Monetary policy and firms' investment: Dynamic panel data evidence from Malaysia

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Abstract

This study examines the effects of monetary policy on firms' balance sheet, with a particular focus on the effects upon the firms' fixed-investment spending. It uses a dynamic panel system GMM estimation proposed by Blundell and Bond (1998). The focal point has given to the two main channels of monetary policy transmission mechanism such as interest rates and broad credit channel in transmitting to firm investment spending. By estimating the firms' investment model using a dynamic neo-classical framework, the empirical results tend to support the relevance of interest rates and broad credit channel in transmitting to the firm balance sheet condition that is firm's investment spending. The results also reveal that the effect of monetary policy channels to the firms' investment are heterogeneous fashioned, which is the small firms who faced financial constraint are responded more due to monetary tightening as compared to the large firm (less constraint firms). Thus, the monetary authority has to concern the microeconomic aspects of the firm in formulation their monetary policy.

Keyword: Monetary policy, Financial Constraint, Firm Investment, Dynamic Panel Data

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1. Introduction

This paper explores the role of monetary policy transmission mechanism on firms' investment spending through interest rates and broad credit channel by using disaggregated publicly listed companies' data set. For this purpose, these following research strategies have employed in examining the relevance of both monetary policy channels. First, I construct the firm user cost of capital as a proxy for interest rates channel using the methodology proposed by Chirinko et al. (1999), Mojon et al. (2002) and Chatelain et al. (2003b). Then, the firm investment function has estimated using the neo-classical model in dynamic panel GMM estimation, which linked the firm investment spending to firm sales growth, cash flow-capital ratio (broad credit channel) and more importantly the growth of user cost of capital (interest rates channel). The sample of the firms have been splitting into two categories that is small and large firm in investigating the heterogeneity effect of monetary policy and also to examine the role of financial constraint (cash flow-capital ratio) in assessing the relevance of asymmetric information in credit market.

There is a well documented in the existing literature that most of the main channels of monetary policy transmission mechanism have been examined mainly using macro information. However, the mechanism through which monetary policy influences the economy is still debatable. Previous literatures have identified two main channels such as interest rates and credit channel in transmitting to real sector economy at macro level[1]. As argued by Chirinko et al. (1999), studying in the aggregate level commonly fail to find an economically significant relationship between investment spending and the firm user cost of capital. This failure has caused by biased estimates due to problems of simultaneity, capital market frictions and firm heterogeneity. Therefore, by using micro panel data set it is possible to handle all related problem in macro level data set. In addition, by using micro panel data it also permits to measure the firm specifics variables such as user cost of capital, sales and cash flow in estimating the determinants of firm investment spending.

[1] For example, BERNANKE, B. S. & GERTLER, M. 1995. Inside the black box: The credit channel of monetary policy transmission. *Journal of Economic Perspectives,* 9, 27-48., have identified two mechanisms through which the credit channel of monetary policy operates, such as the bank lending channel (BLC) and balance sheet channel (BSC). The BSC emphasis on the impact of changes in monetary policy on the borrower's balance sheet, whereas BLC focuses on the possible effect of monetary policy actions on the supply of loans by the banking system. The interest rates channel is also known as money channel has been a standard feature in the traditional Keynesian model by using IS-LM framework.

The theory of monetary policy transmission mechanism has stated that firm investment spending has influenced by monetary policy actions through at least two channels such as interest rates and credit channel. First, interest rates channel refers to direct impact of interest rate changes through the user cost of capital on firm's investment activity. According to this channel, firm adjusts their level of capital stocks until the marginal productivity of capital equals the cost of funds under perfect capital market. Second, changes in interest rates affect the net cash flow (i.e. cash flow after interest payments)available to a firm. Given imperfect capital markets due to information asymmetric, the availability of net cash flow will have a direct effect on investment. This mechanism generally refer to as the 'broad credit channel'. (Chatelain et al., 2003). The existence of a credit channel would imply that monetary policy affects not only current interest rates, but also the size of the external finance premium via reduced current and expected future profits, lowering equity prices and hence collateral, which in turn amplifies the monetary policy effect on firms investment. Therefore, under asymmetric information, the sensitivity of investment to cash flow should be different across firm. For instance, the investment by small firm which is has information problem are likely to severe and should be more sensitive to the cash flows than large firms.

Therefore, this study contributes to the existing literature by extending the issue of the transmission mechanism of monetary policy in several important aspects. First, this study provides first empirical evidence by using micro level data in investigating monetary policy transmission channel such as interest rates and broad-credit channel in a small-open economy, i.e. Malaysia. In addition, by studying the effect of monetary policy on firm investment, it can also investigate the relevance of firm's balance sheet conditions in the monetary transmission mechanism. Second, this study also contributes to the literature by estimating the determinants of firm investment using a dynamic neo-classical model as well as investigates the heterogeneous effect of monetary policy under the present of the firm financial constraint by splitting the sample size that is large and small firms. Finally, this study use the most recent panel data technique that is the generalized method of moment (GMM), which is has an advantage in dealing with the endogeneity issues among the regressors.

Several interesting features have emerged from this study. First, this paper finds that the existence of two monetary policy channel such as interest rates and broad credit channel in transmitting the firm investment spending in Malaysian economy. Second, there is also a heterogeneous effect of monetary policy according to the difference firm size, which is the investment by small and constrained firm is very sensitive to tight monetary policy as compared to the large firm.

The rest of the paper has structured as follow. Section 2 provides the literature review about firm investment and the channel of monetary transmission. Section 3 describe the theoretical framework, meanwhile section 4 explain the econometric framework. Section 5 presents the empirical result and robustness checking, and finally sections 6 summarize and conclude.

2. Literature Review

Most of the literatures on transmission mechanism of monetary policy have focused on macro level in investigating the main channel of monetary policy transmission mechanism[2]. However, there is a limited studied has examined the transmission mechanism of monetary policy by using micro level data (disaggregated data set), in particular to investigate the relevance of two main channels of monetary transmission such as interest rates and broad-credit channel on firm balance sheet variables such as investment spending. For example, Chatelain et al. (2003b) have estimated the firm's investment function using neo-classical framework in dynamic panel data methodology (GMM). In addition, the role interest rates channel has identified through the firm user cost of capital, meanwhile cash flow-capital ratio has used as a proxy for financial constraint in examining the existence of broad-credit channel in imperfect capital market. The empirical results have supported the relevance of interest rates and broad credit channel in all countries examined in Euro area. Specifically, the user cost of capital as a measurement of interest rates channel have a significant long-run effect on firm investment in Germany, Italy, Belgium, Luxembourg and France. The cash flow-capital ratio is also statistically significant in influencing the firm investment in all country except Luxembourg. In addition, sales growth has a substantial impact on the investment rate in all countries except Austria and Spain.

Another study in Europe, for instance, Mojon et al. (2002) have estimated firm investment spending by using the error correction form in the dynamic neoclassical model. By identifying the interest rate channel using the user cost of capital, they also

[2] The excellent literature survey about the monetary transmission mechanism can be found from EGERT, B. & MACDONALD, R. 2009. Monetary transmission mechanism in central and eastern Europe: surveying the surveyable *Journal of Economic Survey,* 23**,** 277-327.

found the significant negative effect of the user cost of capital on firms' investment spending in Germany, France, Italy and Spain. In fact, the long run elasticity of the capital stock with respect to sales and user cost of capital are not significant different from 1, which is implied that a simple Cobb-Douglas production functions can not be rejected. In addition, while the average interest rate on debt is generally higher for small firms than for large firms, however, there is little evidence that the effects of monetary policy on small firm are larger.

In Japan, Nagahata and Sekine (2005) have employed the corporate panel data in estimating the accelerator-type of investment function by using the dynamic GMM estimators in autoregressive distributed lag model (ARDL) and error-correction model (ECM) approach. They also found that monetary policy in Japan worked through the interest rates channel, but the effect of monetary policy through credit channel was blocked due to the weakening in the Japanese firms' balance sheet. In addition, the coefficient on the user cost of capital, which reflects the interest rates, are also similar to those found in Euro area such as in Italy and France. In fact, the weakening in the bank balance sheet conditions, hindered investment by smaller non-bond issuing firms more severely as compared with the larger bond-issuing firms.

Recent studied by Guariglia and Mateut (2006) have used the panel data technique in investigating the credit and trade credit channel on inventory investment in the UK manufacturing firms. By estimating the error correction inventory investment equations augmented with the coverage ratio and trade credit to assets ratio, they found that both the credit and the trade credit channel operate in the UK, which is the trade credit channel tend to deteriorate the role of traditional credit channel. As a result, if firms also have access to the trade credit, they can avoid the external financing constraint in the period of monetary tightening by increasing trade credit as an alternative to the bank and market financing.

In a small-open economy, there is a limited study has used micro data set in investigating the channel of monetary policy transmission mechanism. For example, Agung (2000) has estimated the firm investment model in Indonesia by using Tobin's-q and Euler equation investment model, and found that the existence of financial constraint and agency cost for the listed firms in raising external funds. This study also indirectly supports the existence of broad credit channel of monetary policy in Indonesia. Therefore, the response of real sector activity (investment) to monetary policy in Indonesia depends on three factors such as financial structures of firm, the segmentation of financial market between large and small firms and the degree of financial or credit friction in the credit or capital market. Another study by Rungsomboon (2005) by using Tobin's-q investment model has supported the existence of the balance sheet channel in Thailand and also found that the firms have faced greater liquidity constraint due to the financial crisis. In addition, small firms and non-bond-issuing firms are found more adversely affected by the financial crisis than large and bond-issuing firms. However, Agung (2000) and Rungsomboon (2005) are not taking into account the role of interest rates channel (user cost of capital) in their investment model. As noted before, interest rates channel plays a vital role in influencing to the firms investment spending in Japan and Euro area.

In Malaysian context, all studies about the issues of monetary policy transmission mechanism have focused on macro level and still limited in the literature[3]. Recent study by Ang (2009) has examined the roles of three financial policies such as interest rates restraints, directed credit programs and reserve and liquidity requirement on private investment in Malaysia at macro level. By estimating the neoclassical investment model in time series ARDL approach, he found that interest rates restraints appear to have a positive effect on private investment. In addition, the empirical results also show that a negative and significant effect of directed credit programs in private sector capital formation in Malaysia. On the other hand, higher reserve and liquidity tends to encourage private investment.

To the author's best knowledge, so far there is no empirical study has investigated the transmission mechanism of the monetary policy at micro level, in particular to examine the role of interest rates and broad credit channel on firm investment in a small open economy, i.e. Malaysia. Therefore, based on this backdrop, this study makes a novel contribution to the existing literature by extending the issue of monetary policy transmission mechanism via interest rates and broad credit channel on investment spending by using disaggregated firm-level data set.

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[3] For example, AZALI, M. 1998. The roles of money and credit in the monetary policy transmission mechanism : Preliminary evidence using Malaysian quarterly data. *Asian Economic Review*, 395-405.; AZALI, M. & MATTHEWS, K. 1999. Money-Income and Credit-Income Relationships during the Pre-and the Post-Liberalization Periods: Evidence from Malaysia. *Applied Economics,* 31**,** 1161-1170.; IBRAHIM, M. 2005. Sectoral effect of monetary policy: Evidence from Malaysia. *Asian Economic Journal,* 19**,** 83-102. and TANG, H. C. 2006. The relative important of monetary policy transmission channels in Malaysia. *CAMA Working Paper Series.* The Australian National University.
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3. Theoretical Framework

Most of the empirical studies, for example Mairesse et al. (1999), Chirinko et al. (1999), Chatelain et al. (2003b) and Bond et al. (2003)[4] have used a neo-classical demand for capital in investigating the determinants of investment using firm level data. According to the neo-classical theory, the demand for capital has derived from firm production function. By assuming a constant elasticity of the substitution (CES), the neo-classical production function can be parameterized as;

$$F\left(L_{it},K_{it}\right)=TFP_i A_t\left[\beta_i L_{it}^{\frac{\sigma-1}{\sigma}}+\alpha_i K_{it}^{\frac{\sigma-1}{\sigma}}\right]^{\frac{\sigma}{\sigma-1}\upsilon}\quad,\ \alpha_i+\beta_i=1 \qquad [1]$$

Where, σ is the elasticity of substitution between capital (K) and labor (L), υ represents return to skill, $TFP_i A_t$ is the total factor productivity. The first-order condition for a firm's optimization problem leads to the equality between the marginal product of capital (F_K) and the user cost of capital (UC_{it}) as follows;

$$F_K\left(L_{it},K_{it}\right)=UC_{it} \qquad [2]$$

By substituting the marginal productivity of capital in equation [2] into production function in equation [1], the first order conditions of firm profit maximization is;

$$\log K_{it}=\theta\log Y_{it}-\sigma\log UC_{it}+\log H_{it}$$

or

$$k_{it}=\theta y_{it}-\sigma uc_{it}+h_{it} \qquad [3]$$

Where, k_{it} is log of capital stock, uc_{it} is log of user cost of capital, h_{it} is log of firm specific variables, $\theta=\left(\sigma+\frac{1-\sigma}{\upsilon}\right)$ and $h_{it}=\log\left[\left(TFP_i A_t\right)^{\frac{\sigma-1}{\upsilon}}\left(\upsilon\alpha_i\right)^{\sigma}\right]$. Equation [3] stated that the stock of capital (k_{it}) firm i at time t has determined by three factors such as firm output or sales (y_{it}), firm user cost of capital (uc_{it}) and firm specific

[4] The excellent review about modeling strategies, empirical results and policy implications relating on business fixed investment can be found from CHIRINKO, R. S. 1993. Business fixed investment spending: modelling strategies, empirical results, and policy implications. *Journal of Economic Literature,* 31**,** 1875-1911, BOND, S. & REENEN, J. V. 1999. Microeconometric models of investment and employment. London: Institute of Fiscal Studies.

variables (h_{it}). The variable h_{it} depends on the time-varying term A_t and the firm-specific term TFP_i[5].

In order to estimate equation [3], the new specification in terms of autoregressive distributed lag model (ARDL) has used in this study. The dynamic neo-classical investment model have been estimated by Mairesse et al. (1999), Mojon et al. (2002), Chatelain et al. (2003b), Bond et al. (2003) and Nagahata and Sekine (2005). For example, the dynamic neo-classical investment model in $ARDL(2,2)$ can be written as follows;

$$k_{it} = \alpha_1 k_{i,t-1} + \alpha_2 k_{i,t-2} + \phi_1 y_{it} + \phi_2 y_{i,t-1} + \phi_3 y_{i,t-2} + \sigma_1 uc_{it} + \sigma_2 uc_{i,t-1} + \sigma_3 uc_{i,t-2} + \theta_1 h_{it} + \theta_2 h_{i,t-1} + \theta_3 h_{i,t-2} \qquad [4]$$

In order to transform equation [4] into neo-classical investment model, we need to first differencing equation [4] and using the approximation of capital stock, $k_t - k_{t-1} = \frac{I_t}{K_{t-1}} - \delta$.[6] In addition, by replacing year-specific productivity growth $(\Delta \log A_t)$ by time dummies (λ_t), a firm-specific productivity growth $(\Delta \log TFP_i)$ by η_i and add a random term υ_{it}, the dynamic neo-classical investment model in $ARDL(2,2)$ can be expressed as follow;

$$\left(\frac{I_{it}}{K_{i,t-1}}\right) = \alpha_1\left(\frac{I_{i,t-1}}{K_{i,t-2}}\right) + \alpha_2\left(\frac{I_{i,t-2}}{K_{i,t-3}}\right) + \phi_1 \Delta y_{it} + \phi_2 \Delta y_{i,t-1} + \phi_3 \Delta y_{i,t-2} + \sigma_1 \Delta uc_{it} + \sigma_2 \Delta uc_{i,t-1} + \sigma_3 \Delta uc_{i,t-2} + \lambda_t + \eta_i + \upsilon_{it} \qquad [5]$$

Most of the empirical studies in Europe and Japan have used the cash flow capital ratio $\left(\frac{CF_{it}}{K_{i,t-1}}\right)$ in investigating the relevance of broad credit channel or financial constraint on firm investment spending. Therefore, the augmented version

[5] The elasticity of capital to sales is unity $(\theta = 1)$, if the production function has constant return to scale $(\upsilon = 1)$, or if the elasticity of substitution is unity $(\sigma = 1)$, that is in the Cobb-Douglas function.

[6] $\Delta k_{it} = \log\left[\frac{K_{it}}{K_{i,t-1}}\right] = \log\left[1 + \frac{\Delta K_{it}}{K_{i,t-1}}\right] \cong \frac{\Delta K_{it}}{K_{i,t-1}} \cong \frac{I_{it}}{K_{i,t-1}} - \delta$, where, Δk_{it} is the net growth in capital stock (K), δ is the average depreciation rate and I_{it} is the investment of firm i in year t.

of neo-classical investment model in estimating the firm investment functions can be expressed as;

$$\left(\frac{I_{it}}{K_{i,t-1}}\right)=\alpha_1\left(\frac{I_{i,t-1}}{K_{i,t-2}}\right)+\alpha_2\left(\frac{I_{i,t-2}}{K_{i,t-3}}\right)+\phi_1\Delta y_{it}+\phi_2\Delta y_{i,t-1}+\phi_3\Delta y_{i,t-2}+\sigma_1\Delta uc_{it}+\sigma_2\Delta uc_{i,t-1}$$
$$+\sigma_3\Delta uc_{i,t-2}+\theta_1\left(\frac{CF_{it}}{K_{i,t-1}}\right)+\theta_2\left(\frac{CF_{i,t-1}}{K_{i,t-2}}\right)+\theta_3\left(\frac{CF_{i,t-2}}{K_{i,t-3}}\right)+\lambda_t+\eta_i+\upsilon_{it}$$

[6]

Where, λ_t is unobservable time-specific effects, η_i is unobserved firm-specific effects and υ_{it} is the remainder stochastic disturbance term, which is assumed to be independent and identically distributed with mean zero and variance σ_υ^2.

3.1 *User Cost of Capital* (UC)

Most of the previous studies have derived the firm user cost of capital (uc_{it}) by using Hall and Jorgenson (1967) approach. Therefore, following Mojon et al. (2002) and Chatelain et al. (2003b), the firm user cost of capital based on the accounting proportions of debt and equity can be expressed as follows;

$$UC_{it}=\frac{P_{st}^I}{P_{st}}\frac{(1-itc_t-\tau_t z_s)}{(1-\tau_t)}\left[AI_{it}\left(\frac{D_{it}}{D_{it}+E_{it}}\right)(1-\tau_t)+(LD_t)\left(\frac{E_{it}}{D_{it}+E_{it}}\right)-(1-\delta_s)\frac{\Delta P_{st+1}^I}{P_{st}^I}+\delta_s\right]$$

[7]

Where, s is the sector-specific index, p_{st} the price of final goods, p_{st}^I is the price of capital goods of sector s, τ_t the corporate income tax rate, z the present value of depreciation allowances and itc is an investment tax credit. AI is the apparent interest rates, measured as interest payment (interest expense) over gross debt, LD the long-term debt rate used as a proxy for the opportunity cost of equity, E is the book value of equity, D the book value of debt and δ_s is the industry-specific rate of economic depreciation. However, it is very difficult to verify the prices of capital goods (p_{st}^I) and the price of final goods (p_{st}) in Malaysian firm level data. Therefore, in this study Producer Price Index (PPI) has used as a proxy for prices of the investment goods and Consumer Price Index (CPI) as a proxy for price of final goods. In Malaysia, the present value of depreciation allowance (z) and investment tax credit (itc) are very difficult to estimate. Therefore, z and itc are assumed to be zero.

The inclusion of the user cost of capital (UC) and cash flow-capital ratio (CF / K) into the investment models in equation [6] permits in analyzing the interest rates and broad credit channel of monetary policy transmission channel. The role of interest rates channel can be tested by checking the signs and significance of the coefficient on the user cost of capital that is σ_1, σ_2 and σ_3. The expected sign is negative because an increase in interest rates will increase the user cost of capital and subsequently decreased the firm investment spending. The role of broad credit channel can be tested by checking the coefficient of θ_1, θ_2 and θ_3. The expected sign is positively and significantly for the small firm (constrained firm) relative to the large firm (unconstrained firm). This indicates that the small firm is heavily relied on internal fund as a cheaper source of funds and has some difficulties to access external financing.

4. Econometric Methodology

4.1 Data/ Sample Selection

This study uses the firm balance sheet data which spanning from 1990 up to 2008 (19 years). The firms in this study are main board publicly listed companies, which covers 650 firms. The data set have collected from Thompson datastream. For the estimation analysis, the following sample selections are applied. First, this study just considered the non-financial firm. This means that all financial firms are removed form the sample size. Second, we select the firms that are consecutively present in the sample at least five years in order to use sufficient number of lags as an explanatory variable. Third, in order to eliminate outliers, following Nagahata and Sekine (2005), the firm whose have a negative value of the user cost of capital have been dropped in the sample size. Finally, after cleaning the data set, this study have unbalanced panel of 332 firms, which is equivalent to 2 035 firm-year observations or an average 6.13 observations per group.

In addition, in dealing with the heterogeneity effect of monetary policy, the sample of the firms' have divided into two categories that is small and large firm. The small firms are subject to greater informational problem and will be affecting more strongly by a monetary policy tightening. Therefore, the firms have segmented by using their total asset. In order to segment the firm, first, the average (mean) of total asset has computed for each firm. Second, the median value of an average are then computed to generate thresholds in segmenting firms into small and large category. The firm has considered large if their mean of asset is greater than the median value and vice versa. Specifically, there are 165 firms in large category and 167 firms in small category.

4.2 Variables Definitions

In order to estimate the baseline neo-classical investment model in equation [8], this section briefly discusses the specific definitions of the variables used in this study.

Investment (I_{it})

It refers the current-period of investment spending at time t, which is includes the capital expenditure on property, plants and equipment from firms' uses of funds statement. Capital expenditure has been used as a proxy of investment by many researchers such as Kaplan and Zingales (1997), Chirinko et al. (1999), Bhagat et al. (2005), Love and Zicchino (2006) and Moyen (2004).

Capital Stock (K_{it})

The capital stock has referred to net firm fixed asset. It includes property, plant and equipments at period t less accumulated reserves for depreciation, depletion and amortization.

Cash Flow $(CF_{i,t})$

It defined as operating income after tax earning plus depreciation, which has calculated at the beginning of period t. The depreciation includes total depreciation, amortization and depletion. This variable has used as a measurement for the degree of market imperfections caused by financial constraint. Under asymmetric information, the sensitivity of the firm investment to the cash flow likely to be different across firms. In fact, the relationship between cash flow (financial constraint) on investment spending can also relate the relevance of broad credit channel in monetary policy transmission mechanism.

Sales (y_{it})

It refers to the net sales or revenue that has calculated at the year-end-period of sales in particular year. The inclusion of this variable is also consistent with the neo-classical investment model.

User Cost of Capital (UC)

As mentioned before, the derivation of user cost of capital is based on methodology proposed by Mojon et al. (2002) and Chatelain et al. (2003b). The user cost of capital can identify the existence of interest rates channel of monetary policy transmission mechanism.

4.3 Dynamic Panel GMM Estimation

The inclusion of the lagged dependent variables in the baseline neo-classical investment model in equation [6] implies that there is correlation between the regressors and the error term since lagged of investment ratio $\left(\frac{I_{i,t-1}}{K_{i,t-2}}\right)$ depends on $\varepsilon_{i,t-1}$. Therefore, due to this correlation, the dynamic panel data estimation in equation [6] suffers from Nickell (1981) bias, which disappears only if T is larger or approach to infinity. In order to deal with the endogeneity issue, this study used the generalized method of moments (GMM) estimators which developed by Anderson and Hsiao (1982), Arellano and Bond (1991), Arellano and Bover (1995) and recently extended by Blundell and Bond (1998).

In order to remove the firm-specific effects (η_i), Arellano and Bover (1995) proposed forward orthogonal deviation transformation or forward Helmert's procedure. This transformation essentially subtracts the mean of future observations available in the sample from the first $T-1$ observations and its main advantage is to preserves sample size in panels with gaps. First-difference transformation has some weakness, which is, if some explanatory variable (x_{it}) is missing, then both $\Delta x_{i,t}$ and $\Delta x_{i,t+1}$ are missing in the transformed data (Roodman, 2009). However, under orthogonal deviations, the transformed $x_{i,t+1}$ need not go missing. This procedure can be expressed as follows;

$$x_{i,t+1} = c_{it}\left[x_{it} - \frac{1}{T_{it}}\sum_{s>t} x_{is}\right] \quad [8]$$

Where, T_{it} is the number of time-series observations on firm i, c_{it} is the scale factor that is $\sqrt{\frac{T_{it}}{T_{it}+1}}$ and $\sum_{s>t} x_{is} = x_{it} + x_{i,t+1} + ... + x_{iT}$. As noted by Hayakawa (2009), by using a Monte Carlo simulation study, he found that the GMM estimator of the model transformed by the forward orthogonal deviation tends to work better than transformed by the first difference. Therefore, this study has used forward orthogonal deviation transformation in order to eliminate the firm-specific variable.

However, by transformation using forward orthogonal deviation, it introduces a new bias that is the correlation between the transformed error terms with the transformed lagged dependent variable. Similarly, the transformed of explanatory variables that is the sales growth (Δy_{it}), the growth of user cost of capital (Δuc_{it}) and cash flow-capital ratio $\left(\frac{CF_{it}}{K_{i,t-1}}\right)$ are also potentially becomes endogenous because they are related to the transformed error term. Therefore, three assumption can be made regarding to the explanatory variable. For instance, explanatory variable can be a predetermined variable that correlated with the past error and endogenous variables have potentially correlated with the past and present error. In contrast, strictly exogenous variable is uncorrelated with either current, past or future error. Specifically, X_{it} is said to be predetermined if $E[X_{it}\varepsilon_{is}] \neq 0$ for $s < t$ but $E[X_{it}\varepsilon_{is}] = 0$ for all $s \geq t$. In addition, X_{it} is assumed exogenous if $E[X_{it}\varepsilon_{is}] \neq 0$ for $s \leq t$ but $E[X_{it}\varepsilon_{is}] = 0$ for all $s > t$, and X_{it} is said to be strictly exogenous if $E[X_{it}\varepsilon_{is}] = 0$ for all t and s.

Arellano and Bover (1995) and Arellano and Bond (1991) recommend that the lagged levels or untransformed of the regressors are used as an instrument for the transform variable. This refers to the difference GMM. However, Alonso-Borrego and Arellano (1999) and Blundell and Bond (1998) show that in the case of lagged dependent and the explanatory variables are persistent over time or nearly a random walk, therefore lagged levels of these variables are weak instruments for the regression equation in differences. This happens either as the autoregressive parameter (α) approaches unity, or as the variance of the individual effects (η_i)

increases relative to the variance of the transient shocks (ε_{it}). Hence, to decrease the potential bias and imprecision associated with the difference estimator, Blundell and Bond (1998) have proposed system GMM approach by combining both regression in differences and regression in level. In addition to the regression in difference, the instruments for the regression in level are the lagged differences of the corresponding instruments.

However, as noted by Roodman (2009), the system GMM can generate moment conditions prolifically. Too many instruments in system GMM overfits endogenous variable even as it weakens the Hansen test of the instruments joint validity. Previous researchers, for example Beck and Levine (2004), Calderon et al. (2002) and Cardovic and Levine (2005) and Roodman (2009) have practiced two main techniques in limiting the number of instruments such as use only certain lags instead of all available lags for instruments and combine instruments through addition into smaller sets by collapsing the block of instrument matrix.

In addition, this study will also apply both estimators that is one-step and two-step estimator in the system GMM. As argued by Baltagi (2009), both parameters asymptotically similar if the ε_{it} is $i.i.d$. However, Bond (2002) stated that a one-step result is more favour than two-step results. This is because his simulation studies have shown that the two-step estimator is less efficient when the asymptotic standard error tends to be too small or the asymptotic t-ratio tends to be too big. Therefore, Windmeijer (2005) has provided a bias correction for the standard error in the two-step estimators. As noted by the author, the two-step GMM performs somewhat better than one-step GMM in estimating coefficient, with lower bias and standard errors. In fact, the reported two-step standard errors with the correction are quite accurate; therefore, the two-step estimation with corrected standard errors seems modestly superior to cluster robust one-step estimation.

The successful of the GMM estimator in producing unbiased, consistent and efficient results are highly dependent on the appropriate adoption of the instruments. Therefore, there are three specifications test as suggested by Arellano and Bond (1991), Arellano and Bover (1995) and Blundell and Bond (1998). Firstly, Sargan or Hansen test of over-identifying restrictions, which tests the overall validity of the instruments by analyzing the sample analogue of the moments conditions used in the estimation process. If the moment condition holds, then the instrument is valid and the model has correctly specified. Secondly, the serial correlation tests that is there is no serial correlation among the transformed error term. Finally, to test the validity of extra moment's conditions on the system GMM, the difference in Hansen test is used. This test measures the difference between the Hansen statistic generated from the system GMM and the difference GMM. Therefore, failure to reject the three null hypotheses gives support to the estimated model.

5. Estimation Results[7]

This section focuses on the results of estimating the baseline dynamic neo-classical investment model in equation [6]. The main results are the system GMM in one-step and two-step estimation by using the forward orthogonal deviation transformation. The focal points are to examine the role of interest rates and broad credit channel in transmitting to the firm investment spending for the whole sample (Table 1) and sub-sample analyses that is small firm (Table 2) and large firm (Table 3). In addition, the long-run coefficient has also presented in Table 4.

The Full Sample

In Table 1, the system GMM in one-step and two-step estimation have showed that interest rates channel, which is proxies by user cost of capital has contemporaneously and statistically significantly in influencing the firm investment. For example, in one-step estimation, a one percent growth of user cost of capital lead to a decline the rate of investment (investment ratio) by amount 0.191 percent. However, the lagged effect of user cost of capital growth is statistically insignificantly in influencing the firm investment. In two-step estimation, the contemporaneous effect of user cost of capital on investment is smaller than one-step, which is investment has reduced at 0.159 percent in responding to a one percent growth in user-cost of capital growth. However, the total coefficient of the user cost of capital is quite similar in both estimation and statistically significant at least at one percent significant level in influencing the investment spending. For instance, investment has decreased at 0.222 percent in one-step and 0.216 percent in two-step estimation in responding to one percent growth in user cost of capital. The significant and a negative effect of user cost of capital growth on firm investment in Malaysia have supported the relevance of interest rates channel in monetary transmission. This finding is also consistent with previous studies in Euro area and Japan as mentioned previously.

[7] All model are estimated using the Arellano and Bond dynamic panel system GMM estimations by using the Stata xtabond2 command written by Roodman (2009).

The contemporaneous effect of cash flow-capital ratio as a proxy for broad credit channel on firm investment is statistically insignificantly. However, there is a significant lagged response of investment spending on cash flow capital ratio. In addition, the total effect of cash flow-capital ratio on investment is also statistically significant at least at one percent significant level; however, the effect is relatively small. For example, the total coefficient is 0.027 and 0.042 in one-step and two-step estimation respectively. This means that, 10 percent increase in cash flow-capital ratio has generated an increase in investment rate at 0.27 percent in one-step and 0.42 percent in two-step estimation, respectively.

Sales growth has a substantial effect on firm investment either contemporaneously or with a lagged effect. For example, one percent increases in sales growth lead to an increase contemporaneously in investment rate at 0.150 in one-step and 0.145 in two-step estimation. In addition, the total coefficient of sales growth is 0.209 and 0.230 in one-step and two-step estimation, which is statistically significant at least at one percent significant level.

In addition, in one-step and two-step estimation, both specification tests that is AR(2) for testing the serial correlation and Sargan/Hansen test for testing the validity of instrument adopted are also valid. For instance, as shown in Table 1 the p-value for AR (2) and Sargan/Hansen test are higher, that is statistically insignificant at least at ten percent significant level. This implied that, the empirical model has correctly specified due to no serial correlation (autocorrelation) in the transformed residuals and the instruments (moments conditions) used in the models are valid. The validity of additional moment conditions such as difference in Hansen tests have also statistically insignificant in all model[8].

Sub-Sample Results

The analysis from whole sample results cannot explain the possible heterogeneity effect of monetary policy, in particular the difference role of interest rates and broad credit channel according to the firm size, which is the small and large firm. Under asymmetric information, small firm is heavily relied on internal financing than external financing because external financing is more costly for small firm than large firm. Therefore, it has expected that the cash flow-capital ratio play a significant role in influencing the investment by a small firm. In addition, the effect of user cost

[8] The detailed results for the difference in Hansen test is not reported in order to safe the space. The full results are available upon request.

of capital has also expected higher to the small firm than large firm because small firm has some difficulties to access external financing.

Table 2 and Table 3 are summarized the sub-sample analysis. As can be seen, the effect of user cost of capital growth on firm investment spending are heterogeneous fashioned, which is small firm behave strongly than large firm in responding to the tightening of monetary policy. Interestingly, the user cost of capital growth has a contemporaneous and significantly in influencing the investment by both firms in one-step and two-step estimation. For example, one percent growth in user cost of capital has contemporaneously reduced the small firm investment at 0.190 percent and 0.160 percent in one-step and two-step estimation, respectively. In comparison, the contemporaneous effect of user cost of capital on large firm investment spending is relatively lower, for example, investment has reduced at 0.174 percent in one-step estimation and 0.162 percent in two-step estimation. As expected, the total coefficient of the user cost of capital growth on investment spending is relatively higher for the small firm as compared to the large firm. For example, the total effect of user cost of capital to small firm investment is -0.320 percent in one-step estimation and -0.280 percent in two-step estimation, whereas, the total effect for the large firm investment is -0.201 and -0.187 percent in one-step and two-step estimation, respectively. The negative response of investment to the user cost of capital has supported the existence of interest rates channel in the monetary transmission mechanism.

The result in Table 2 (small firm) and Table 3 (Large firm) have indicated that the different role of cash flow-capital ratio in determining the firm investment. For the small firm, investment spending only significantly and positively influenced by the first period lagged of cash flow-capital ratio, whereas the contemporaneous and two-period lagged of cash flow-capital ratio is insignificantly in influencing the investment spending. In addition, the total effect of cash flow-capital ratio on investment is statistically significant at least at 1 percent significant level for small firm, while there is no significant effect to the large firm. However, the total effect of cash flow-capital ratio to small firm investment spending is relatively small, which is 0.012 and 0.020 in one- step and two-step estimation, respectively. This finding stated that the small firm are heavily relied on internal financing as a cheaper source of finance and cannot access to the external financing which is more expensive. In contrast, the large firm is not highly dependent on internal financing because they are accessible to the external finance such as debt and equity market. Therefore, this finding tends to support the existence of broad credit channel in monetary transmission in Malaysia.

Besides user cost of capital growth and cash flow-capital ratio, the firm investment (small and large firm) has also significantly influenced by sales growth, and the effect is relatively higher than user cost of capital growth and cash flow-capital ratio. Specifically, the sensitivity of investment to the sales growth is comparatively higher for small firm as compared to the large firm. For example, the total coefficient of sales growth for small firm is 0.262 and 0.267 in one-step and two-step estimation, whereas, for large firm the total coefficient is 0.156 in one-step and two-step estimation. This means that 10 percent increase in sales growth lead to an increase small firm investment at 2.62 percent in one-step and 2.67 percent in two-step estimation, while, investment by large firm has increased relatively lower at 1.56 percent in one-step and two-step estimation.

In addition, the serial correlation test stated that the GMM estimation estimations have not serially correlated at the second order or AR (2). In fact, the Sargan and Hansen test have showed that the system GMM estimation has well specified and the instruments employed are valid because the p-value is greater that 0.1. The validity of additional moment conditions such as difference in Hansen tests have also statistically insignificant in all model, but not reported in order to safe the space.

Table 1: System GMM Estimation - Whole Sample (Forward Orthogonal Deviation Transformation)

Independent Variables	one-step estimation			two-step estimation		
	coef.	robust standard error	p-value	coef.	corrected standard error	p-value
(I_{t-1}/K_{t-2})	0.025	0.118	0.831	0.019	0.094	0.839
(I_{t-2}/K_{t-3})	0.028	0.056	0.619	0.003	0.050	0.951
$\sum(I_{i,t-n}/K_{i,t-n-1})$	**0.053**	**-**	**0.808**	**0.022**	**-**	**0.977**
$\Delta \log UCC_{i,t}$	-0.191	0.045	0.000***	-0.159	0.037	0.000***
$\Delta \log UCC_{i,t-1}$	-0.035	0.036	0.324	-0.038	0.025	0.133
$\Delta \log UCC_{i,t-2}$	-0.016	0.016	0.323	-0.019	0.015	0.210
$\sum \Delta \log UCC_{i,t-n}$	**-0.222**	**-**	**0.000*****	**-0.216**	**-**	**0.000*****
$(CF_{it}/K_{i,t-1})$	0.001	0.002	0.655	0.001	0.001	0.408
$(CF_{i,t-1}/K_{i,t-2})$	0.009	0.002	0.000***	0.008	0.001	0.000***
$(CF_{i,t-2}/K_{i,t-3})$	0.017	0.015	0.263	0.033	0.021	0.114
$\sum(CF_{i,t-n}/K_{i,t-n-1})$	**0.027**	**-**	**0.000*****	**0.042**	**-**	**0.000*****
$\Delta \log Sale_{i,t}$	0.150	0.032	0.000***	0.145	0.0281	0.000***
$\Delta \log Sale_{i,t-1}$	0.019	0.040	0.633	0.039	0.026	0.141
$\Delta \log Sale_{i,t-2}$	0.040	0.019	0.037**	0.046	0.019	0.016**
$\sum \Delta \log Sale_{i,t-n}$	**0.209**	**-**	**0.000*****	**0.230**	**-**	**0.000*****
Number of observations	2035			2035		
Observations per group	6.13			6.13		
Number of instruments	76			76		
no. of firms	332			332		
AR(2)- *p-value*	0.284			0.557		
Sargan test - *p-value*	0.967			0.967		
Hansen test - *p-value*	0.513			0.513		

Note: ** Significant at 5% percent level; *** significant at 1% level. The *p-value* of the total coefficient has tested by using Wald statistic.

Year dummy and constant are not included in order to safe space. All *p-value* of the difference in Hansen tests of exogeneity of instruments subsets are also rejected at least at 10 percent significant level, but not reported here. The full results are available upon request.

Instrument for orthogonal deviation equation:

Lags 2 to all available lags for all endogenous variables (lagged dependent variable), lags 1 to all available lags for all predetermined variables (cash flow-capital ratio and sales growth) and all lags for strictly exogenous variable (user cost of capital growth).

The estimation also collapses the instruments matrix as proposed by Calderon et al. (2002) and Roodman (2009). The two-step estimations are based on Windmeijer (2005).

Table 2: System GMM Estimation - Small Firms' (Forward Orthogonal Deviation Transformation)

Independent Variables	one-step estimation			two-step estimation		
	coef.	robust standard error	p-value	coef.	corrected standard error	p-value
(I_{t-1}/K_{t-2})	0.047	0.164	0.773	0.033	0.176	0.849
(I_{t-2}/K_{t-3})	0.020	0.036	0.584	0.055	0.045	0.223
$\sum(I_{i,t-n}/K_{i,t-n-1})$	**0.067**	**-**	**0.7633**	**0.088**	**-**	**0.347**
$\Delta \log UCC_{i,t}$	-0.190	0.065	0.003***	-0.160	0.049	0.001***
$\Delta \log UCC_{i,t-1}$	-0.102	0.060	0.089*	-0.073	0.048	0.129
$\Delta \log UCC_{i,t-2}$	-0.028	0.018	0.121	-0.047	0.015	0.002***
$\sum \Delta \log UCC_{i,t-n}$	**-0.320**	**-**	**0.002*** **	**-0.280**	**-**	**0.000*** **
$(CF_{it}/K_{i,t-1})$	0.002	0.002	0.199	0.002	0.002	0.156
$(CF_{i,t-1}/K_{i,t-2})$	0.010	0.002	0.000***	0.009	0.002	0.000***
$(CF_{i,t-2}/K_{i,t-3})$	0.018	0.033	0.578	0.002	0.035	0.964
$\sum(CF_{i,t-n}/K_{i,t-n-1})$	**0.030**	**-**	**0.000*** **	**0.013**	**-**	**0.000*** **
$\Delta \log Sale_{i,t}$	0.155	0.054	0.004***	0.167	0.050	0.001***
$\Delta \log Sale_{i,t-1}$	0.043	0.032	0.178	0.048	0.030	0.111
$\Delta \log Sale_{i,t-2}$	0.064	0.024	0.007***	0.052	0.026	0.042**
$\sum \Delta \log Sale_{i,t-n}$	0.262	-	0.000***	0.267	-	0.002***
Number of observations	856			856		
Observations per group	5.13			5.13		
Number of instruments	41			41		
no. of firms	167			167		
AR(2)- *p-value*	0.642			0.316		
Sargan test - *p-value*	0.228			0.228		
Hansen test - *p-value*	0.500			0.500		

Note:

* Significant at 10% percent level; ** Significant at 5% percent level; *** significant at 1% level. The *p-value* of the total coefficient has tested by using Wald statistic.

Year dummy and constant are not included in order to safe space. All *p-value* of the difference in Hansen tests of exogeneity of instruments subsets are also rejected at least at 10 percent significant level, but not reported here. The full results are available upon request.

Instrument for orthogonal deviation equation:

Lags 2 to all available lags for all endogenous variables (lagged dependent variable), lags 1 to all available lags for all predetermined variables (cash flow-capital ratio and sales growth) and all lags for strictly exogenous variable (user cost of capital growth).

The estimation also collapses the instruments matrix as proposed by Calderon et al. (2002) and Roodman (2009). The two-step estimations are based on Windmeijer (2005).

Table 3: System GMM Estimation - Large Firms' (Forward Orthogonal Deviation Transformation)

Independent Variables	one-step estimation			two-step estimation		
	coef.	robust standard error	p-value	coef.	corrected standard error	p-value
$\left(I_{t-1} / K_{t-2}\right)$	0.196	0.269	0.467	0.141	0.203	0.489
$\left(I_{t-2} / K_{t-3}\right)$	0.078	0.093	0.403	0.058	0.114	0.612
$\sum\left(I_{i,t-n} / K_{i,t-n-1}\right)$	**0.274**	**-**	**0.636**	**0.199**	**-**	**0.704**
$\Delta \log UCC_{i,t}$	-0.174	0.046	0.000***	-0.162	0.044	0.000***
$\Delta \log UCC_{i,t-1}$	-0.011	0.053	0.833	-0.006	0.055	0.918
$\Delta \log UCC_{i,t-2}$	-0.016	0.032	0.609	-0.019	0.034	0.574
$\sum \Delta \log UCC_{i,t-n}$	**-0.201**	**-**	**0.000*****	**-0.187**	**-**	**0.002*****
$\left(CF_{it} / K_{i,t-1}\right)$	0.040	0.098	0.687	0.039	0.052	0.454
$\left(CF_{i,t-1} / K_{i,t-2}\right)$	0.050	0.059	0.397	0.037	0.043	0.388
$\left(CF_{i,t-2} / K_{i,t-3}\right)$	0.013	0.017	0.450	0.016	0.016	0.322
$\sum\left(CF_{i,t-n} / K_{i,t-n-1}\right)$	**0.103**	**-**	**0.601**	**0.092**	**-**	**0.401**
$\Delta \log Sale_{i,t}$	0.148	0.039	0.000***	0.118	0.037	0.001***
$\Delta \log Sale_{i,t-1}$	0.007	0.064	0.912	0.016	0.027	0.558
$\Delta \log Sale_{i,t-2}$	0.001	0.034	0.976	0.022	0.025	0.361
$\sum \Delta \log Sale_{i,t-n}$	**0.156**	**-**	**0.004*****	**0.156**	**-**	**0.006*****
Number of observations	1179			1179		
Observations per group	7.15			7.15		
Number of instruments	41			41		
no. of firms	165			165		
AR(2)- *p-value*	0.217			0.337		
Sargan test - *p-value*	0.160			0.160		
Hansen test - *p-value*	0.644			0.644		

Note:

*** significant at 1% level. The *p-value* of the total coefficient has tested by using Wald statistic.

Year dummy and constant are not included in order to safe space. All *p-value* of the difference in Hansen tests of exogeneity of instruments subsets are also rejected at least at 10 percent significant level, but not reported here. The full results are available upon request.

Instrument for orthogonal deviation equation:

Lags 2 to all available lags for all endogenous variables (lagged dependent variable), lags 1 to all available lags for all predetermined variables (cash flow-capital ratio and sales growth) and all lags for strictly exogenous variable (user cost of capital growth).

The estimation also collapses the instruments matrix as proposed by Calderon et al. (2002) and Roodman (2009). The two-step estimations are based on Windmeijer (2005).

Table 4: Long run coefficient of user cost of capital, cash-flow and sales on firm investment

	Whole sample		Small Firms		Large Firms	
	one-step	two-step	one-step	two-step	one-step	two-step
User cost of capital	-0.234 (0.138)**	-0.221 (0.128)**	-0.343 (0.177)**	-0.307 (0.132)**	-0.277 (0.195)	-0.233 (0.205)
Cash flow-capital ratio	0.029 (0.016)**	0.043 (0.015)***	0.032 (0.017)**	0.014 (0.008)**	0.142 (0.092)	0.115 (0.085)
sales growth	0.221 (0.052)***	0.235 (0.046)***	0.281 (0.105)***	0.293 (0.104)***	0.215 (0.093)**	0.195 (0.081)***

Note: number in parenthesis is standard error computed by delta method[9].
** Significant at 5 percent significant level, *** significant at 1 percent significant level

The long-run effects of the explanatory variables have defined as the sum of the coefficients on the explanatory variable divided by one minus the sum of the coefficient on the lagged dependent variables.

In Table 4, for the whole sample, the long-run coefficient of user cost of capital growth, cash flow-capital ratio and sales growth on firm investment is relatively higher than the effect in the short run. The effect of interest rates channel (user cost of capital) is also relatively higher for the small firm as compared to the large firm. However, in the long-run the user cost of capital growth is only statistically significant in influencing the small firm investment, whereas insignificantly influenced the large firm investment. In addition, the cash flow-capital ratio has also statistically significantly in influencing the small firm investment, whereas, insignificantly in influencing the large firm.

6. Summary and Conclusion

The channel of monetary policy transmission mechanism using macro level evidence have been studied extensively by prior studies, however a little attention has been given in investigating the micro econometric evidence of monetary transmission mechanism, in particular to firm level evidence. Therefore, based on the gap of previous literature, this study extends the existing literature by focusing on two main channel such as interest rates (derived from user cost of capital) and broad-credit

[9] In order to compute delta-method for standard error, I follow the procedure proposed by PAPKE, L. E. & WOOLDRIDGE, J. M. 2005. A computational trick for delta-method standard errors. *Economics Letters,* 86**,** 413-417. According to this procedure, first we need to estimate the gradient with respect to the parameters in the long-run effect, then use the estimated gradient to transform the particular explanatory variable, and then estimate the new transformed model. The estimated standard error of transformed lagged dependent variable is the standard error for long run coefficient. Then, the standard t-statistic can be used to test the significant of the particular variable by dividing the long coefficient on estimated standard error.

channel (cash flow-capital ratio) in transmitting to the firm balance sheet variables, in particular to the firm investment spending.

By estimating the neo-classical investment model using dynamic panel system-GMM approach, this finding tends to support the relevance of interest rates and broad credit channel in transmitting to firm balance-sheet condition, in particular to firm investment spending. Specifically, the firm fixed investment spending is very sensitive to changes in the user cost of capital and the financial constraint (cash flow-capital ratio effects). In addition, the effect of monetary policy is also heterogeneous fashioned, which is small firm has affected more strongly to the interest rates channel as compared to large firm. The small firm also statistically significantly influenced by internal fund (cash flow-capital ratio) as a cheaper source of financing. In contrast, the large firm is not relied on internal financing as a source of investment spending. The significant of cash flow-capital ratio on small firm investment spending has indicated that the small firms have experienced financial constraint under imperfect financial markets. In contrast, the large firm has not significantly affected by cash flow-capital ratio, which indicated that they are not subject to the liquidity constraint and can access to the external financing such as short-term credit market, bonds and financial instruments in the capital market. Therefore, the existence of broad-credit channel in Malaysia has supported the relevance of informational asymmetries in explaining the investment behavior.

This study has several implications to the implementation of monetary policy. First, since the interest rates channel plays a significant role in influencing the firm investment, therefore the monetary authority has a greater chance to stabilize the firm investment by altering the monetary policy variables such as short-term interest rates or overnight policy rate. For example, monetary authority can fine-tune the investment cycle by implementing an easing monetary policy during the slowdown in economic activity. Second, the existence of broad credit-channel implied that monetary policy has thought to be more effective when firms face tighter financial constraint, in particular for the small firm. Therefore, the small firm has to monitor closely their financial condition, in particular the cash flow as a cheaper source of financing. Third, the empirical finding indicated that, the response of real sector economy, in particular investment to the monetary policy shocks depends on the degree of financial constraint, the segmentation of firm (small and large firm) and output (sales). Therefore, the monetary authority has to monitor precisely the microeconomic indicators of the firm in formulating their monetary policy. In addition, the monetary authority has also to observe precisely the credit market conditions and liquidity in the financial market in order to ensure that the domestic liquidity is reasonable to support the business agenda.

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