The Asset Price and Investment Technology

자본재 비용함수가 자산가격 변동에 미치는 영향 분석

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This paper evaluates the importance of investment installment costs in a sticky price model by comparing two different adjustment cost specification: one depends upon investment-to-capital stock ratio, and the other depends upon investment growth. The two specifications are considered since the former has been adopted in the empirical literatures and the latter has been adopted in the theoretical literatures. The adjustment cost specifications affects the relationship between asset price and value of capital stock, and also the dynamic process of investment and output. When the installment cost depends upon the investment growth, there is a stronger positive asset price response to a positive technology shock. In addition the investment growth specification generates a hump-shaped response of investment and output, that is frequently observed in the empirical literatures.

Key words: Asset price, Average q, Investment adjustment costs, Marginal q
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Ⅰ. Introduction

Whereas in the long-run the supply of new capital, i.e. investment, is relatively elastic, in the short-run investment is inelastic. One modeling technique to incorporate the elasticity of investment is adjustment costs, which describe higher short-run installment costs of capital than the long-run costs. This paper compares two adjustment cost specifications; one is a function of the investment-per-capital ratio, and the other is a function of investment growth. Both specifications explain the properties of investment elasticity which are more elastic in the long-run than in the short-run. The former emphasizes the scale efficiency that a firm holding a larger capital stock faces smaller installment costs. Chirinko and Fazzari (1994), and Blanchard et al (1993) adopt this specification in their empirical research to detect the relationship between investment and the stock market. The latter emphasizes investment rigidity that a firm conducting stable investment spending faces smaller installment costs. Dupor (2001) and Christiano et al (2005) conduct computational analysis with investment growth adjustment costs.

Much empirical research of investment is based on Hayashi (1982), which refines Tobin's Q theory. The theory is that a firm raises investment when the ratio of market value to replacement cost of capital stock, average q, rises. Firms decide on investment based on shadow value of capital stock, marginal q, since it represents potential profits that an additional capital stock generates. Hayashi (1982) provides foundation for employing average q instead of marginal q in empirical research. It provides convenience to empirical research since average q is observable but not marginal q. Hayashi explains that average q is equivalent to marginal q under three conditions: the completely competitive goods market, a linear homogeneous production function, and a linear homogeneous adjustment cost function with investment and capital. The adjustment cost specification of the ratio of investment-per-capital stock satisfies the third condition and the studies test correlation of investment and average q.

The cost specification of the ratio of investment-per-capital stock does not explain the investment behavior suggested in empirical research employing vector autoregressive estimation. Structural vector autoregressive estimation (SVAR) reports a hump-shaped response of investment and output such as Altig et al (2006) and Christiano et al (2005). The hump-shaped response of investment implies investment rigidities and the investment-growth adjustment cost describes them quite well. Significant changes in investment growth raise installment costs while a firm minimizes installment costs by gradual changes of investment. The other specification implies that a small-sized firm faces larger capital installment costs than a large-sized firm rather than investment rigidities. Economic models explaining SVAR results employ the adjustment cost specification of investment growth.

Suppose a company that purchases investment goods the same amount each period. It has optimal staff and equipment for capital installment each period. It does not need to employee more staff and equipment and also it does not have any resources. Significant increase in investment compared to lagged investment is followed by significant increase of installation costs since it is harder to find experienced staff. The adjustment cost specification of the investment growth describes that a constant spending on investment goods over time reduces the capital installation costs. Suppose two different capital size companies purchase the same amount of investment goods. A large-sized company faces smaller installment costs than a small-sized company does because a large-sized company has accumulated knowledge and technology for the capital installation. The cost specification of a ratio of investment-capital describes that the size of the capital stock reduces the installation costs.

This paper studies the relationship between asset prices and investment technology in a general equilibrium framework. I emphasize the adjustment cost specifications, which generate various characteristics of investment such as rigidity and scale efficiency. Furthermore the cost specification changes the relationship between asset price and the value of capital stock. When the adjustment cost is linear homogeneous with investment and capital, asset price is equivalent to the value of capital stock. The other cost function implies that asset price is smaller than the value of capital stock by the adjustment cost.

Asset price signals the value of current capital stock. The value of capital stock measures potential profits that capital stock generates in the future. Investment-capital adjustment cost indicates that capital stock contributes in goods production and also in creating new capital stock. In other words, the installation costs of new capital stock are reflected in the value of capital stock. On the other hand, investment growth adjustment cost indicates that capital stock contributes only in goods productions and previous investment effects the current installation costs. Investment is cash-outflows and the adjustment cost is reflected cash-flows not in the value of capital stock. Consequently asset price shows the difference from the value of capital stock by the adjustment cost.

Basu (1987) explains the role of the adjustment cost in asset price movements. He uses a parameter that represents the effect of adjustment cost at the steady state to explain the role of the cost. The larger adjustment costs are accompanied with the lower volatility of both investment and asset price. He assumes that supply of capital stock is not flexible both in the long-run and short-run, and it exaggerates the effect of the adjustment cost on an economy. My paper excludes the long-run effect of adjustment costs on resources, and assumes that supply of capital is flexible in the long-run. Both adjustment cost specifications conclude that the larger adjustment costs, both investment and asset price have lower volatility.

There are several literatures explain the asset price puzzle with investment adjustment cost along with habit formation, such as Boldrin et al (2000), Jermann(1998), De Paoli(2010). Investment adjustment cost restricts the consumption smoothing ability and emphasizes the impact of shocks on consumption and output. My paper studies in detail how the specification alters the relationship between asset price and value of capital stock.

A positive technology shock raises output and investment. The productivity of capital stock rises when output increases faster than capital stock does. Investment rigidity generates gradual changes in investment and a more sluggish accumulation of capital stock. Consequently I observe a higher productivity of capital when there is investment rigidity. Productivity of capital stock is a main factor in determining asset price since asset price measures the value of capital stock by the contribution to potential profits. Investment growth adjustment cost reports larger and more persistent responses of asset price to a positive shock than the other cost specification.

This paper assumes that a monetary authority changes short-term interest rates to stabilize economic fluctuations. Without additional monetary shocks, the authority implements contractionary policy to positive technology shocks. When the policy sticks to interest-rate smoothing, asset prices in an economy with investment rigidities change very little. On the other hand, asset prices in an economy without the rigidities display smaller responses with stronger interest-rate smoothing.

Many papers analyze the effect of technology shocks in business cycle, such as Gali, Fisher and Christiano et al (2003). They do not agree on the empirical effects on production input such as working hours. Basu et al (2004) discusses the effect of technology shocks and suggests that a monetary policy rule could counter-act a positive technology shock. The monetary authority implements contractionary policy when it targets economic stability. There are discussions about asset prices as a monetary policy instrument such as Dupor (2001, 2002, and 2005) and Carlstrom and Fuerst (2003). My paper discusses monetary policy and asset prices whose policy instrument is short-term nominal interest rates.

Section 2 explains an economic model and it discusses the role of adjustment costs in detail. Section 3 presents a complete macroeconomic framework, and discusses adjustment costs with computational simulation results. In this section, I deliberate asset prices and the adjustment cost with an alternative interest-rate smoothing rule. Section 4 concludes.

II. The Model Economy

The economic model is traditional RBC model with nominal rigidities and investment adjustment costs. Investment adjustment costs depending upon investment growth follows the specification employed in Christiano et al (2005). The adjustment cost has no impact in the steady state but it does in the dynamics. The other investment adjustment costs depending upon investment-to-capital ratio is assumed to have the same characteristics assumed in the first case.

There are three types of agents in the economy: firms, households and the government. A firm produces output with labor and its own capital. The capital market does not exist so each firm accumulates capital by investment. The Calvo type price stickiness is adopted such that each firm has a chance to optimize its price with probability $(1-\theta)$ for each period.

Infinite-lived households consume the final goods and supply labor. The households save wealth with government issued risk-free bonds and the stocks of firms. The monetary policy follows the Taylor rule government spending is assumed to be zero for simplicity.

The labor market is completely competitive, while the final goods market is monopolistically competitive and the elasticity of substitution among goods of monopolist is ϵ. The aggregate output and price index are denoted with Y_t and P_t and a firm z's output and price are Y_t^z and P_t^z on time t. The demand for final goods is assumed to have constant elasticity of substitution such that the aggregate output is expressed as $Y_t = \left\{ \int_0^1 (Y_t^z)^{\frac{\epsilon-1}{\epsilon}} dz \right\}^{\frac{\epsilon}{\epsilon-1}}$ and price index is $P_t = \left\{ \int (P_t^z)^{\frac{1}{\epsilon}} dz \right\}^{\epsilon}$. Optimal consumption decisions implies as following,

$$\frac{Y_t^z}{Y_t} = \left(\frac{P_t^z}{P_t} \right)^{-\epsilon} \tag{1}$$

where the elasticity of substitution ϵ is positive.

1. Investment and Price Setting

A firm z purchases investment goods(I_t^z) and labor(N_t^z), and it optimizes its price P_t^z with probability $(1-\theta)$ each period. The firm pays its profits as dividends to shareholders after it pays labor cost and purchases investment goods. The value of a firm z, $V_t(z)$ is defined as the present value of life-time cash flow (CF_t^z), and the firm maximizes its value with investment (I_t^z), employment (N_t^z), and output price (P_t^z);

$$V_t(z)=\max_{\{I_t^z,N_t^z,K_t^z,P_t^z\}}E_t\sum_{k=0}^{\infty}\Lambda_{t,t+k}CF_{t+k}^z \tag{2}$$

$$s.t \qquad K_t^z=\Psi_t^z+(1-\delta)K_{t-1}^z \tag{3}$$

$$\text{where} \quad CF_t^z=A_t^z\frac{P_t^z}{P_t}(K_{t-1}^z)^{\alpha}(H_{t-1}^z)^{1-\alpha}-w_tN_t-I_t^z$$

where $\Lambda_{t,t+k}$ denotes the intertemporal marginal rate of substitution of the household and A_t^z is total factor productivity. Capital installment technology, Ψ_t^z, denotes and adjustment cost function of a firm z at time t. Assuming a complete set of state contingent claim, a firm′s time dependent discount factor is the intertemporal marginal rate of substitution. The investment adjustment cost is a function of investment growth rate, $\Psi_t=(1-s_{(I_t/I_{t-1})})I_t$ and it is increasing and convex in investment. In addition, adjustment costs have no effect on the steady state, such that $s(1)=s(1)'=0$ and $s''=k>0$.

To simplify notation, the superscript z is dropped from all variables except output price, P_t^z. The optimal investment makes marginal cost equal to the marginal benefit each period:

$$\lambda_t\left(1-s_t-\frac{I_t}{I_{t-1}}s_t'\right)+\beta E_t\Lambda_{t,t+1}\lambda_{t+1}\left(\frac{I_{t+1}}{I_t}\right)^2 s'_{t+1}=1 \tag{4}$$

where λ_t is the Lagrangian multiplier for the capital evolution process (3) and s_t is defined as $s(I_t/I_{t-1})$. The right-hand side of equation (4) is the price of investment purchase, which is one since the final goods are used for investment or consumption. The benefits of investment purchases are the value of created capital and the present value of net adjustment cost saving, which are in the left hand side of equation (4). The first term in the left-hand side of equation (4) is the value of the created capital with marginal investment, where s_t and s_t' measure the efficiency of capital installment. When the capital installment is less efficient, then created capital stock is smaller; s_t and s_t' are larger, created capital stock per investment purchase $\left(1-s_t-\frac{I_t}{I_{t-1}}s_t'\right)$ is smaller. Increased investment purchases reduces the cost of investment purchases in the following period. When current investment purchases create enough capital stock, it decreases the need for investment also with installment cost in the next period. The installment costs savings from current investment are $\lambda_{t+1}\left(\frac{I_{t+1}}{I_t}\right)^2 s_{t+1}'$, the second term of the left hand side.

Equation (5) shows that productivity of capital stock determines the value of capital stock.

$$\lambda_t - \beta E_t \Lambda_{t,t+1}\lambda_{t+1}(1-\delta) = \alpha\beta E_t\left\{\Lambda_{t,t+1}\left(1-\frac{1}{\epsilon}\right)\frac{P^z_{t+1}}{P_{t+1}}\frac{Y_{t+1}}{K_t}\right\} \tag{5}$$

The shadow value of capital, marginal q, rises when marginal revenue product of capital increases. Additional capital stock is more efficient in production, the value of capital stock is higher. Equation (5) indicates that instantaneous value of marginal q relies on the present value of the marginal revenue stream.

The optimal capital stock equation (5) is transformed as following,

$$\lambda_t K_t - \beta E_t \Lambda_{t,t+1}\lambda_{t+1}K_{t+1} = \beta E_t \Lambda_{t,t+1}\begin{Bmatrix} CF_{t+1} - \frac{1}{\epsilon}\frac{P^z_{t+1}}{P_{t+1}}Y_{t+1} \\ +(I_{t+1}-(1-s)I_t\lambda_{t+1}) \end{Bmatrix} \tag{6}$$

$$V_t - \beta E_t \Lambda_{t,t+1} V_{t+1} = CF_t \tag{7}$$

where CF_t is cash flows for time t. Equation (7) is drawn from the definition of firms value, V_t, which is the present value of expected cash flow stream. Substitution of cash flow in equation (6) with (7) builds up the relationship between marginal q and a firm's value, i.e. asset price.

Cash flow, not reflected in the value of capital stock, makes asset price different from the value of capital stock. Mark-up profits are additional cash inflows due to market structures but not productivity of the capital stock (the second term in the bracket of equation (6)). In addition, adjustment cost, increasing with the investment growth, indicates that capital stock has no contribution for reducing installment costs. Consequently, installment cost is not reflected in the value of capital stock. Current investment reduces next period installment cost, and the cost is measured with investment, cash outflows. Adjustment cost, the last term in the bracket of equation (6), are additional cash outflows due to investment technology and it makes asset price lower than the value of capital stock.

Alternative adjustment cost specifications imply a different relationship between the goods market and the asset market. As I specify the adjustment cost as a function of investment-per-capital ratio, $\Psi_t = \left(1 - \hat{s}\left(\frac{I_t}{K_{t-1}}\right)\right) I_t$, investment rigidity disappears. I assume that adjustment cost is convex and increasing with investment, $\hat{s}(I_t/K_{t-1})' > 0$ and $\hat{s}(I_t/K_{t-1})'' > 0$. In addition, the adjustment cost has no impacts on the steady state, that is, $\hat{s}(\delta) = \hat{s}'(\delta) = 0$ and $\hat{s}(\delta)'' = \hat{k} > 0$.

A firm's optimal investment and capital stock conditions are changed as follows,

$$\lambda_t\left(1-\hat{s}_t-\frac{I_t}{K_{t-1}}\hat{s}_t'\right)=1 \tag{8}$$

$$E_t\lambda_t-\beta E_t\Lambda_{t,t+1}(1-\delta)\lambda_{t+1}=\beta E_t\Lambda_{t,t+1}\left\{\begin{array}{l}\alpha\left(1-\frac{1}{\epsilon}\right)\frac{P^z_{t+1}}{P_{t+1}}\frac{Y_{t+1}}{K_t}\\+\left(\frac{I_{t+1}}{K_t}\right)^2\hat{s}'_{t+1}\lambda_{t+1}\end{array}\right\} \tag{9}$$

where $\hat{s}_t$ is a function of investment-per-capital ratio at period t, $\hat{s}_t=\hat{s}(I_t/K_{t-1})$.

The optimal investment equates marginal benefits to marginal costs as reported in equation (8). Marginal purchasing cost is one, the price of investment goods, and installment costs are the value of foregone capital stock, $\lambda_t\left(\hat{s}_t+\frac{I_t}{K_{t-1}}\hat{s}_t'\right)$. Inefficiency of installment is measured with $\hat{s}_t$ and $\frac{I_t}{K_{t-1}}\hat{s}_t'$ such that the created capital stock is smaller when $\hat{s}_t$ and $\frac{I_t}{K_{t-1}}\hat{s}_t'$ are larger. Marginal benefits of investment are the value of created capital stock, the left-hand side of equation (8).

The optimal capital stock condition (9) indicates that the value of capital rises when the expected marginal revenue product of capital increases. Current capital is more valuable when the adjustment costs are expected to rise. Both productivity of capital and adjustment cost are reflected in the value of capital stock. The value of capital stock reflects contribution of capital on both production and investment technology. Depending upon investment technology, the role of capital stock in potential profits is different. Investment growth adjustment cost reports the contribution of capital stock only in production (equation 5), and investment-per- capital reports it in both production and investment technology (equation 9).

The optimal capital stock equation (9) builds up the relation of the firm' s value per capital (V_{t+1}) and the value of capital (λ_t) by transformation:

$$\lambda_t K_t - E_t \Lambda_{t,t+1} \lambda_{t+1} K_{t+1} = \beta E_t \Lambda_{t,t+1} \left\{ CF_{t+1} - \frac{1}{\epsilon} \frac{P^z_{t+1}}{P_{t+1}} Y_{t+1} \right\} \tag{10}$$

$$CF_t = V_t - \beta E_t \Lambda_{t,t+1} V_{t+1}$$

Asset price signals the value of capital stock. Asset price measures lifetime cash flows and the value of capital stock measures its contribution to lifetime profits. Mark-up profits are cash flows from market-structure and they are not reflected in the value of capital stock. When adjustment cost is a function of investment-per-capital ratio, the mark-up profits raise asset price above the value of capital stock. Comparison of equation (6) and (10) indicates that rigidity in investment amplifies the role of investment in the asset price.

Two adjustment cost specifications show the difference in the value of capital stock and in the relationship between asset price and the capital value. The capital value corresponds only to the marginal revenue product of capital with investment growth adjustment costs; whereas the capital value corresponds to both the marginal revenue product of capital and the adjustment cost with investment-per-capital adjustment cost. Asset price corresponds to the capital value and to mark-up profits in both adjustment cost specifications. Only investment growth adjustment cost reports that asset price corresponds to the capital value.

The first order conditions for labor demand and price decisions are given as follows:

$$(1-\alpha)\left(1-\frac{1}{\epsilon}\right)\frac{P^z_t}{P_t}\frac{Y_t}{H_t} = w_t \tag{11}$$

$$P^z_t / P_t = \begin{cases} \pi P^z_{t-1} / P_t & with\ prob.\ \theta \\ P^{z*}_t / P_t & with\ prob. (1-\theta) \end{cases} \tag{12}$$

The optimal labor demand condition, equation (11), equates marginal cost of labor to the marginal revenue product of labor. Equation (12) shows that a firm z optimizes its optimal price with probability (1-θ). When a firm can not choose its optimal price, it updates its price with the average inflation rate (Yun, 1996).

A firm maximizes the present value of profit stream with price after taking into account the probability θ, marginal cost of production and price elasticity of demand.

$$\max_{\{p_t^z\}} \sum_{k=0}^{\infty} \theta^k \beta^k E_t \left\{ \Lambda_{t,t+k} \left(\frac{P_t^z}{P_{t+k}} - mc_{t+k} \right) \left(\frac{P_t^z}{P_{t+k}} \right)^{-\varepsilon} Y_{t+k} \right\} \tag{13}$$

The price optimizing problem (13) shows that the economy faces monopolistic competition and Calvo style price stickiness. A firm z's outputs are determined with the relative price of its good(P_t^z) to the average price (P_{t+k}), and the mark-up depends on price elasticity of demand and the expected real marginal cost of production. The solution of the problem (13) is the following,

$$P_t^{z*} = \frac{\epsilon}{\varepsilon - 1} \frac{\sum_{k=0}^{\infty} \theta^k \beta^k E_t \left\{ \Lambda_{t,t+k} Y_{t+k} P_{t+k}^{\varepsilon} mc_{t+k} \right\}}{\sum_{k=0}^{\infty} \theta^k \beta^k E_t \left\{ \Lambda_{t,t+k} Y_{t+k} P_{t+k}^{\varepsilon-1} \right\}} \tag{14}$$

The average price (P_t) on period t is composed with two parts; (1-θ) portion of producers set their prices at t and the other portion θ of producers update price levels with the average inflation π. Price index P_t at time t is summarized as follows:

$$P_t = \left\{ (1-\theta)(P_t^{z*})^{1/\epsilon} + \theta(\pi P_{t-1})^{1/\epsilon} \right\}^{\epsilon} \tag{15}$$

2. Consumption and Labor Supply

An infinite lived household maximizes lifetime utility with consumption(C_t), and labor supply(H_t). A household saves income for future consumption with risk free bond(B_t) and stock(x_t). A firm z's stock purchase is denoted with $(P_t^x(z)x_t(z))$, and stock purchase over all firms is denoted with $P_t^x x_t\left(=\int P_t^x(z)x_t(z)dz\right)$, where $P_t^x(z)$ is the stock price of a firm z in terms of consumption goods and P_t^x is the stock price index. Each firm pays its profit to stockholders in forms of dividend $(D_t(z)x_t(z))$ each period and the aggregate dividends are $D_t x_t\left(=\int D_t(z)x_t(z)dz\right)$.

Risk free bond purchases are B_t/P_t and it pays nominal interest R_{t+1} to the holders in the following period. The government transfer payments (T_t) are added to the household income on time t.

A household's lifetime utility maximization problem is summarized as follows,

$$\max_{\{C_{t+k},H_{t+k},B_{t+k},x_{t+k}\}_{k=0}^{\infty}} \sum_{k=0}^{\infty}\beta^k E_t\{\ln C_{t+k}+\eta\ln(1-H_{t+k})\} \tag{16}$$

$$\text{s.t} \quad C_t+P_t^x x_t+\frac{1}{R_t}\frac{B_t}{P_t}\le w_t H_t+(D_t+P_t^x)x_{t-1}+\frac{B_{t-1}}{P_t}$$

where η is leisure preference parameter and $C_t\left(=\left(\int C_t(z)^{\frac{\varepsilon-1}{\varepsilon}}dz\right)^{\frac{\varepsilon}{\varepsilon-1}}\right)$ is the consumption index over all diversified goods. Labor supply to a firm z is denoted to $H_t(z)$ and the aggregate labor supply is $H_t\left(=\int H_t(z)dz\right)$. The labor market is completely competitive and production technology is assumed to be identical across firms, such that all firms pay real wage w_t and labor income of the household is w_tH_t.

The first order condition of the problem (16) with w_t is,

$$E_t P_t^x - \beta E_t \Lambda_{t,t+1} P_{t+1}^x = \beta E_t \Lambda_{t,t+1} D_{t+1} \tag{17}$$

A firm z distributes profits $(CF_{t+k}(z))$ to shareholders, $j=1,\ldots,J$, as dividends $(D_{t+k}(z))$ per share (x_{t+k}) at period $(t+k)$, and $\int x_{t+k-1} D_{t+k}(z) dj = CF_{t+k}(z)$.

Taking into account a firm's profits are the difference of firm's value and the expected value of a firm in the following period $\beta(E_t\Lambda_{t,t+1} V_{t+1} - \beta E_t \Lambda_{t,t+2} V_{t+2})$ and it is equivalent to $E_t P_t^x x_{t-1} - \beta E_t \Lambda_{t,t+1} P^x_{t+1} x_t$. Without loss of generality, I assume that aggregate outstanding stock is one for all periods.

III. General Equilibrium

1. Log-linearization

This section presents the general equilibrium condition in the log-linearized formula. In the log-linearized equations lower-case letter of each variables denotes a percentage deviation around its steady state value and upper-case letter without time subscript denotes the steady state value.

A firm's investment decision equations (4) and the optimal capital condition (5) are log-linearized around the steady state as follows,

$$\begin{aligned} \mu_t - \beta(1-\delta) E_t \{c_t - c_{t+1} + \mu_{t+1}\} \\ = \alpha\beta\left(1 - \frac{1}{\epsilon}\right)\frac{Y}{K} E_t\{c_t - c_{t+1} + w_{t+1} + h_{t+1} - k_t\} \end{aligned} \tag{18}$$

$$\mu_t = \kappa E_t\{\Delta i_t - \beta \Delta i_{t+1}\} \tag{19}$$

where μ_t is the percentage deviation of marginal q from its steady state and Δx_t denotes the growth of x_t. Marginal q measures contribution of capital stock on profits, and major role of capital is a factor of production. Marginal revenue product of capital is a factor in marginal q movements (equation 18), where log-linearized revenue is equivalent to w_t+h_t drawn from the labor demand condition.

The adjustment cost specification is revealed as the response of investment to the capital value such that investment growth responds to marginal q (equation 19). Increase of marginal q signals that additional capital stock creates more profits, and a firm builds up more capital with investment. When adjustment cost, κ, is too large, a firm raises investment little more. In other words, to minimize installment cost, a firm keeps the investment growth rate and it avoids the volatile investment spending.

The asset price equation (6) is log-linearized after the asset price P_t^x replaces the firm's value $E_t\{\Delta_{t,t+1} V_{t+1}\}$.

$$\left(1+\frac{1}{\epsilon}\frac{\beta}{1-\beta}\frac{Y}{K}\right)E_t\Delta_t p_t^x = E_t\Delta_t(\mu_t+k_t)+\frac{\beta}{\epsilon}\frac{Y}{K}E_t(w_{t+1}+h_{t+1}) - \beta\delta E_t(i_{t+1}-i_t-\mu_{t+1}) \tag{20}$$

Time difference of a variable $\Delta_t x_t$ takes into account the discount factor such as $\Delta_t x_t = \{x_t - \beta E_t(c_t - c_{t+1} + x_{t+1})\}$. Equation (20) reveals that the capital value corresponds to the role of capital stock only in production. Costs occurred with creating capital stock are not reflected in the capital value, but in the asset price. Asset price measures the potential profits that a capital stock creates, and it also measures cash flows resulted from non-production activity such as mark-up profits and capital installment cost. Mark-up profits, the second bracket in equation (20), result from the market structure, and the installment cost, the third bracket in equation (20), results from investment technology. A firm benefits from investment by the value of the created capital stock, $(i_t+\mu_{t+1})$, and investment costs the price of investment goods, i_{t+1}. The size of the created capital stock measures the costs of the capital installation. Investment activity is not reflected in the value of capital stock, since the capital stock does not work in the capital installation. The limited role of the capital stock in the installment implies that the capital accumulation process is not an important factor of the value of capital. On the other hand, investment is a part of cash-flows and the asset price should adjust the cash-flows which are not reflected in the value of capital. When the benefits of investment are larger than the costs, the net benefits of investment pushes the asset price up.

I compare alternative adjustment cost specification, a function of investment-per-capital ratio. The optimal investment and capital stock conditions (19, and 18) are changed as follows:

$$\mu_t - \beta(1-\delta)E_t\{c_t - c_{t+1} + \mu_{t+1}\} \\ = \beta E_t\left\{\alpha(1-\frac{1}{\epsilon}\frac{Y}{K}(c_t - c_{t+1} + w_{t+1} + h_{t+1} - k_t) + \hat{\kappa}\delta^2(i_{t+1} - k_t)\right\} \tag{21}$$

$$\mu_t = \delta\hat{\kappa}(i_t - k_{t-1}) \tag{22}$$

where $\hat{\kappa}$ is the adjustment cost parameter and μ_t is the log-linearized shadow value of capital, marginal q. Capital works as a production factor and it also works in creating new capital stock. Marginal q measures the value of capital stock based on its role in the marginal revenue productivity, the first bracket in the right hand side of equation (21) and also in the efficiency of capital installation, the second bracket of equation (21). Marginal q rises when the marginal revenue of capital stock increases; or marginal q rises when adjustment costs fall due to capital stock. Equation

(22) represents investment decision, such as investment-per-capital rises when marginal q increase. Investment decision shows the adjustment cost specification such that investment-per-capital ratio responds to marginal q. A firm raises investment purchase if marginal q increases. When benefits of additional capital stock rise, a firm builds up more capital stock with investment. When the adjustment cost, $\hat{\kappa}$, is larger, the investment-per-capital ratio is less sensitive. Unlike equation (19) investment growth rate is not restricted to any costs, however installment cost falls with larger capital stock. The asset price equation (10) is modified with an alternative adjustment cost function.

$$\left(1+\frac{1}{\epsilon}\frac{\beta}{1-\beta}\frac{Y}{K}\right)E_t\Delta_t P^x_{t+1} = E_t\Delta_t(\mu_t+k_t)+\frac{\beta}{\epsilon}\frac{Y}{K}(w_t+h_t) \tag{23}$$

The asset price rises when the value aggregate capital stock is larger (equation 23). When current capital stock creates larger cash flows, the asset market raises the firm's value. The installment cost adjusts marginal q, and it changes the asset price through marginal q.

Equation (24) is derived from Calvo-style staggered price setting (equations 14 and 15). It captures the marginal cost of production in the labor market for computational convenience.

$$\pi_t = \beta E_t\pi_{t+1} + \frac{(1-\theta)(1-\beta\theta)}{\theta}\frac{1-\alpha}{1+\alpha(\epsilon-1)}(w_t+h_t-y_t) \tag{24}$$

Equation (25) and (26) are log-linearized Euler equations of the household. Households have logarithmic utility over consumption and it implies that the intertemporal elasticity of consumption is the real interest rate (25). In addition, household preference is separable over leisure and consumption, and the marginal rate of substitution of consumption and leisure is the ratio of working hours to leisure time, equation (26).

$$r_t^n = E_t(c_{t+1} - c_t) + E_t\pi_{t+1} \tag{25}$$

$$c_t = w_t - \frac{H}{1-H}h_t \tag{26}$$

Equation (27) is the log-linearized production function. The capital evolution process is described in equation (28). The installment cost has no impact on the capital evolution process because of the assumption of an adjustment cost function, $s = s' = 0$.

$$y_t = a_t + \alpha k_t + (1-\alpha)h_t \tag{27}$$

$$k_{t+1} = \frac{I}{K}i_t + (1-\delta)k_t \tag{28}$$

Equation (29) is the log-linearized resource constraint. Aggregate expenditures are household consumption c_t and investment.

$$y_t = \frac{C}{Y}c_t + \frac{I}{Y}i_t \tag{29}$$

Monetary authority uses short-term interest rates as a policy instrument, equation (30). It adjusts the current interest rate to the lagged interest rate, current inflation and output, that is the Taylor rule. Monetary authority cannot separate out if the variation of output is due to supply shocks or demand shocks.

$$r_t^n = \rho^r r_{t-1}^n + (1-\rho^r)(\rho^\pi E_t\pi_{t+1} + \rho^y y_t) + ms_t^\pi \tag{30}$$

where ρ^{rn}, ρ^π and ρ^r are policy parameters. Monetary shock ms_t^π follows independent and identical distribution with the variance σ^π.

$$a_t = (1-\rho^a)\ln(A) + \rho^a a_{t-1} + as_t^a \tag{31}$$

The technology follows stationary autoregressive process with the coefficient ρ^a. The technology shock as_t^a is independent and identically distributed with the variance σ^a.

2. Model Simulations

In this section a quantitative analysis is performed to illustrate the effect of investment adjustment cost on the asset price in a sticky price framework. I choose quite conventional values for most parameters. The discount parameter β and total factor productivity A are set to 0.99 and one respectively. The capital share α is 0.32. The depreciation rate δ is 0.025 and labor disutility parameter η is 2.75. The probability of a firm does not change its price for each period is set to 0.6, and the firm makes the average period of price adjustment is two and a half quarters. The serial correlation coefficient for the technology shock is assumed to be 0.95.

The autoregressive parameter ρ^m in the monetary policy rule is set to 0.5 and the coefficient on inflation ρ^π and output ρ^y are 1.5 and 0.1 respectively. The nominal interest rate rises 1.5 percent in response to a permanent one percent increase in inflation rate.

I compare two adjustment cost functions, investment growth versus investment-per-capital. The investment elasticity parameter is taken to be 2.6 at which output volatility is equivalent in two cases. Economic variables display different dynamic processes not only qualitatively but also quantitatively depending upon investment adjustment costs. I minimize the long-run effects of adjustment cost on output by equating the volatility in two cases. It is consistent with the assumption about the adjustment cost specification such that adjustment cost has no impacts on steady-state in section 2.

I consider an alternative value of ρ^{rn}, and adjust elasticity parameter κ. When the autoregressive parameter rises to 0.9, elasticity of investment parameter κ increases to 3.6 that equates output volatility of two cases.

〈표 1〉 Parameter value

	Investment Growth	Investment per Capital
A	1	1
α	0.32	0.32
β	0.99	0.99
δ	0.025	0.025
κ	2.6	2.6
η	2.75	2.75
θ	0.6	0.6
π	1.0	1.0
ρ^{rn}	0.801	0.801
ρ^{π}	1.5	1.5
ρ^{y}	0.2	0.2
ρ^{a}	0.95	0.95
σ^{a}	0.125	0.00685
σ^{rn}	0.038	0.0011

3. Results

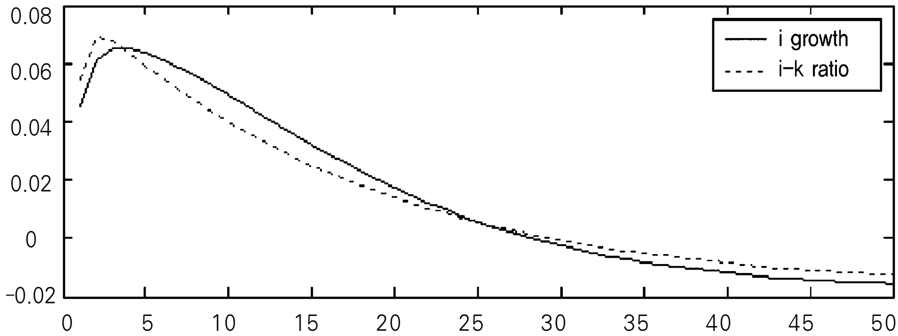
This section draws the impulse responses of economic variables to one standard deviation technology shock. Two cases display 4 different features of investment, and it affects the asset price movements. 1) Efforts to reduce adjustment costs generate different responses of investment in two cases. In the $(i-k)$ case, a firm has a motivation to accumulate capital in the early periods, since the larger capital stock reduces adjustment costs. In the Δi case, a firm has a motivation to avoid the drastic changes in the growth of investment, since it generates larger installation costs. 2) As long as investment is positive it generates adjustment costs in the $(i-k)$ case. On the other hand a firm, in the Δi case, has zero adjustment costs when investment spending is constant over all periods. Current investment raises current adjustment costs, but it reduces next adjustment costs. The smaller adjustment costs indicate that the same size of investment creates more capital stock, and consequently the larger value of created capital stock. The costs of an investment purchase are smaller than the benefits of an investment purchase, and it is observed when the investment growth falls. 3) The responses of the asset price in the Δi case are larger than the $(i-k)$ case, because of the smaller present value of adjustment costs. The benefits of optimal management of the investment growth push up the asset price. 4) Monetary policy suppresses the initial increase of aggregate demand and the smaller increase of aggregate demand results in the smaller increase of asset price. The stronger interest rate smoothing rule of the policy suppresses more the initial increase of aggregate demand. Consequently, both marginal revenue product of capital and marginal q fall.

The adjustment cost specification affects investment decisions through efforts to reduce installation costs. Depending upon the investment technology, a firm takes into account lagged investment or its accumulated capital stock for investment decision. Figure 1 draws the investment responses to a positive technology shock and the main variable affecting investment decision, marginal q.

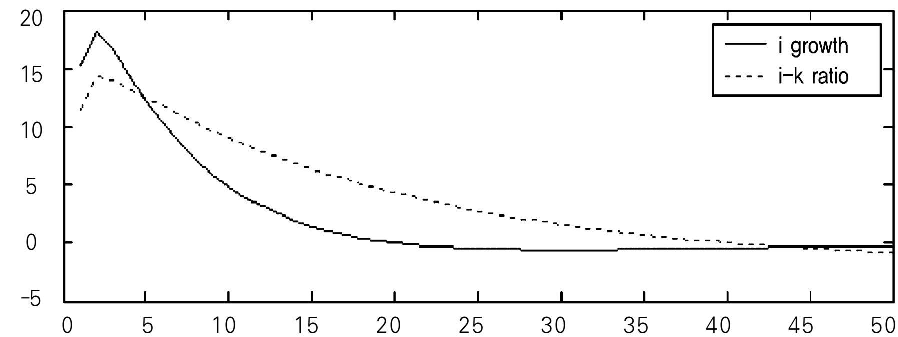
The marginal revenue product of capital stock measures the contribution of the capital stock in production, figure 1(a). Price and capital productivity are the factors leading movements of marginal revenue product of the capital stock. A positive technology shock raises productivity and it reduces production costs. Lower production costs push down the price level, while the price rigidity mitigates pressure on price movements. When an increase in output is larger than a decrease in price, the higher productivity causes the higher marginal revenue product of capital. The marginal revenue of the Δi case, the first parenthesis of equation (18), jumps up when the positive shock is realized. It rises for 3 quarters and then falls continuously since the effects of the shock on productivity diminishes continuously. The $(i–k)$ case also shows that marginal revenue, the first parenthesis of equation (21), jumps up in the first period. After 3 quarters it continuously falls along with the capital productivity. Compared to the $(i–k)$ case, marginal revenue in the Δi case shows gradual changes due to investment rigidity. Changes in productivity result from the relative changes of output to the capital stock. Investment rigidity generates gradual changes in aggregate demand and a more gradual accumulation of the capital stock.

〈Figure 1〉 Impulse response of marginal q to a one-percent of standard deviation technology shock.

(a) marginal revenue product of capital



(b) shadow value of capital



(c) investment

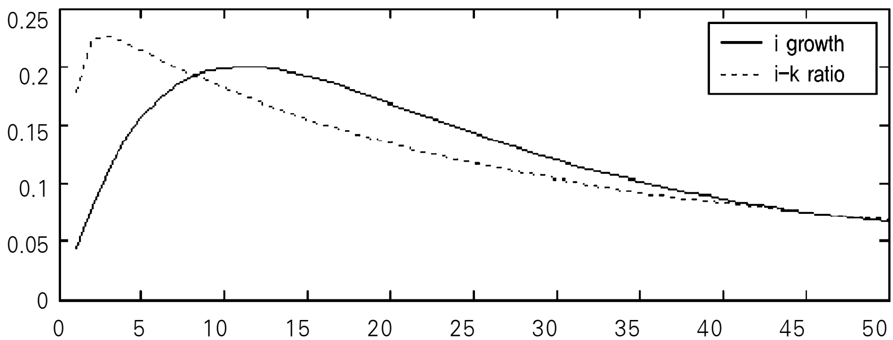


Figure 1(b) describes the shadow value of the capital stock, marginal q. The Δi case shows that marginal q jumps up in the first quarter, and it decreases from the third quarter. The $(i-k)$ case displays the positive responses to a positive technology shock such that it jumps up in the first quarter and converges to zero from third quarter. Both cases demonstrate that marginal q decreases faster than marginal revenue, since marginal q measures the present value of marginal revenue product of capital, equation (18) and (21). Only for the $(i-k)$ case, marginal q captures the costs and benefits of investment since the capital stock reduces adjustment costs.

In early periods, investment is larger than the capital accumulation, and the costs, investment spending, are larger than the benefits, more efficient creation of the capital stock. In later periods, effects of a technology shock on investment decrease, and saving effects on adjustment costs increase. Reflection of investment technology on marginal q results the larger initial response in the Δi case than the $(i-k)$ case. In addition, marginal q in the Δi case decreases faster than in the $(i-k)$ case.

The higher marginal q raises investment, and the investment responses are different depending upon the investment technology. Figure 1(c) displays each investment response to a percent standard deviation technology shocks. Investment in the Δi case has a hump-shaped response. It jumps up 5 percent in the first quarter, and then gradually rises for ten quarters and converges to zero. Monetary policy suppresses the increase of aggregate demand since its priority is economic stability. Effects of policy diminish and for two quarters aggregate demand rises. The larger aggregate demand causes the higher marginal revenue product of capital, and it raises marginal q. Investment in the $(i-k)$ case shows similar features to marginal q. It jumps up in the first quarter, rises for 2 quarters and converges to zero from 4th quarter. Compared to the $(i-k)$ case, the Δi case displays gradual changes due to the investment rigidity, the characteristic that the $(i\text{-}k)$ case does not have. The investment technology in the $(i\text{-}k)$ case generates scale efficiency of capital stock. The larger capital stock is the more efficient in creating the capital stock, and a firm raises investment instantly to accumulate capital stock quickly.

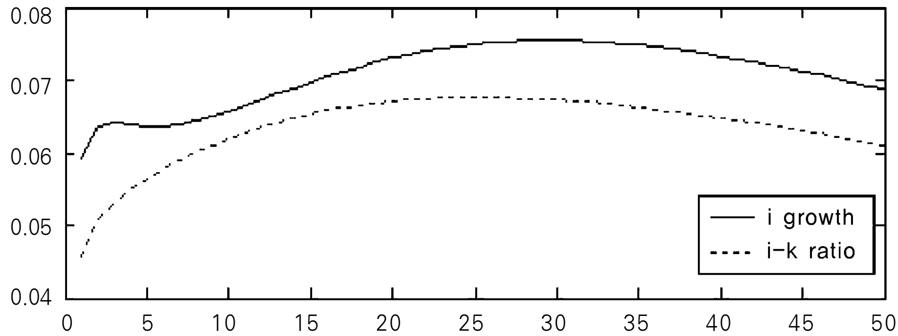
Figure 2 illustrates the responses of the asset price and major variables affecting the asset price movements. The asset price is a leading variable that forecasts potential profits a firm creates in the future, and the value of the capital stock measures profits the aggregate capital stock generates. Consequently the value of capital stock is a major determinant of the asset price movements.

The asset price rises when a technology shock raises profits, as in figure 2(a). In the Δi case, the asset price displays a short-term and a long-term hump-shaped response. It jumps up in the first quarter and displays short-term fluctuations for 5 quarters. Beyond the fifth quarter the asset price draws hump-shaped responses with a peak at the 30th quarter. The asset price in the $(i\text{-}k)$ case shows more gradual changes. It jumps up in the first period, gradually rises for 6 years, and then gradually approaches zero. The long-run responses of the asset price in both cases are similar to the value of capital stock, the first term in equation (20) and (23). The short-run responses of asset price in the $(i\text{-}k)$ case are due to the higher mark-up profits. On the other hand, the short-run responses of the asset price in the Δi case are related to both net benefits of investment and mark-up profits.

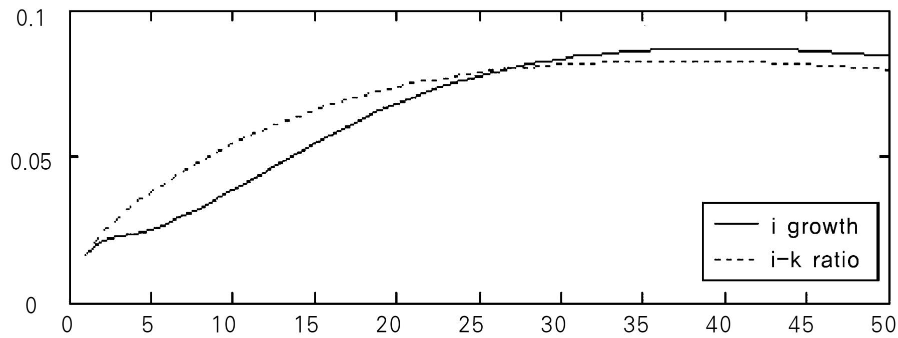
Marginal q, in the $(i\text{-}k)$ case, incorporates the capital accumulation process, but not in the Δi case. Since the capital stock reduces adjustment cost, the value of capital stock should adopt the costs and savings of the capital creation. In the Δi case, the capital stock does not a¤ect the capital creation process, and marginal q is irrelevant to the capital accumulation process. The asset price reflects the value of the aggregate capital stock, and also cash-flows which are not incorporated in the value of the capital stock. The costs and benefits of investment in the (i-k) case are reflected in the asset price through marginal q, but not in the Δi case. The asset price in the Δi case incorporates the net benefits of investment directly. Investment spending is cash-outflows, but an appropriate management of investment growth results in net savings in capital installation, which is discussed in figure 2(c). The value of the created capital stock from current investment ($\mu_t + i_t$) and a firm will spend i_{t+1} in the following quarter. Current investment raises adjustment costs, but it reduces the future investment and raises the efficiency of the capital creation. When the benefits of investment surpass the costs of an investment purchase, the net benefits push up price to 6 percent.

〈Figure 2〉 Impulse response of asset price to a technology shock

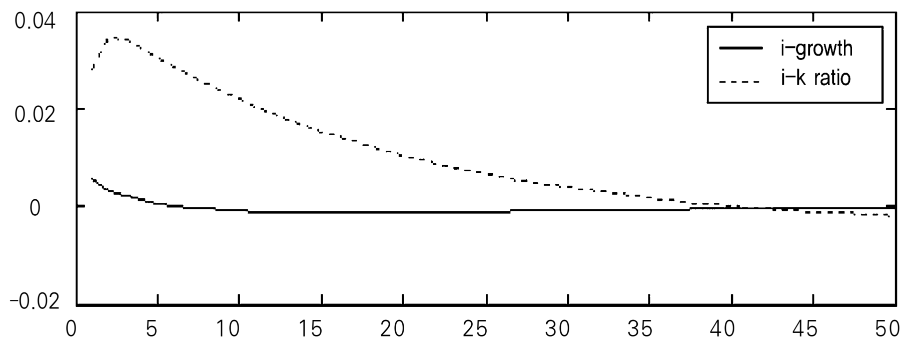
(a) asset price



(b) marginal q+capital stock



(c) adjustment costs



The value of aggregate capital stock shows different responses depending upon the investment technology, as in figure 2 (b). The Δi case displays a slow increase in the value of capital stock for 5 quarters, and it starts to increase more rapidly for the 30 quarters. The capital value for the $(i\text{-}k)$ case draws a concave curve; it rises faster in the early periods and the growth rates are smaller in the long-run. The initial responses of the two cases are very similar, but not the growth rates. For the $(i\text{-}k)$ case, the growth rate continuously falls, while the growth rate of the Δi case rises from the 5th quarter.

Movements of the value of capital stock are decomposed into the movements of the capital accumulation and of marginal q, the first term in the left-hand side of equation (20) and (23). Capital accumulation dominates the marginal q effect in the capital value movements. The difference in investment for the two cases is larger than marginal q. Furthermore, the direction of the marginal q response is opposite to the value of capital stock such that marginal q falls continuously from the 5th quarter in both cases, but not for the capital value. In the $(i\text{-}k)$ case, the larger capital stock reduces installation costs and a firm has incentive to create more capital stock in the short-run. A firm conducts more investment at the present time than the future, and the capital accumulation speed decreases. In the Δi case, the smaller variation of investment growth reduces the installation costs. A positive technology shock raises investment but the initial growth of investment is negligibly small. The history of positive investment growth easily generates larger investment, and the capital accumulation is then accelerated.

Figure 2(c) compares the responses of the capital installation costs in the two cases. Adjustment costs in the $(i\text{-}k)$ case jump up when the shock is realized, rise for 3 quarters, and then decrease gradually following the 4th quarter. The costs move along with the relative movements between investment and capital stock, equation (21). Since new capital installation is more efficient with the larger capital stock, a firm raises investment in the first quarter. The costs decrease as investment falls and the capital accumulation rises. The investment costs in the Δi case jump up, gradually decreases for 6 years and slowly converges to zero. Except the first 7 quarters, the costs are negative over all periods. A firm reduces the costs through minimizing changes in investment growth rates, but the effects of one time shock do not last forever.

Investment growth rates are negative from the 10th quarter, and it means the costs of investment falls significantly. The gap between investment growth and marginal q makes the asset price different from marginal q, equation (20). Investment, in terms of cash-flows, is reflected in the asset price movements, and marginal q, in terms of the benefits of investment, is reflected in the asset price also. Compared to the i case, the $(i-k)$ case has larger investment costs over all periods. In the early periods, a firm in the $(i-k)$ case focuses on the capital accumulation to save future adjustment costs. In the following periods, the larger capital stock saves adjustment costs. Although the decrease of the installation costs is accelerated over time, a positive investment is accompanied with the positive costs all the time. In the Δi case, a firm manages the growth of investment. Initial increase of investment is not significant since the adjustment cost function is convex. Current investment raises current adjustment costs but it reduces future adjustment costs. The smaller adjustment costs raise the amount of the created capital stock, and the benefits of investment rise. In addition, falling investment growth indicates that the future purchasing costs are falling. When the present value of savings is larger than the costs, the investment costs accompanied with current investment could be negative.

Although investment is positive, the decrease of investment growth results in the negative investment costs.

Figure 3 describes the responses of nominal variables along with output. In the $(i\text{-}k)$ case, there are nominal rigidities which include rigidities in both inflation and interest rates, and interest rates a¤ect consumption and investment planning. In addition to the nominal rigidities, in the Δi case there is an investment rigidity which affects production and also aggregate demand. Investment supplies a production

factor, capital, and it is also a component of aggregate demand. The investment rigidity is caused by the adjustment cost specification, and it is observed only in the i case.

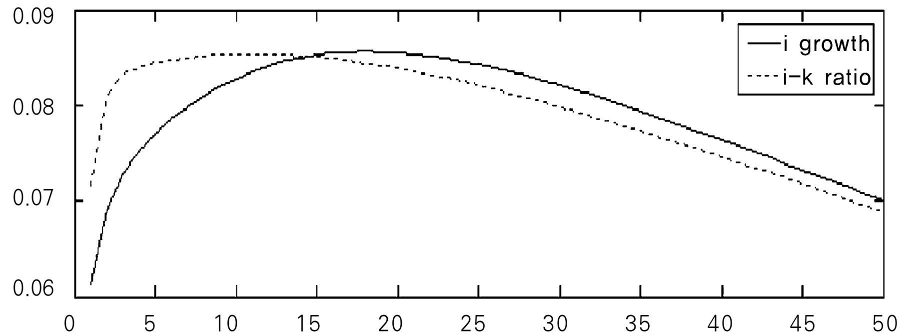
Figure 3(a) compares the aggregate demand movements of the two cases. Output in the Δi case rises gradually for 20 quarters, and converges to zero gradually. Output in the $(i\text{-}k)$ case jumps up 7 percent, rises relatively dramatically for 3 quarters, and then increases gradually for another 7 quarters. Compared to the $(i\text{-}k)$ case, output in the Δi case shows gradual changes over all periods and it reflects the real rigidity located in investment. Investment directly affects the responses of output, as a component of the aggregate demand, equation (29). The investment rigidity is totally reflected in output through aggregate demand, as the goods market equilibrium indicates.

A positive technology shock reduces the price of output, and lowering the price level boosts aggregate demand. Responses of inflation rates are drawn in figure 3(b). Inflation rate in the Δi case drops 2 percent and displays medium-run fluctuations. It rises for 3 quarters relatively quickly, falls gradually from the 4th quarter, and then rises again from 23rd quarter. Inflation rate in the $(i\text{-}k)$ case also has the medium-run fluctuations. It jumps down in the first quarter, rises for 3 quarters, falls gradually over 20 quarters and then rises again gradually. The responses of inflation in both cases are quite similar. The price decision rule, equation (24), indicates that the marginal cost of production and expectation of future inflation are the major determinants of current inflation. Effects of the lower marginal costs of production due to a positive shock are similar across the two cases.

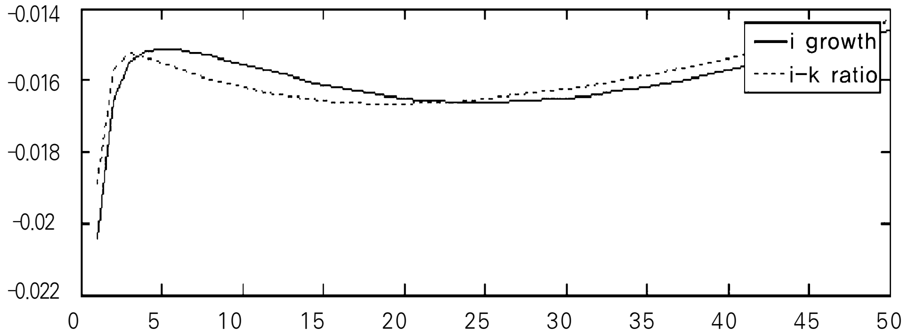
Figure 3(c) draws the responses of nominal interest rates to a positive technology shock. The interest rate in the Δi case has medium-run fluctuations. It initially falls 1.2 percent, continues to fall for 4 quarters, and then reaches a trough around negative 1.6 percent. The interest rate in the $(i-k)$ case does not have the medium-run fluctuations. It gradually decreases for 5 years and then slowly converges to zero. The monetary authority changes nominal interest rates to stabilize economic fluctuations, equation (2.30). In the $(i-k)$ case, the initial increase in aggregate demand is expected to be significant. The larger aggregate demand lessens the pressure lowering the price level. On the other hand, in the Δi case, the initial increase in aggregate demand is less significant due to the investment rigidity. The higher productivity is not connected to the larger output, but to the lower factor demand and the lower price level.

〈Figure 3〉 Impulse response of nominal variables and output

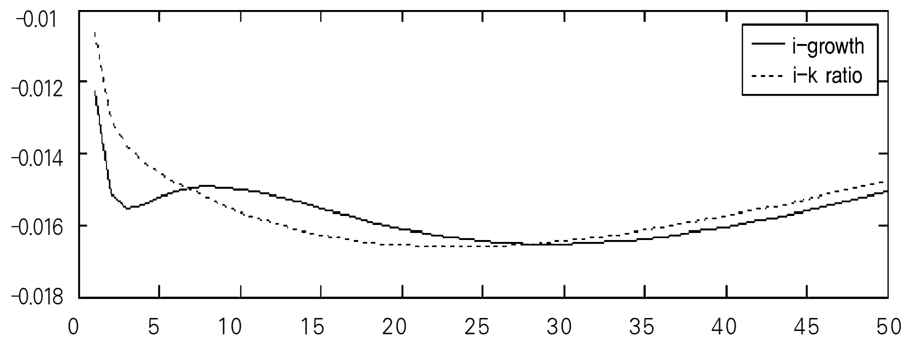
(a) output



(b) inflation



(c) nominal interest rates

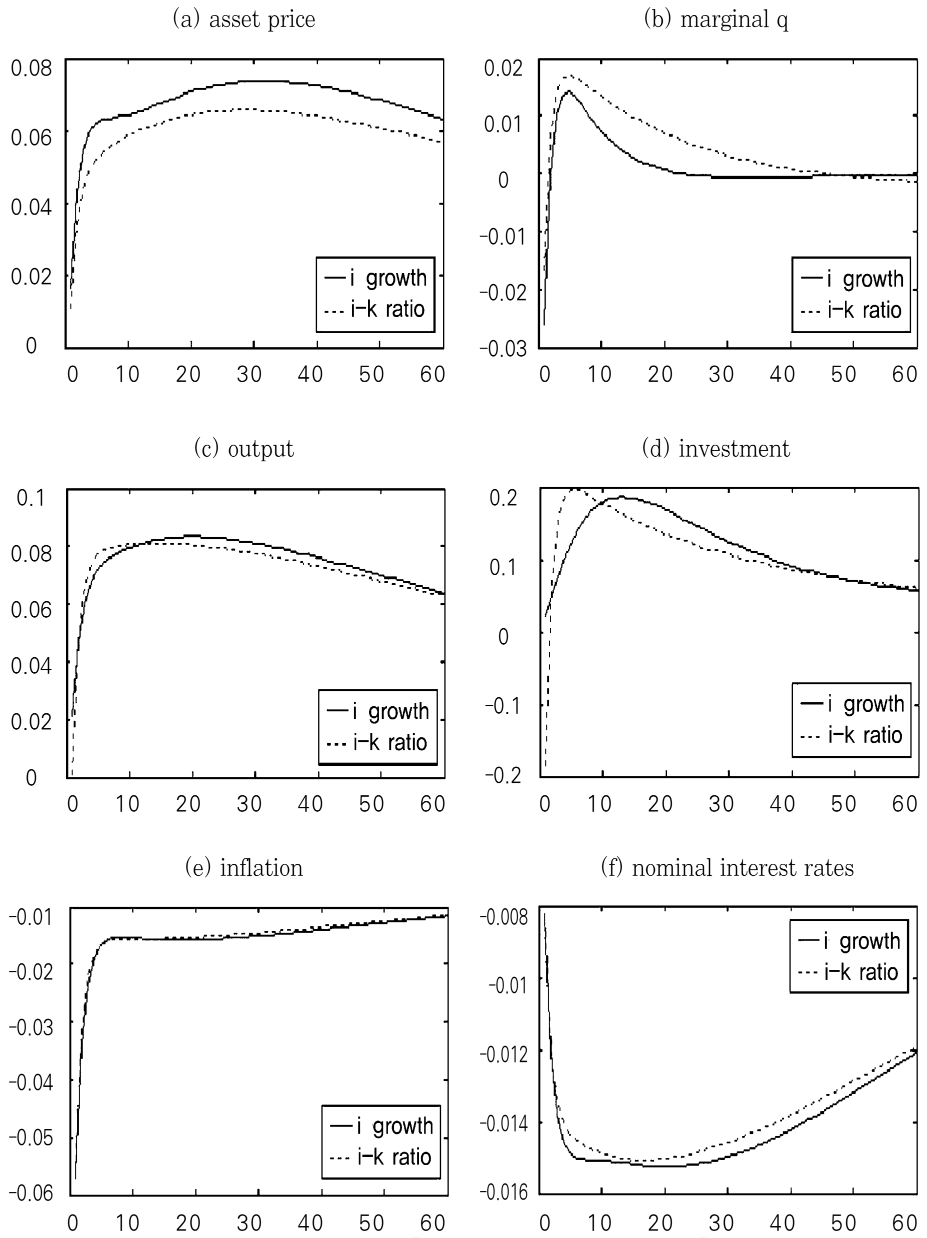


Due to the lower inflation, the monetary authority lowers interest rates in both cases. The interest rate in the Δi case falls more than the $(i\text{–}k)$ case, and real interest rate in the $(i\text{–}k)$ case rises more than the Δi case. In the $(i\text{–}k)$ case, nominal interest rates suppress the initial increase of aggregate demand, but the effects of the policy diminish quickly. The interest rate gradually falls over 20 quarters. In the Δi case, the gradual increase of aggregate demand accompanied by speedy increase of inflation. Because of the speedy increase of inflation, the interest rate falls quickly to reduce the effects of inflation on consumption.

The authority takes into account three variables when it sets the interest rates: aggregate demand, inflation and lagged interest rates. The larger output and lower inflation lead the monetary authority to raise real interest rate. While the interest rate in the $(i\text{–}k)$ case gradually decreases for periods, it displays medium-run fluctuations in the Δi case. The $(i\text{–}k)$ case has only nominal rigidities but not real rigidities, and it helps the authority to achieve its target. Monetary policy is effective in the short-run rather than in the long-run, and the initial increase of aggregate demand is not significant due to real rigidity.

Figure 4 shows the responses of economic activity under an alternative policy which has stronger interest rate smoothing. The previous interest rate smoothing parameter ρ^r is set to 0.5, and it is set to 0.9 with the new policy. Since stronger interest rate smoothing excludes rapid changes of the interest rate, it generates stronger effects of monetary policy on the economic activity. The monetary policy suppresses the initial changes of aggregate demand. Because of the smaller increases of economic activity, the asset price rises less than the previous policy. The asset price displays smaller initial responses under new policy in both cases, figure 4(a). It reaches the responses of the previous policy in 3 quarters and the responses are similar with old policy from the fourth quarter.

〈Figure 4〉 The effects of a technology shock, where the monetary authority has stronger interest-rate smoothing; $\kappa = 3.6\ \rho^{m} = 0.9$



Marginal q in both cases has smaller initial responses than the previous policy, as in figure 4(b). Marginal q in the Δi case falls negative 2 percent in the first quarter. It rises to 1 percent in the third quarter and it displays similar responses to previous policy afterwards. Marginal q in the $(i-k)$ case falls to negative 2 basis points and increases to 1.7 basis points in the fifth quarter. Compared to the Δi case, the $(i-k)$ case has more sensitive marginal q to monetary policy such that it has larger negative initial response and its peak also larger than i case. In addition, marginal q changes more gradually with new policy. Marginal revenue falls in the first quarter, and it lowers contribution of the capital stock on the profit generating process.

Output in both cases have smaller initial responses under the new policy, figure 4(c). The initial response of output is about a half of that relative to the previous policy in the Δi case. From the 5th quarter it shows similar response to the previous policy. In the $(i-k)$ case, output has negligibly small initial responses and it rises to the previous policy level for 5 quarters. The monetary policy raises real interest which affects consumption and savings decision of the households. The new policy implies that the higher interest rate lasts longer than the previous policy, and the households raise saving and reduces consumption. The smaller increases in consumption results in the smaller increases in aggregate demand.

Figure 4(d) draws the investment responses under the new policy. Investment in the Δi case displays the similar responses to previous policy except that it is slightly smaller over all periods. Investment in the $(i-k)$ case falls negative 20 percent in the first quarter and it rises to 20 percent for 7 quarters. A positive technology shock raises productivity of factors. Nominal rigidities hinder the increase in aggregate demand, and a firm reduces inputs with higher productivity and a smaller increase in aggregate demand.

In the Δi case, investment does not fall in the first quarter. Although a firm has an incentive to reduce production factors, it raises investment slightly. Negative investment in the first quarter is followed by the larger investment growth in the following quarter. The higher growth of investment hampers efficiency in capital installation. Therefore a firm raises investment slightly and manages the growth of investment over all periods.

The new policy generates similar responses of inflation rates in two cases to each other, as seen in figure 5(e). In each case, the inflation rate in the first period falls negative 5.5 percent, which doubles that of the previous policy. Likewise, the interest rates in both cases are similar to each other, figure 5(f). Stronger interest-rate smoothing generates smaller initial response of interest rates. It decreases to negative 1.5 percent through 5 quarters and it takes longer than old policy to reach negative 1.5 percent.

4. Conclusion

This paper elaborates the relationship between the asset price and the investment technology. The relationship is built on efforts to reduce investment adjustment costs, since the efforts a¤ect investment spending. Investment plays a role in production such as supplying a production factor, and also it is a part of aggregate demand. I consider two adjustment cost specifications; one is a convex function of an investment-capital stock ratio, the $(i\text{-}k)$ case, and the other is a convex function of the growth of investment, the Δi case.

In the $(i\text{-}k)$ case, a firm raises investment in the early periods of positive shocks realized. The larger capital stock reduces investment adjustment costs, and the contribution of the capital stock on the capital installation is reflected in the value of the capital stock. In the Δi case, a firm avoids drastic changes of investment, and it draws a hump-shaped response to a positive technology shock. Adjustment costs are not reflected in the value of the capital stock since the capital stock has no role in the capital installation.

The value of capital stock is a major determinant of the asset price movements. In the $(i\text{-}k)$ case, the asset price moves along the value of capital stock. In the Δi case, the asset price is different from the value of the capital stock by the present value of net benefits of an investment spending. Appropriate management of investment growth reduces adjustment costs and raises the benefits of an investment. It pushes up asset price. The net benefits of investment are not adjusted in the value of capital stock in the Δi case, since the capital stock has no role in capital installation. The capital accumulation behavior is not reflected in the value of capital stock. The asset prices adjust the net benefits of an investment purchase. In the $(i\text{-}k)$ case, adjustment costs always occur as long as investment is positive, and it is reflected in the value of capital stock already.

The priority of monetary policy is the economic stability, and the policy hinders the increase of aggregate demand. The policy is effective only in the short run, and the stronger interest rate smoothing suppresses more of the increase of aggregate demand. The slight increase of aggregate demand lowers marginal revenue of capital, and it results in smaller marginal q in the early periods.

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요 약

본 논문은 자본재 투자 비용함수가 기업가치에 미치는 영향을 분석하고, 이를 위하여 두 가지 형태의 자본재 투자 비용함수를 고려한다. 첫 번째 자본재 투자비용 함수는 기 보유 자본재(capital stock) 대비 자본재 구입비용(investment)에 따라 증감한다. 동 함수는 기업가치(asset price)를 대상으로 하는 계량경제 모형에서 빈번히 사용되는 함수이다. 두 번째 자본재 투자비용 함수는 전기 자본재 구입비용 대비 자본재 구입비용에 따라 증감한다. 동 모형은 투자를 대상으로 하는 일반균형 모형에서 사용되는 함수이다. 두 가지 형태의 자본재 투자비용 함수는 서로 다른 기업가치와 자본재 가치의 상호관계를 형성한다. 그 결과 자본재 투자비용 함수에 따라 서로 다른 투자와 생산의 충격반응곡선이 도출된다. 후자의 경우 구조식 시계열분석(SVAR)와 유사한 충격반응 곡선을 그린다. 또한 후자의 경우 양(+)의 공급충격에 대하여 기업가치의 반응이 더 크게 나타난다.

※ 국문 색인어: 기업가치, 자본재 설치비용, 자산가격, 투자