The Interest Rate Channel of Monetary Transmission in the Low Inflation Era in Korea

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Introduction

It seems obvious from both anecdotal and statistical evidence that over the years the economic and financial environments in Korea have changed fundamentally, along many dimensions, in large part since the outbreak of the 1997 financial crisis. As one striking illustration among many, we may look at the substantially lower inflation rates. We can conjecture that the evolving environment may have led to changes in the behaviors of households and firms, presumably making them more efficient or innovative. There has also been a change in the conduct of monetary policy. The Bank of Korea adopted explicit inflation targeting in 1998 and has begun to put more emphasis on interest rates in its day-to-day implementation of policy, by striving to keep the overnight call money rate, the policy rate, closer to its target.

These trends may be associated with what appears to be a change in the effectiveness of monetary policy. Hence, a better understanding of how the interest rate channel. The central element of monetary transmission – has changed in its effects on the economy during the recent low inflationary period

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will be conducive to more efficient implementation of an interest rate-focused monetary policy.

Most empirical attempts to identify the marginal impact of a single driving variable on investment based on aggregate data have been unsuccessful, due to the bias of the estimates arising mostly from the simultaneity problem or from the inability to address firm heterogeneity. While a variety of econometric techniques such as VAR approaches or structural models has been employed to solve the simultaneity problem, none is entirely satisfactory. One of the empirical frustrations involves the difficulty of finding a role for the user cost of capital in estimating the neoclassical investment equation using aggregate data. The estimated elasticity of investment with respect to the user cost of capital has been frequently found to be too small, as opposed to the case when quantity variables are used.

To circumvent this problem, recent studies have shown a tendency to employ firm-level micro data to estimate the impact of the cost of capital on investment. For example, Chirinko et al. (1999) estimated the neoclassical investment equation with U.S. firm-level panel data, finding the estimated elasticity of the capital stock with respect to the user cost to be approximately -0.25. While their estimate is relatively small, other recent empirical studies such as Chatelain et al. (2001) and Chatelain and Tiomo (2001) have claimed estimated elasticities in four major European countries ranging from -0.25 to -0.67, depending to some extent upon the model specifications and econometric techniques.

The neoclassical investment model is appropriate for analysis of the traditional interest rate channel of monetary transmission. It offers a straightforward link between financial cost and investment through the user cost of capital – the user cost being the key parameter through which monetary policy aspects investment. The connection to monetary policy comes via the link between the policy rate and the financial cost: a policy-induced interest rate increase translates into an increase in the financial cost and the user cost of capital. These changes in turn lead to a reduction in investment spending.

Using firm-level panel data in the neoclassical models, several empirical attempts including Chatelain et al. (2001) were made in 2001 to assess the strength of the interest rate channel for major European countries. Their approaches do not appear wholly satisfactory, however, in the sense that the link between the policy-induced interest rate and the user cost of capital was somewhat cavalierly treated, making it difficult to identify cleanly what might be referred to as the first-round impact of monetary policy in the cost-of-capital channel. The novelty of this paper is that it estimates more precisely the first-round effect based on the second-round one of monetary policy in the interest rate channel. the response of investment spending to a change in the user cost of capital.

The goal in this paper is to examine how the strength of the cost-of-capital channel of monetary transmission has changed in Korea in the recent low inflation era relative to the prevailing high inflation environment, by deploying a two-step process. The process begins by estimating a variant of the neoclassical model of investment, incorporating firms' cash flow based on sizable firm-level panel data over the 1988-1998 (high inflation) and 1999-2004 (low inflation) periods. This allows identification of estimates of the user cost elasticity over these different periods. Based on an expanded version of the user cost equation derived from the neoclassical theory of investment, we then generate estimates for the elasticity of the user cost of capital with respect to the policy rate over the different periods, by decomposing its chain into two parts – the elasticity of the financial cost with respect to the policy rate, and that of the user cost with respect to the financial cost. In combination, this two-step process makes it possible to pin down more precisely each sequence of transmission running from the policy rate to investment via the user cost, and thereby to identify how the effectiveness of the interest rate channel has changed in the recent low inflation period, compared to the high one.

This paper is organized as follows. Section 2 first derives the econometric equations for investment and the user cost of capital based on the neoclassical theory of investment. In Section 3, the firm-level panel data for 471 manufacturing and non-manufacturing firms over the 1988-2004 period is then described, with the summary statistics of regression variables being briefly characterized. After considering a variety of regression specifications, estimation techniques and biases, we present estimates for the user cost elasticity over the high and low inflation periods. Two approaches – the combination of three partial elasticities, and embedding the marginal effect of a change in policy rate on the user cost – are applied to obtain the estimates for the policy rate elasticity of the user cost. Taken together, the results identify the elasticity of investment with respect to monetary policy over the high and low inflation periods, which is the primary concern of this paper. Section 4 then summarizes the key empirical findings and suggests some implications for monetary policy.

Neoclassical Model of the User Cost of Capital and Investment

1. Analytic Model

The neoclassical investment model has been most widely used to explore the link between investment and taxes or interest rates, and is therefore well-suited to analysis of the effect of either fiscal or monetary policy on investment. The neoclassical theory of investment focuses on a derived demand for the flow of investment by firms. The derived demand is determined from a desired (or optimal) stock of capital obtained by Jorgenson's condition (the marginal product of capital is equal to the user cost) and some exogenous dynamic adjustment mechanism that specifies the rate at which a firm's capital stock approaches its desired level (Abel (1990), Hassett and Hubbard (1997)). Solving dynamic optimization by a competitive firm i of the present value of its net cash flow over an infinite horizon, subject to the evolution of capital accumulation, yields an expanded version of the user cost equation (1) for firm i (see Appendix A for a derivation of equation (1)). The i subscript in the following specification denotes firm-specific variables and parameters:

$$UC_{i,t} = \frac{p_t^I}{p_t^Y(1-\tau_t)}(1-TC_{i,t}-TDA_{i,t})(r_t+\delta-\frac{\dot{p}_t^I}{p_t^I}) \quad (1)$$

$$= P \times T \times R$$

where p_t^I is the asset purchase price, $p_t^Y(1-\tau_t)$ is the after-tax industry output price, τ_t is the corporate income tax rate, $TC_{i,t}$ is an investment tax credit, $TDA_{i,t}$ is the present value of tax depreciation allowances, r_t is a financial cost of capital, δ is the asset-specific constant rate of depreciation, and $\dot{p}_t^I / p_t^I$ is the capital gain (or loss) on assets.

Observe that the initial Jorgensonian user cost is adjusted for the investment tax relief ($TC_{i,t}$ and $TDA_{i,t}$) and the asset purchase price relative to the real industry output price, albeit absent the adjustment cost of capital. In a simplified version, the user cost can be decomposed into three parts: relative price (P), investment tax (T) and rental cost (R), containing two components - the opportunity cost of funds, a primary concern in our analysis, and the constant rate of depreciation.

The desired stock of steady-state capital ($K_{i,t}^*$) in equation (2) can be derived by setting the marginal product of capital[1)] equal to the user cost, and rearranging in

1) The output function ($Y_{i,t}$) of a competitive firm i with a constant elasticity of substitution has the following form of the Cobb-Douglas production function: $Y(K,L) = A[\alpha K^{-\theta} + (1-\alpha)L^{-\theta}]^{-1/\theta}$, where A is the efficiency parameter, α is the distribution parameter, θ is the substitution parameter, and the scale parameter equals one. The elasticity of substitution (σ) - defined as the elasticity of the capital/labor ratio with respect to the marginal rate of substitution between capital and labor can be denoted as $1/(1+\theta)$. Then the marginal product of capital (Y_K) is $Y_K = \alpha A^{-\theta}(Y/K)^{(1+\theta)}$. See Jorgenson (1972).

terms of the capital. The desired stock of capital for firm i is expressed as a well-known function of its real output (or real sales), $Y_{i,t}$, and the user cost of capital, $UC_{i,t}$ - proportional to $Y_{i,t}$ and inversely dependent on $UC_{i,t}$. $Y_{i,t}$ in equation (2) is assumed to be a constant return to scale in capital and labor and a Cobb-Douglas production function of a competitive firm i with a constant elasticity of substitution between the two inputs ($\sigma = 1/(1+\theta) = 1$). It is obvious in equation (2) that the output elasticity will be greater than the user cost elasticity if $\sigma < 1$. In addition, σ is closely tied to the user cost elasticity in the derived demand for the flow of investment:

$$K^*_{i,t} = (\frac{\alpha}{A^\theta})^\sigma Y_{i,t} (UC_{i,t})^{-\sigma} \qquad (2)$$

where A > 0, $0 < \alpha < 1$, θ > -1. Dynamics are required when translating the demand for capital stock to the demand for flow of gross investment ($I_{i,t}$), which consists of net investment and replacement investment. As in Chirinko et al. (1999), net investment (I^N_t) for the current period t – the change in the capital stock between periods t-1 and t – is scaled by the existing capital, $K_{i,t-1}$. An exogenous dynamic adjustment mechanism is introduced so that the net investment ratio ($I^N_t / K_{i,t-1}$) adjusts based on the weighted geometric mean of the relative changes in the desired capital stock for the past through period t, i.e., $\prod_{h=0}^{n} (K^*_{i,t-h} / K^*_{i,t-h-1})^{\alpha_h}$. Replacement investment scaled by the existing capital ($I^R_t / K_{i,t-1}$) is assumed to take place at the constant rate of depreciation, δ_i. Taking the logs of the net investment ratio and of equation (2), substituting the log of equation (2) into the log of the net investment ratio for $\ln K^*_{i,t-h}$ and $\ln K^*_{i,t-h-1}$, and adding δ_i and a white noise error ($u_{i,t}$) to it yields the following autoregressive distributed lag (ADL) investment model of equation (3):

$$\frac{I_{i,t}}{K_{i,t-1}} = \ln[I_t^N / K_{t-1}] + \delta_i = \ln\left(\sum_{h=0}^{n} (K^*_{i,t-h} / K^*_{i,t-h-1})^{\alpha_h}\right) + \delta_i$$

$$= \sum_{h=0}^{n} \alpha_h [(\ln Y_{i,t-h} - \ln Y_{i,t-h-1}) - \sigma(\ln UC_{i,t-h} - \ln UC_{i,t-h-1})] + \delta_i$$

$$= \sum_{h=0}^{n} \alpha_h \ln\left(\frac{\Delta Y_{i,t-h}}{Y_{i,t-h-1}} + 1\right) - \sigma \sum_{h=0}^{n} \alpha_h \ln\left(\frac{\Delta UC_{i,t-h}}{UC_{i,t-h-1}} + 1\right) + \delta_i + u_{i,t}$$

$$\cong \sum_{h=0}^{n} \alpha_h \left(\frac{\Delta Y_{i,t-h}}{Y_{i,t-h-1}}\right) - \sigma \sum_{h=0}^{n} \alpha_h \left(\frac{\Delta UC_{i,t-h}}{UC_{i,t-h-1}}\right) + \delta_i + u_{i,t} \qquad (3)$$

where $0 < \alpha_h < 1$, representing a mixture of static or regressive expectations and technological constraints such as delivery lags, gestation lags, and other frictions (Chirinko (1993), Breitung et al. (2003)). It is worthwhile to note that both $Y_{i,t}$ and $UC_{i,t}$ enter the gross investment model as the distributed lags of percentage changes.

2. Econometric Specification

Equation (3) is based on the assumption of a perfect capital market. But, as the claim of a balance sheet channel of monetary transmission emphasizes, it seems more realistic and acceptable to presume that a firm's investment could be sensitive to its "collateralizable" net worth (internal funds) position, owing to the asymmetric information and agency problems in the imperfect capital market. In this case, small firms that are most likely to face disproportionately large premiums for external finance show a tendency to rely almost exclusively on internal funds for their capital investment. To consider the short-term finance constraints, the ratio of liquidity to the existing capital ($LIQ_{i,t}/K_{i,t-1}$) enters equation (3) as a measure of internal funds, as with recent empirical models of investment including Fazzari et al. (1988), Chirinko and Schaller (1995) and Chirinko et al. (1999) among others:[2)]

$$\frac{I_{i,t}}{K_{i,t-1}} = \delta_i + \sum_{h=0}^{n} \alpha_h \left(\frac{\Delta Y_{i,t-h}}{Y_{i,t-h-1}} \right) - \sigma \sum_{h=0}^{n} \alpha_h \left(\frac{\Delta UC_{i,t-h}}{UC_{i,t-h-1}} \right) + \sum_{h=0}^{s} \lambda_h \left(\frac{LIQ_{i,t-h} - LIQ_i^*}{K_{i,t-h-1}} \right) + u_{i,t}$$

$$= \gamma_i + \sum_{h=0}^{n} \alpha_h \left(\frac{\Delta Y_{i,t-h}}{Y_{i,t-h-1}} \right) - \sum_{h=0}^{n} \beta_h \left(\frac{\Delta UC_{i,t-h}}{UC_{i,t-h-1}} \right) + \sum_{h=0}^{s} \lambda_h \frac{LIQ_{i,t-h}}{K_{i,t-h-1}} + \varepsilon_{i,t} \quad (4)$$

Since equation (4) has long-run properties, it seems reasonable to associate the actual liquidity ratio with its long-run level, $LIQ_{i,t-h} - LIQ_i^*$. Letting $LIQ_{i,t}^*$ approximate a constant and assuming that the firm approaches this level in the relatively short-run, would lead to the model specification of equation (4). In this case, the long-run level of liquidity scaled by the existing capital, $LIQ_i^*/K_{i,t-h-1}$, will be absorbed into a firm-specific fixed effect, γ_i. Thus, only liquidity in the level scaled by the capital ($LIQ_{i,t}/K_{i,t-1}$) enters equation (4). Cash flow can properly be

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2) According to the claim of the balance sheet channel of monetary transmission, the premium for external funds is inversely dependent on the share of a firm's capital investment that is financed by its own net worth. The less net worth a firm seeking bank credit has, the more likely it is to default because its cushion of assets is not sufficient to pay off its loans. The lender needs to be compensated for the higher agency costs (monitoring/bankruptcy costs) of the lender-borrower relationship by a larger premium. It is for the most part small firms with relatively lower collateralizable net worth (i.e., lower credit-worthiness) than large firms that are likely to face disproportionately large premiums for external finance. Thus, small firms show a tendency to rely almost exclusively on internal funds and intermediated credit such as bank loans, due to their poor access to open market credit in the face of the large premiums charged them. In contrast, large firms with good access to credit including bank loans and other sources of short-term credit will face less financial pressure. See Fazzari et al. (1988, 2000), Gertler and Gilchrist (1993), Bernanke et al. (1996, 1998), Schaller (1993), Chirinko and Schaller (1995), Kashyap et al. (1994), Gilchrist and Himmelberg (1995, 1998), Hubbard (1998), and Chirinko et al. (1999).

used as a measure of liquidity. In particular, when incorporating non-static expectations in the derivation of the demand for investment with elasticity of substitution less than one, the lag lengths of the output and user cost of capital may differ, and the magnitude of the response of investment to the output will be larger than the response to the user cost of capital in equation (4). It is worthwhile to note that the sum[3)] of β s captures the elasticity of the long-term capital stock with respect to the user cost of capital, which is key to evaluating the effects of monetary policy on investment.

Since the focus of this paper is to tap a panel of firm data, it is necessary to construct a more concrete definition of the user cost of capital, by allowing firm-specific variation at the industry and capital asset level. To this end, the specification of the user cost in equation (5), modified to reflect firm heterogeneity available from the micro data sources, is more appropriate relative to equation (1):

$$UC_{i,g,j,t} = \frac{p^I_{j,t}}{p^Y_{g,t}(1-\tau_t)}(1-TC_{g(j),t}-TDA_{j,t})(R_{i,t}+\delta_{g(j)}-\frac{\dot{p}^I_{j,t}}{p^I_{j,t}}) \qquad (5)$$

where $UC_{i,g,j,t}$ is the user cost of capital generated by taking the industry g which firm i belongs to and the tangible fixed asset j at time t into consideration, $p^I_{j,t}$ is the purchase price for asset j at time t , $p^Y_{g,t}$ is the industry g output price at time t, $TC_{g(j),t}$ is an investment tax credit applied to the asset j of the industry g at time t, $TDA_{j,t}$ is the present value of tax depreciation allowances (corporate tax rate $\tau_t \times$ the present value of the future depreciation allowances) applied to the asset j at time t, and thereby $(1-TC_{g(j),t}-TDA_{j,t})$ implies an effective after-tax purchase price of one unit of asset

3) In equation (4), the sum of βs, $SUM(\beta)$, can be expressed as the elasticity of the long-run capital stock with respect to the user cost when the lag operator equals one: $SUM(\beta)=(\Delta K_{i,t}/K_{i,t})/(\Delta UC_{i,t}/UC_{i,t})$.

j, $R_{i,t}$ is the after-tax financial cost $((1-\tau_t)r_t)$, $\delta_{g(j)}$ is the constant economic rate of depreciation applied to the asset j of the industry g (the same over time), and $\dot{p}^I_{j,t} / p^I_{j,t}$ is the capital gain (or loss) on the asset j at time t.

Estimates of the Effect of the Policy Rate on Investment

1. Panel Dataset and Summary Statistics of Regression Variables

In this section, a panel dataset is used to measure the user cost of capital of equation (5) and also for the regression estimates of equation (4). The dataset is constructed from the Kis-Value Industrial Database containing firms' financial statement data maintained by Korea Information Service. The panel dataset consists of Korean statutory audited firms excluding financial institutions for the period 1988 to 2004. After filtering out 50 firms with missing or false observations for the sample variables, or negative values in their interest expenses to total borrowings and bond payables, their real capital stock or their user cost of capital, we ends up with 570 firms. Further, trimming the outliers[4] for the sample variables used for regression estimation yields a final sample of 471 firms (396 firms from manufacturing industry and 75 firms from other industries) that provide a balanced panel of 8,007 annual observations for the regression for the period 1988 to 2004.

We now briefly describe how the sample variables used for the regression estimation of equation (4) are constructed. Real gross investment ($I_{i,t}$) is constructed as $I_{i,t} = (NIV_{i,t} + D_{i,t}) / p^I_{i,t}$, where $NIV_{i,t}$ is net investment at time t measured by net

4) An observation is classified as an outlier if the absolute value of the deviation of a variable (X_{ijt}) corresponding to firm i's asset j at time t from its mean in a specific year is greater than six times its standard deviation (σ_{jt}) based on Chevyshev Inequality: $|X_{ijt} - \overline{X}_{jt}| > 6 \times \sigma_{jt}$.

increase in tangible fixed assets from the statement of cash flows, and $D_{i,t}$ refers to replacement investment (the book value of depreciation expenses from the statement of cash flows) at time *t*. Deflating nominal investment with the firm-specific purchase price index for assets ($p^I_{i,t}$) will yield real gross investment ($I_{i,t}$).[5)]

Assuming that investment and disinvestment take place in the middle of the year, firm-level real capital stock ($K_{i,t}$) at the end of time *t* can be measured based on its initial condition (defined as the book value of net tangible assets in 1988 divided by $p^I_{i,1998}$), using real investment ($I_{i,t}$) and the depreciation rate ($\delta_{i,t}$) in the modified capital accumulation equation (6):

$$K_{i,t} = (1-\delta_{i,t})K_{i,t-1} + (1-\delta_{i,t}/2)I_{i,t}{}^{6)} \tag{6}$$

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5) The firm-specific purchase price index for assets is a weighted average of eight types of assets *j*, $p^I_{i,t} = \sum_{j=1}^{8} \omega_{i,j,t}\, p^I_{j,t}$, where $\omega_{i,j,t}$ is the proportion of the book value of asset *j* in total tangible fixed assets (excluding land) presented in the balance sheet for firm *i* at time *t*, and $p^I_{j,t}$ is the purchase price of asset *j* at time *t*. For buildings, structures, machinery, ships-airplanes, and vehicles, $p^I_{j,t}$ is the price deflator calculated with data from the composition of gross capital formation by type of capital good in the national accounts. We use the producer price index (PPI), however, for the purchase prices of tools, office equipment and other tangible assets.

6) Given that investment and disinvestment take place in the middle of the year, the depreciation rate $\delta_{i,t}$ can be formulated as

$$\delta_{i,t} = \frac{D_{i,t}}{\underbrace{\frac{1}{2}VFA_{i,t-1}}_{\text{value of tangible assets in the first half of the year}} + \underbrace{\frac{1}{2}(VFA_{i,t} + D_{i,t})}_{\text{value of tangible assets in the second half of the year}}} = \frac{2D_{i,t}}{D_{i,t} + VFA_{i,t} + VFA_{i,t-1}}$$

The traditional effective rate of depreciation, $\delta_{i,t} = D_{i,t}/VFA_{i,t-1}$ ($VFA_{i,t-1}$ is the book value of tangible assets at the end of time *t*-1), is based on the assumption that the new investment or disinvestment occurs at the end of the year. If we assume that investment and disinvestment take place in the middle of the year, $\delta_{i,t}$ would overestimate the actual rate of depreciation because the denominator, $VFA_{i,t-1}$, cannot account for the value of depreciation for new investment occurring in the middle of the year. Conversely, $\delta_{i,t}$ would be underestimated, since

We measure liquidity in equation (4) with cash flow ($CF_{i,t}$), which includes all profits, operating & non-operating, before deducting interest and income taxes (EBIT) from the Kis-Value Industrial Database for firm *i* at time *t*. As with recent empirical models of investment, firm *i*'s real output ($Y_{i,t}$) is measured by its real sales ($S_{i,t}$): nominal sales taken from the income statement deflated by the industry-specific output price deflator used to define the user cost of capital ($P^{Y}_{g,t}$)[7] in equation (5).

For the firm-specific user cost of capital ($UC_{i,g,j,t}$), we have data for eight different tangible assets (buildings, structures, machinery, ships-airplanes, vehicles, tools, office equipment, and other tangible assets) and 30 types of industries (21 types belonging to the manufacturing industry and the remaining nine to other industries). The firm-specific user cost of capital, $UC_{i,g,j,t}$, is a weighted average of the asset user costs of the industry *g* that firm *i* belongs to, with the weight being the proportion of tangible asset *j* in total assets.[8]

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a firm can keep registering the value of depreciation until the end of the year even though disinvestment has already taken place in the middle of the year. To address this problem, we assume that the actual value of tangible assets for the second half of the year, $VFA_{i,t-1} + INV_{i,t}$, can be proxied by $VFA_{i,t} + D_{i,t}$, derived from the equation $VFA_{i,t} = VFA_{i,t-1} + INV_{i,t} - D_{i,t}$, where $INV_{i,t}$ is the actual value of firm *i*'s new gross investment on tangible assets in the middle of the year. The underlying reason for this assumption is that $VFA_{i,t} + D_{i,t} - VFA_{i,t-1}$ seems to be an acceptable measure of $INV_{i,t}$ unavailable in our dataset. It can be shown from the modified depreciation rate above that $D_{i,t} = VFA_{i,t-1} \cdot \delta_{i,t} + (\delta_{i,t}/2)INV_{i,t} \cong K_{i,t-1} \cdot \delta_{i,t} + (\delta_{i,t}/2)I_{i,t}$. Substituting for the depreciation expense in the traditional capital accumulation equation with this result yields equation (6). See Gabor-Wolf (2004).

7) The deflator, $P^{Y}_{g,t}$, is defined as the industry-specific output at current prices deflated by the output at constant price taken from the gross domestic product by kind of economic activity and gross national income in the national accounts.

8) The firm-specific user cost is defined as: $UC_{i,g,j,t} = \sum_{j=1}^{8} \lambda_{j,t} UC_{g(i),j,t}$, where $\lambda_{j,t}$ is the proportion of tangible asset *j* in total assets.

The investment tax credit ($TC_{g(j),t}$) is applied to the asset *j* of the industry *g* at time *t* and varies across assets and industries. The present value of tax depreciation allowances ($TDA_{j,t}$) for the asset *j* as defined above can be created by determining the present value of the future depreciation allowances using an appropriate depreciation formula.9) The corporate income tax rate (τ_t) has been lowered continuously from 38.3% in the period 1988 to 1990 to 29.7% now (see Appendix C).

The after-tax financial cost ($R_{i,t}$) - a key variable for this study - is measured by $R_{i,t} = (1-\tau_t)r_{i,t}$, where $r_{i,t}$ is the interest expenses to total borrowings and bonds payable available from the financial statement analysis of the Bank of Korea. From this after-tax financial cost, we then deduct the GDP deflator rate to reflect the capital gain (or loss) on the asset *j* at time *t* ($\dot{p}^I_{j,t} / p^I_{j,t}$), which yields the after-tax real financial cost. The constant economic rate of depreciation applied to the asset *j* of the industry *g*; $\delta_{g(j)}$, is the same for all firms belonging to the industry *g* and for all

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9) The present value of the future depreciation allowances (θ_j) can be approximated by: $\theta_j = \sum_{t=1}^{\bar{t}} \frac{D_{j,t}}{(1+r^L)^t}$, where $D_{j,t}$ is the depreciation expense for one unit of asset *j* at time *t*, r^L is the discount rate for the depreciation expense (the yield on corporate bonds with 3-year maturity), and tis the lifetime of the asset *j* for tax purposes calculated based on enforcement regulations of the corporate income tax law. The lifetime of asset *j* is measured based on the Appendix B. To obtain $D_{j,t}$, it is necessary to apply an appropriate depreciation formula to each asset: we employ a straight-line formula for buildings and structures and a declining balance formula for other assets. For the straight-line formula, the depreciation expenses are assumed to be the same for all years:

$D_{j,t}$ = [(historical cost of asset *j* - estimated salvage value of asset *j*)/(estimated useful life of asset *j*)]

Meanwhile, the declining balance formula can be constructed by : $D_{j,t}$ = [previous year-end book value of asset *j* (historical cost of asset *j* - accumulated depreciation of asset *j*)*γ]; where γ denotes the depreciation rate for the declining balance formula taken from the depreciation rate schedule of the corporate income tax law, and the asset *j* is assumed to have no salvage value. See Hall and Jorgenson (1967).

years.[10)]

Inflation rates in most countries have fallen considerably since the mid-1990s, and a period of low and stable inflation at around the 5% level began from 2000.[11)] Figure 4 illustrates that Korea's CPI inflation rate averaged 6.3% annually during the 1988 - 1998 period, but began to slow down in 1999 and more than halved to an annual average of 2.8% over the 1999-2004 period[12)]. Since the focus of this paper is to examine whether the interest rate channel of monetary transmission has changed in the recent low inflation period, relative to the high one, for analytical convenience the periods before and after 1999 are denoted as the high and low inflation periods, respectively.

[Figure 4 in Appendix D Inserted here]

Table 1 presents summary statistics for the regression variables over the high and low inflation periods, as previously denoted. For the high inflation period, the mean of the gross investment-to-capital ratio ($I_{i,t}/K_{i,t-1}$) shows strong growth of 36.8% relative to other variables. Considering that the mean of the real depreciation rate amounts to 24.2%, however, the mean of the net real investment ratio grow by about 12.6 %. While the means of the cash flow-to-capital ratio ($CF_{i,t}/K_{i,t-1}$) and real sales

10) For buildings and structures, we apply the ratio of 1/lifetime of asset *j* as their economic depreciation rate, while using the estimated depreciation rates for other assets constructed by Hyun and Pyo (1997) due to the paucity of alternative acceptable measures.

11) Trend of CPI Inflation Rate (Annual, %)

	1980-84	1985-89	1990-94	1995-99	2000-04
World	14.1	15.5	30.4	8.4	3.9
Advanced Countries	8.7	3.9	3.8	2.0	1.8
Developing Countries	31.4	48.0	53.2	13.1	5.6

Source: IMF, *World Economic Outlook*

12) In addition, AA--rated corporate bond yields marked an annual average of 14.6% prior to 1999, but have fallen sharply to around 7% in the post-crisis period (1999-2004).

growth ($\Delta S_{i,t}/S_{i,t-1}$) - substituted for output growth in equation (4) - are moderate at 16.4% and 8.5%, respectively, the mean of the user cost growth ($\Delta UC_{i,t}/UC_{i,t-1}$) is more modest at 4.4%. The within-firm standard deviation in Table 1 represents quite large variations for all three variables, substantially exceeding their means. The statistic of firm-specific time variation provides interesting information on firm-level variation across time. This indicates the proportion of time-series variation of a variable that can be explained by firm-specific factors. If this statistic approaches one, almost all time-series variation is firm-specific. Around 95% of time-series variation is firm specific for the real sales growth and the cash flow-to-capital ratio, while around 75% to 80% is firm specific for the user cost growth and the gross investment ratio.

[Table 1 Inserted here]

In the low inflation period, the mean and within-firm standard deviation of the gross investment-to-capital ratio are lower than those in the high inflation period, with 98% of time-series variation being firm specific (compared to a lower figure of 80% in the high inflation period). In addition, the mean of the user cost growth turns out to have small negative values, and the within-firm standard deviation and firm-specific time variation are almost equal to those in the high inflation period. The summary statistics for sales growth are also not substantially different from those in the high inflation period. The firm-specific time variation of the cash flow ratio turns out to be slightly increased, from 95% over the high inflation period to 99% in the low one. In the low inflation period, therefore, the time-series variation for all variables, excluding the user cost growth, is for the most part firm specific.

Figures in Appendix D illustrate the evolution of all regression variables in the sample period. Figure 1 in Appendix D shows that the gross investment ratio dropped sharply between 1988 and 1993 before leveling off up to 1997, and after falling significantly in 1998 it began a very slow decline. Figure 1 also reveals relatively large low-frequency movements of the user cost growth over the sample period. When comparing the investment ratio with the trend of the user cost growth, it turns out that there seemed to be a modest negative correlation between the two variables over the high inflation period, while the correlation was not clear-cut thereafter. This finding is essentially consistent with estimates for the user cost elasticity of capital over the different periods, as will be analyzed below. Figure 2 in Appendix D, tracing out the movements of all three variables, indicates that the patterns of both real sales growth and the cash-flow ratio were similar to those of the investment ratio over the pre-crisis period, after which there were larger swings of both variables, especially in 1998 - 2001.

Figure 3 in Appendix D illustrates the annual growth rates of the user cost of capital and its components over the sample period. The user cost growth was modest, being between around 0.1% - 0.2%. Note that the after-tax real financial cost tended to move in tandem with the user cost, with its value being lower than the latter. However, an effective after-tax purchase price of one unit of asset *j*, $(1-TC_{g(j),t}-TDA_{j,t})$, appears to have a modest negative correlation with the purchase price of asset *j* relative to the after-tax industry *g* output price, $p^{I}_{j,t}/p^{Y}_{g,t}(1-\tau_t)$.

2. Estimates of the Effect of the User Cost of Capital on Investment

This section aims to identify the fixed effect (FE), the first difference (FD) and fixed effect instrumental variable (FEIV) estimates for the user cost elasticity of the capital stock.

We begin by estimating the neoclassical model of investment (equation (4)) with and without cash flows, using both the FE and FD methods and the firm-level panel data over the high inflation period from 1988 to 1998. Table 3 presents two alternative estimators that eliminate firm-specific fixed effects using both the FE and

FD models. All four regressions reported in Table 3 give estimates for the distributed lag coefficients of the user cost growth ($\Delta UC_{i,t}/UC_{i,t-1}$). All of the individual coefficients of $\Delta UC_{i,t}/UC_{i,t-1}$ have the expected negative signs, and most of them turn out to be statistically significant. The sum of the estimated individual coefficients denoted as *SUM*(β) - representing the elasticity of the long-term capital stock with respect to the user cost of capital - ranges narrowly from -0.253 to -0.291. The null hypotheses that *SUM*(β) is zero or minus unity are both rejected, confirming that the user cost elasticity is statistically different from minus one as well as zero. Including cash flow to the model does not change *SUM*(β) significantly, while it lowers the sum of the individual coefficients of sales growth, *SUM*(α), from 0.220 to 0.163 in the FE regression and from 0.146 to 0.064 in the FD regression. One plausible explanation for the lower coefficients on sales growth may be the simultaneity between sales growth and the cash flow ratio, given the modest positive correlation of 0.153 between them. Meanwhile, the correlation between the user cost growth and the cash flow ratio turns out to be nearly zero (-0.029). It seems most likely that the estimated *SUM*(β) in the regression with cash flow captures the conventional substitution effect of the user-cost change.

[Table 3 Inserted here]

Table 4 reports the FE and the FD estimates for the neoclassical model of investment in the recent low inflation period of 1999 through 2004. Table 4 shows the estimates with a more parsimonious specification, dropping the insignificant lags of the user cost in particular. It is important to note that the estimated *SUM*s, notably the *SUM*(β) in absolute value, are markedly reduced in the FE and the FD regressions with and without cash flow. The estimated *SUM*(β) in absolute value has fallen to a level ranging from -0.019 to -0.027, with the contemporaneous user cost effect alone being significant. This is in sharp contrast to the corresponding estimates of -0.253 to -0.291 in the high inflation period. The result appears to be in line with the widely-held view that firms' investment has recently become less sensitive to changes in the real financial cost (i.e., the user cost), relative to the pre-crisis period, essentially due to the less-binding finance constraints alleviating their need to resort to external borrowings. In addition, it seems likely that firms' investment lag[13)] in response to the change in the user cost has shortened noticeably in the recent low inflation period. The estimates for the $SUM(\alpha)$ and $SUM(\psi)$ have also declined to a large extent, if not so dramatically as those of the $SUM(\beta)$. On balance, the evidence suggests the possibility that the traditional neoclassical theory of investment may no longer be suitable to account for the recent patterns of firms' investment behavior.[14)]

[Table 4 Inserted here]

As just discussed, the firms' investment ratio is modestly correlated with other regressors − especially sales growth and the cash flow ratio. The firms' sales growth is also positively correlated to some extent with the cash flow ratio. Thus, including cash flow lowers the effects of sales growth. There is, however, almost no correlation between user cost growth and the cash flow ratio. Consistent with this finding, the aforementioned FE and the FD estimates for the *SUM*s are relatively volatile, depending upon whether the FE or the FD regression is employed, and whether cash flow is included or not. In this case, the estimated *SUM*s including $SUM(\beta)$ can be biased and thereby inconsistent. To get around the possible problem of simultaneity, the FEIV estimation may therefore prove useful.

Table 5 presents the FEIV estimators over the high inflation period (refer to the

13) See Avner and William (1996).

14) Firms' investment in the recent low inflation period may be more influenced by other factors, such as the growing uncertainty about investment timing associated with the difficulty in finding new profitable business lines, and the alleviation of finance constraints due mainly to the lower interest rates and improved finance structures, among others.

instrument lists in the table footnote). Hausman tests reject the FE and the FD estimates in favor of the FEIV estimates for the model with the same specifications as in Table 3 for the high inflation period. The model in Table 3 is then reestimated with the instrument variables in a parsimonious specification, excluding the insignificant lags of the regressors. Note that the FE and FD estimates in Table 4 are suitable to the low inflation period, because the Hausman test cannot reject the null hypothesis that the FE and the FD estimates are equal to the FEIV estimates. In the FEIV estimates for the high inflation period in Table 5, only the contemporaneous term is significant for sales growth. The FEIV estimates for the $SUM(\beta)$ are -0.247 for the regression without cash flow and -0.259 for the regression with cash flow. However, the FEIV estimates for the $SUM(\psi)$ reach 0.304, almost tripling the FE and the FD estimates (0.098 - 0.113) for the low inflation period in Table 4. This result may provide evidence to support the widely-held view that firms' investment decisions at the time were influenced by their internal funds (liquidity) − i.e., their finance constraints − in an important way.

In sum, three key findings can be drawn from the results in Tables 4 and 5. First, the estimate for the long-run user cost elasticity ($SUM(\beta)$) turns out to be -0.259 for the high inflation period. However, it falls dramatically in absolute value for the recent low inflation period to move within a narrow range from -0.019 to -0.027. This result confirms that the user cost elasticity − the second-round impact of monetary policy in the cost-of-capital channel − is significantly different from zero but much less than unity in absolute value. Second, the long-run user cost elasticities in absolute value appear to be largely similar to or even higher than the long-run sales elasticities, providing evidence against the simple accelerator models that include only sales. Third, the estimated $SUM(\psi)$ amounts to 0.304 in the high inflation period, almost triple the corresponding estimates (0.098 - 0.113) in the low inflation period. This evidence suggests that firms' internal funds (liquidity) were another important factor determining their investment in the pre-crisis period.

[Table 5 Inserted here]

3. Estimates of the Effect of the Policy Rate on the User Cost of Capital

This section is devoted to identifying the first-round effects of monetary policy in the cost-of-capital channel for the high and low inflation periods. This issue is dealt with by generating estimates for the elasticity of the user cost with respect to the policy rate (overnight call money rate) based on the specification of the user cost in equation (5). The elasticity of the user cost with respect to the policy rate can be decomposed into two parts – the elasticity of the financial cost with respect to the policy rate and that of the user cost with respect to the financial cost.

3.1. Estimation Methods

The first-round impact of monetary policy in the cost-of-capital channel can be traced out by a chain of the three partial elasticities. Monetary policy does not have a direct effect on the user cost. The connection to monetary policy comes via the link between the policy rate and the after-tax financial cost: a policy-induced interest rate increase translates into an increase in the financial cost, which in turn implies a higher user cost of capital. The chain of the three partial elasticities in equation (7) is a useful device[15] to capture the interest rate channel of monetary transmission at work. As already discussed, the estimate for the long-run user cost elasticity ($SUM(\beta)$), denoted as $\varepsilon^{K_{i,t}}_{UC_{i,t}}$ in equation (7), represents the second-round impact of monetary policy in the interest rate channel. The elasticity of the user cost with respect to the policy rate ($\varepsilon^{UC_{i,t}}_{r^c_t}$) in equation (7) is the first-round effect of monetary policy in the interest rate channel. $\varepsilon^{UC_{i,t}}_{r^c_t}$ can be decomposed into two parts - the elasticity of the

15) The simple and clear-cut decomposition of equation (7) will remain conceptually robust, *ceteris paribus*, when a change occurs in one of the partial elasticities.

financial cost with respect to the policy rate ($\varepsilon_{r_t^c}^{R_{i,t}}$), and that of the user cost with respect to the financial cost ($\varepsilon_{R_{i,t}}^{UC_{i,t}}$):

$$\varepsilon_{r_t^c}^{K_{i,t}} = \varepsilon_{UC_{i,t}}^{K_{i,t}} \times \underbrace{\varepsilon_{R_{i,t}}^{UC_{i,t}} \times \varepsilon_{r_t^c}^{R_{i,t}}}_{\varepsilon_{R_t^c}^{UC_{i,t}}} \qquad (7)$$

where r_t^c is the monetary policy indicator or policy rate, and $R_{i,t}$ is the after-tax financial cost as the key determinant of the user cost of capital.

The elasticity of the user cost with respect to the financial cost ($\varepsilon_{R_{i,t}}^{UC_{i,t}}$) can be directly estimated from the user cost equation (5).[16] However, given that $\varepsilon_{r_t^c}^{R_{i,t}} = \frac{\partial R_{i,t}}{\partial r_t^c}(\frac{r_t^c}{R_{i,t}})$, there is some difficulty in directly estimating the marginal effect of a change in the policy rate (overnight call money rate) on the after-tax financial cost ($\frac{\partial R_{i,t}}{\partial r_t^c}$), because r_t^c has only the time variation common to all firms, as opposed to $R_{i,t}$ which allows firm-level variation. To get around that problem, we obtain an approximation of $\frac{\partial R_{i,t}}{\partial r_t^c}$ by the weighted average of the marginal effect of the monthly change in the policy rate on the bank lending rate ($\frac{\partial r_t^B}{\partial r_t^c}$) and long term interest rate ($\frac{\partial r_t^L}{\partial r_t^c}$), where r_t^B is a weighted average of commercial banks' interest rates on loans

16) $\varepsilon_{R_{i,t}}^{UC_{i,t}}$ can be approximated by $\frac{\partial UC_{i,t}}{\partial R_{i,t}}\frac{\overline{R}_{i,t}}{\overline{UC}_{i,t}}$, where $\overline{R}_{i,t}$ and $\overline{UC}_{i,t}$ represent the average after tax financial cost and the average user cost, respectively. From the equation (5), $\frac{\partial UC_{i,t}}{\partial R_{i,t}}$ turns out to be $\frac{p_{j,t}^I}{p_{g,t}^Y(1-\tau_t)}(1-TC_{g(j),t}-TDA_{j,t})$. Thus, an approximation of $\varepsilon_{R_{i,t}}^{UC_{i,t}}$ defined as $\frac{p_{j,t}^I}{p_{g,t}^Y(1-\tau_t)}(1-TC_{g(j),t}-TDA_{j,t})\frac{\overline{R}_{i,t}}{\overline{UC}_{i,}}$.

to firms and r_t^L an average yield on high-grade corporate bonds adjusted to AA-basis. Thus, an approximation of $\frac{\partial R_{i,t}}{\partial r_t^c}$ is defined as $\frac{\partial \hat{R}_{i,t}}{\partial r_t^c} = \frac{\partial r_t^B}{\partial r_t^c} \times SB + \frac{\partial r_t^L}{\partial r_t^c} \times LB$, where SB is the weight of firms' short-term borrowing and LB the weight of firms' long-term borrowing. Notice that this simplified approximation is based on the source of the firm-level financial debt over which the after-tax financial cost (firms' average interest expenses to total borrowings and bonds payable) at the firm level, $R_{i,t}$, in equation (5) has been constructed.[17] Using $\frac{\partial \hat{R}_{i,t}}{\partial r_t^c}$,[18] $\varepsilon_{r_t^c}^{R_{i,t}}$ can be approximated by $\varepsilon_{r_t^c}^{R_{i,t}} \cong \frac{\partial \hat{R}_{i,t}}{\partial r_t^c}(\frac{\bar{r}_t^c}{\bar{R}_{i,t}})$, where $\bar{r}_t^c$ and $\bar{R}_{i,t}$ denote the average policy rate and the average after-tax financial cost, respectively, over the high and low inflation

17) For example, short-term borrowing from financial institutions accounts for about 48% of firms' total financial debt and long-term borrowing (new issues of corporate bonds) around 19% on average over the whole period. The average weights of firms' short-term and long-term borrowings turn out to change only modestly over time. The approximation, however, is based on the assumption that a monthly change in the policy rate does not change the weights of firms. short-term and long-term borrowings. This assumption may be valid only in the short-run. If firms adjust their leverage in response to the policy-induced interest rate changes, the elasticity of financial cost with respect to the policy rate could be lower than it would be without adjustments of their financing structures. Furthermore, we obtain the estimates of $\frac{\partial r_t^B}{\partial r_t^c}$ and $\frac{\partial r_t^L}{\partial r_t^c}$ for the different periods by regressing the monthly bank lending rate and the monthly average yield on corporate bonds, respectively, on the monthly policy rate and taking the resulting coefficients for the corresponding periods.

18) To obtain an approximation of $\frac{\partial \hat{R}_{i,t}}{\partial r_t^c}$, we first estimate the marginal effect of the monthly change in the policy rate on the bank lending rate ($\frac{\partial r_t^B}{\partial r_t^c}$) and long term interest rate ($\frac{\partial r_t^L}{\partial r_t^c}$) for the different periods. Then multiplying the estimates of $\frac{\partial r_t^B}{\partial r_t^c}$ (i.e., $\frac{\partial \hat{r}_t^B}{\partial r_t^c}$) and $\frac{\partial r_t^L}{\partial r_t^c}$ (i.e., $\frac{\partial \hat{r}_t^L}{\partial r_t^c}$) by the average weights of firms' short-term borrowing (SB) and long-term borrowing (LB) over the corresponding periods yields $\frac{\partial \hat{R}_{i,t}}{\partial r_t^c}$. For example, as seen in the second row (B) in Table 6, $\frac{\partial \hat{R}_{i,t}}{\partial r_t^c}$ ends up at 0.319, which is calculated by $\frac{\partial \hat{r}_t^B}{\partial r_t^c}(=0.471) \times SB(=0.471) + \frac{\partial \hat{r}_t^L}{\partial r_t^c}(=0.66) \times LB(=0.192)$.

periods.

Another approach to estimating the first-round impact of monetary policy in the cost-of-capital channel involves equation (8), which follows a two-step process to estimate the effect of a change in the policy rate on the capital stock with a balanced panel consisting of our 471 firms. Equation (8) can be decomposed into two parts: the elasticity of the long-term capital stock with respect to the user cost corresponding to the estimate for the long-run user cost elasticity ($SUM(\beta)$), and the weighted average of the firm-specific percentage change in the user cost as a result of a change in the policy rate (Δr_t^c). Of particular importance is the second part of equation (8), which measures the effect of a change in the policy rate on the user cost, i.e., the first-round effect of monetary policy.[19] The change in the user cost for the total sample of 471 firms ($\sum_{i=1}^{471} \Delta UC_{i,t}$) can be decomposed into the chain of two marginal effects attributed to a change in the policy rate (Δr_t^c), $\sum_{i=1}^{471}([\frac{\partial UC_{i,t}}{\partial R_{i,t}} \frac{\partial \hat{R}_{i,t}}{\partial r_t^c}]\Delta r_t^c)$, where $\frac{\partial \hat{R}_{i,t}}{\partial r_t^c}$ is an approximation of $\frac{\partial R_{i,t}}{\partial r_t^c}$, as described above. Note that $\omega_{i,t-1}^K$ is firm i's share of the total sample capital stock ($K_{i,t}/K_t$) in equation (8).

$$\sum_{i=1}^{471} \frac{I_{i,t}}{K_{t-1}} = \sum_{i=1}^{471} \frac{\Delta K_{i,t}}{K_{t-1}} = \sum_{i=1}^{471} \frac{\Delta K_{i,t}}{K_{i,t-1}} \frac{K_{i,t-1}}{K_{t-1}}$$

$$= SUM(\beta) \sum_{i=1}^{471} \frac{\Delta UC_{i,t}}{UC_{i,t-1}} \frac{K_{i,t-1}}{K_{t-1}}$$

$$= SUM(\beta) \sum_{i=1}^{471} (\frac{\Delta UC_{i,t}}{UC_{i,t-1}}) \omega_{i,t-1}^K$$

19) Equation (8) is a modified version of the formula designed to estimate the effect of a tax change on the capital stock by Chirinko et al. (1999).

$$\cong SUM(\beta)\left\{\sum_{i=1}^{471}\frac{[\frac{\partial UC_{i,t}}{\partial R_{i,t}}\frac{\partial \hat{R}_{i,t}}{\partial r_t^c}]\Delta r_t^c}{UC_{i,t-1}}\omega_{i,t-1}^K\right\} \quad (8)$$

3.2. Estimation Results

Table 6 presents the estimates for the elasticity of the user cost with respect to the call money rate, drawn using the chain of the three partial elasticities in equation (7). The estimate for the elasticity of the user cost with respect to the financial cost ($\varepsilon_{R_{i,t}}^{UC_{i,t}}$) obtained using equation (5) amounts to 0.712 over the high inflation period, larger than the corresponding estimate of 0.514 for the low inflation period. In contrast, the estimate for the elasticity of the financial cost with respect to the policy rate ($\varepsilon_{r_t^c}^{R_{i,t}}$) for the high inflation period is reduced to 0.304, distinctively lower than the estimate of 0.816 for the low inflation period. This result may be attributable to the much higher marginal effect of a change in the policy rate on the after-tax financial cost ($\frac{\partial \hat{R}_{i,t}}{\partial r_t^c}$) for the low inflation period. The elasticity of user cost with respect to the policy rate ($\varepsilon_{r_c^t}^{UC_{i,t}}$), captured by the chain of $\varepsilon_{R_{i,t}}^{UC_{i,t}}$ and $\varepsilon_{r_t^c}^{R_{i,t}}$ taken together, ends up at 0.216 for the high inflation period and 0.419 for the low inflation period.

[Table 6 Inserted here]

Table 7 reports the estimates for the percentage change in the user cost for the total sample of 471 firms as a result of a change in the policy rate (Δr_t^c). Assuming that the marginal effect of a change in the policy rate on the after-tax financial cost, as approximated by $\frac{\partial \hat{R}_{i,t}}{\partial r_t^c}$ is the same for all 471 firms, a change in the policy rate (Δr_t^c) is expected to have an effect on the percentage change in the user cost of 3.154$\times$ Δr_t^c

for the high inflation period. Meanwhile, the impact rises substantially to 10.247× Δr_t^c for the low inflation period.

[Table 7 Inserted here]

4. Estimates of the Effect of the Policy Rate on Investment

The two-step process that we have followed above will make it possible to determine each sequence of the transmission running from the policy rate to investment via the user cost and to identify how the effectiveness of the interest rate channel has changed over time. Table 8 provides a summary of the estimates for the two key partial elasticities embedding the interest rate channel of monetary transmission. Substituting for the user cost elasticity ($\varepsilon_{UC_{i,t}}^{K_{i,t}}$) with the estimate for the long-run user cost elasticity ($SUM(\beta)$) and multiplying it by the estimate for the elasticity of the user cost with respect to the policy rate ($\varepsilon_{r_t^c}^{UC_{i,t}}$) yields the estimate for the elasticity of the capital stock with respect to the policy rate ($\varepsilon_{r_t^c}^{K_{i,t}}$), which is the primary concern of this study.

The third row (C) of Table 8 indicates that the capital stock decreases by 0.056% in response to a one percent increase in the policy rate for the high inflation period, while declining by merely 0.011% in the low inflation period. An illustrative calculation to assess whether the estimates for $\varepsilon_{r_t^c}^{K_{i,t}}$ are economically significant will be informative. The estimated $\varepsilon_{r_t^c}^{K_{i,t}}$ for the high inflation period suggests that if the call money rate increases by 25 basis points (5%) from the current level of 5%, the long-run capital stock will fall by 0.280% (= 0.056×0.05). With the estimated $\varepsilon_{r_t^c}^{K_{i,t}}$ for the low inflation period and the same scenario, however, the long-run capital stock will decline by 0.055% (= 0.011×0.05). This result can be interpreted as real evidence that the strength of the cost-of-capital channel has been markedly weakened since 1999 in Korea, so as to amount to only approximately 20% of that during the high inflation period. The underlying reason for this evidence may be attributed to the dramatic decline in the user cost elasticity in the recent low inflation period. Moreover, considering that the estimated $SUM(\psi)$ of 0.113 for the low inflation period is much less than the corresponding estimate of 0.304 for the high inflation period, as noted in Tables 4 and 5, it seems conceivable that the effectiveness of the broad credit channel (what is referred to as a financial accelerator hypothesis) may also have been substantially attenuated.

[Table 8 Inserted here]

Table 9 presents the estimates for the strength of the interest rate channel of monetary transmission running through the percentage change in the user cost for the total sample of 471 firms. Based on equation (8), multiplying the estimate for the long-run user cost elasticity ($SUM(\beta)$) by the estimated impact of a change in the policy rate (Δr_t^c) on the weighted average of the firm-specific percentage change in the user cost yields the estimate for the percentage change in the capital stock ($\Delta K_{i,t}/K_{i,t-1}$, the investment/capital ratio) as a result of a change in the policy rate for the total sample of 471 firms. The estimates for $\Delta K_{i,t}/K_{i,t-1}$ in response to Δr_t^c as shown in the third row (C) of Table 9 are -0.817$\times \Delta r_t^c$ and -0.277$\times \Delta r_t^c$ for the high and low inflation periods, respectively. The effectof a change in the policy rate by Δr_t^c on the percentage change in the capital stock turns out to be much larger in absolute value for the high inflation period than for the low inflation one, by a factor of almost three. An illustrative calculation using these estimates suggests that if the call money rate rises by 5% from the current level of 5% (Δr_t^c = 25 bp), the investment/capital ratio ($\Delta K_{i,t}/K_{i,t-1}$) for the total sample of 471 firms would fall by

0.204% (= 0.817×0.25) for the high inflation period. However, the dampening effect of the call money rate increase of 25 bp on $\Delta K_{i,t}/K_{i,t-1}$ will be only 0.069% (= 0.277 × 0.25) for the low inflation period.

[Table 9 Inserted here]

Overall, it is worthwhile to note that the two estimation methods discussed above, even though offering somewhat different approaches to estimation, provide very similar estimates of the strength of the interest rate channel over the high and low inflation periods. Given the estimated elasticity of the capital stock with respect to the call money rate ($\varepsilon^{K_{i,t}}_{r^c_t}$) for each period and a 25 bp (5%) increase in the call money rate from the current level of 5%, the investment/capital ratio ($\Delta K_{i,t}/K_{t-1}$) is predicted to fall by 0.204% to 0.280% for the high inflation period. However, the investment/capital ratio would decline very modestly for the low inflation period, ranging quite narrowly from -0.055% to -0.069%.

Summary and Policy Implications

This paper aims to investigate how the strength of the cost-of-capital channel of monetary transmission has changed in the recent low inflation period (1999 - 2004) relative to the high one in Korea. To this end, this paper provides a two-step process. First, we determine the long-run user cost elasticities for the high and low inflation periods by estimating a variant of the neoclassical model of investment with sizable firm-level panel data. Second, we then generate estimates for the elasticity of the user cost with respect to the policy rate for the different periods by decomposing its chain into two parts – the elasticity of the financial cost with respect to the policy rate, and that of the user cost with respect to the financial cost. This two-step process pins down 24 more precisely each sequence of transmission running from the policy rate to investment via the user cost, and thereby identifies how the effectiveness of the interest rate channel has changed in the recent low inflation period, compared to the past high one.

Key findings drawn from this study can be summarized as follows. First, the estimate for the long-run user cost elasticity turns out to be -0.259 for the high inflation period. It falls dramatically in absolute value for the recent low inflation period to move within a narrow range from -0.019 to -0.027. This result confirms that the estimates for the user cost elasticity are significantly different from zero but much less than unity in absolute value. The estimation of the elasticity of the user cost with respect to capital stock, based on the real gross investment model excluding cash flows over the 1988-2004 period, shows that the estimated user cost growth coefficient is almost zero and statistically insignificant - although the estimation result is less reliable due to the relative shortness of the estimation period.[20] Therefore, relative to other comparable investment studies, our estimates for the user cost elasticity are small in absolute value and even more so for the low inflation period. Chirinko et al. (1999) claim that the estimated elasticities for the U.S.A. are approximately -0.25. Chatelain et al. (2001) and Chatelain-Tiomo (2001) find these elasticities for four major European countries to lie in a range from -0.25 to -0.67. The strikingly small estimates for the recent low inflation era in Korea would support the widely-held view that firms' investment has recently become less sensitive to the change in the financial cost (i.e., the user cost), relative to the pre-crisis period. This

20) The estimation results obtained using aggregate data are presented in what follows.

$$I_t/K_{t-1} = \underset{(4.28)}{0.767}(\Delta GDP_t/GDP_{t-1}) - \underset{(-0.184)}{0.007}(\Delta UC_t/UC_{t-1}) + \underset{(19.42)}{0.726}(I_{t-1}/K_{t-2})$$

In contrast to the case when micro firm-level data are used, here micro data on the annual averages of the 471 firms are used for the gross investment-to-capital ratio and the growth rate of the user cost, real GDP is used instead of real sales revenue, and time lags are included to alleviate endogeneity. The t-values are in parentheses and *Adj*. R^2 is 0.93.

result may be essentially traced back to the growing uncertainty about investment timing associated with the difficulty in finding new profitable business lines, and the less-binding finance constraints which alleviate their need to resort to external borrowing. In addition, the contemporaneous user cost effect alone is significant for the low inflation period, suggesting that firms' investment lag in response to the change in the user cost has shortened noticeably. On balance, the evidence suggests the possibility that the traditional neoclassical theory of investment may not be suitable to account for the recent patterns of firms' investment behavior.

Second, the estimated sum of cash flow ratio is 0.113 for the low inflation period, much less than the corresponding estimate of 0.304 for the high inflation period. This result seems to provide evidence that the effectiveness of the broad credit channel may also have been attenuated to a great extent.

Third, given the estimated elasticities of the capital stock with respect to the call money rate ($\varepsilon^{K_{i,t}}_{r^c_t}$) for each period, and a 25 bp (5%) increase in the call money rate from the current level of 5%, the investment/capital ratio is predicted to fall within a range from -0.204% to -0.280% for the high inflation period. However, the dampening effect of the policy rate increase on the investment/capital ratio would be very modest for the low inflation period, ranging quite narrowly from -0.055% to -0.069%. This result implies that the effectiveness of the interest rate channel in the low inflation period has been substantially weakened, so as to remain only approximately 20 to 30 percent of what would be predicted for the high inflation period. The underlying reason for that evidence may be attributed to the dramatic decline in the user cost elasticity ($\varepsilon^{K_{i,t}}_{UC_{i,t}}$) in absolute value for the recent low inflation period, even though elasticity of the user cost with respect to the policy rate ($\varepsilon^{UC_{i,t}}_{r^c_t}$) has risen by more than a factor of two relative to the high inflation period.

The evidence presented here suggests some policy implications. First, given the profound attenuation of the interest rate channel of monetary transmission over the recent post-crisis period, the monetary authority needs to take a renewed interest in finding practical means of preserving monetary policy effectiveness. Considering that the main culprit is the substantial decline in user cost elasticity in the recent era of low inflation, it seems important to provide an environment that renders investment more responsive to a policy-induced change in the user cost. Scope for implementation by the authority of workable and dependable policies to this end appears very limited, however, in the sense that firms' investment undertaken in response to the policy-induced change in the user cost tends to be principally self-determined. One practical way around this difficulty might be through tax-related policy, rather than monetary policy. Increasing tax incentives to investors by extending the investment tax relief scheme, for example, or alleviating various regulatory burdens, might serve to reduce firms' costs in adjusting their capital stocks and enhance their investment responsiveness to the policy-induced user cost change. This issue, clearly, confronts the authority with a new and serious challenge, which may not be so easy to address.

Second, it is worth noting that, as of the final year of the sample period (2004), the 471 firms used here account for 54 % of the total assets of all firms listed on the KOSPI and KOSDAQ exchanges and 29% of those of all Korean non-financial firms. While the data may not be fully representative of Korean economy as a whole, it seems most likely that the above estimates yield a reasonable characterization of the aggregate effect of monetary policy on investment, operating through the interest rate channel. This is in contrast with the often unsuccessful results of estimation using aggregate data, and suggests the benefit of using firm-level micro data in future studies.

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Appendix A

Derivation of the User Cost of Capital

Let $K_{i,t}$ and $L_{i,t}$ be a competitive firm *i*'s stock of capital and amount of labor employed at time *t*, respectively. Let $Y(K_{i,t}, L_{i,t})$ be the output function of firm *i* that is concave with respect to $K_{i,t}$ and $L_{i,t}$ ($Y'(\bullet) > 0, Y''(\bullet) < 0$), and let $I_{i,t}$ be the real gross investment of firm *i* at time *t*. Let τ_t be the corporate income tax rate. Assuming that p_t^Y denotes the output price of the industry which firm *i* belongs to, p_t^I represents the purchase price of the investment asset, and $\Im_{i,t}$ is firm *i*'s investment tax relief (investment tax credits, $TC_{i,t}$, and tax depreciation allowances, $TDA_{i,t}$) at time *t* yields firm *i*'s net cash flow ($NCA_{i,t}$) equation (A-1). Firm *i* aims to maximize the discounted value of its net cash flow over an infinite horizon, (A-2), subject to the typical capital stock accumulation equation (A-3) in continuous time and the condition that K_t is given:

$$NCA_{i,t} = (1-\tau_t)[p_t^Y Y(K_{i,t}, L_{i,t}) - \omega_t L_{i,t}] - p_t^I(1-\Im_{i,t})I_{i,t} \tag{A-1}$$

$$V_t = Max\int_{s=t}^{\infty} NCA_{i,s}e^{-rs}ds \tag{A-2}$$

$$\text{s.t.}\quad \dot{K}_{i,t} = I_{i,t} - \delta K_{i,t-1} \tag{A-3}$$

where ω_t is the nominal wage rate, *r* is the constant rate of interest that discounts the net cash flow at time *s*, and δ is the constant rate of depreciation. To solve the firm's maximization problem, we end up choosing $L_{i,t}$ and $I_{i,t}$ so as to maximize the current value Hamiltonian of equation (A-4). Differencing $H_{i,t}$ with respect to $I_{i,t}$ and setting the derivative equal to zero produces the first order necessary condition of equation (A-5). Further, using the relation between the shadow price of capital, $q_{i,t}$, defined as the discounted value of the stream of marginal net cash flow that is made possible by an additional unit of installed capital at time *t*. and the current value Hamiltonian, i.e., $\partial(e^{-rt}q_{i,t})/\partial t = -e^{-rt}H_{i,t}/\partial K_{i,t}$ (Arrow and Kurtz, 1971), and rearranging the resulting equation in terms of $\dot{q}_{i,t}$ yields equation (A-6). Substituting for $q_{i,t}$ in equation (A-6) with the counterpart of equation (A-5) and imposing Jorgenson's condition stating that the marginal product of capital (Y_K) is equal to the user cost of capital ($UC_{i,t}$), letting $\dot{q}_{i,t}$ equal $\dot{p}_t^I(1-\Im_{i,t})$, and rearranging the resulting equation in terms of $UC_{i,t}$, we obtain equation (A-7), which is the same as equation (1) in the text :

$$H_{i,t} = NCA_{i,t} + q_{i,t}(\dot{K}) \tag{A-4}$$

$$= [(1-\tau_t)(p_t^Y Y(K_{i,t}, L_{i,t}) - \omega_t L_{i,t}) - p_t^I(1-\Im_{i,t})I_{i,t}] + q_{i,t}(I_{i,t} - \delta K_{i,t-1})$$

$$\frac{\partial H_{i,t}}{\partial I_{i,t}} = 0 \quad \Rightarrow \quad q_{i,t} = p_t^I(1-\Im_{i,t}) \tag{A-5}$$

$$\frac{\partial e^{-rt}H_{i,t}}{\partial K_{i,t}} = -\partial[e^{rt}q_{i,t}]/\partial t \quad \Rightarrow \quad \dot{q}_{i,t} = (r_t+\delta)q_{i,t} - (1-\tau_t)(p_t^Y Y_K) \tag{A-6}$$

$$UC_{i,t} = \frac{p_t^I}{p_t^Y}\frac{(1-\Im_{i,t})}{1-\tau_t}(r_t + \delta - \frac{\dot{p}_t^I}{p_t^I}) \tag{A-7}$$

Appendix B

Useful Life of Assets

(year)

	1988-1994	1995-1998	1999-2004
Buildings	26	30	30
Structures	26	30	30
Machinery	Industry-specific Useful Life		
Ships-Airplanes	7	10[1)]	12[2)]
Vehicles	7	4	5
Tools	3	4	5
Office Equipment	6	4	5
Other Tangible Assets	6	4	5

Notes: 1) The useful life of ships-airplanes for the transport industry is 4 years.
2) The useful life of ships-airplanes for the transport industry is 5 years.
Source: *Enforcement Regulations of the Corporate Income Tax Law*, Korea Ministry of Legislation

Appendix C

Corporate Income Tax Rate

(%)

	1988-1990	1991-1993	1994	1995	1996-2001	2002-2004
Corporate Income Tax Rate	38.3	36.6	34.4	32.3	30.8	29.7

Notes: The corporate income tax rate here represents the maximum corporate income tax rate, which is calculated as the corporate income tax rate × (1 + defense tax rate or special tax for rural development rate + inhabitant tax rate). Notice that the defense tax was abolished in 1991 and replaced by the special tax for rural development in 1995.
Source: "An Empirical Study on Alternative Measures of Marginal Tax Rates in Korea," Roh et al. (2004).

Appendix D

Figure 1. Investment/Capital Ratio and User Cost Growth Rate

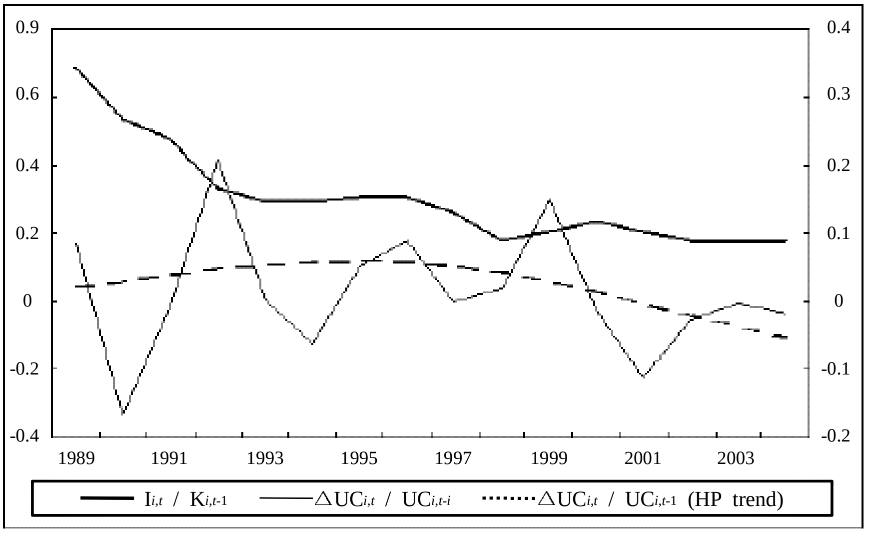


Figure 2. Investment Ratio, Sales Growth and Cash Flow Ratio

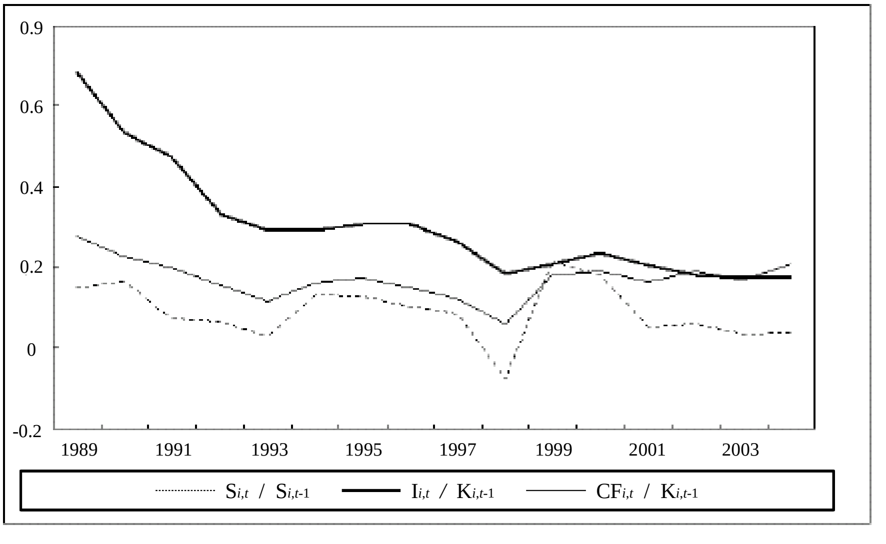


Figure 3. User Cost of Capital and Its Main Components

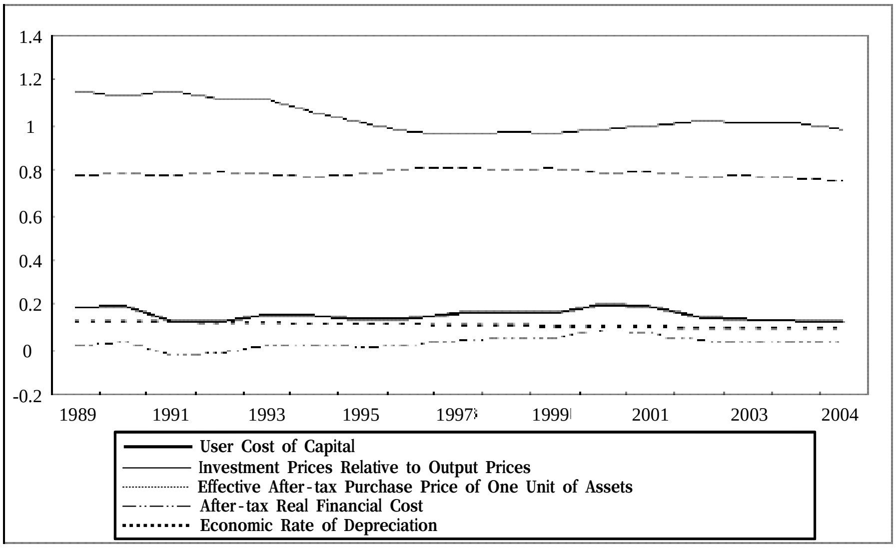
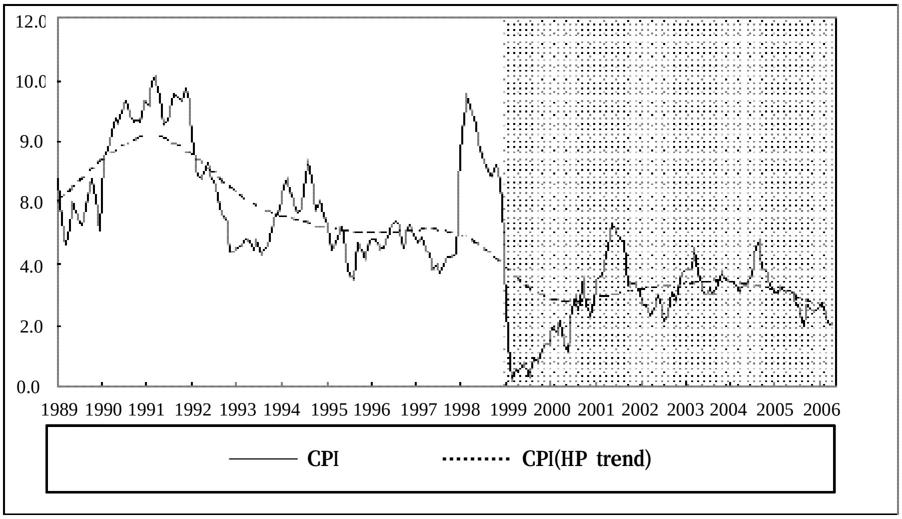


Figure 4. CPI Inflation Rate[1)]



Note: 1) The rates of increase of CPI compared with the corresponding period of the previous year

Appendix E

Table 1. Summary Statistics of Regression Variables in the High and Low Inflation period

Variable	Mean		Within-firm S.D.[1)]		Firm-specific Time Variation[2)]	
Period	HIP[3)]	LIP[3)]	HIP	LIP	HIP	LIP
$I_{i,t}/K_{i,t-1}$	0.368	0.197	0.325	0.174	0.805	0.984
$\Delta UC_{i,t}/UC_{i,t-1}$	0.044	-0.009	0.382	0.316	0.754	0.756
$\Delta S_{i,t}/S_{i,t-1}$	0.085	0.096	0.283	0.351	0.944	0.957
$CF_{i,t}/K_{i,t-1}$	0.164	0.187	0.247	0.370	0.945	0.998

Notes: 1) The within-firm standard deviation is defined as the standard deviation of mean-differenced time-series observation, $(X_{i,t} - X_i)$, in each variable for firm i at time t.

2) The firm-specific time variation is computed as 1 minus R^2 of the regression as follows: $(X_{i,t} - X_i) = \alpha_t + \xi_{i,t}$, where α_t is the coefficient on a time dummy and $\xi_{i,t}$ an error term.

3) HIP & LIP denote the high and low inflation periods, respectively.

Table 2. FE and FD Estimates of Investment Equation Over the Whole Period[1)]

Regression Equation:

$$I_{i,t}/K_{i,t-1} = \alpha_n(L)[\Delta S_{i,t}/S_{i,t-1}] + \beta_k(L)[\Delta UC_{i,t}/UC_{i,t-1}] + \psi_s(L)[CF_{i,t}/K_{i,t-1}] + \phi_i + \varepsilon_{i,t}$$

Estimation period: 1988-2004

	Excluding Cash Flow		Including Cash Flow	
	Fixed Effect	First Difference	Fixed Effect	First Difference
$\Delta S_{i,t}/S_{i,t-1}$				
α_0	0.089 (10.22)	0.028 (3.38)	0.081 (9.32)	0.019 (2.31)
α_1	0.077 (8.72)	0.026 (3.06)	0.057 (6.57)	0.014 (1.62)
α_2	0.042 (4.74)	-	0.019 (2.18)	-
α_3	0.025 (3.15)	-	0.017 (2.13)	-
$SUM(\alpha)$	0.234 (11.97)	0.054 (3.72)	0.174 (9.01)	0.033 (2.27)
$\Delta UC_{i,t}/UC_{i,t-1}$				
β_0	-0.095 (-10.38)	-0.079 (-7.72)	-0.090 (-10.02)	-0.080 (-7.87)
β_1	-0.048 (-5.02)	-0.025 (-2.08)	-0.042 (-4.67)	-0.025 (-2.11)
β_2	-0.038 (-4.04)	-0.023 (-2.02)	-0.034 (-3.69)	-0.026 (-2.28)
β_3	-0.020 (-2.61)	-0.007 (-0.92)	-0.018 (-2.46)	-0.008 (-0.97)
$SUM(\beta)$	-0.201 (-9.13)	-0.134 (-3.99)	-0.183 (-8.55)	-0.138 (-4.14)
$CF_{i,t}/K_{i,t-1}$				
ψ_0			0.045 (6.30)	0.074 (9.27)
ψ_1			0.074 (9.72)	0.078 (8.92)
ψ_2			0.061 (8.15)	0.039 (4.57)
$SUM(\psi)$			0.180 (17.97)	0.191 (9.93)

Note: 1) The FE and the FD regressions include a full set of year dummies to capture the effect of macro influences on the individual firm's investment. T-values are in parentheses.

Table 3. FE and FD Estimates of Investment Equation Over the High Inflation period[1)]

Regression Equation:

$$I_{i,t}/K_{i,t-1} = \alpha_n(L)[\Delta S_{i,t}/S_{i,t-1}] + \beta_k(L)[\Delta UC_{i,t}/UC_{i,t-1}] + \psi_s(L)[CF_{i,t}/K_{i,t-1}] + \phi_i + \varepsilon_{i,t}$$

Estimation period: 1988-1998

	Excluding Cash Flow		Including Cash Flow	
	Fixed Effect	First Difference	Fixed Effect	First Difference
$\Delta S_{i,t}/S_{i,t-1}$				
α_0	0.155 (8.66)	0.116 (5.98)	0.144 (7.97)	0.073 (3.63)
α_1	0.065 (3.33)	0.030 (1.46)	0.019 (1.00)	-0.009 (-0.43)
$SUM(\alpha)$	0.220 (8.43)	0.146 (4.41)	0.163 (6.14)	0.064 (1.86)
$\Delta UC_{i,t}/UC_{i,t-1}$				
β_0	-0.127 (-9.22)	-0.150 (-8.74)	-0.125 (-9.38)	-0.139 (-8.37)
β_1	-0.077 (-5.98)	-0.065 (-3.88)	-0.059 (-4.78)	-0.069 (-4.26)
β_2	-0.063 (-4.87)	-0.048 (-2.98)	-0.058 (-4.68)	-0.071 (-4.93)
β_3	-0.009 (-1.03)	-0.007 (-0.68)	-0.011 (-1.27)	-0.012 (-1.20)
$SUM(\beta)$	-0.277 (-8.18)	-0.270 (-5.44)	-0.253 (-7.79)	-0.291 (-6.06)
$CF_{i,t}/K_{i,t-1}$				
ψ_0			0.082 (5.53)	0.178 (9.98)
ψ_1			0.217 (9.64)	0.175 (7.12)
ψ_2			0.074 (3.54)	0.028 (1.13)
$SUM(\psi)$			0.373 (15.22)	0.381 (9.29)

Note: 1) The FE and the FD regressions include a full set of year dummies. T-values are in parenthese.

Table 4. FE and FD Estimates of Investment Equation Over the Low Inflation period[1)]

Regression Equation:

$$I_{i,t}/K_{i,t-1} = \alpha_n(L)[\Delta S_{i,t}/S_{i,t-1}] + \beta_k(L)[\Delta UC_{i,t}/UC_{i,t-1}] + \psi_s(L)[CF_{i,t}/K_{i,t-1}] + \phi_i + \varepsilon_{i,t}$$

Estimation period: 1999-2004

	Excluding Cash Flow		Including Cash Flow	
	Fixed Effect	First Difference	Fixed Effect	First Difference
$\Delta S_{i,t}/S_{i,t-1}$				
α_0	0.036 (4.02)	0.015 (1.83)	0.031 (3.41)	0.011 (1.39)
α_1	0.041 (4.90)	0.027 (3.36)	0.031 (3.59)	0.021 (2.57)
$SUM(\alpha)$	0.078 (5.74)	0.041 (2.99)	0.062 (4.50)	0.032 (2.28)
$\Delta UC_{i,t}/UC_{i,t-1}$				
β_0	-0.019 (-1.92)	-0.027 (-3.37)	-0.019 (-1.95)	-0.027 (-3.34)
$SUM(\beta)$	-0.019 (-1.92)	-0.027 (-3.37)	-0.019 (-1.95)	-0.027 (-3.34)
$CF_{i,t}/K_{i,t-1}$				
ψ_0			0.025 (2.98)	0.038 (4.60)
ψ_1			0.043 (5.73)	0.048 (5.55)
ψ_2			0.031 (3.96)	0.026 (3.13)
$SUM(\psi)$			0.098 (7.14)	0.113 (5.61)

Note: 1) The FE and the FD regressions do not include a full set of year dummies, considering that the firm-specific time variation of the gross investment-to-capital ratio amounts to 98% in the low inflation period, compared to a much lower figure of 80% in the high inflation period. T-values are in parentheses.

Table 5. FEIV Estimates[1)] of Investment Equation Over the High Inflation period[2)]

Regression Equation:

$$I_{i,t}/K_{i,t-1} = \alpha_n(L)[\Delta S_{i,t}/S_{i,t-1}] + \beta_k(L)[\Delta UC_{i,t}/UC_{i,t-1}] + \psi_s(L)[CF_{i,t}/K_{i,t-1}] + \phi_i + \varepsilon_{i,t}$$

Estimation period: 1988-2004 (whole period),
1988-1998 (high inflation period)

	Excluding Cash Flow		Including Cash Flow	
	Fixed Period	High Inf. Period	Whole Period	High Inf. Period
$\Delta S_{i,t}/S_{i,t-1}$				
α_0	0.082 (9.15)	0.150 (6.44)	0.073 (8.18)	0.112 (4.75)
α_1	0.074 (8.16)	-	0.051 (5.68)	-
α_2	0.041 (4.52)	-	0.031 (3.46)	-
$SUM(\alpha)$	0.197 (11.29)	0.150 (6.44)	0.155 (8.94)	0.112 (4.75)
$\Delta UC_{i,t}/UC_{i,t-1}$				
β_0	-0.089 (-8.45)	-0.159 (-6.97)	-0.088 (-8.56)	-0.161 (-7.28)
β_1	-0.045 (-4.13)	-0.063 (-2.67)	-0.042 (-4.01)	-0.066 (-2.92)
β_2	-0.032 (-3.34)	-0.025 (-1.13)	-0.031 (-3.26)	-0.032 (-1.52)
$SUM(\beta)$	-0.166 (-7.89)	-0.247 (-4.73)	-0.161 (-7.85)	-0.259 (-5.14)
$CF_{i,t}/K_{i,t-1}$				
ψ_0			0.046 (6.30)	0.095 (5.38)
ψ_1			0.084 (11.31)	0.209 (7.36)
$SUM(\psi)$			0.130 (14.31)	0.304 (9.90)

Notes: 1) For the whole period, the instruments are the values of $\Delta S_{i,t}/S_{i,t-1}$, and $\Delta UC_{i,t}/UC_{i,t-1}$ lagged three through five years, when the cash flow/capital ratio is excluded. When the cash flow/capital ratio is included, the instruments are those of $\Delta UC_{i,t}/UC_{i,t-1}$ lagged three through four years, $\Delta S_{i,t}/S_{i,t-1}$ lagged three through five years, and $CF_{i,t}/K_{i,t-1}$ lagged two through five years. For the high inflation period, the instruments are the values of $\Delta S_{i,t}/S_{i,t-1}$ lagged one through four years, and $\Delta UC_{i,t}/UC_{i,t-1}$ lagged three through six years, for the case when the cash flow/capital ratio is excluded. When the cash flow/capital ratio is included, the instruments are those of $\Delta S_{i,t}/S_{i,t-1}$ lagged only two year, $\Delta UC_{i,t}/UC_{i,t-1}$ lagged three through five years, and $CF_{i,t}/K_{i,t-1}$ lagged two through six years.

2) The FEIV regression includes a full set of year dummies. T-values are in parenthese.

Table 6. Elasticity of the User Cost with Respect to the Call Money Rate[1)]

	Whole Period (1988-2004)	High Inf. Period (1988-1998)	Low Inf. Period (1999-2004)
(A) $\varepsilon^{UC_{i,t}}_{R_{i,t}}$	0.631	0.712	0.514
(B) $\varepsilon^{R_{i,t}}_{r^c_t}$ $= \frac{\partial \hat{R}_{i,t}}{\partial r^c_t} \times (\bar{r}^c_t / \bar{R}_{i,t})$	0.405 (=0.490×0.826)	0.304 (=0.319×0.952)	0.816 (=1.397×0.584)
(C) $\varepsilon^{UC_{i,t}}_{r^c_t}$ $(=(A)\times(B))$	0.256	0.216	0.419

Note: 1) Each elasticity is determined by averaging the annual averages during the period concerned for the total sample of 471 firms.

Table 7. Effect of a Policy Rate Change (Δr^c_t) on the User Cost[1)]

	Whole Period (1988-2004)	High Inf. Period (1988-1998)	Low Inf. Period (1999-2004)
$\sum_{i=1}^{471}(\frac{\Delta UC_{i,t}}{UC_{i,t-1}})\omega^K_{i,t-1} = \left\{\sum_{i=1}^{471}\frac{[\frac{\partial UC_{i,t}}{\partial R_{i,t}}\frac{\partial \hat{R}_{i,t}}{\partial r^c_t}]\Delta r^c_t}{UC_{i,t-1}}\omega^K_{i,t-1}\right\}$	$4.376 \times \Delta r^c_t$	$3.154 \times \Delta r^c_t$	$10.247 \times \Delta r^c_t$

Note: 1) The marginal effect, $\partial UC_{i,t}/\partial R_{i,t}$ is determined by averaging the annual averages in the period concerned for the total sample of 471 firms. The estimates of $\partial \hat{R}_{i,t}/\partial r^c_t$ for the different periods are same as those used in Table 6. $\omega^K_{i,t-1}$ is firm i's share of the total sample capital stock ($K_{i,t}/K_t$).

Table 8. Elasticity of the Capital Stock w.r.t. the Policy Rate[1)]

	Whole Period (1988-2004)	High Inf. Period (1988-1998)	Low Inf. Period (1999-2004)
(A) $\varepsilon^{UC_{i,t}}_{r^c_t}$	0.256	0.216	0.419
(B) $\varepsilon^{K_{i,t}}_{UC_{i,t}} = SUM(\beta)$	-0.161	-0.259	-0.027
(C) $\varepsilon^{K_{i,t}}_{r^c_t} (= (A) \times (B))$	-0.041	-0.056	-0.011

Note: 1) Each elasticity is determined by averaging the annual averages during the period concerned for the total sample of 471 firms.

Table 9. Effect of a Change in Policy Rate on the Investment/Capital Ratio

	Whole Period (1988-2004)	High Inf. Period (1988-1998)	Low Inf. Period (1999-2004)
(A) $\sum_{i=1}^{471} (\frac{\Delta UC_{i,t}}{UC_{i,t-1}}) \omega^K_{i,t-1} = \left\{ \sum_{i=1}^{471} \frac{[\frac{\partial UC_{i,t}}{\partial R_{i,t}} \frac{\partial \hat{R}_{i,t}}{\partial r^c_t}] \Delta r^c_t}{UC_{i,t-1}} \omega^K_{i,t-1} \right\}$	4.376 × Δr^c_t	3.154 × Δr^c_t	10.247 × Δr^c_t
(B) $SUM(\beta)$	-0.161	-0.259	-0.027
(C) $\sum_{i=1}^{471} \frac{\Delta K_{i,t}}{K_{i,t-1}} = (A) \times (B)$	-0.705 × Δr^c_t	-0.817 × Δr^c_t	-0.277 × Δr^c_t

Note: 1) Each marginal effect, $\partial \hat{R}_{i,t} / \partial r^c_t$ and $\partial UC_{i,t} / \partial R_{i,t}$ is determined by averaging the annual averages in the period concerned for the total sample of 471 firms. $\omega^K_{i,t-1}$ is firm *i*'s share of the total sample capital stock ($K_{i,t} / K_t$).