International Journal of Social Science and Economic Research

ISSN: 2455-8834

Volume:02, Issue:09 "September 2017"

AGGREGATE PRIVATE FIXED INVESTMENT AND UNCERTAINTY IN THAILAND

Tho Dinh NGUYEN, Ph.D.

Associate Professor of Economics, Hatinh University, 447 March 26 Street, Hatinh City, Vietnam

ABSTRACT

This paper estimates the relationship between aggregate private fixed investment and uncertainty using the Partial Adjustment Model (PAM). Our findings consistently suggest a negative relationship between aggregate private fixed investment and uncertainty of exchange rates. The average long-term government bond rate is also found to be a significant factor that determines private investment. Higher government bond rates raise the cost of financing of all risk class investments, hence reduce investment.

Keywords: Investment, Uncertainty, Irreversibility, Exchange Rate, Thailand

JEL Classification: O16, D92, E22, F41, C23

1. INTRODUCTION

When investments are irreversible they are very sensitive to uncertainty of future returns. Dixit (1989a), Leahy (1993), Pindyck (1993), Caballero and Pindyck (1996) show that the effect of irreversibility and uncertainty on investment aggregated at (competitive) industry-wide level is the same as for the case of (monopolist) individual firm (McDonald and Siegel, 1986; Pindyck, 1990). For a monopolist, irreversibility means that firms cannot disinvest in the future if negative shocks arrive and cause the asymmetric distribution of marginal profitability of capital; hence a higher required return is needed to compensate for possible future loss, which raises the "hurdle rate" or investment trigger. Thus, the firm invests less today to reduce the probability of having more capital than desired in the future. In a competitive industry with constant returns to scale, the distribution of marginal profitability of capital does not depend on an individual firm's current investment but depends on aggregate industry-wide investment. Irreversibility means new firms can enter and existing firms can expand freely when there are positive shocks, but cannot exit or contract when there are negative shocks[1]. Aggregate uncertainty raises the entry

[1] With constant returns to scale, expansion/contraction can be viewed exactly similar to new entry/exit.

ISSN: 2455-8834

Volume:02, Issue:09 "September 2017"

threshold higher than the average cost, hence reduces aggregate investment in the same way as in the monopolist case but for different reasons. It is now aggregate (industry-wide) shocks that cause the adverse investment impact but not idiosyncratic (firm-level) shocks.

In the short run, volatility changes cause adverse changes in investment. Higher uncertainty results in a lower investment output ratio in anticipation of possible lower future demands, and vice versa, lower uncertainty causes the investment output ratio to rise. The long-run impact is unclear because the reason for firms setting a higher required return to trigger investment when volatility is high is that volatility increases both the chance for a firm to experience a period of high realised return as well as a period of low returns. Higher return is required to compensate for the period of low returns. The impact of uncertainty and irreversibility on an average realised return is, therefore, not known, and it does not give us any conclusive indication of the effect of uncertainty and irreversibility on the average investment output ratio.

If the marginal profitability of capital is a convex function of the sources of uncertainty, i.e. input cost or output prices, uncertainty can have positive impact on investment as a direct result of the Jensen's inequality effect. This effect is shown by Hartman (1972) and Abel (1983, 1984, 1985), who demonstrated that uncertainty raises the expected marginal revenue of capital; hence increases investment.

Economic theory suggests many different sources of uncertainty that may directly or indirectly influence the uncertainty of future returns on investments. Firms are very concerned about the fluctuation of interest rates because changes in interest rates directly affect the cost of financing, especially when firms are highly leveraged, and indirectly affect the rates at which the future payoffs on investments are discounted. Changes in relative prices of domestic goods and foreign goods can substantially influence input costs if firms rely on imports of materials or capital goods, and significantly affect output prices if firms export their final products.[2] It should also be noted that our sources of uncertainty are common for all firms, hence can work as good proxies for aggregate uncertainty as opposed to idiosyncratic uncertainty.

As the basis for the empirical analysis of investment uncertainty relationship, we attempt to examine the relationship between uncertainty and aggregate investment in Thailand. Pindyck and Solimano (1993) highlight a number of drawbacks associated with the use of aggregate data. Firstly, the task is extremely difficult because aggregate data are usually poor and fragmentary in developing countries. Moreover, they are generally not available for a long period of time and when available, they are expected to suffer from substantial errors in measurement. It is difficult

[2] See Dixit (1989b) and Pindyck and Solimano (1993) for discussion on the use of exchange rate uncertainty in empirical studies on investment-uncertainty relationship.

ISSN: 2455-8834

Volume:02, Issue:09 "September 2017"

to measure the separate sensitivity of the different types of investment and disinvestments to uncertainty and irreversibility as the effects might be cancelled out at aggregate level. Given these difficulties, we do not expect to obtain conclusive results on the response of investment to uncertainty but only attempt to exploit as much information as we can out of the data available. Our methodology will include both descriptive and formal regression analysis.

2. DATA DESCRIPTION AND ESTIMATION METHODOLOGY

We choose the time frame before the global subprime debt crisis to avoid the impact of credit booming and investment surge just before the global crisis and prolong credit crunch and economic bust after the global crisis. The aggregate data sets used in the following analysis are published by the Bank of Thailand and covers the period between 1980-2002 inclusive. Unfortunately, only data aggregated at national level are available for time series regression and there are not sufficient data at industrial level for cross sectional regression analysis. In addition, data on investments are only available on annual basis. The Autoregressive Distributed Lagged (ADL) approach turns out to be useful for the purpose of examining the dynamic structures of our investment models. The models are therefore structured using the partial adjustment mechanism (PAM) initiated by Marc Nerlove as basic rationale.

Our choice of uncertainty proxy is the fluctuation of exchange rate uncertainty (Bell and Campa, 1997; Pindyck and Solimano, 1993). The uncertainty proxy for exchange rates is calculated using the relative changes (first difference of natural logarithm of the exchange rate). Irreversibility is usually associated with firm or industry or even country specifics, which are not easily observed with time series. Thus, unless we have cross sectional data for investment, modelling irreversibility is almost impossible for aggregate data at national level for a single country. Because disaggregated data at industry level are not available, our options are very limited.

We examine the sensitivity of private fixed investment to uncertainty. Private Investment driven by potential profitability is generally more sensitive to uncertainty and irreversibility than public investment, which is essentially driven by total social benefit of the general public and is not affected by short-term pecuniary profit potentials.

With given technology and relative cost of capital to other input costs (rents, labours, or materials) there is a long run desired capital stock, which is optimally required to produce a specific amount of output for the economy in static equilibrium. In dynamic equilibrium, the optimal capital stock is achieved by adjusting the flows of capital, i.e. investment. In each period there is a desired investment level that provides sufficient flows of capital to offset the natural depreciation of existing capital stock and to provide new capital to meet the expansion of

ISSN: 2455-8834

Volume:02, Issue:09 "September 2017"

aggregate demands. This is because at aggregate level, it is reasonable to assume that depreciation rate is relatively stable in the long run. Assuming the economy is in a steady state, growing at the balanced warranted natural rate and is characterised by the simple Cobb-Douglas production function with constant returns to scale, then if there is no significant shock in technology, input costs and/or output demands, desired investment should be commensurate with the aggregate output and the corresponding optimal capital stock. In such a state of the economy, investment output ratio should be relatively stable.

Thus, investment is determined by various factors. In our model, the investment output ratio, $\frac{PFI_t}{GDP_t}$, is used as the dependent variable to control the impact of output demands, GDP_t, on investment, PFI_t. The model then examines the impact of some investment determinants that affect input costs including interest rates, IR_t, and exchange rates, XR_t . Uncertainty is assumed to be a more important source of variation that deviates average investment from its long-run equilibrium and determine the short-run desired investment output ratio in each period of time. Uncertainty is measured by unexpected shocks in the above mentioned investment determinants. This is consistent with the results presented in Dixit and Pindyck (1994), which suggest uncertainty has a stronger effect on investment than other investment determinants, especially when irreversibility (at least partial) is a common phenomenon. The following reduced-form investment function is then defined[3]:

$$Y_t^* = \beta_0 + \mathbf{b'X} + u_t \quad (1)$$

where Y_t^* is the desired ratio of investment to aggregate output; β_0 is the constant; **b** is a k x 1 vector of linear coefficients; **X** is a k x 1 vector of the uncertainty proxies, other investment determinants and its lags; u_t is the error term, which controls for the impact of all other factors that are not fully explained by the model and is assumed to be independently and identically distributed with mean zero and standard error, σ.

Since the desired investment output ratio is not directly observed, we assume that the actual change in investment output ratio in any given period t is some fraction γ $(0 \le \gamma \le 1)$ of the desired change for that period and specify the partial adjustment mechanism as:

$$Y_t - Y_{t-1} = \gamma(Y_t^* - Y_{t-1}) \quad (2)$$

If $\gamma = 0$, it means that there is no adjustment in investment output ratio even if the desired

[3] The structure of our model is very similar to the model used by Pindyck and Solimano (1993).

ISSN: 2455-8834

Volume:02, Issue:09 "September 2017"

investment output ratio has changed. If the actual change in investment output ratio is equal to the desired change, the economy instantly adjusts to the desired level and $\gamma = 1$. However, there are a number of reasons that make the adjustment towards the desired investment output ratio incomplete. Rigidity, inertia, contractual obligations, habit resistance, time to build, etc. can cause firms to make only partial adjustments and γ is expected to lie between 0 and 1. Rearrange (2) and substitute (1) into the rearranged equation and we have the final form of the Partial Adjustment Model (PAM):

$$Y_t = \gamma Y_t^* + (1-\gamma)Y_{t-1} \qquad (3)$$

$$Y_t = \gamma \beta_0 + (1-\gamma)Y_{t-1} + \gamma \mathbf{b}'\mathbf{X} + \gamma u_t \qquad (4)$$

The Autoregressive Distributed Lag (ADL) Model (4) can be estimated using the simple Ordinary Least Squares (OLS) method. If u_t satisfies the usual assumptions of the Classical Linear Regression Model (CLRM), so will γu_t [4]. Even though Y_{t-1} depends on u_{t-1} and all the previous disturbance terms, it is not related to the current error term u_t because under the assumptions of the CLRM u_t is not serially correlated. Thus, OLS estimation of (4) yields consistent estimates if u_t satisfies the CLRM assumptions; hence γu_t. However, OLS estimates tend to be biased in finite or small samples. To check for the consistency of the estimates, the Generalised Instrumental Method (GIM) using $\mathbf{X}_{t-1}$ as instruments will be employed.

The number of lags of $\mathbf{X}_t$ is determined using the Akaike Information Criterion (AIC) and the Schwarz Bayesian Criterion (SBC). The appearance of the lagged terms of $\mathbf{X}_t$ in the explanatory variables may create multicollinearity problems as $\mathbf{X}_t$ tend to highly correlate with its lags, which leads to imprecise estimation, i.e. the standard errors tend to be large resulting in erroneous inference of statistical insignificance of some coefficients. However, the purpose of our research is to test for the total effects of $\mathbf{X}_t$ and multicollinearity between $\mathbf{X}_t$ and its lags will not be a serious problem. Moreover, the gradual checks and drops of insignificant variables will ensure the inclusion of all significant variables in our model, avoiding problems associated with parsimonious models.

Our central purpose is to examine the relationship between uncertainty and aggregate investment. Most investment expenditures are irreversible or at least partially irreversible because sunk costs cannot be recovered if market conditions turn out to be worse than expected.

[4] If u_t is not serially correlated and homogeneously distributed with mean zero and variance σ^2 then γu_t is also not serially correlated and homogeneously distributed with mean zero and variance $(\gamma\sigma)^2$.

ISSN: 2455-8834

Volume:02, Issue:09 "September 2017"

Thus, like other research on real options, irreversibility is implicitly assumed in our model. Irreversibility however poses no serious problem for public investment when profitability is not an issue.

To find the determinants that can best explain investment, it would be ideal to start from a general testing model that includes all the theoretical explanatory variables and then gradually drop the insignificant factors and run the regression again. However, that approach is only feasible if a very large number of observations are available and the estimated parameters are stable over time. Such severe requirement is generally not available for annual macroeconomic data. Firstly, quality macroeconomic data for developing countries generally do not exist for a very long period of time. Available data are usually fragmented and suffer greatly from measurement errors. Persistent high inflation and volatile exchange rates contribute to the mismeasurement of relative price changes over time. Secondly, as a result of rapid technological progress, continuous reform induced institutional changes and industrial evolution in developing countries, macroeconomic relations do not stay the same over time. Thus, raising the number of observations would improve the precision of the estimates statistically on the one hand. On the other hand though, in doing so, it is necessary to increase the sample period and thus increase the chance of having unstable estimated parameters in the sample. A number of remedies can be used to reduce the problem, e.g. to change the data from norminal data to real data series to control for the inflation, using monthly or quarterly data instead of yearly data, or using dummy variables when the structural change can be observed. The task is not always simple however and would raise a number of other issues.

To investigate the dynamic relationship between investment and its determinants, we choose to include uncertainty proxy measured as the unexpected change of exchange rate, XRU_t, and other determinants. The regressions help identify the sources of uncertainty that are most significant to investment and other investment determinants to control for the impact of those determinants on investment.

3. RESEARCH FINDINGS AND IMPLICATIONS

To examine the prediction of the real options theory on the relationship between investment and uncertainty, we need a representative proxy for investment that is determined by market forces under rational expectation of the future paths of input costs and output demands. Thailand's business and investment environment has suggested that Thailand was the magnet for foreign investors, attracting both real and speculative investment in the late 1980s and early 1990s. During this period, forward expectation is pushed upwards (perhaps, irrationally too high) among foreign investors and it is the speculative force that affects foreign private investment and

ISSN: 2455-8834

Volume:02, Issue:09 "September 2017"

influences the way in which real investment should be made otherwise. Thus, profit driven domestic private investment, which is generally sensitive to uncertainty and irreversibility, will be central to our analysis.

Table 1: Private Fixed Investment and Exchange Rate Uncertainty

$\frac{PFI_t}{GDP_t}$	(a) ADL	(b) GIM[††]
$\frac{PFI_{t-1}}{GDP_{t-1}}$	.8677**	.8692**
	(.0609)	(.1141)
IR_t	.5719[#]	.5453
	(.3257)	(.4578)
IR_{t-1}	-.8437*	-.8524*
	(.3036)	(.3389)
XRU_t	-.4274**	-.4277**
	(.0511)	(.0534)
Constant	.0804**	.0830**
	(.01861)	(.0207)
$\bar{R}^2$	.9551	.9553
F statistic**	$112.68_{(4,17)}$	$107.85_{(4,16)}$
Durbin's h	-.02 (.98)	1.74[¤]
White's	$.5324_{(1)}$	$.2541_{(1)}$
Sargan's		$2.10_{(1)}$
AIC	56.61	
SBC	53.88	

** Significance at 1% level; * Significance at 5% level; [#] Significance at 10% level;
[##] Significance at 20% level
[¤] Durbin Watson d statistic
[†] Instrument XRU_{t-2}; [††] Instrument IR_{t-1}, XRU_{t-2}

Table 1 reports the results for the regressions of the ratio of private fixed investment to GDP on the interest rate and exchange rate uncertainty proxy using the autoregressive distributed lagged (ADL) method discussed earlier. The diagnostic regressions to search for the sources of uncertainty that matter most to aggregate private investments identify exchange rate shocks as the only significant measure of risk that investors are worried about.

The inclusion of the lagged term, $\frac{PFI_{t-1}}{GDP_{t-1}}$, of the dependant variable, $\frac{PFI_t}{GDP_t}$, as an explanatory

ISSN: 2455-8834

Volume:02, Issue:09 "September 2017"

variable would pose some statistical problems. $\frac{PFI_{t-1}}{GDP_{t-1}}$ like $\frac{PFI_t}{GDP_t}$ is stochastic and need to be distributed independently of the stochastic disturbance term. If this assumption is not satisfied, the OLS estimators are not only biased but also not consistent. The interpretation of the results under that situation would be misleading. By construction, our partial adjustment model should pose no such problem as long as there is no serial correlation of the disturbance terms because if u_t in (1) satisfies the usual assumptions of the Classical Linear Regression Model (CLRM), so will γu_t in (4). The Durbin's *h* test of serial correlation for autoregressive regression models confirms that there is no serial correlation in our models. To examine if higher order of autoregressive scheme, AR(*p*), is a problem, we use LM test (Breusch-Godfrey (BG) Test), with the longest length of the lag, *p*, defined by experimentation (starting from *p*=1, LM test is implemented until the LM statistic is no longer significant. White's test of heteroskedasticity also suggests heteroskedasticity is not present in our models. Additional regressions, using Newey-West standard errors to adjust for heteroskedasticity and autocorrelation confirm that the significance of the estimates are generally unchanged either heteroskedasticity and autocorrelation are adjusted or not.

To double check for the consistency of the ADL estimates reported in column (a) of *Table 1*, the regression is run again using the generalised instrument method (GIM). The GIM regression result reported in column (b) of the table is almost identical to column (a). The current shocks of exchange rate have very significant negative effects on investment. Following the method used by Pindyck and Solimano (1993), the investment determinants are included in the regression equation (a) of *Table 1*. The interest rates are the long-term government bond rates, capturing the cost of risk free capital. An increase in the government bond rates will generally shift all the interest rates corresponding to different risk classes, raising the cost of capital and reduce investment. Exchange rates affect firm investments in two ways: (i) through output demands of exporting firms; and (ii) through input costs if firms import materials or service debts denominated in foreign currency. An increase in XR_t means depreciation would have a positive impact on investment under (i) and a negative impact under (ii). The total effect is ambiguous however. At aggregate level and in the short-run, depreciation improves exports, contracts imports and expands aggregate demands, hence stimulates aggregate investment to meet the output demand. In addition, depreciation attracts foreign capital inflow, increasing the availability of capital denominated in the local currency, hence reduces cost of capital and encourages investment. The total effect of exchange rates on investment is therefore positive in the short-run.

Only interest rate, IR_t, and exchange rate, XR_t, appear to provide useful information. Columns (a)

ISSN: 2455-8834

Volume:02, Issue:09 "September 2017"

and (b) of *Table 1* report the regression results using the ADL and the GIM methods when interest rate, IR_t, is included. As predicted, the investment output ratio is negatively affected by the average monthly long-term government bond rates of the last period before the current period. The impact of exchange rate uncertainty on private investment remains strongly significant and negative.

When investment is reversible the positive Jensen's inequality effect overwhelms the real options negative impact of uncertainty on investment. Assuming the marginal profitability of capital is a convex function of interest rates and exchange rates, then higher interest rate uncertainty and exchange rate volatility push the expectation of payoffs upwards, resulting in higher investment.
The use of Autoregressive Distributed Lag (ADL) Model, specifically the Partial Adjustment Model (PAM), has made it possible for us to examine the dynamic structure of the aggregate investment equations for Thailand. To investigate the implications of real options for investment uncertainty relationship, the research focuses on the analysis of private investment, which is profit driven investment in real sector. The use of aggregate data makes it difficult for us to model irreversibility explicitly. Irreversibility is therefore implicitly assumed as a characteristic of private investment, where new firms can enter and existing firms can expand freely when there are positive shocks, but cannot exit or contract when there are negative shocks.

When investments are irreversible, they are very sensitive to uncertainty of future returns. The regression results consistently indicate that uncertainty of exchange rate has a very significant negative impact on aggregate private investment. The average long-term government bond rate is also found to be a significant factor that determines private investment. Higher government bond rates raise the cost of financing of all risk class investments, hence reduce investment. Risks associated with exchange rates are also found to be an important factor that determines excess returns (Nguyen, 1998) and has negative impact on private investment (Bende-Nabende and Slater, 2003) in Thailand. In previous research, Larrin and Verara (1993) also found that macroeconomic instability has a negative impact on private investment in Thailand, Malaysia, Singapore and Korea. Similar results are reported in Serven and Solimano (1993) for Latin America after 1982.

The results can be explained by the implications of the real options theory and also other theories that explain the relationship between uncertainty and investment. Irreversibility causes the asymmetric distribution of marginal profitability of capital; hence higher required return is needed to compensate for the possible loss in the future when there are negative shocks. Aggregate uncertainty raises the "hurdle rate" or investment trigger higher than the average cost, hence reduces aggregate investment. In a short run, volatility changes cause adverse changes in investment. Higher uncertainty results in a lower investment output ratio in anticipation of

ISSN: 2455-8834

Volume:02, Issue:09 "September 2017"

possible lower future demands, and vice versa, lower uncertainty causes the investment output ratio to fall.

REFERENCES

Abel, Andrew B. 1983. "Optional Investment Under Uncertainty." *American Economic Review*, Vol. 73 (March), pp. 228-33.

Abel, Andrew B. 1984. "The Effects of Uncertainty on Investment." *Journal of Economic Dynamics and Control*, Vol. 7 (February), pp. 39-54.

Abel, Andrew B. 1985. "A Stochastic Model of Investment, Marginal *Q* and the Market Value of the Firm." *International Economic Review*, Vol. 26, pp. 305-22.

Bell, Gregory K. and Jose M. Campa. 1997. "Irreversible Investments and Volatile Markets: A Study of the Chemical Processing Industry." *The Review of Economics and Statistics*, Vol. 79, pp. 79-87.

Bende-Nabende, A. and Slater, J.R. 2003. "Long-run determinants of private capital formation in developing countries: A co-integration analysis", Unpublished Working Paper.

Caballero, Ricardo J. and Robert S. Pindyck. 1996. "Uncertainty, Investment, and Industry Evolution." *International Economic Review*, Vol. 37, No. 3, August, pp. 641-662.

Dixit, Avinash K. 1989a. "Entry and Exit Decisions under Uncertainty." *Journal of Political Economy*, Vol. 97 (June), pp. 620-638.

Dixit, Avinash K. 1989b. "Hysteresis, Import Penetration, and Exchange Rate Pass Through." *Quarterly Journal of Economics*, Vol. 104 (May), pp. 205-28.

Larrin, F. and Verara, R. 1993. "Investment and Macroeconomic Adjustment: The Case for East Asia" in Serven, L. and Solimano, A., *Striving for Growth after Adjustment: The Role of Capital Formation*, The World Bank, Washington D.C. 1993, pp. 229-274.

Leahy, John V. 1993. "Investment in Competitive Equilibrium: The Optimality of Myopic Behavior." *The Quarterly Journal of Economics*, Vol. 108, No. 4 (November), pp. 1105-1133.

Nguyen, Tho. 1998. "A Test of the Arbitrage Pricing Theory on the Stock Exchange of Thailand." *MSc Dissertation*, SOAS, University of London.

ISSN: 2455-8834

Volume:02, Issue:09 "September 2017"

Pindyck, Robert S. 1990. "Irreversibility, Uncertainty, and Investment." *National Bureau of Economic Research Working Paper*, No. 3307, March. Published in *Journal of Economic Literature*, Vol. XXIX (September), 1991, pp. 1110-1148.

Pindyck, Robert S. 1993. "A Note on Competitive Investment under Uncertainty." *The American Economic Review*, Vol. 83, No. 1 (March), pp. 273-77.

Pindyck, Robert S. and Andres Solimano. 1993. "Economic Instability and Aggregate Investment." *NBER Macroeconomics Annual 8*, pp. 259-303.

Pintobtaeng, Prapas. 1988. "Politics on Roadside." Research and Textbook Centre, Kirk University.

Serven, L. and Solimano, A., *Striving for Structural Adjustment: The Role of Capital Formation*, The World Bank, Washington D.C. 1993, pp. 147-180.

