Exchange Rate Regimes, Capital Account Opening and Real Exchange Rates: Evidence from Thailand

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ABSTRACT: This paper examines the roles of pegged exchange rate regime and capital account opening inducing persistent RER appreciation in the lead-up to the 1997 currency crisis in Thailand. The three-sector (primary, manufacturing, and nontradable) economy-wide model is constructed and policy simulation experiments are undertaken. Key findings are imposing capital control under a pegged exchange rate regime would have averted the persistent *internal* RER appreciation and boom in nontradable sector. However, it would not have averted persistent *external* RER appreciation. Exports and output would have eventually declined because of the capital shortage. A freely floating regime only with a high developmental level of foreign exchange and financial markets would have been able to avert both persistent *internal* and *external* RERs appreciation. The export and output would have eventually increased. However, this regime would have generated fluctuations in domestic prices and output. The managed floating regime (combined with inflation targeting) would have helped reduce such adverse effects while retaining the benefit from exchange rate flexibility. In a context where the foreign exchange and financial markets are not well developed, capital control measures could be beneficial to ensure smooth functioning of a managed floating regime.

Key words: Exchange rate regime, Capital account, and Real exchange rate

JEL classification: O11, F32, F41

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* I would like to thank Professor Chandra Athukorala and Professor Warwick McKibbin for their guidance and useful comments. Detailed and constructive comments from Professor David Vines are also gratefully acknowledged. I have also benefited from discussions with Professor Max Corden.

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1. Introduction

In the past decade, an increasing number of emerging-market economies have fallen victim to currency crises. Notable examples include the Mexican crisis in 1994, the Asian crisis in 1997–98, and the Argentine and Turkish crises at the dawn of the new millennium. These events, which caused massive economic collapse in the affected countries with considerable global repercussions, have given rise to a large literature on the economic fundamentals that make countries vulnerable to currency crises.

The consensus emerging from this literature is that a persistent, significant appreciation of the real exchange rate (RER) is an integral part of economic preconditions that make a country vulnerable to currency crisis.[1] There are two facets to the hypothesized link between RER appreciation and vulnerability. First, a persistent real appreciation undermines the competitiveness of the tradable good sector, leading to a widening current account deficit and dwindling foreign exchange reserves. The foreign reserve position (relative to accumulated foreign currency obligations) is a key determinant of a country's ability to defend the exchange rate in face of rapid outflows of financial capital in anticipation of possible currency depreciation. Second, and related to the first point, under a pegged exchange rate regime, persistent RER appreciation acts as an important leading indicator of possible nominal exchange collapse following speculative capital outflows. Such an appreciation implies that the authorities would be unable to defend the currency peg successfully in the event of speculative capital outflows, because domestic economic adjustment required to face the new lower (or negative) net capital inflows scenario cannot be accomplished through fiscal and monetary policies alone.

Despite this consensus, the underlying causes of persistent RER appreciation in the lead-up to the recent currency crises remain a controversial issue. Two common features of the macroeconomic policy of these countries, namely a prolonged adherence to a *de facto* pegged exchange rate regime and significant capital account opening, are central to the debate.

On the one hand, a number of authors argue that persistent RER appreciation mainly resulted from a wrong exchange rate regime choice, which was not consistent with an increasingly liberal capital account regime (Obstfeld and Rogoff, 1995; Summer, 1998; Mussa *et al.*, 2000; Fischer, 2001). In particular, Fischer (2001: p.10) argues that when a pegged regime

[1] See for example Sachs *et al.* (1996), Dornbusch (1997), Goldstein (1998), Fischer (2001), Athukorala and Warr (2002), Schneider and Tornell (2004).

has been in place for some time, a belief gradually develops among market participants that the exchange rate will not change. This removes perception of risk from foreign borrowing and encourages excessive short-term capital inflows, resulting in RER appreciation along with a boom in the nontradable sector. The trade and current account balances tend to deteriorate. A *de facto* pegged exchange rate regime invariably constrains the role of exchange rate adjustment in averting such adverse macroeconomic developments (Obstfeld and Rogoff, 1995). The key inference of these studies is that a hard peg or a floating exchange rate regime would have avoided RER appreciation even in the context of significant capital account opening.

On the other hand, some analysts emphasize the role played by capital account in RER appreciation (Reinhart and Smith, 2001; Stiglitz, 2001; Corden, 2002). They argue that given massive short-term capital inflows triggered by capital account opening, RER appreciation was unavoidable, regardless of the nature of the exchange rate regime choice. In particular, Corden (2002: p. 252) argues that

> '… Inevitably, when there is a boom, there will be real appreciation irrespective of whether the exchange rate is fixed or flexible. … There is little reason why a boom that is based on, or at least ends, in euphoria should not go on its merry way under a currency board or a floating regime as much as under a fixed-but-adjustable-regime. For avoiding the adverse effect of a boom, exchange controls or taxes that discourage excessive short-term borrowing matter.'

The massive short-term capital inflows under a floating regime induce RER appreciation through nominal exchange rate appreciation, particularly when the domestic economy is characterized by significant wage-price rigidity. Under a fixed exchange rate regime, appreciation takes place through an increase in domestic nontradable prices. Thus, an inference drawn from this viewpoint is that the surveillance of capital inflows, together with control of volatile short-term capital inflows, could have avoided excessive RER appreciation.

This paper aims to address the debate on the roles of pegged exchange rate regime and capital account opening inducing persistent RER appreciation in the lead-up to the 1997 currency crisis through an in-depth case study of Thailand. The methodology of this paper involves conducting simulation experiments of alternative policy scenarios using an economy-wide model constructed and estimated for the Thai economy. The common practice in the literature in this subject area is to use a single RER index to represent both internal and external competitiveness.

This is not a satisfactory approach because the underlying assumption of the law of one price does not normally hold (Little *et al.*, 1993). The macroeconomic model developed in this paper explicitly delineates the *internal* RER, which measures the relative profitability of domestic tradable production *vis-à-vis* nontradable production, and the *external* RER, which measures the profitability of domestic tradable goods in the global context. The use of an economy-wide model, instead of the single-equation approach, has the virtue of enabling us to incorporate interactions among various macroeconomic variables, and the dynamics involved in these relationships.

Thailand provides an excellent case study of the subject at hand for three reasons. Firstly, Thailand experienced persistent appreciation of *internal* and *external* RERs, from the late 1980s leading up to the 1997 currency crisis.[2] Secondly, Thailand pursued a pegged exchange rate regime as well as accelerated capital account opening in the lead-up to the recent crisis. The exchange rate during the period 1987–96 averaged out at around 25 baht per US dollar. As well, Thailand commenced liberalizing controls of capital and financial account in the late 1980s. These two aspects of macroeconomic policy are widely cited as the main causes of the persistent RER appreciation and the currency crisis in Thailand (Alba *et al.*, 1999; Lópex-Mejia, 1999; Warr, 1999; Rajan, 2001). However, the relative importance of these two factors has not yet been examined.

The rest of the paper is organized as follows. The following section provides key features of the macroeconomic model. The econometric procedure and the model performance are discussed in sections 3 and 4. Section 5 presents the alternative simulation experiments. Discussion of the results is in section 6. The final section summarizes the major findings and policy implications. The macroeconomic model and the variable measurements are provided in Appendix I.

2. Key Features of the Model

The model is an extended version of the Salter-Swan framework where an economy consists of two types of goods — tradable and nontradable. Tradable goods are further disaggregated into primary and manufactured goods. This is done to allow for the different features, which vary

[2] The magnitude of *internal* RER appreciations in 1996 was close to that in 1983, which led to a considerable devaluation and dramatic economic recession in 1984, while the average magnitude of *external* RER appreciation was far greater than that in 1983. The persistent RER appreciation in the lead up to the 1997 crisis is referred to as RER misalignment (Jongwanich, 2002).

between the two sectors (Corbo, 1985).[3] There are six main building blocks in the model, namely prices and wages, production capacity, aggregate demand, money market, external balance, and labour market.

Following Corbo (1985), domestic output prices are derived from the weighted average of tradable (P_T) and nontradable (P_N) prices. The nontradable price (Equation 1.3 in Appendix I) is determined according to the mark-up formulation in which the price is set as a mark-up on the cost of production. The mark-up is hypothesized to depend on excess demand (ED). Suppose that cost of production has two main components — wages adjusted by labour efficiency (W / LP), and imported raw material prices (eP^*_{IMR}). Thus, the nontradable price can be derived as a function of excess demand, wages adjusted by labour efficiency, and imported raw material prices. For the tradable (primary and manufacturing) sector (Equations 1.1 and 1.2), prices are jointly determined by the law of one price and domestic condition factors (wage, excess demand and imported raw material price). Including the domestic factors reflects the fact that some tradable goods could be differentiated from foreign competing goods.

The wage (compensation per worker) in each sector (Equations 2.1–2.3) is determined by the inflation-augmented Phillips curve.[4] With the assumption of labour mobility across sectors, the rate of change of nominal wage (adjusted by labour productivity) in each sector $\Delta(W / LP)$ can be expressed as a function of inflation expectations (ΔP^e), and the deviation of total unemployment rate from the natural rate ($U - U^*$). Moreover, minimum wage (MW) is incorporated to capture the impact of the minimum wage setting by the government on the determinants of market wage.

The production block (Equations 3.1–3.3) represents the supply side potential of the economy. The (potential) output in each sector ($\overline{Y}_i$) depends on trend of total factor productivity ($\overline{TFP}$), labour force (adjusted by the natural rate of unemployment) ($\overline{L}$), capital stock (K), and land (la) (Giorno *et al.*, 1995). The production is linked to an aggregate demand through

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[3] Ideally, these two sectors should have been disaggregated further into exportables and importables, but this is not possible because of data limitations. However, this is not considered to be a major limitation because there were no noticeable fluctuations in the terms of trade (in terms of both domestic and foreign currencies) in Thailand during the half decade prior to the crisis (the focus of the simulation experiments of this study) (McKibbin and Martin, 1998). Therefore, exportables and importables can reasonably be assumed to be facing the same prices. Tradables are treated as a composite commodity, comprised of exportables and importables.

[4] The non-linear model is also investigated but the unemployment rate becomes insignificant and does not perform well in terms of the standard diagnostic test.

changes in capital stock. Hence, the potential output of the economy is endogenous to aggregate demand (in the short to medium run), rather than being exogenous.

Aggregate demand is represented by the standard national account identity: summation of consumption (C), investment (I), government expenditure (G), exports (X), and imports (IM). Consumption is determined through a two-stage budgeting procedure. At the first step, consumer decides how much income will be allocated to total consumption, based on the life cycle model (Equation 4.1). That is, household aims to maximize the present value of lifetime utility subject to budget constraint, which is equal to current net worth plus the present value of expected income over the remaining working life of the agent. The basic model is extended to incorporate demographic and distributional shifts (*DEPEND*), uncertainty of household income (*UNCER*), and liquidity (credit) constraint (PDC_C). The first variable is to capture the difference of marginal propensity to consume and wealth across all cohorts in an economy. While child-dependency and the retired generation have a higher marginal propensity to consume but a lower income than a working generation, an increase in the proportion of the former tends to increase aggregate consumption. Uncertainty of household income and liquidity (credit) constraint can lead to a precautionary element in saving decisions so that aggregate consumption tends to be reduced within these situations. The next step is to allocate aggregate consumption amongst the three goods (Equations 4.1.1–4.1.3). The demand function is assumed to have constant elasticity in terms of its own price (P_i), income ($P^C C$), and other goods prices (P_j). The three crucial properties as postulated in consumer theory — adding-up, homogeneity, and symmetry — are tested and imposed.

Private investment (Equations 4.2.1–4.2.3) is based on an extended framework of the neoclassical investment model (Jorgenson, 1967). With the price taker assumption in the factor market and with the Cobb-Douglas production function, (steady-state) investment can be derived as a positive relationship with the output level (Y) and a negative relationship with the rental cost of capital (CK). The basic model is extended to incorporate the fact that it takes time to plan, build, and install new equipment so that the gross domestic investment tends to adjust the difference between steady-state desired investment and investment in the previous period. The response of private investment to the gap between steady-state and actual investment is assumed to vary systematically with three economic factors: (1) the availability of financing (PDC_I), (2) the level of public sector investment (*GI*), and (3) the economic uncertainty condition (*UNCER*).[5]

[5] These three well known economic factors in influencing private investment were widely incorporated in numerous studies (e.g. Blejer and Khan, 1984; Agénor, 2000).

The first two factors tend to reduce the gap between desired and actual investment, thereby increasing actual investment. By contrast, the last factor is likely to enlarge this gap and reduce actual investment.

Government expenditure (G) is decomposed into government investment (GI) and consumption (GC), which are treated as exogenous in the model (Equation 4.4). Government consumption expenditure is treated solely as nontradable consumption.

Budget constraints are imposed on the private and public sectors to ensure that the model is internally consistent (Equations 4.3 and 4.4.1). Over and above the government budget constraint, the fiscal policy rule (Equation 4.4.2) is incorporated into the model to ensure that the intertemporal government budget constraint is satisfied, i.e. $Debt_0 = \sum_{s=0}^{\infty}(T_s - G_S)/(1+in)^s$ where T is the tax revenue, G is the government expenditure, and in is the interest rate. In other words, the value of debt in period 0 is equal to the future stream of tax revenue less the future stream of government spending (McKibbin, 1996).[6]

Merchandise exports in primary and manufacturing (Equations 4.5.1 and 4.5.2) are modeled in terms of a reduced form equation derived from both demand and supply framework. The quantity of export is derived as a function of capacity output of an economy ($\overline{Y}$), the ratio of world prices (adjusted by exchange rate) to domestic prices (eP^* / P), and foreign demand (Y^W). The determinants of (merchandise) primary and manufacturing imports (Equations 4.6.1 and 4.6.2) are based on the traditional specification of imports for a small open economy where the supply of imports is assumed to have infinite elasticity. Thus, the quantity of imports in each sector is solely determined by the demand condition. In other words, the quantity of imports is a function of domestic real income (*Y*) and the ratio of world (import) prices to domestic prices ($eP^{\$} / P$).

Domestic interest rate (*in*) is determined by both demand for and supply of money.[7] Money supply (Equation 5.1) is determined through the money multiplier approach. According to this approach, the money supply establishes the relationship with the money base through the

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[6] This means that in this study the government will introduce a lump sum tax ($\overline{T}$) over and above personal income tax when interest costs of debts exceed the base case. At the baseline, there is no lump sum tax. Therefore, the steady state level of government debt depends on the steady state level of government spending.

[7] Note that when the monetary authorities are independent and allowed to conduct monetary policy through policy interest rate, e.g. under the inflation targeting framework, the domestic interest rate is changed to depend on the policy rate. See details when a floating regime is incorporated within this core model.

multiplier. The demand for money (Equation 5.2) is specified as a function of domestic interest rate, domestic output price, and real income. Private domestic credit (Equation 5.3) is determined through the monetary identity to ensure that the money market is internally consistent. The current account balance (Equation 6.1), net capital inflows (Equation 6.2), and items of net error and omissions yield the balance of payments identity (Equation 6.3) that will affect the money base through changes in foreign exchange reserves.

Finally, the RER is separated into two concepts — *internal* and *external* RERs. The *internal* RER refers to the relative prices of tradable to nontradable goods (Equation 1.4.1). This measure reflects the incentives to allocate domestic resources across tradable and nontradable sectors. When there is an increase in prices of the nontradable sector (*internal RER* appreciates), resources tend to be geared towards this sector so that available resources for producing tradable products decline. The *external* RER refers to the (geometric) trade-weighted average of tariff-ridden world (tradable) prices adjusted by nominal exchange rate to domestic (tradable) prices (Equation 1.4.2). When there is an increase in this index (real depreciation), domestic goods are relatively cheaper for foreigners.

In this model, the long-run (steady-state) properties as well as homogeneity properties in each equation are imposed in the model. Such long-run (steady-state) properties are needed to ensure that a set of structural economic relationships is constrained to be consistent with a neo-classical steady state, in which the long-run output level is solely determined by supply-side factors, such as level of technology, and availability of factor inputs. Aggregate demand (equals output) is equal to production capacity (i.e. potential output) and its equality is brought by the wage-price flexibility in the long run. However, in the short run, the model exhibits the features of Keynesian-type economy, i.e. nominal wage-price stickiness and the demand determined economy. These features are found in the model such as the MSG (McKibbin and Sachs, 1992); Multimode econometric model (Laxton *et al*., 1999); Vines and Warr (2003).

3. Econometric Procedure

The 'general to specific' (unrestricted dynamic) modelling procedure (Hendry *et al*., 1984) is the core methodology for estimating each behavioural equation (henceforth referred to GSM).[8] The advantage of the GSM methodology is to be able to apply in terms of either the set of variables is non-stationary or a mixture of stationary and non-stationary series (Wickens and Breusch, 1988;

[8] There are two exceptions. First, the disaggregate private consumption equations are obtained by using a 'seemingly unrelated regression equation (SUR)' model in order to take into account the related error terms as well as to test and impose the adding-up, homogeneity, and symmetry restrictions. Secondly, the wage equation is determined by simple OLS estimation.

Pesaran *et al.*, 2001). Moreover, recent Monte Carlo studies revealed that in the case of finite sample, the GSM gives precise estimates and valid t-statistics, even in the presence of endogenous explanatory variables (Inder, 1993; Hendry, 1995).[9]

The GSM procedure is to embed the relationship being investigated within a sufficiently complex dynamic specification, including lagged dependent and independent variables so that a parsimonious specification of the model can be uncovered. Under this procedure, estimation begins with an autoregressive distribution lag (ADLs) specification of an appropriate lag order:

$$Y_t = \alpha + \sum_{i=1}^{m} A_i Y_{t-i} + \sum_{j=1}^{k}\sum_{i=0}^{m} B_{ij} X_{j,t-i} + \mu_t \qquad (3.1)$$

where α is a constant, Y_t is the endogenous variable, $X_{j,t}$ is the j^{th} explanatory variable and A_i and B_{ij} are the parameters.

Equation (3.1) can be rearranged by subtracting Y_{t-1} on both sides and turns the set of explanatory variables in terms of differences representing the short-run dynamics. The lagged levels of both dependent and explanatory variables are still left in the rearranged functional form on the right-hand-side in order to capture the long-run multiplier of the system.

$$\Delta Y_t = \alpha + \sum_{i=1}^{m-1} A_i^* \Delta Y_{t-1} + \sum_{j=1}^{k}\sum_{i=0}^{m-1} B_{ij}^* \Delta X_{j,t-1} + C_0 Y_{t-m} + \sum_{j=1}^{k} C_1 X_{j,t-m} + \mu_t \qquad (3.2)$$

where $A_i^* = -\left[I - \sum_{i=1}^{m-1} A_i \right]$, $B_{ij}^* = \left[\sum_{i=0}^{m-1} B_{ij} \right]$, $C_0 = -\left[I - \sum_{i=1}^{m} A_i \right]$, $C_1 = \left[\sum_{i=0}^{m} B_{ij} \right]$, and the long-run multiplier of the system is given by $C_0^{-1} C_1$.

Equation (3.2) is known as the error correction mechanism (ECM) representation of the model. This is the particular formulation generally used as the 'maintained hypothesis' of the specification search. The estimation procedure involves first estimating the unrestricted equation (3.2), and then progressively simplifying it by restricting statistically insignificant coefficients to zero and reformulating the lag patterns where appropriate in terms of levels and differences to achieve orthogonality. The long-run homogeneity can be tested and imposed in each equation. As part of the specification search, it is necessary to check rigorously at every stage even the

[9] Even when all data series under consideration are non-stationary ($I(1)$), comparative Monte Carlo studies of cointegration technique find that this procedure is equally as good as the Phillips Hansen procedure in dealing with small data samples (Phillips and Loretan, 1991; Inder, 1993). The Monte Carlo evidence also suggests that the Johansen estimation procedure, which is based on the full vector autoregression (VAR), deteriorates significantly in small samples, generating estimates with 'fat tails' (frequent outliers) and sometimes substantial mean bias (Hargreaves, 1994). Therefore, GSM is chosen for estimating the behavioural equations in this study.

more general of models for possible misspecification. Such checks will involve both a visual examination of the residual from the fitted version of the model and the use of tests for serial correlation, heteroskedasticity and normality in the residual, and the appropriateness of the particular functional form used. In particular, any suggestion of autocorrelation in the residual should lead to a rethink about the form of the general model. Above all, theoretical consistency must be born in mind throughout the testing down procedure.

4. The Model

The model is estimated using annual data for Thailand over the period 1970–2002. The full model — the estimated behavioural equations and identities — is presented in Appendix I. All behavioural equations are theoretically sound in specification and pass the standard *F*-test for overall statistical significance. They also pass the standard diagnostic test for serial correlation (DW and LM), heteroskedasticity (ARCH), normality in the residual (NORM), and functional form (RESET). The DF test suggests that the residuals of the regressions have achieved stationarity.[10] However, the statistical acceptability and the theoretical reasonableness of individual equations do not necessarily imply that taken as a system the model will provide a faithful representation of the economic system. Hence, examination of model performance is necessary.

We apply two widely used methodologies to investigate performance of the model — historical simulation and standard diagnostic simulations. The first methodology is to check the performance of overall model by comparing the original (observed) data series with the predicted series for each endogenous variable. The latter series is given by the 'base (historical) simulation', which is obtained by simulating the model over the sample period. To allow the lag response in each equation in the model, the simulation period is considered during 1977–2002. The second methodology is to apply three standard diagnostic simulation experiments — demand shock (a permanent increase in government consumption), supply shock (a permanent increase in technological progress in the tradable sector) and monetary shock (a permanent devaluation of nominal exchange rate).

For the first methodology, performance of the model is summarized by two widely used statistical measures — the mean absolute percentage error (MAPE) and the Theil inequality coefficient. The model performs quite well based on these two. The Theil inequality

[10] The standardized recursive residuals and recursive coefficients suggest the stability of estimates. In each equation, the Wu-Hausman is conducted to ensure that there is no evidence of simultaneity. See details of the Wu-Hausman test within ADLs in Pesaran and Pesaran (1997, p. 201–03).

measurement is close to zero for all endogenous variables. For almost all cases, the bias and variance proportions are small, which implies that the error of prediction is concentrated on covariance proportions. Almost all variables tend to be associated with MAPE at less than ten per cent. An examination of the observed and simulated series reveals that the direction of actual endogenous variables during the sample period is predicted well, particularly domestic prices and RERs. In addition, three simulation experiments show simulation properties of the core model are theoretically reasonable (Appendix II).[11]

There are two key points that reflect characteristics of the Thai economy. Firstly, there are significant differences in the determinants of domestic prices in each sector. For primary products, the tariff-ridden world price in terms of domestic currency is the crucial variable in determining the movement of the domestic primary price. In the short run, demand pressure also affects the domestic primary price. However, the law of one price holds for primary products in the long run. In contrast, the law of one price does not hold for the manufacturing sector. Domestic cost can still influence firm's decision-making when setting the manufacturing price. As expected, domestic factors dominate the movement of the nontradable price in both the short and long run. In the long run, the homogeneity of degree one holds for domestic prices in all these three sectors. With the evidence of price rigidity (the homogeneity of degree one does not hold for the short run), changes in nominal factors, such as nominal exchange rate, lead to short to medium-term changes in real variables, including *internal* and *external* RERs.

Secondly, determinants of output and aggregate demand vary significantly among the three sectors, reflecting their different characteristics. For example, capital accumulation is far more important in determining output in the manufacturing sector, compared to the primary and nontradable sectors, where production is relatively more labour-intensive. Income elasticity of demand is greater for manufacturing and nontradable goods compared to primary goods. The magnitude of income elasticity of demand for manufacturing imports is far greater compared to primary imports. Thus, an identical shock would have different impacts on the three sectors.

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[11] A permanent increase in government consumption, which dominates in nontradable sector, would not have affected total output in the long run. However, the structure of an economy would have been changed. A share of the nontradable output would have enlarged whereas that in tradable sector contracted. This would have made an adverse effect to trade balance. Both *internal* and *external* RERs would have appreciated, compared with the historical base in the long run. A permanent increase in technological progress in the tradable sector would have increased total output and exports in the long run. Tradable output would have increased more than nontradable output. Even though *internal* RER would have exhibited appreciation, the *external* RER would have depreciated reflecting an increase in a country's international competitiveness. A permanent devaluation of nominal exchange rate would have increased output, particularly tradable output, only in the short run. In the long run, the output and its structure would not have been affected. It reflects the long-run neutrality when the nominal exchange rate had continuously maintained depreciation.

5. Simulation Experiments

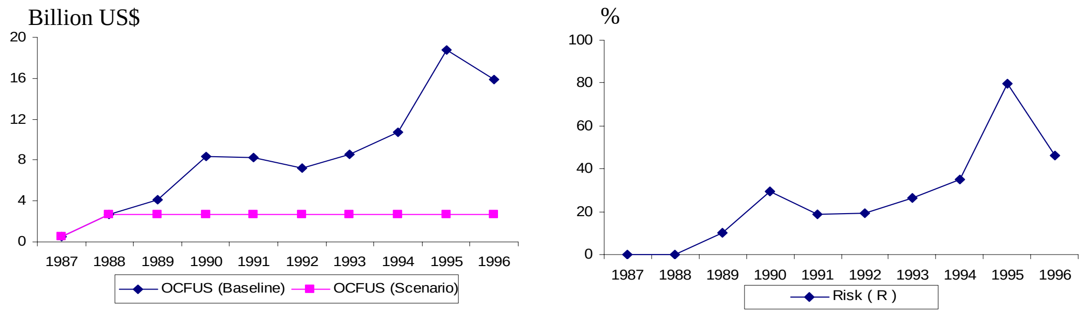
In order to probe into the roles of pegged exchange rate regime and capital account opening driving the persistent RERs appreciation in the lead-up to the 1997 currency crisis in Thailand, three key simulation experiments are undertaken during the period 1988–96. The year 1988 is used as the starting point because it is the year when implementation of the financial liberalization program was commenced. In addition, the period 1986–87 can be regarded as the period where the country to some extent attained the external balance.[12] The year 1996 is used as the ending point because it is the year when the bust began with the collapse of export growth. The historical shocks are used during this period under the different exchange rate regimes and degrees of capital account opening.

5.1 A Pegged Exchange Rate Regime with Capital (Inflows) Controls

The main question addressed in this experiment is, if Thailand had imposed capital (inflows) control measures and reduced the amount of capital flows net of FDI ($OCF^{\$}$) given the existing pegged exchange rate regime, what would have happened to the *internal* and *external* RERs and other key variables in interest? To answer this question, the capital control measures are introduced in the model in the form of risk for foreign investors (R) through equation $OCF^{\$}$ (Equation 6.2).

Risk (R) is introduced in a manner that the levels of $OCF^{\$}$ between 1988 and 1996 were equal to the 1988 $OCF^{\$}$ level, i.e. US$2.7 billion (Figure 1). Note that the simulation results are not significantly affected when altering the $OCF^{\$}$ level by using the 1989 and 1990 levels. The $OCF^{\$}$ levels during the period 1991–95 are not appropriate because they were very high. Setting high levels of $OCF^{\$}$ is unlikely to illustrate the effect of capital (inflows) controls.

Figure 1: The Net Other Form of Capital Flows ($OCF^{\$}$) and Risk ($R$)



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[12] The annual average of current account and balance of payment between 1986 and 1987 were US$-31 million and US$690 million, respectively. These figures are far lower than those during the period 1988–96, equaling US$-7,337 and US$3,880 million, respectively.

5.2 A Freely Floating Exchange Rate Regime with Capital Liberalization

This experiment examines the impact on the *internal* and *external* RERs and other key macroeconomic variables when the Thai government had pursued a freely floating exchange rate regime with capital liberalization since 1988. In a freely floating exchange rate regime, there is no direct intervention by the central bank to achieve the particular exchange rate target. Thus, under this regime, exchange rate responds both to market force (especially expectations) and to monetary policy acting on interest rate (e.g. under inflation targeting framework) (Corden, 2002: p.23). The country does not need to hold (much) foreign exchange reserves.

To examine this scenario, three additional assumptions are needed. Firstly, the exchange rate is determined according to the uncovered interest parity as in equation (5.1);

$$in = f\left(i^* + \frac{E_t e_{t+1} - e_t}{e_t},\ risk\right) \qquad (5.1)$$

where in is the domestic interest rate, i^* is the world interest rate, e_t is the nominal exchange rate at time *t*, $E_t e_{t+1}$ represents the expected exchange rate at time *t* and $risk$ is the country's risk.[13]

Given debate on the alternative approaches to the formulation of exchange rate expectations[14], two alternative forms, namely the adaptive expectations (backward-looking expectations) and the combination of forward- and backward-looking expectations (henceforth referred to forward-looking expectations) are used. Under the adaptive expectations, the expected exchange rate at period *t* ($E_t e_{t+1}$) is the weighted average between the exchange rate at time *t* (60 per cent) and that at time *t-1* (40 per cent). The $E_t e_{t+1}$ under the forward-looking expectations is the 40 per cent weight of exchange rate at time *t+1* and the rest of the current rate.[15] These two forms of expectations could be used to reflect the different developmental level of foreign exchange (and financial) market. As argued by a number of studies (e.g. Krugman, 1993; Mussa, 1993; Mussa *et al.,* 2000), having a significant degree of forward-looking expectations in the exchange rate is not automatic. Instead, it needs to have a well-functioning foreign exchange market and financial market efficiency. Thus, the forward-looking expectations in exchange rate is used to reflect a case where Thailand would have had the significant degree of foreign

[13] The country's risk is calibrated to ensure that the uncovered interest parity is held during the period 1988–96.

[14] See for example Liu and Maddala (1992), and McCallum (1994).

[15] We found that when the weight associated with the current exchange rate is changed, there is no major change in the simulation results.

exchange (and financial) market efficiency when conducting a freely floating exchange rate regime.

Secondly, changes in foreign exchange reserves are set at zero ($\Delta R^{\$} = 0$). With the perfect capital mobility assumption (i.e. the coefficient associated with interest rate differentials in $OCF^{\$}$ equation becomes infinity), $OCF^{\$}$ is changed to ensure that the changes in foreign exchange reserves are equal to zero while the uncovered interest parity is held.

Finally, following the 1997 crisis, the Bank of Thailand (BOT) adopted the inflation targeting framework as a new nominal anchor. According to this framework, the central bank uses interest rate policy to influence the economy. The Taylor rule (Taylor, 1993) is used as guidance for conducting the monetary policy. We apply this simple rule as a policy reaction function of monetary authorities in the model as follows[16];

$$i = \bar{r} + \pi + \omega_1 \cdot \left[\pi - \bar{\pi}\right] + \omega_2 \cdot y \qquad (5.2)$$

where i is the policy interest rate, $\bar{r}$ is the (long-run) average real interest rate (= 4.5 per cent, an average of real interest rate during the period 1988–96), π is the inflation, $\bar{\pi}$ represented the targeted inflation (= 2.5 per cent), y is the deviation of output from the potential one, and ω_1 and ω_2 are the coefficients associated with the inflation and output (0.6:0.4).[17] Note that within this monetary policy framework, the mechanism in the money market block is changed from the core macroeconomic model. In this scenario, changes in policy interest rate will affect the domestic interest rate in the core macroeconomic model. Changes in domestic interest rate affect money demand while money supply under this regime is endogenised to equal to money demand.

[16] When there is credible inflation targeting, it provides a nominal anchor for inflation expectations (de Brouwer and O’Regan, 1997; Corbo and Schmidt-Hebbel, 2003). This point is examined by assuming that inflation expectations (in wage equations (Equations 2.1–2.3)) had equaled the inflation target (2.5 per cent) rather than lagged inflation as in the core model. The results of key variables, especially RERs are more or less comparable. In addition, we also examine the result when the forecast inflation is used in equation (6.6) rather than the contemporaneous value. The result is not significantly affected. However, the variation of inflation under the forward-looking rule tends to be slightly less than that under the contemporaneous rule. This result is consistent with earlier studies (e.g. de Brouwer and O’Regan, 1997; Debelle and Wilkinson, 2002).

[17] The interbank rate (*Inter*) is used as a policy rate. The target set at 2.5 per cent is the mid point between 0 and 5 percent (the average rate during the period 1970–96). The coefficients associated with the inflation (from target) and output (from its potential) are consistent with the simple regression to determine the weight between inflation (from target) and output gap after the crisis. The coefficient is also consistent with interviewing high-profile staff from the BOT.

5.3 A Managed Floating Exchange Rate Regime

As argued by a number of empirical studies, many countries, especially developing countries, are reluctant to pursue a freely floating exchange rate regime because this regime might result in volatility in key macroeconomic variables. The last scenario takes into account this concern. We suppose Thailand had pursued a managed floating exchange rate regime.

The managed floating exchange rate regime is referred to as the situation where the monetary authorities adjust interest rate policy and/or intervene in the foreign exchange market to deliberately affect the exchange rate without a particular commitment (Corden, 2002). The main objectives of the intervention under this regime are to moderate exchange rate movements and to ensure that the price of domestic tradable goods reflects a realistic and stable incentive for the private sector (Krueger and Chinoy, 2004: p.61). A nominal anchor such as inflation targeting often accompanies this regime while the central bank tends to collect some foreign exchange reserves.

To examine this scenario, three additional assumptions are needed. First, it is assumed that the exchange rate is determined by the uncovered interest parity with two alternatives of exchange rate expectations as in the previous scenario.

Second, instead of assuming no change in foreign exchange reserves, it is assumed that the BOT aims to accumulate foreign exchange reserves during a time of capital inflows. Here we arbitrarily assume that the annual changes in foreign exchange reserves are equal to the 1988 level, i.e. US$2.1 billion ($\Delta R^{\$} = 2.1$).[18] Within this regime, $OCF^{\$}$ is changed to ensure that the change in foreign exchange reserves is equal to US$2.1 billion while uncovered interest parity is maintained.

Finally, the policy rule as in equation (5.2) is modified as in equation (5.3). Equation (5.3) assumes the Thai government is concerned about the movement of exchange rate and the effect of exchange rate changes on international competitiveness (as argued by Krueger and Chinoy, 2004: p.61). Hence, the third objective is introduced into the policy rule that the central bank tends to maintain the level of *external* RER close to the average level between 1986 and 1987 ($RER_T^{external}$) where the country attained the external balance (see footnote 12 above). We arbitrarily set the coefficient associated with the *external* RER target to equal 0.4, which equals to

[18] Nevertheless, the simulation results are not significantly affected when altering the predetermined levels by using 1989 and 1990 levels. The change in reserve levels during the period 1991–95 is not appropriate because it was the period where there were massive increases in foreign exchange reserves.

the coefficient of output gap. This modified form of policy rule is widely used in the context of a small open economy (e.g. de Brouwer and O'Regan, 1997; Ball, 1998).

$$i = \bar{r} + \pi + \omega_1 \cdot \left[\pi - \bar{\pi}\right] + \omega_2 \cdot y + \omega_3 \left[RER^{external} - RER_T^{external}\right] \tag{5.3}$$

As argued by Corden (2002: p.69), a managed floating exchange rate regime could be associated with and without capital control measures. Nevertheless, the theoretical underpinning of the co-existence between a managed floating regime and capital controls is not fully coherent. Hence, this study runs the simulation experiment of this scenario with and without capital controls. With a capital control alternative, it is arbitrarily assumed that the country's risk is increased by three percentage points from the historical base level, i.e. *risk*/100 + 0.03.[19]

6. Simulation Results

6.1 A Pegged Exchange Rate Regime with Capital Controls

Capital controls affect RERs through adjustment of the economy to the capital shortage. The capital shortage from introducing capital controls would have led to an increase in domestic interest rate and a decline in private domestic credit. As a result, output would have continuously dropped, compared to the historical base (Figure 2(A)). Among the three sectors, nontradable output would have been reduced with greater magnitude than tradable (primary and manufacturing) output. The less output contraction in tradable sector than nontradable sector would have resulted from a reduction of imports that helped to mitigate reduction in other components of aggregate demand, particularly investment. The capital controls would also have helped to allocate resources from nontradable to tradable sectors. Such benefits would have offset the negative effects of capital shortage. In particular, the primary sector, which is labour-intensive, would have experienced output expansion as a result of imposing capital controls (Figure 2(A)).

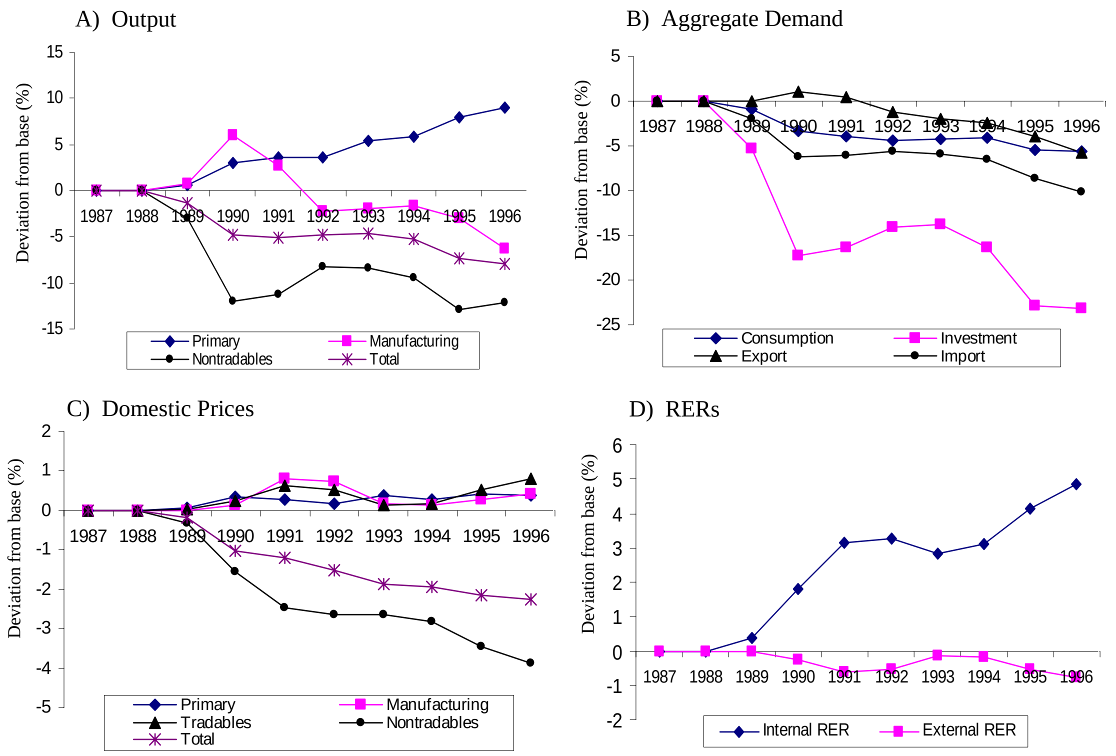
Different patterns of domestic demand changes for the three sectors would have had an impact on domestic prices. The directional impacts would have been clear in the primary and nontradable sectors. That is, the price of primary products would have increased from the historical base, whereas that of nontradable products would have decreased (Figure 2(C)). Where

[19] The increased risk assumption is based on the findings of the World Bank (cited in McKibbin and Martin, 1998: p.14–5). They argue that the risk premium, measured by the comparison of internal rate of return on Thai government bonds (10 years) with that on US bonds of similar maturity, increased from around 0.9 per cent before the crisis to a peak of about 4.5 per cent after the crisis. Hence, *risk*/100, which was on average around 1.5 per cent, is increased by 3 per cent to reach the risk premium at 4.5 per cent.

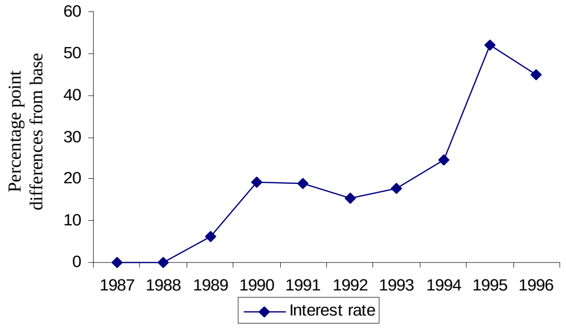
the manufacturing sector is concerned, its nature of capital intensity would have led to a larger scale reduction in production capacity than in demand during the period 1992–96. This would have enlarged excess demand in the manufacturing sector so that the manufacturing price would have increased from the historical base. As a result, the *internal* RER would have significantly depreciated, compared with the historical base, while the *external* RER would have appreciated (Figure 2(D)). This implies that capital controls would have helped avoid the persistent *internal* RER appreciation and reduced the boom in the nontradable sector. However, this policy choice would have jeopardized the country's international competitiveness, thereby hindering an improvement in exports and economic growth overall.

The capital controls would have reduced the current account deficit significantly (Figure 2(F)). The lower income level would have caused a reduction in imports. Even though there would have been a negative effect on exports from the reduction in investment and production capacity, its magnitude of reduction tends to smaller than the reduction in imports. Besides, the lower level of $OCF^{\$}$ would have reduced the interest payments.

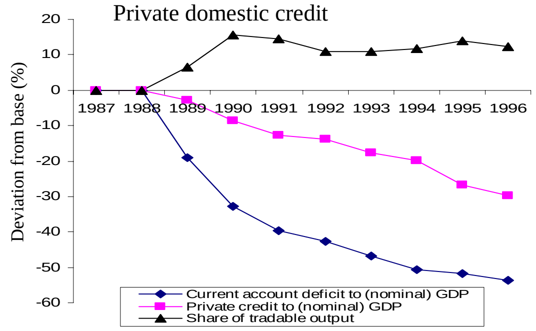
Figure 2: Key Variables under a Pegged Exchange Rate Regime with Capital Controls



E) Interest rate



F) Share of tradable output, Current account and Private domestic credit



6.2 A Freely Floating Exchange Rate Regime with Capital Liberalization

6.2.1 Backward-looking Exchange Rate Expectations

Had Thailand pursued a freely floating regime with backward-looking expectations since 1988, the nominal exchange rate would have continuously appreciated (Figure 3(A)). Such directional change of the exchange rate during this period would have been dominated by the presence of net capital inflows. As a result, both *internal* and *external* RERs would have appreciated from the historical base throughout the simulation period (Figure 3(E)). The appreciation of *internal* RER would have come from the appreciation of the nominal exchange rate and the different degree of exchange rate pass-through into domestic prices. Where the latter is concerned, the degree is the smallest in the nontradable sector and the largest in the primary sector. The *external* RER appreciation would have resulted from the imperfect degree of exchange rate pass-through in tradable prices. Such RERs appreciation would have led to reduction in exports that further reduced other components of aggregate demand (Figure 3(D)).

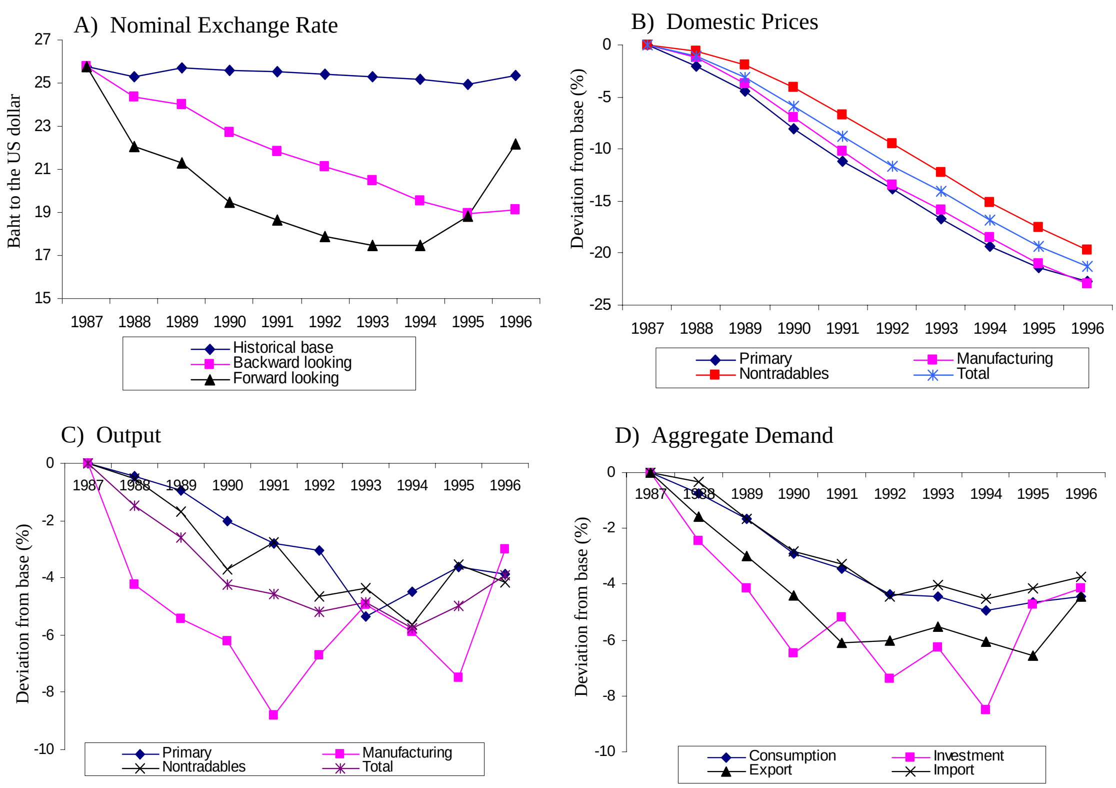
As a result, primary and manufacturing output would have reduced from the historical base (Figure 3(C)). It would have negatively affected demand for nontradable output. However, the *internal* RER appreciation would have reflected that domestic resources were still allocated in favour of the nontradable sector. Thus, the reduction of nontradable output would have been less than that of tradable one. With the reduction in both tradable and nontradable output, the GDP level would have been lower from the historical base.

The current account balance would have been improved in spite of currency appreciation (Figure 3(F)). Even though export volume would have declined from currency appreciation, import volume would have been restrained as a result of the negative income effect from the overall economic slowdown. While the import price was higher than the export price during the simulation period, the decline in import value would have been greater than that in export value.

Thus, the trade balance would have improved from the currency appreciation.[20] In addition, the short-term capital flows ($OCF^{\$}$) would have reduced from the historical base, thereby improving the service account balance.

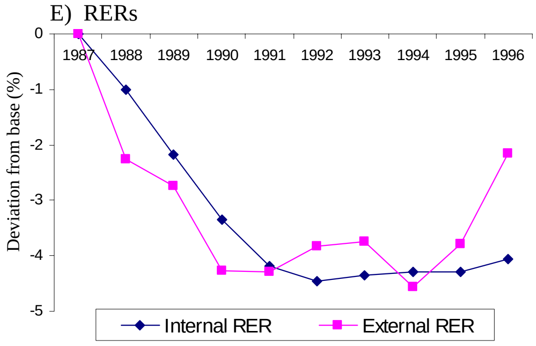
All in all, if Thailand had pursued a freely floating exchange rate under a circumstance where private agents form their currency expectations adaptively, the persistent appreciation of both *internal* and *external* RERs would not have been averted. The resources would still have been relatively concentrated in the nontradable sector while exports and output would have been lower than the historical base. The current account improvement would have mainly come from the reduction in income (i.e. overall economic slowdown) rather than an improvement in country's competitiveness.

Figure 3: Key Variables under a Freely Floating Exchange Rate Regime with Adaptive Expectations

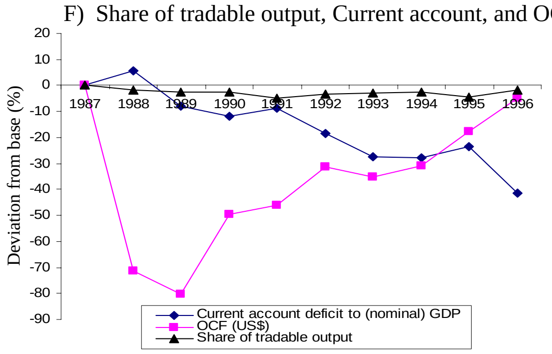


[20] The J-curve phenomenon in Thailand is also found in Vines and Warr (2003).

E) RERs



F) Share of tradable output, Current account, and OCF



6.2.2 Forward-looking Exchange Rate Expectations

In this sub scenario, economic agents form their expectations of future exchange rate by looking forward to what the exchange rate would be in the following period rather than solely relying on the historical data.[21] When economic agents change the expectations, the major impact is on exchange rate movements. When the exchange rate exhibits a downward trend (i.e. $e_{t-1} \geq e_t \geq e_{t+1}$), the forward looking expectations would result in a greater degree of appreciation. When the exchange rate in the following period would be further expected to appreciate as happened during the period 1988–94, the cost of foreign borrowing would become lower for agents with the forward-looking expectations than the backward-looking ones. All other things being equal, this would induce more capital inflows, exerting pressure on the currency to appreciate. The same rationale could be applied to explain when the exchange rate exhibits an upward trend (i.e. $e_{t-1} \leq e_t \leq e_{t+1}$) as occurred in 1995–96 (Figure 3(A)).

The effect of changing the expectation formulation on the exchange rate would have had considerable influence on the pattern and magnitude of key economic variables. Comparing with Scenario 6.2.1 (backward-looking expectations), the turning point where the degree of *internal* RER appreciation would have declined, compared to the historical base would have been reached more quickly in this sub scenario than in the previous sub scenario (Figures 4(C) and 3(E)). This turning point implies that the incentive to allocate resources into the nontradable sector would have declined, compared with the previous period. From 1990 onwards, more resources would have been geared toward tradable sector, and the persistent *internal* RER appreciation would have been avoided. This implies that a freely floating exchange rate regime with a certain degree of forward-looking expectations would have slowed down the boom in the nontradable sector faster

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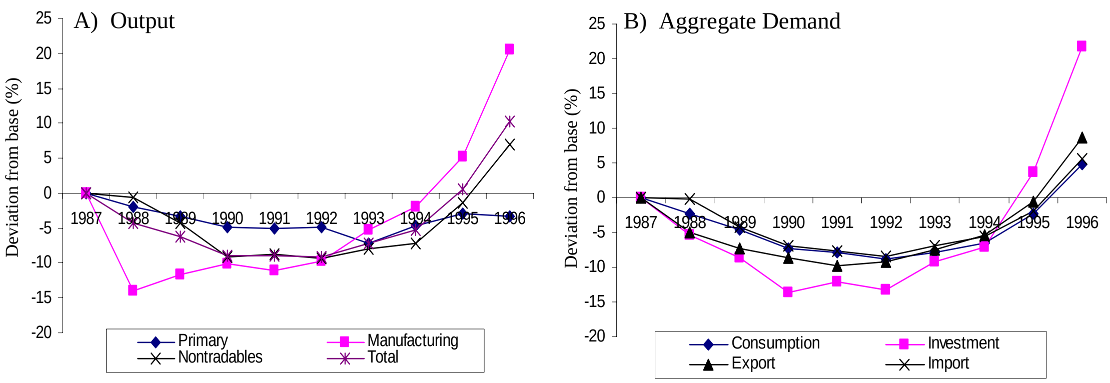
[21] This study applies a model consistent expectations method in solving the future value of nominal exchange rate. To allow the adjustment of nominal exchange rate, we solved the model until 2002 (i.e. the forecasted value of year 2002 was used as the terminal condition for solving the forward-looking expectations). Note that when the year 1997 or 2000 was used as the terminal condition, the results are still comparable.

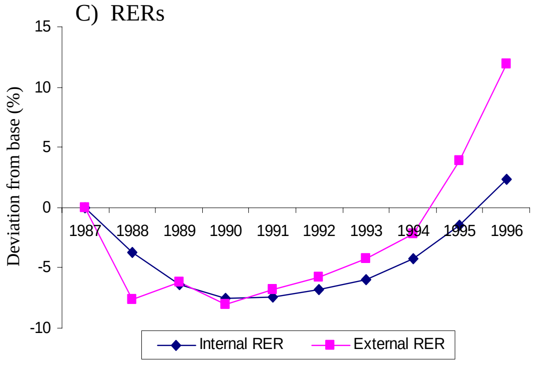
than that under the adaptive expectations. As well, compared to Scenario 6.2.1 (backward-looking expectations), the magnitude of *external* RER appreciation under this sub scenario would have been greater and less during the period 1988–93 and 1994–96, respectively (Figures 4(C) and 3(E)). In 1995–96, the *external* RER under this sub scenario would have been depreciated from the historical base by 3.9 and 12.0 per cent, respectively.

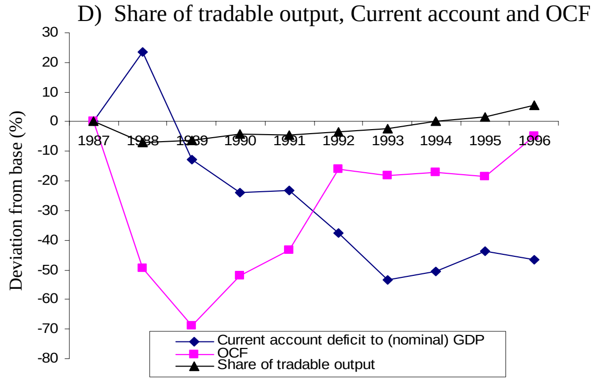
Consistent with the pattern and magnitude of RERs, the level of total output would have first contracted from the historical base. However, during the period 1995–96, the output would have been higher than the historical base by 0.5 per cent and 10.3 per cent, respectively (Figure 4(A)). The tradable output, especially manufacturing output, would have been a key contributor to overall output expansion during the last two years. This result would have contrasted with Scenario 6.2.1 (backward-looking expectations) where output would have declined from the historical base throughout the simulation period.

A comparison between these two alternative forms of expectations for private agents indicates that the persistent RERs appreciation would have been averted when economic agents were forward looking to what the exchange rate would be in the following period, rather than relying solely on historical data. The nontradable boom would have been avoided, resources would have been relatively geared more towards tradables, and exports would have been higher, compared to the historical base (Figures 4(B) and (D)). In other words, the stage of development in the foreign exchange market is the key factor in determining how fast the market mechanism works. However, having forward-looking expectations would have led to a greater degree of fluctuations in key variables, e.g. RERs, GDP, and domestic prices that would call for concern. For example, the variance of total output and price changes in the forward-looking manner would have been 39.4 and 69 per cent of the historical base, respectively, compared to 1.8 and 51 in the backward-looking expectations.

Figure 4: Key Variables under a Freely Floating Regime with Forward-looking Expectations





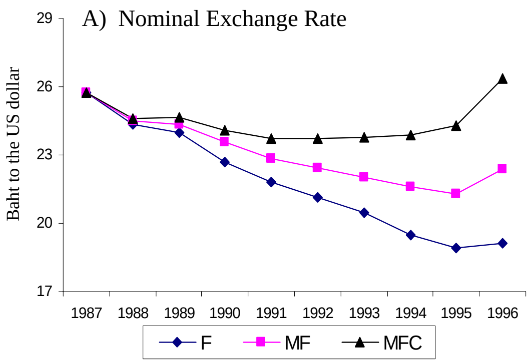


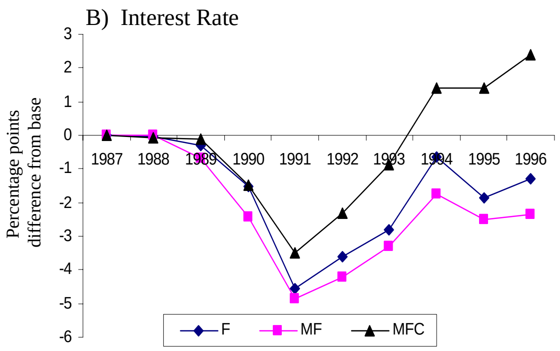
6.3 A Managed Floating Exchange Rate Regime

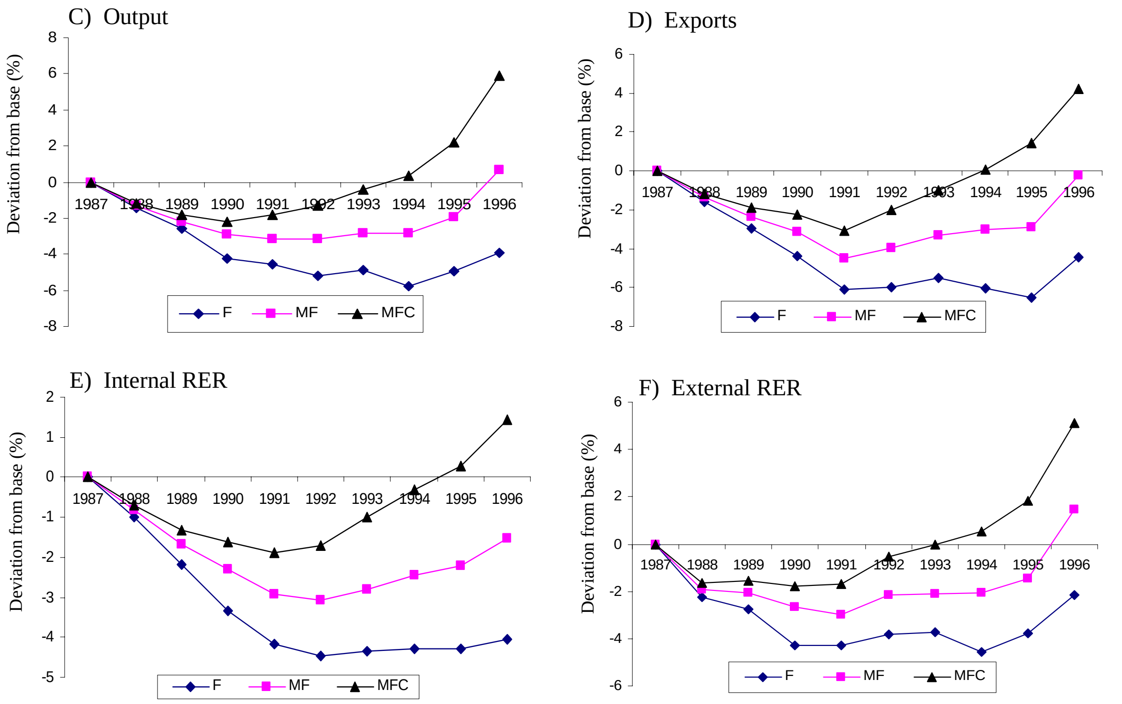
6.3.1 Backward-looking Expectations without Capital Controls

The major departure of simulation outcomes between this scenario and Scenario 6.2.1 (the freely floating regime) is that both *internal* and *external* RERs would still have appreciated from the historical base, but magnitude of such appreciations would have been lower than that in Scenario 6.2.1 (Figures 5(E) and (F)). This would have mainly come from a lower magnitude of nominal exchange rate appreciation, because under the managed floating regime, the monetary authorities would have been allowed to intervene in the foreign exchange market to attain positive reserve changes. Besides, the monetary authorities would have been allowed to use the nominal interest rate to influence the movement of exchange rate to attain the *external* RER target. Since there would not have been any major difference in the impact on *internal* and *external* RERs between the freely floating and managed floating regimes except the lower magnitude under the latter, the directional impact on other macroeconomic factors would have been more or less the same. However, magnitudes of changes in these variables would have been lower than those under scenario 6.2.1 (Figure 5).

Figure 5: Key Comparisons among a Freely Floating (F), Managed Floating without capital controls (MF) and Managed Floating with control (MFC) (Backward-looking Expectations)







6.3.2 Backward-looking Expectations with Capital Controls

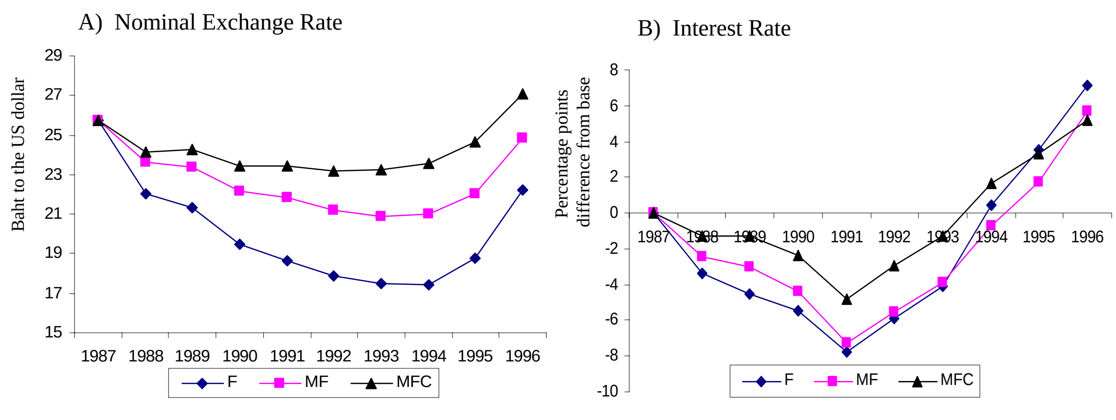
Imposing capital control measures, i.e. increases in the risk for foreign investors, would have lowered the dollar value of $OCF^{\$}$ level by 7.0 per cent, compared to that under Scenario 6.3.1. The exchange rate under this scenario would have become less appreciated than that under Scenario 3.1 (Figure 5(A)). Meanwhile, the capital controls would have increased the domestic interest rate as a result of capital shortage (Figure 5(B)). However, the positive effect of output under this scenario compared to that under Scenario 6.3.1 (Figure 5(C)) would have reflected that a positive effect of currency depreciation tended to dominate the negative effect from interest rate increase. The *internal* and *external* RERs would have been less appreciated, compared to those in scenario 6.3.1 (Figures 5(E) and (F)).

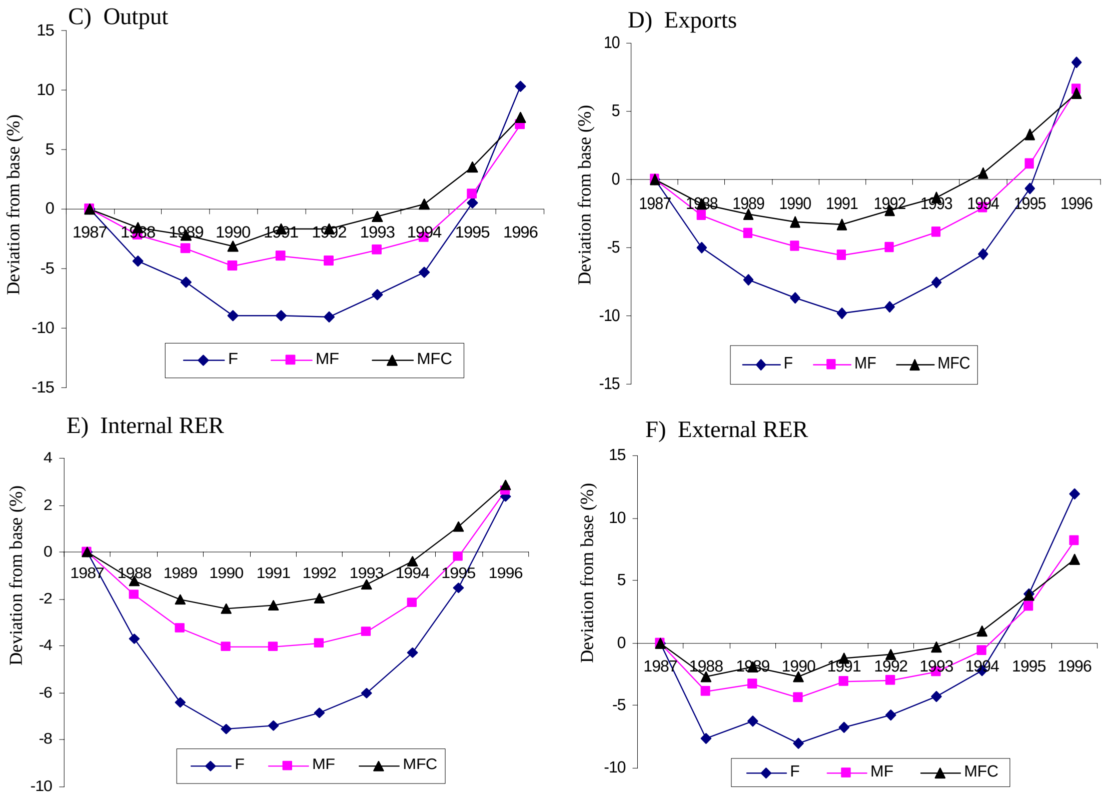
All in all, the managed floating regime with capital controls would have increased the effectiveness in avoiding the persistent RERs appreciation compared to the managed floating regime *per se* when economic agents form expectations of the future exchange rate adaptively. The relative boom in the nontradable sector would have reduced while exports and output would have increased from the historical base, particularly in 1995–96.

6.3.3 Forward-looking Expectations without Capital Controls

Compared to Scenario 6.2.2 (the freely floating regime), the degree of exchange rate appreciation under the managed floating regime would have been lower (Figure 6(A)). Hence, both *internal* and *external* RERs would have appreciated by a lesser magnitude than those under Scenario 6.2.2 (Figure 6(F)). This would have been an exception in 1995–96 due to the presence of *external* RER target in the policy rule. The *external* RER in these two years would have tended to be greater than the target level (i.e. the 1988 *external* RER) when pursuing the freely floating regime. Thus, the policy rule under the managed floating regime would have slowed down changes in nominal exchange rate through an adjustment of nominal interest rate. The exchange rate in this scenario would have depreciated from the previous period less than what would have been in Scenario 6.2.2. In 1995–96, the nominal exchange rate under this sub-scenario would have depreciated from the previous period by 8.8 per cent, compared to 12.9 per cent in Scenario 6.2.2. The implication of the slowdown changes in exchange rate is the fluctuations of key economic variables would have been reduced, while retaining the benefits from allowing nominal exchange rate to be flexible. The variance of output and prices changes as a per cent of the historical base would have been 14.1 and 20.2, respectively, compared to 39.4 and 69 in Scenario 6.2.2. Share of tradable output would have increased from the historical base since 1990, particularly in 1995–96. Export would have been increased from the historical base, clearly noticed in 1995–96. In addition, the export and output loss in the first few years of pursuing this regime would have been significantly less than the freely floating regime (Figures 6(C) and (B)).

Figure 6: Key Comparisons among a Freely Floating (F), Managed Floating without capital controls (MF) and Managed Floating with controls (MFC) (Forward-looking Expectations)





6.3.4 Forward-looking Expectations with Capital Controls

The imposition of capital controls, which results in an increase in the country's risk for foreign investors, would have lowered the dollar value of $OCF^{\$}$ by 6 per cent, compared to that under Scenario 6.3.3.[22] As a result, the nominal exchange rate and interest rate in this scenario would have been higher than those in Scenario 6.3.3 (Figures 6(A) and (B)). Because of the greater degree of currency depreciation, the *internal* and *external* RERs would have depreciated relatively more than those in scenario 6.3.3 (Figures 6(E) and (F)). Interestingly, during the period 1995–96 when the exchange rate would have considerably depreciated, imposing capital controls over and above the managed floating regime would have created a negative effect on RERs and other key variables. Since the managed floating regime with forward-looking expectations would have resulted in considerably currency depreciation, imposing capital controls would have become less necessary. Even though the exchange rate would have further

[22] The percentage reduction of $OCF^{\$}$ between Scenario 6.3.3 and 6.3.4 (forward-looking expectations) is lower than that between Scenario 6.3.1 and 6.3.2 (backward-looking expectations). This implies that, with the same increased level of the country's risk, the effectiveness of capital controls under forward-looking expectations would have been less than that under backward-looking expectations.

depreciated after imposing capital controls, there would have been an increase in excess demand (i.e. demand would have grown faster than capacity), and a considerable increase in domestic prices in both tradable and nontradable goods. As a result, in 1996, the *external* RER in this scenario would have appreciated more, compared to that in scenario 6.3.3 (Figure 6(F)). As well, there would not have been a difference in the *internal* RER between these two sub-scenarios (Figure 6(E)). Hence, the positive effect on output would have been reduced. Deviation from the historical base would have been more or less the same between scenarios 6.3.3 (no capital controls) and 6.3.4 (capital controls).

7. Conclusion

This paper examines the roles of pegged exchange rate regime and capital account opening in driving the persistent real exchange rates (RERs) appreciation in the lead-up to the 1997 currency crisis through an in-dept case study of Thailand. Three key policy simulation experiments are undertaken during the period 1988–96 through the macroeconomic model. The three simulations are composed of the imposition of capital controls under a pegged exchange rate regime, a freely floating exchange rate regime with capital liberalization (combined with inflation targeting as a new nominal anchor) and a managed floating exchange rate regime with and without capital control (combined with inflation targeting).

We found that capital control under a pegged exchange rate would have rectified the persistent *internal* RER appreciation and boom in nontradable sector. However, it would not have averted persistent *external* RER appreciation. Exports and output would have eventually declined because of the capital shortages. By contrast, the freely floating exchange rate regime only with a high developmental level of foreign exchange (and financial) market would have been able to rectify both persistent *internal* and *external* RERs appreciation, particularly during the period 1995–96. Exports and output would have eventually increased, particularly in 1995–96. However, it would have generated output and prices fluctuations. The managed floating regime, in which the monetary authorities have a view on the desired level and path of the real and nominal exchange rate, would have helped reduce these adverse effects while retaining the benefit from exchange rate flexibility. When the foreign exchange and financial markets are still not well developed as in Thailand, capital control measures could be beneficial to ensure smooth functioning of a managed floating regime. However, the need for capital control measures diminishes when the country’s foreign exchange and financial markets gain maturity.

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Appendix I
The Macroeconomic model*

1. Domestic prices

$$P = P_T^{\varphi_1} P_N^{(1-\varphi_1)}$$

$$P_T = P_P^{\varphi_3} P_M^{(1-\varphi_3)}$$

$$\varphi_1 = \frac{P_P Y_P + P_M Y_M}{PY} \quad \text{and} \quad \varphi_3 = \frac{P_P Y_P}{P_P Y_P + P_M Y_M}$$

$$ED_i = Y_i / \overline{Y}_i$$

1.1 Primary prices

$$\Delta \ln P_P = \underset{(5.92)^*}{0.06} + \underset{(10.23)^*}{0.52}\Delta \ln\left(e_f P_P^*\right) + \underset{(1.96)^{**}}{0.19}\Delta \ln\left(ED_P\right) - \underset{(-5.89)^*}{0.40}\left[\ln P_P(-1) - \ln\left(e_f P_p^*\right)(-1)\right] + \underset{(3.08)^*}{0.12}D72 + \underset{(3.08)^*}{0.12}D98$$

Adjusted R^2 = 0.82, SEE = 0.04, DW = 1.71, DF = -4.76, ARCH – $\chi^2(1)$ = 0.20, LM1 – F(1, 25) = 0.11, RESET – F(1, 25) = 0.60, NORM – $\chi^2(2)$ = 1.88

Wald test for joint coefficient equality test for e_f and P_P^* – $\chi^2(2)$ = 2.44 (p-value = 0.30)

Wald test for the long-run homogeneity – $\chi^2(1)$ = 0.001 (p-value = 0.98)

1.2 Manufacturing prices

$$\Delta \ln P_M = \underset{(3.08)^*}{0.09} + \underset{(3.82)^*}{0.32}\Delta \ln\left(e_f P_M^*\right) + \underset{(1.94)^{**}}{0.20}\left(ED_M\right)(-1) - \underset{(-5.54)^*}{0.49}\left[\ln P_M(-1) - \underset{(-5.51)^*}{0.92}\ln\left(e_f P_M^*\right)(-1) - 0.08\ln\left(W_M / LP_M\right)(-1)\right] + \underset{(4.94)^*}{0.10}D7374 - \underset{(-4.81)^*}{0.09}D9902$$

Adjusted R^2 = 0.82, SEE = 0.02, DW = 2.11, DF = -6.32, ARCH – $\chi^2(1)$ = 0.44, LM1 – F(1, 24) = 0.54, RESET – F(1, 24) = 0.002, NORM – $\chi^2(2)$ = 0.43

Wald test for joint coefficient equality test for e_f and P_M^* – $\chi^2(2)$ = 1.28 (p-value = 0.52)

Wald test for the long-run homogeneity – $\chi^2(1)$ = 0.59 (p-value = 0.44)

1.3 Nontradable prices

$$\Delta \ln P_N = \underset{(3.01)^*}{0.26} + \underset{(2.10)^{**}}{0.09}\Delta \ln\left(e_f P_{IMR}^*\right) + \underset{(3.18)^*}{0.28}\Delta \ln\left(W_N / LP_N\right) + \underset{(2.39)^{**}}{0.15}\Delta \ln\left(ED_N\right) + \underset{(2.31)^{**}}{0.19}\ln\left(ED_N\right)(-1) - \underset{(-3.12)^*}{0.29}\left[\ln P_N(-1) - \underset{(-2.97)^*}{0.59}\ln\left(W_N / LP_N\right)(-1) - 0.41\ln\left(e_f P_{IMR}^*\right)(-1)\right] + \underset{(8.09)^*}{0.14}D7374 - \underset{(-5.99)^*}{0.06}D9902$$

Adjusted R^2 = 0.82, SEE = 0.02, DW =1.70, DF = -4.64, ARCH – $\chi^2(1)$ = 0.52, LM1 – F(1, 22) = 0.31, RESET – F(1, 22) = 0.19, NORM – $\chi^2(2)$ = 0.99

Wald test for joint coefficient equality test for e_f and P_{IMR}^* – $\chi^2(2)$ = 0.76 (p-value = 0.68)

Wald test for the long-run homogeneity – $\chi^2(1)$ = 2.73 (p-value = 0.12)

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* T ratios of regression coefficients are given in parentheses, with statistical significance defined as – * 1 per cent, ** 5 per cent, *** 10 per cent and **** 15 per cent

1.4 Real exchange rates

1.4.1 Internal RER

$$Internal\ RER = \frac{P_T}{P_N} \cdot 100$$

1.4.2 External RER

$$External\ RER = \frac{e_f P_T^*}{P_T} \cdot 100$$

2. Domestic wages

2.1 Primary wages

$$\Delta \ln\left(W_P / LP_P\right) = -0.009 + \Delta \ln P^C(-1) - 0.02\left(U_A\right) + 0.18D79 + 0.23D93$$
$$\quad (-0.69) \qquad (-1.97)^{**} \qquad (2.40)^{**} \qquad (3.15)^{*}$$

Adjusted R^2 = 0.60, SEE = 0.07, DW = 1.44, DF = -5.28, ARCH – $\chi^2(1)$ = 1.80, LM1 – F(1,26) = 0.58, RESET – F(1, 26) = 0.39, NORM – $\chi^2(2)$ = 1.85
Wald test for the homogeneity – $\chi^2(1)$ = 2.77 (0.11)

2.2 Manufacturing wages

$$\Delta \ln\left(W_M / LP_M\right) = 0.02 + \Delta \ln P^C(-1) - 0.007\left(U_A\right) - 0.22D99$$
$$\quad (3.48)^{*} \qquad (-1.78)^{**} \qquad (-5.80)^{*}$$

Adjusted R^2 = 0.67, SEE = 0.04, DW = 1.79, DF = -5.07, ARCH – $\chi^2(1)$ = 0.57, LM1 – F(1,27) = 1.13, RESET – F(1, 27) = 1.35, NORM – $\chi^2(2)$ = 2.06
Wald test for the homogeneity – $\chi^2(1)$ = 3.39 (0.08)

2.3 Nontradable wages

$$\Delta \ln\left(W_N / LP_N\right) = 0.74\Delta \ln P^C(-1) + (1-0.74)\Delta \ln P^C(-2) - 0.006\left(U_A\right) + 0.08\Delta \ln\left(MW\right)$$
$$(5.12)^{*} \qquad (-1.61)^{***} \qquad (1.68)^{***}$$
$$-0.09D75 + 0.14D80$$
$$(-2.71)^{*} \qquad (4.27)^{*}$$

Adjusted R^2 = 0.72, SEE = 0.03, DW = 2.46, DF = -6.72, ARCH – $\chi^2(1)$ = 0.34, LM1 – F(1,24) = 2.22, RESET – F(1, 24) = 0.08, NORM – $\chi^2(2)$ = 0.32
Wald test for the homogeneity – $\chi^2(1)$ = 1.65 (0.21)

$$U_A = U - U^*$$

3. Production capacity

$$P\overline{Y} = P_P\overline{Y}_P + P_M\overline{Y}_M + P_N\overline{Y}_N$$

3.1 Primary sector

$$\ln \overline{Y}_P = \ln \overline{TFP_P} + 0.33\ln \overline{L}_P + 0.25\ln K_P + 0.42\ln la$$

3.2 Manufacturing sector

$$\ln \overline{Y}_M = \ln \overline{TFP_M} + 0.19\ln \overline{L}_M + 0.81\ln K_M$$

3.3 Nontradable sector

$$\ln \overline{Y}_N = \ln \overline{TFP_N} + 0.54\ln \overline{L}_N + 0.46\ln K_N$$

$$K_{i,t} = K_{i,t-1} + I_i + GI_i + \delta_i K_{i,t-1},$$

$$\overline{L}_{i,t} = LF\left(1 - U^*\right)\cdot \chi_{i,t}$$, and

$$\chi_{i,t} = L_{i,t} / \sum L_{i,t}$$

4. Aggregate demand

$$PY = P^C C + P^I I + P^G G + P^X X - P^{IM} IM$$
$$Y_P = C_P + I_P + GI_P + X_P - IM_P$$
$$Y_M = C_M + I_M + GI_M + X_M - IM_M$$
$$Y_N = C_N + I_N + GI_N + GC$$

4.1 Private consumption

$$\underset{(-7.34)^*}{\Delta \ln C = -0.26} + \underset{(9.51)^*}{0.71\Delta \ln Y^d} + \underset{(1.07)^{****}}{0.03\Delta \ln PDC_C} - \underset{(-2.49)^*}{0.02\Delta \ln UNCER} - \underset{(-5.98)^*}{0.73}[\ln C(-1)$$
$$- \underset{(-5.73)^*}{0.90 \ln Y^d(-1)} - 0.10 \ln ASSET(-1)] + \underset{(5.00)^*}{0.17 \ln DEPEND(-1)} - \underset{(-4.03)^*}{0.04 D9902}$$

Adjusted R^2 = 0.89, SEE = 0.01, DW = 1.41, DF = -5.07, ARCH – $\chi^2(1)$ = 0.25, LM1 – F(1, 23) = 2.54, RESET – F(1, 23) = 0.02, NORM – $\chi^2(2)$ = 0.88

Wald test for the long-run unit-wealth homogeneity – $\chi^2(1)$ = 0.60 (p-value = 0.44)

$$Y^d = Y - \left[\left(T_P + \overline{T}\right)/ P\right],$$
$$T_P = \tau\left[PY + InF_P + InD_G\right],$$
$$InF_{P,t} = \left(i_t^* / 100\right) e_t \cdot F_{P,t-1}^{\$} \quad \text{and} \quad InD_{G,t} = \left(i_{G,t} / 100\right) ClaimG_{t-1}$$
$$PDC_C = \ln\left[1 + \frac{\Delta PDC / P^C}{Y^d}\right],$$
$$Assets = \frac{M_2 - PDC + eF_P^{\$}}{P^C} + K_{pri}$$
$$K_{pri,t} = K_{pri,t-1} + I_t - \left[\left(\delta_p + \delta_M + \delta_N\right)/3\right] K_{pri,t-1},$$
$$UNCER = \sqrt{\frac{\sum_{j=1,\dots,3}\left[Y(t-j) - \frac{\sum Y(t-j)}{3}\right]^2}{3}}$$

4.1.1 Primary consumption

$$P_P C_p = P^C C - P_M C_M - P_N C_N$$

4.1.2 Manufacturing consumption

$$\ln C_M = \underset{(-8.58)^*}{-3.32} - \underset{(-3.73)^*}{0.31 \ln P_P} - \underset{(-6.07)^*}{0.71 \ln P_M} - \underset{(-3.85)^*}{0.33 \ln P_N} + \underset{(20.83)^*}{1.35 \ln\left[P^C C\right]} - \underset{(-3.21)^*}{0.01T}$$

Equation log-likelihood = 70.27

System log-likelihood = 167.71

4.1.3 Nontradable consumption

$$\ln C_N = -1.16 - 0.38 \ln P_P - 0.14 \ln P_M - 0.46 \ln P_N + 1.00 \ln\left[P^C C\right] + 0.009T$$

(-6.21)* (-13.02)* (-2.47)* (-11.17)* (31.86)* (5.33)*

Equation log-likelihood = 94.22
DF = -4.02

4.2 Private investment

$$P^I I = P_P I_P + P_M I_M + P_N I_N$$

4.2.1 Primary investment

$$\Delta \ln I_P = 0.34 + 1.68 \Delta \ln Y_P - 0.20 \Delta \ln(CK_P) - 0.03 \Delta \ln UNCER + 0.06 \Delta PDC_I + 0.27 \ln GI(-1)$$

(0.82) (1.55)*** (-1.32)*** (-1.23)**** (1.56)*** (3.86)*

$$- 0.49\left[\ln I_P(-1) - (\alpha_{K,P} \cdot \delta_P)\left[\ln \overline{Y}_p(-1) - \ln CK_P(-1)\right]\right] - 0.26D7980 - 0.76D9899$$

(-3.62)* (-1.52)*** (-4.15)*

Adjusted R^2 = 0.63, SEE = 0.23, DW = 2.38, DF = -6.59, ARCH – $\chi^2(1)$ = 1.54, LM1 – F(1, 22) = 1.72, RESET – F(1, 22) = 0.57, NORM – $\chi^2(2)$ = 0.22, δ_P = 0.085 and $\alpha_{K,P}$ = 0.25

4.2.2 Manufacturing investment

$$\Delta \ln I_M = -1.42 + 1.90 \Delta \ln Y_M - 0.46 \Delta \ln(CK_M) + 0.02 \Delta PDC_I + 0.16 \ln GI(-1) - 0.12\left[\ln I(-1)\right.$$

(-1.67)** (4.40)* (-1.48)*** (1.28)*** (1.66)** (-1.68)**

$$\left. -(\alpha_{K,M} \cdot \delta_M)\left[\ln \overline{Y}_M(-1) - \ln CK_M\right]\right] - 0.38D9899$$

(-2.72)*

Adjusted R^2 = 0.68, SEE = 0.17, DW = 2.31, DF = -6.44, ARCH – $\chi^2(1)$ = 0.44, LM1 – F(1, 24) = 4.36, RESET – F(1, 24) = 1.25, NORM – $\chi^2(2)$= 0.98, δ_M = 0.074 and $\alpha_{K,M}$ = 0.81

4.2.3 Nontradable investment

$$\Delta \ln I_N = 0.22 + 1.83 \Delta \ln Y_N - 0.39 \Delta \ln(CK_N) - 0.01 \Delta \ln UNCER + 0.03 \Delta PDC_I - 0.05\left[\ln I_N(-1)\right.$$

(1.65)** (3.80)* (-1.25)*** (-1.27)*** (1.31)*** (-1.56)***

$$\left. -(\alpha_{K,N} \cdot \delta_N)\left[\ln \overline{Y}_N(-1) - \ln CK_N\right]\right] - 0.17D8586 - 0.36D9899$$

(-2.51)* (-5.48)*

Adjusted R^2 = 0.78, SEE = 0.09, DW = 1.61, DF = -4.50, ARCH – $\chi^2(1)$ = 0.36, LM1 – F(1, 23) = 1.90, RESET – F(1, 23) = 0.28, NORM – $\chi^2(2)$ = 4.33, δ_N = 0.074 and $\alpha_{K,N}$ = 0.46

$$Ck_i = 1 + \left[\frac{P_{K,i}\left(in/100 - \Delta \ln P_{K,i}(-1) + \delta_i\right)}{P_i}\right],$$

$$PDC_I = \left[\frac{\Delta PDC/P}{1000}\right]$$

4.3 Private budget constraint

$$Y^d = \frac{1}{P}\left(P^C C + P^I I + \left[\Delta M_2 + e\Delta F_P^{\$} - \Delta PDC\right]\right)$$

4.4 Government sector

$$P^G G = P_P GI_P + P_M GI_M + P_N\left(GI_N + GC\right)$$

4.4.1 Government budget constraint

$$e\Delta F_G^{\$} - \Delta ClaimG = T_P - P^G G + InF_G - InD_G + \overline{T}$$

$$InF_{G,t} = \left(i_t^* / 100\right)e_t \cdot F_{G,t-1}^{\$}$$

4.4.2 Government policy rule

$$\overline{T} = \left(InD_{G,t} - InD_{G,t}^B\right) - \left(InF_{G,t} - InF_{G,t}^B\right)$$

4.5 Exports

$$P^X X = e_I P_{X,P}^{\$} X_P + e_I P_{X,M}^{\$} X_M + OTH_X$$

4.5.1 Primary exports

$$\Delta \ln X_P = 4.42 + 0.64\Delta \ln \overline{Y}_P(-1) + 0.22\Delta \ln\left[\left(e_f P_p^*\right)/P_P\right] - 0.48\left[\ln X_P(-1) - \ln \overline{Y}_P(-1)\right] + 0.52\ln\left[\left(e_f P_p^*\right)/P_P\right](-1)$$

(3.69)* (1.84)* (1.01)**** (-3.66)* (1.32)***

$$-0.25D83 + 0.016T$$

(-2.31)** (3.23)**

Adjusted R^2 = 0.60, SEE = 0.10, DW = 1.98, DF = -5.49, ARCH – $\chi^2(1)$ = 0.87, LM1 – F(1, 24) = 1.21, RESET – F(1, 24) = 1.68, NORM – $\chi^2(2)$ = 0.71

Wald test for the long-run unit-capacity homogeneity – $\chi^2(1)$ = 0.40 (p-value = 0.52)

4.5.2 Manufacturing exports

$$\Delta \ln X_M = 2.73 + 1.31\Delta \ln \overline{Y}_M + 0.30\Delta \ln\left[\left(e_f P_M^*\right)/P_M\right] - 0.27\left[\ln X_M(-1) - \ln \overline{Y}_M(-1)\right] + 0.35\ln\left[\left(e_f P_M^*\right)/P_M\right](-1)$$

(4.04)* (3.54)* (1.03)**** (-3.71)* (1.46)***

$$-0.35D75 - 0.24D96 + 0.02T$$

(-3.35)* (-2.28)* (2.58)*

Adjusted R^2 = 0.67, SEE = 0.09, DW = 1.68, DF = -4.56, ARCH – $\chi^2(1)$ = 0.14, LM1 – F(1, 23) = 1.74, RESET – F(1, 23) = 0.27, NORM – $\chi^2(2)$ = 0.28

Wald test for the long-run unit-capacity homogeneity – $\chi^2(1)$ = 4.11 (p-value = 0.05)

4.6 Imports

$$P^{IM} IM = e_I P_{IM,P}^{\$} IM_P + e_I P_{IM,M}^{\$} IM_M + OTH_{IM}$$

4.6.1 Primary Imports

$$\Delta \ln IM_P = -1.36 + 1.18\Delta \ln Y - 0.42\Delta \ln\left[\left(e_I P_{IM,p}^{\$}\right)/P_P\right] - 0.16\ln IM_P(-1) + 0.15\ln Y(-1)$$

(-1.27)**** (2.36)** (-2.25)** (-1.60)*** (1.24)****

$$-0.11\ln\left[\left(e_I P_{IM,p}^{\$}\right)/P_P\right](-1) - 0.29D73 - 0.44D86$$

(-1.15)**** (-2.25)** (-3.62)*

Adjusted R^2 = 0.62, SEE = 0.11, DW = 1.91, DF = -5.12, ARCH – $\chi^2(1)$ = 0.04, LM1 – F(1, 23) = 2.87, RESET – F(1, 23) = 0.57, NORM – $\chi^2(2)$ = 0.08

4.6.2 Manufacturing Imports

$$\Delta \ln IM_M = -6.31 + 1.52 \Delta \ln Y - 0.78 \Delta \ln\left[\left(e_I P^{\$}_{IM,M}\right)/P_M\right] - 0.40 \ln IM_M(-1) + 0.64 \ln Y(-1)$$

(-2.79)* (2.52)* (-3.12)* (-3.44)* (3.51)*

$$-0.28 \ln\left[\left(e_I P^{\$}_{IM,M}\right)/P_M\right](-1) - 0.27D8285$$

(-1.85)** (-3.12)*

Adjusted R^2 = 0.71, SEE = 0.08, DW = 2.12, DF = -5.83, ARCH – $\chi^2(1)$ = 4.35, LM1 – F(1, 24) = 2.31, RESET – F(1, 24) = 2.46, NORM – $\chi^2(2)$ = 0.35

5. Money market

5.1 Money supply

$$\Delta M_2 = 31.27 + 3.14 \Delta\left(eR^{\$}\right) + 1.64 \Delta CBCP - 0.36 M_2(-1) + 1.20\left(eR^{\$}\right)(-1) + 1.24 CBCP(-1)$$

(2.27)** (7.95)* (8.07)* (-4.07)* (8.94)* (6.84)*

$$+ 0.65 CBCPU(-1) - 533.68 D9802$$

(2.62)* (-5.92)*

Adjusted R^2 = 0.88, SEE = 57.06, DW = 1.64, DF = -4.65, ARCH – $\chi^2(1)$ = 0.01, LM1 – F(1, 23) = 1.19, RESET – F(1, 23) = 0.46, NORM – $\chi^2(2)$ = 1.97

5.2 Money Demand

$$\Delta \ln\left(M_2/P\right) = 0.05 + 0.24 \Delta \ln\left(M_2/P\right)(-1) - 1.01 \Delta \ln\left[1 + \left(in/100\right)\right] + 0.37 \Delta \ln Y - 0.06\left[\ln\left(M_2/P\right)(-1)\right.$$

(3.26)* (2.11)** (-2.63)* (2.51)* (-3.43)*

$$\left. - \ln Y(-1)\right] - 0.35 \ln\left[1 + \left(in/100\right)\right](-1) - 0.09 D7374 + 0.07 D8284 + 0.08 D97$$

(-1.60)*** (-4.07)* (3.65)* (2.55)*

Adjusted R^2 = 0.70, SEE = 0.03, DW = 1.71, DF = -4.52, ARCH – $\chi^2(1)$ = 1.24, LM1 – F(1, 22) = 0.41, RESET – F(1, 22) = 0.12, NORM – $\chi^2(2)$ = 0.52

Wald test for the long-run unit-income homogeneity – $\chi^2(1)$ = 0.03 (p-value = 0.87)

5.3 Private domestic credit

$$\Delta PDC = \Delta M_2 - (e\Delta R^{\$} + \Delta ClaimG + OTHM_2)$$

6. External sector

6.1 Current account

$$CA = e_I\left(\left[P^{\$}_{X,P} \cdot X_P + P^{\$}_{X,M} \cdot X_M\right] - \left[P^{WIM}_P \cdot IMT_P + P^{WIM}_M \cdot IMT_M\right]\right) + \left(i^*/100\right)e \cdot \left(F^{\$}_{P,t-1} + F^{\$}_{G,t-1}\right) + OTHCA$$

6.2 Capital account

$$CAP = -e\left(\Delta F^{\$}_P + \Delta F^{\$}_G\right)$$

$$-\Delta F_P^{\$} = FDI^{\$} + OCF^{\$}$$

$$\Delta OCF^{\$} = -2.09 \; + \; 0.37\Delta\left(in - i^{*}\right) + 40.56\Delta \ln Y(-1) - 24.90\Delta \ln Y^{W}(-1) - 0.47 OCF^{\$}(-1)$$
$$(-1.50)^{***}(1.39)^{***} \quad (2.38)^{**} \quad (-1.06)^{****} \quad (-5.64)^{*}$$
$$+ 0.49\left(in - i^{*}\right)(-1) + 10.58D95 - 18.05D9798$$
$$(2.03)^{**} \quad (4.68)^{*} \quad (-9.95)^{*}$$

Adjusted R^2 = 0.87, SEE = 2.15, DW = 2.31, DF = -6.20, ARCH – $\chi^2(1)$ = 4.01, LM1 – F(1, 22) = 2.04, RESET – F(1, 22) = 3.01, NORM – $\chi^2(2)$ = 1.54

6.3 Balance of payments

$$e\Delta R^{\$} = CA + CAP + OTHBP$$

$$e_f = e_I\left[\frac{US}{Japan}\right]^{0.28}\left[\frac{US}{Singapore}\right]^{0.10}\left[\frac{US}{Malaysia}\right]^{0.06}\left[\frac{US}{China}\right]^{0.06}\left[\frac{US}{Taiwan}\right]^{0.05}\left[\frac{US}{Germany}\right]^{0.05}$$
$$\left[\frac{US}{Hong\ Kong}\right]^{0.05}\left[\frac{US}{Korea}\right]^{0.04}\left[\frac{US}{UK}\right]^{0.03}\left[\frac{US}{Netherland}\right]^{0.03}\left[\frac{US}{Australia}\right]^{0.03}$$

7 Labour market

$$L = L_P + L_M + L_N$$

$$U = \left(\frac{LF - L}{LF}\right)\cdot 100$$

7.1 Primary employment

$$\Delta \ln L_P = 0.60 \; + \; 0.11\Delta\left(\ln Y_P\right) - 0.53\Delta \ln\left(W_P / P_P\right) - 0.08\left[\ln L_P(-1) - \alpha_{L,P} \ln\left[\overline{Y}_P / \left(W_P / P_P\right)\right](-1)\right] - 0.16D74$$
$$(1.25)^{****} \; (1.04)^{****} \quad (-6.92)^{*} \quad (-1.46)^{***} \quad (-2.87)^{*}$$
$$-0.14D83$$
$$(-2.54)^{*}$$

Adjusted R^2 = 0.73, SEE = 0.08, DW = 2.09, DF = -6.63, ARCH – $\chi^2(1)$ = 0.13, LM1 – F(1,25) = 1.54, RESET – F(1, 25) = 0.001, NORM – $\chi^2(2)$ = 1.36, $\alpha_{L,P}$ = 0.33

7.2 Manufacturing employment

$$\Delta \ln L_M = 0.23 \; + \; 0.86\Delta\left(\ln Y_M\right) - 0.90\Delta \ln\left(W_M / P_M\right) - 0.03\left[\ln L_M(-1) - \alpha_{L,M} \ln\left[\overline{Y}_M / \left(W_M / P_M\right)\right](-1)\right]$$
$$(2.00)^{**} \; (6.41)^{*} \quad (-10.92)^{*} \quad (-1.80)^{**}$$

Adjusted R^2 = 0.93, SEE = 0.04, DW = 1.99, DF = -4.30, ARCH – $\chi^2(1)$ = 2.54, LM1 – F(1,27) = 3.90, RESET – F(1, 27) = 3.03, NORM – $\chi^2(2)$ = 0.93, $\alpha_{L,M}$ = 0.19

7.3 Nontradable employment

$$\Delta \ln L_N = 0.31 + 0.57\Delta(\ln Y_N) - 0.79\Delta \ln(W_N / P_N) - 0.05\left[\ln L_N(-1) - \alpha_{L,N} \ln\left[\overline{Y}_N / (W_N / P_N)\right](-1)\right]$$

(2.32)** (4.94)* (-15.22)* (-2.11)**

$$-0.06D7374$$

(-2.72)*

Adjusted R^2 = 0.89, SEE = 0.03, DW = 1.73, DF = -4.72, ARCH – $\chi^2(1)$ = 0.004, LM1 – F(1,26) = 1.19, RESET – F(1, 26) = 0.38, NORM – $\chi^2(2)$ = 4.11, $\alpha_{L,N}$ = 0.54

8 Other related prices

$$\ln P^C = \gamma_1 \ln P_P + \gamma_2 \ln P_M + (1 - \gamma_1 - \gamma_2) \ln P_N$$

$$\gamma_1 = \frac{P_P C_P}{P_P C_P + P_M C_M + P_N C_N}, \quad \gamma_2 = \frac{P_M C_M}{P_P C_P + P_M C_M + P_N C_N}$$

$$\ln P^I = \gamma_3 \ln P_P + \gamma_4 \ln P_M + (1 - \gamma_3 - \gamma_4) \ln P_N$$

$$\gamma_3 = \frac{P_P I_P}{P_P I_P + P_M I_M + P_N I_N}, \quad \gamma_4 = \frac{P_M I_M}{P_P I_P + P_M I_M + P_N I_N}$$

$$\ln P^G = \gamma_5 \ln P_P + \gamma_6 \ln P_M + (1 - \gamma_5 - \gamma_6) \ln P_N$$

$$\gamma_5 = \frac{P_P GI_P}{P_P GI_P + P_M GI_M + P_N (GI_N + GC)}, \quad \gamma_6 = \frac{P_M GI_M}{P_P GI_P + P_M GI_M + P_N (GI_N + GC)}$$

$$\ln P^X = \gamma_7 \ln\left[e_I P^{\$}_{X,P}\right] + (1 - \gamma_7) \ln\left[e_I P^{\$}_{X,M}\right]$$

$$\gamma_7 = \frac{\left[e_I P^{\$}_{X,P}\right] X_P}{e_I\left[X_P \cdot P^{\$}_{X,P} + X_M \cdot P^{\$}_{X,M}\right]}$$

$$\ln P^{IM} = \gamma_9 \ln\left[e_I P^{\$}_{IM,P}\right] + 1 - \gamma_9 \ln\left[e_I P^{\$}_{IM,M}\right]$$

$$\gamma_9 = \frac{\left[e_I P^{\$}_{IM,P}\right] IMT_P}{e_I\left[IMT_P \cdot P^{\$}_{IM,P} + IMT_M \cdot P^{\$}_{IM,M}\right]}$$

Lists of Variables

Exogenous Variables

CBCP	Central bank credit to the private sector (billion baht)
CBCPU	Central bank credit to the public sector (billion baht)
ClaimG	Government domestic credit (billion baht)
DEPEND	Ratio of dependent to non-dependent population
e	Nominal exchange rate (Baht to the US dollar)
e_I	Index of nominal exchange rate (*e*/25.29) (1988 = 1)
e_f	Nominal effective exchange rate (domestic to foreign currencies) (1988 = 1)
$FDI^{\$}$	Foreign direct investment (billions of US dollars)
GI_i	Real government investment in the i^{th} sector (billion baht)
GC	Real government consumption (billion baht)
i^*	World interest rate (US prime rate) (per cent)
i_G	Government bond yield rate (per cent)

InD_G	Interest payment for domestic borrowing of the public sector (billion baht)
InF_G^B	Interest receipts from foreign assets held by the public sector at the historical base
InD_G^B	Interest payment for domestic borrowing of the public sector at the historical base
la	Land (hectare)
LP_i	Labour efficiency in the i^{th} sector (real value added per worker)
LF	Labour force (thousand)
MW	Minimum wage (baht per person)
P^*	Tariff-ridden world prices (1988 = 1)
P_p^*	Tariff-ridden world primary prices (1988 = 1)
P_M^*	Tariff-ridden world manufacturing prices (1988 = 1)
P_{IMR}^*	Import prices of raw materials (1988 = 1)
$P_{IM,P}^\$$	Import prices of primary goods (1988 = 1)
$P_{IM,M}^\$$	Import prices of manufactured goods (1988 = 1)
$P_{X,P}^\$$	Export prices of primary goods (1988 = 1)
$P_{X,M}^\$$	Export prices of manufactured goods (1988 = 1)
T	Time trend
$\overline{TFP_i}$	Trend of total factor productivity in the i^{th} sector
U^*	Natural rate of unemployment (= 2.73 per cent)
Y^W	World income (1988 = 1)
δ_i	Depreciation rate in the i^{th} sector

Endogenous Variables

$ASSET$	Total real private assets (billion baht)
ED_i	Excess demand in the i^{th} sector (output gap)
C	Total real private consumption (billion baht)
C_i	Real private consumption in the i^{th} sector (billion baht)
CA	Current Account (billion baht)
CAP	Capital account (billion baht)
CK_i	Cost of capital in the i^{th} sector
$F_P^\$$	Stock of foreign (capital) assets held by private sector (billions of US dollars)
$F_G^\$$	Stock of foreign (capital) assets held by public sector (billions of US dollars)
in	Domestic lending interest rate (per cent)
I	Total real private investment (billion baht)
I_i	Real private investment in the i^{th} sector (billion baht)
IM	Total real imports (billion baht)
IM_i	Real goods imports in the i^{th} sector (billion baht)
InF_G	Interest receipts from foreign assets held by the public sector (billion baht)
K_i	Net capital stock in the i^{th} sector (billion baht)
L	Total employment (thousand)
L_i	Employment in the i^{th} sector (thousand)

$\overline{L}_i$	Labour force adjusted by natural rate of unemployment in the i^{th} sector (thousand)
M_2	Board money M2 (billion baht)
$OCF^{\$}$	Other form of capital flows (billions of US dollars)
P	Domestic output price (1988 = 1)
P_T	Tradable prices (1988 = 1)
P_N	Nontradable prices (1988 = 1)
P_P	Primary prices (1988 = 1)
P_M	Manufacturing prices (1988 = 1)
P^C	Implicit price deflator of consumption (1988 = 1)
P^I	Implicit price deflator of investment (1988 = 1)
P^G	Implicit price deflator of government (1988 = 1)
P^X	Implicit price deflator of exports (1988 = 1)
P^{IM}	Implicit price deflator of imports (1988 = 1)
PDC	Stock of private domestic credit (flows = ΔPDC) (billion baht)
$R^{\$}$	Stock of foreign exchange reserves (billions of US dollars)
RER	Real exchange rate (1988 = 100)
T_P	Total tax (billion baht)
$\overline{T}$	Lump-sum tax for policy simulation
U	Unemployment rate (per cent)
$UNCER$	Economic uncertainty
W_i	Nominal wages in the i^{th} sector (baht per person)
X	Total real exports (billion baht)
X_i	Real goods exports in the i^{th} sector (billion baht)
Y	Real GDP (billion baht)
Y_i	Real GDP in the i^{th} sector (billion baht)
Y^d	Real disposable income (billion baht)
$\overline{Y}$	Total real potential output (billion baht)
$\overline{Y}_i$	Real potential output in the i^{th} sector (billion baht)

Note: 1. A separation of output (gross domestic product, GDP at constant (1988) prices) and its components into primary, manufacturing and nontradable sectors is based on the International Standard of Industrial Classification (ISIC). The output in primary sector (Y_P) consists of agricultural, mining, and quarrying (ISIC 01, 02, 05, and 10-14). Manufacturing output (Y_M) covers all production activities classified under ISIC 15 -37. Nontradables (Y_N) covers the remaining items of national accounts. The same classification is applied in disaggregating the components of aggregate demand.

2. The tariff-ridden world price of primary goods (P_P^*) expressed in foreign currency is obtained as the weighted average of seven world commodity prices, namely rice, rubber, tapioca, shrimp, maize, cotton, and tin. The tariff-ridden world price of manufactured goods (P_M^*) expressed in foreign currency is obtained as the weighted average of manufacturing producer prices for Thailand's main trading partners. The tariff-ridden imported raw materials price (P_{IMR}^*) is measured by the import price index (excluding prices of food and beverages, and animal and vegetable oil). Import duty rates on primary and manufactured products are measured by the ratio of total duty collection to value of import.

Appendix II
The model performance

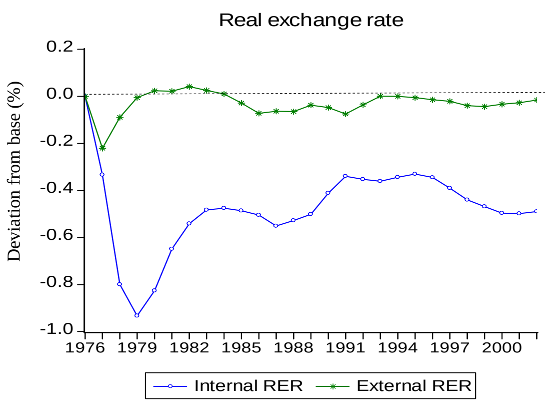
1. Measures of the prediction accuracy of the model, 1977-2002

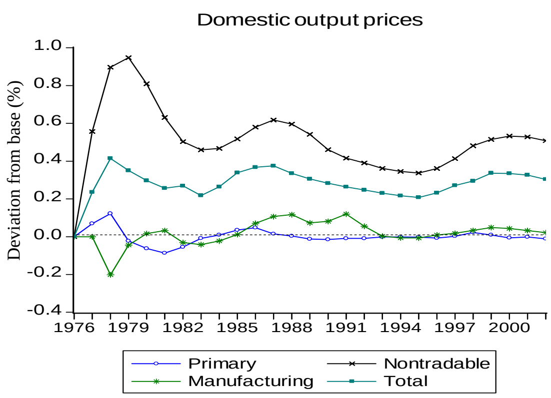
Variables	MAPE	Theil	Proportion		
			Bias	Variance	Covariance
Internal RER ($RER^{Internal}$)	2.35	0.01	0.219	0.000	0.780
External RER ($RER^{External}$)	1.62	0.01	0.078	0.043	0.879
Tradable price (P_T)	1.65	0.01	0.028	0.291	0.681
Primary price (P_P)	4.36	0.02	0.039	0.049	0.911
Manufacturing price (P_M)	1.66	0.01	0.112	0.150	0.738
Nontradable price (P_N)	2.54	0.01	0.380	0.043	0.577
GDP deflator (P)	1.91	0.01	0.417	0.084	0.499
Consumption deflator (P^C)	1.53	0.01	0.233	0.148	0.619
Primary wage (W_P)	9.99	0.08	0.043	0.046	0.911
Manufacturing wage (W_M)	14.83	0.10	0.151	0.261	0.587
Nontradable wage (W_N)	3.40	0.02	0.031	0.065	0.904
Real GDP (Y)	5.22	0.03	0.123	0.385	0.492
Primary output (Y_P)	9.06	0.06	0.054	0.089	0.857
Manufacturing output (Y_M)	9.96	0.05	0.009	0.497	0.494
Nontradable output (Y_N)	4.20	0.03	0.140	0.311	0.549
Private consumption (C)	5.03	0.03	0.066	0.375	0.559
Private investment (I)	10.25	0.09	0.144	0.339	0.516
Export (X)	5.24	0.02	0.058	0.380	0.562
Import (IMT)	6.69	0.06	0.271	0.298	0.431
Broad money (M_2)	26.24	0.09	0.062	0.362	0.577
Domestic interest rate (in)	8.91	0.05	0.344	0.001	0.655
Total employment (L)	2.91	0.02	0.006	0.225	0.769

Source: Author's calculation.

2. Diagnostic simulations

Figure 2.1: Effects of Permanent Increase in Government Consumption, 1977-2002





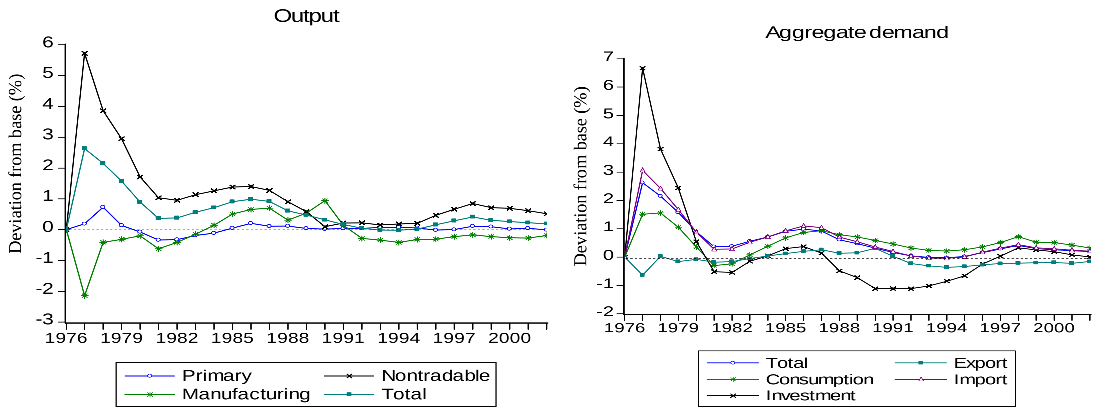


Figure 2.2: Effects of Permanent Increase in Technological Progress in the Tradable (Primary and Manufacturing) Sector, 1977-2002

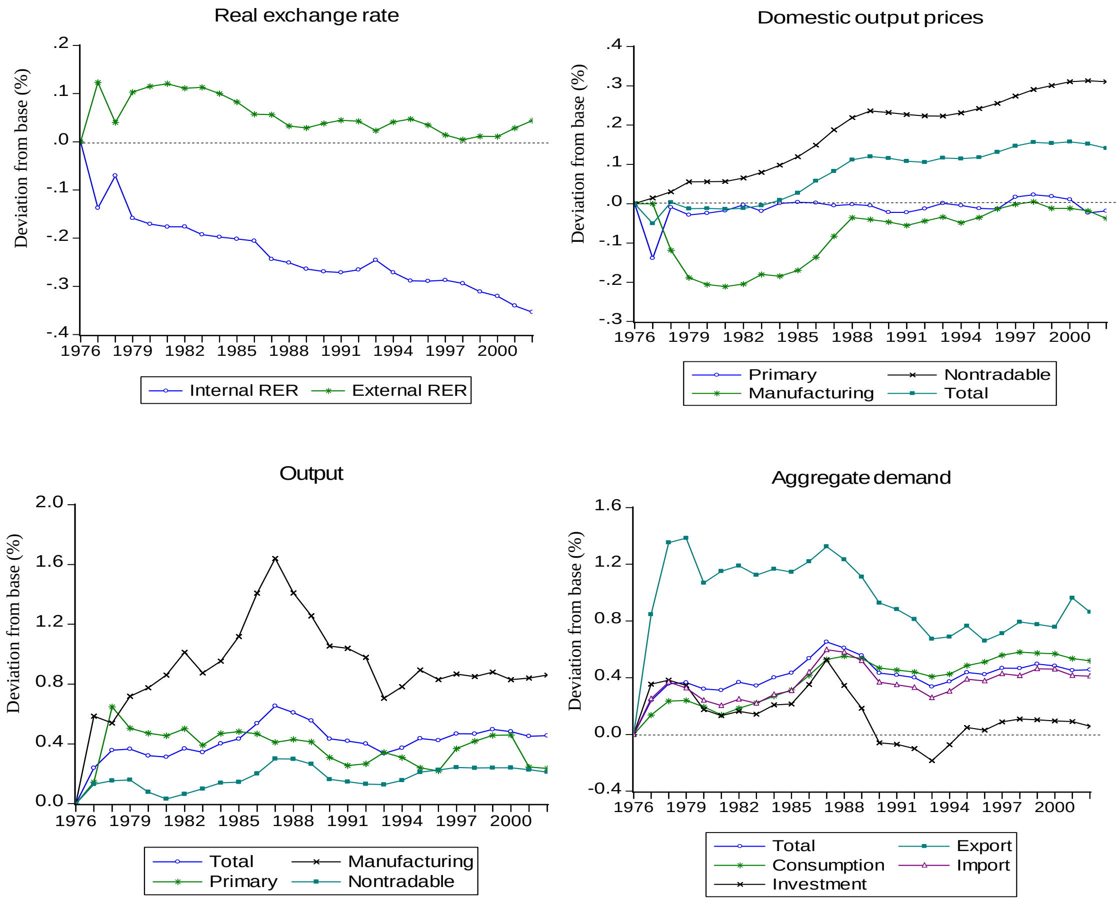


Figure 2.3: Effects of One Per Cent Nominal Exchange Rate Devaluation, 1977-2002