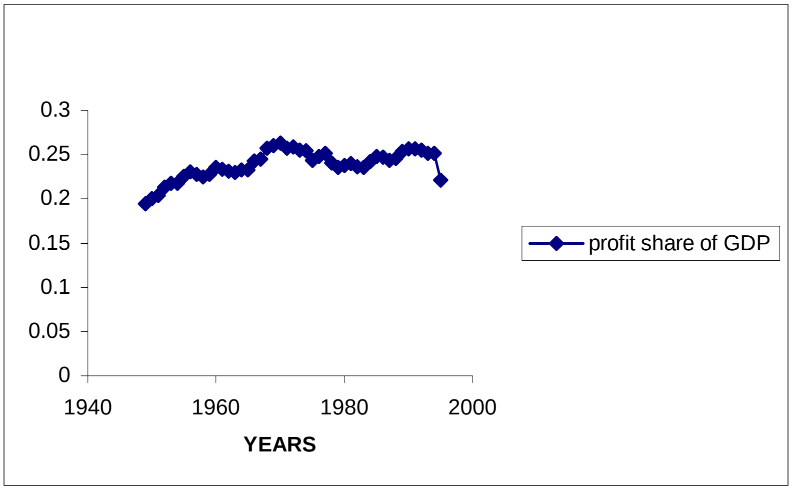

Figure 7 The profit share of GDP (%)

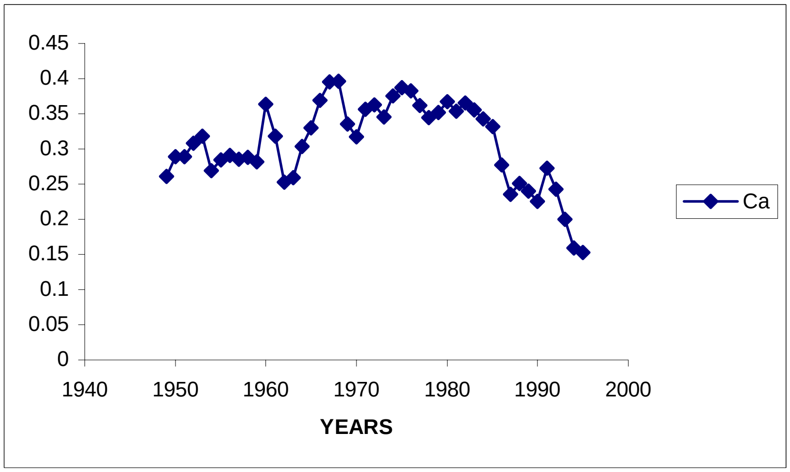

Figure 8 The expected cost of capital (%)

Tables:

Table 1: Estimation results of the function of capital accumulation rate from 1948 to 1995

Dependent variable: $\left(\frac{I}{K}\right)_t$

Expla. Var.	Eq. 1	Eq. 2	Eq. 3	Eq. 4	Eq. 5	Eq. 6	Eq. 7	Eq. 8
Const.	0.03 (0.08)	0.02 (0.02)	-0.06 (0.03)	-0.69 (2.33)	-0.069 (0.33)	0.017 (0.009)	0.019 (0.03)	-0.09* (0.02)
q_t	0.013 (0.014)	0.02* (0.01)		0.04 (0.11)		0.07* (0.01)	0.026* (0.011)	
q_{t-2}								0.03* (0.01)
k		-0.028* (0.011)					-0.029* (0.011)	
Ra_t			0.57* (0.10)		1.31 (0.24)			
Ca_t			-0.08 (0.05)		-0.129 (0.09)			
$\left(\frac{caf}{K}\right)_t$								0.74* (0.11)
$\left(\frac{I}{K}\right)_{t-1}$	0.70 (0.55)	0.72 (0.14)	0.37* (0.11)	0.61 (1.35)	0.27 (0.11)	0.72* (0.05)	0.68* (0.18)	0.35* (0.09)
$\hat{\rho}$	0.315	0.215	0.265	0.375	0.245	0.205	0.155	0.075
$\bar{R}^2$	0.926	0.928	0.948	0.937	0.955	0.968	0.817	0.959
S. E	0.012	0.011	0.009	0.08	0.067	0.01	0.01	0.008
F				F(1,41)	= 18.2	F(4,37	= 1.79	
No. Obs.	45	45	45	45	45	22	23	45

The estimated standard errors in brackets.
$\bar{R}^2$: The corrected coefficient of multiple determination.
S. E: The estimated standard errors of regression.
F (m,n) : Fisher's statistic : F (1,41) = 4.08 and F (4,37) = 2.619 at the 95% confidence level.
$\hat{\rho}$: First-order autocorrelation coefficient.
All equations have been corrected for first-order autocorrelation.
*** Denotes significance at the 5% level.**

Table 2: Estimation results of the function of capital accumulation rate of private equipment from 1948 to 1995

Dependent Variable : $\left(\frac{I_e}{K_e}\right)_t$

Expla. Var.	Eq. 9	Eq. 10	Eq. 11	Eq. 12	Eq. 13
Const.	0.058 (0.099)	0.043 (0.042)	-0.007 (0.011)	0.036 (0.04)	0.11* (0.05)
$q_{e,t}$	0.009 (0.008)		0.047* (0.009)		
$q_{e,t-1}$		0.018* (0.007)		0.02* (0.007)	
$q_{e,t-2}$					0.018* (0.007)
k		-0.038* (0.018)		-0.04* (0.01)	
$\left(\frac{caf}{K}\right)_t$					0.99* (0.22)
$\left(\frac{I_e}{K_e}\right)_{t-1}$	0.67 (0.41)	0.66* (0.16)	0.62* (0.069)	0.62* (0.18)	0.32* (0.13)
$\hat{\rho}$	0.19	0.175	0.135	0.13	0.2
$\overline{R}^2$	0.927	0.932	0.974	0.76	0.948
S.E.	0.02	0.019	0.016	0.02	0.015
F			F(4,37)	=1.55	
No. Obs.	45	45	22	23	45

The estimated standard errors in brackets.

$\overline{R}^2$ **: The corrected coefficient of multiple determination.**

S. E: The estimated standard errors of regression.

F (m,n) : Fisher's statistic: F (4,37) = 2.619 at the 95% confidence level.

$\hat{\rho}$ **: First-order autocorrelation coefficient**

Table 3: Estimation results of the function of capital accumulation rate of private nonresidential structures from 1948 to 1995

Dependent Variable : $\left(\frac{I_s}{K_s}\right)_t$

Expla.Var.	Eq. 14	Eq. 15	Eq. 16	Eq. 17	Eq. 18
Const.	0.020 (0.05)	0.008 (0.018)	-0.016 (0.009)	0.005 (0.024)	-0.08* (0.024)
$q_{s,t}$	0.005 (0.007)	0.012* (0.005)		0.011* (0.005)	
$q_{s,t-2}$			0.03* (0.008)		0.012* (0.005)
k		-0.026* (0.008)		-0.023* (0.007)	
$\left(\frac{caf}{K}\right)_t$					0.55* (0.09)
$\left(\frac{I_s}{K_s}\right)_{t-1}$	0.703 (0.63)	0.74* (0.136)	0.71* (0.082)	0.72* (0.19)	0.4* (0.10)
$\overline{R}^2$	0.885	0.901	0.922	0.86	0.93
$\hat{\rho}$	0.33	0.225	0.295	0.385	-0.06
S. E.	0.009	0.009	0.009	0.007	0.007
F			F(4,37) = 1.01		
No. Obs.	45	45	22	23	45

The estimated standard errors in brackets.

$\overline{R}^2$ **: The corrected coefficient of multiple determination.**

S. E: The estimated standard errors of regression.

F (m,n) : Fisher's statistic: F (4,37) = 2.619 at the 95% confidence level.

$\hat{\rho}$ **: First-order autocorrelation coefficient**

All equations have been corrected for first-order autocorrelation.

*** Denotes significance at the 5% level.**

Appendix: Variable definitions and data sources

I_s **:** the private nonresidential structures.

I_e **:** the private equipment.

K **:** the capital stock. I calculate a value of this variable by applying the method of permanent inventory. The value of the capital stock from 1948 to 1986 is given by Zarin-Nejadan (1989).

d **:** the rate of depreciation. It is fixed at 4% for structures and 20% for equipment.

V **:** Stock market capitalization**.** The data for 1948 to 1986 are given by Zarin-Nejadan (1989). Those of the rest of the period are obtained by using the statistics of Zurich stock exchange.

Π_a **:** expected profits.

These profits are calculated in the following way, in which data are provided by the Federal Bureau of Statistics

$$\begin{aligned}\Pi_a &= \text{surplus net of exploitation} + \text{saving of private firms} \\ &\quad + \text{payment of interest} + \text{depreciation of fixed capital} + \text{direct taxes}\end{aligned}$$