

OPTIMAL LEVEL OF INTERNATIONAL RESERVES:

THE CASE OF THAILAND

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EXECUTIVE SUMMARY

Since the 1997 financial crisis, Thailand has begun to accumulate large amounts of reserves. In part, the accumulation has been done to restore the country's credibility especially after the depletion of the reserves during the crisis. However, there is also an ongoing debate whether or not this reserve accumulation is 'excessive' and a waste of resources. This policy analysis proposes a framework for the determination of a suggestive optimal level of international reserves.

This framework includes the following three aspects of reserves holding:

- 1. Reserves adequacy:** Reserves adequacy is determined using the ratio of reserves to short-term debt equal to one. This will serve as the minimum threshold of reserves holding.

- 2. Optimal level of reserves:** The optimal level of reserves can be determined using the standard cost-benefit approach. That is, the central bank of Thailand needs to consider (1) the benefit of holding reserves in terms of flexibility in adjustment to external shocks and in terms of gaining market confidence as suggested by the IMF (2001b) and (2) the opportunity cost of holding reserves. This follows the model on optimal reserves and sovereign risk by Ben-Bassat and Gottlieb (1992).

- 3. Investment strategy:** An aspect of investment strategy is considered here because of its endogenous effect on reserves level. Higher level of reserves, specifically higher than that of the minimum benchmark, allows for investment in less liquid assets which works to lower opportunity cost and in turn allows for more accumulation of reserves as proposed in the IMF's *Issues in Reserves Adequacy and Management* (IMF 2001b).

Given these three steps, the central bank of Thailand can determine the level of reserves it should hold, sufficient to cover (anticipated) outflows from external shocks but not incurring 'unnecessary' cost.

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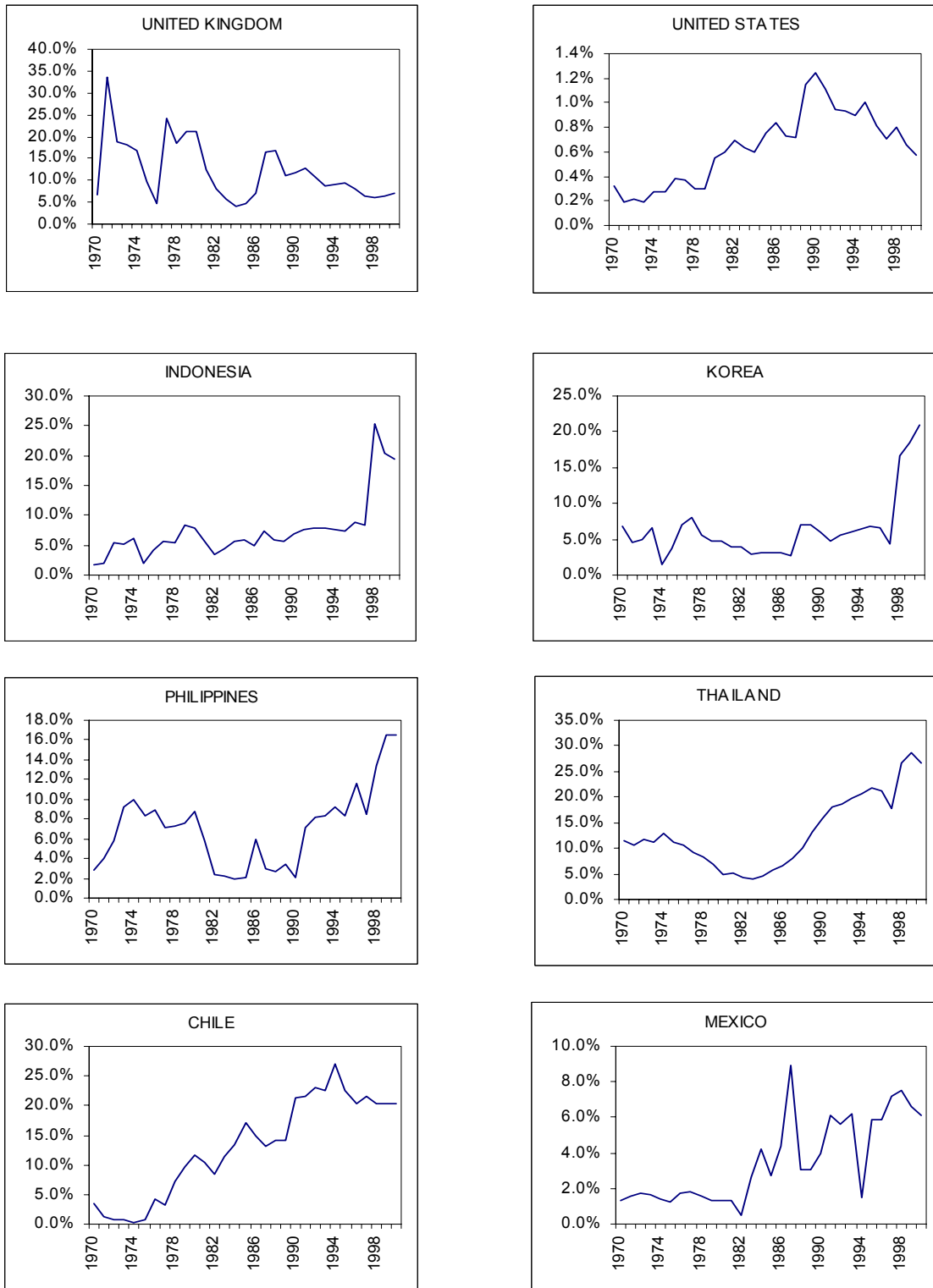
I. BACKGROUND

Many countries affected by currency crisis in the 1990s had lost a large part of their foreign reserves, trying to defend the value of their currencies and eventually had to abandon the fixed exchange rate regime. Due to this reserve run-down associated with the financial crisis, countries have since been accumulating substantial reserves even though flexible exchange rate regimes have been adopted. Thailand, for instance, has been accumulating reserves since the 1997 crisis.

From **Figure1**, large, developed countries (having significant share of the world total income) tend to hold minimal reserves while small countries, especially those that have recently witnessed currency crisis (and reserve depletion) tend to accumulate substantial reserves. This seems to suggest that reserve size still matters for these emerging economies despite the adoption of flexible exchange rate regime.

In the case of Thailand, the rapid accumulation of international reserves actually began in the early 1990s, when Thailand was still under the fixed exchange rate regime and has just started the process of liberalizing international capital movement. The accumulation of reserves in the first half of the 1990s was seen as a *tool* for exchange rate policy as well as the *result* of such policy. The central bank of Thailand needed substantial reserves as it was obliged to buy/sell foreign exchange in order to maintain a fixed rate. At the same time, since the liberalization of international financial flows has led to large surges of capital inflows, the central bank ended up being a net buyer of foreign exchange, hence in the process quickly accumulating reserves.

[Figure1. Reserve/GNP: Selected Countries under Flexible Exchange Rate Regime]



Source: International Financial Statistics

However, this huge surge in capital inflows comprised mainly of short-term loans and portfolio investment. Eighty percent of the total flows were short-term. This implies that the accumulation of reserves during that time was based mainly on the short-term flows. Hataiseree (2000) concluded that such a high share of short-term debts had made Thailand increasingly vulnerable to changes in market sentiment and foreign investors' confidence. It is believed that the implementation of capital account liberalization and the rigid exchange rate had resulted in this rapid building up of short-term external debts.

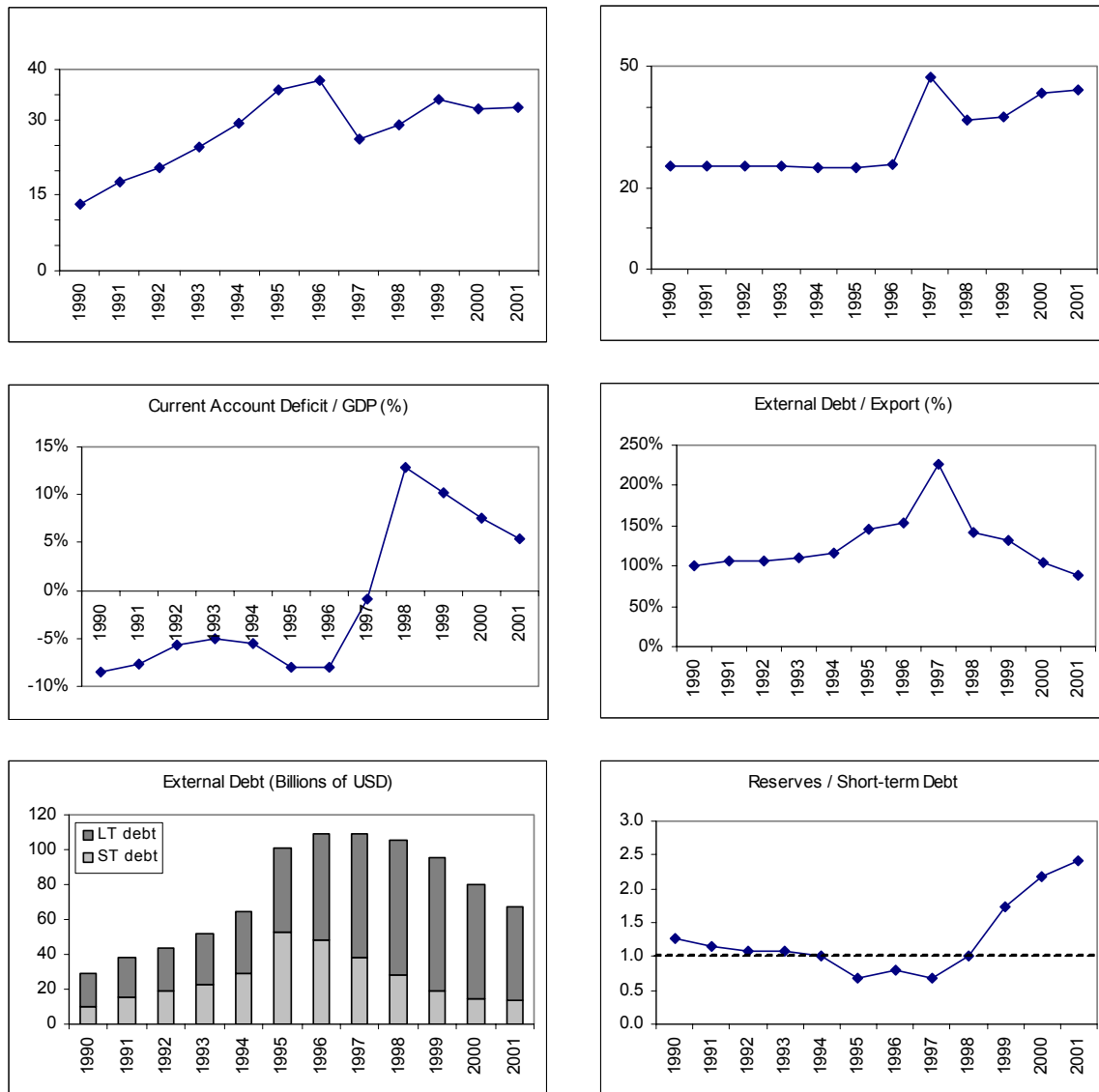
Figure 2 describes some of the key economic variables which have indicated the looming of the crisis. The current account deficit showed sign of troubles especially when it was approaching 10 percent of GDP shortly before the crisis. The ratio of external debt to export reaches over 200 percent during the year of the crisis. Not only that the overall external debt level increased, its composition of short-term debt increased as well. By 1996, short-term debt accounted for about half of the total debt.

Shortly before the 1997 financial crisis, the level of short-term debt has actually exceeded that of the level of reserves. The central bank, thus, lost its credibility in maintaining a fixed exchange rate. This resulted in speculative attacks and capital flights, followed by the depletion of international reserves and *de jure* adoption of a floating exchange rate regime.

Although substantial reserves have been lost defending the exchange rate during the crisis, Thailand has begun to accumulate more reserves once again. As the economy now operates under a floating exchange rate regime, debate on what is the use of this reserves accumulation naturally arises. However, the story of how Thailand came to adopt this floating exchange rate regime actually underlines the urgency with which the

country needs to restore its creditworthiness as well as toughen its crisis prevention. Reserves build-up is clearly one way of achieving that.

[Figure2. Thailand's Key Economic Indicators]



Source: International Financial Statistics and Bank of Thailand (External Debt Data)

II. THE FRAMEWORK

In order to determine the appropriate level of reserves the central bank of Thailand should hold, three major steps as will be undertaken.

First, the minimum amount of reserves is determined. This is the level that could sufficiently satisfy anticipated vulnerabilities, especially of the capital account, as termed by the International Monetary Fund (IMF 2001b).

Second, additional reserves beyond that of the minimum level are determined. The mark-up of reserves above the minimum benchmark serves as a buffer or cushion against exogenous shocks that might require more than standard short-term debt coverage (IMF 2001b). Also, high level of international reserves can serve to establish the economy's creditworthiness. Reserve accumulation, however, entails cost, the opportunity cost of holding reserves.

The central bank, therefore, needs to balance the benefits and costs of its reserves level: (1) the benefit of holding reserves in terms of flexibility in adjustment to external shocks and in terms of gaining market confidence as suggested by the IMF (2001b) and (2) the opportunity cost of holding that reserves. Given these, the optimal level of reserves can be determined using the standard cost-benefit approach.

Third, investment strategy is taken into account. One aspect on the strategy on reserve asset investment is discussed here because of its endogeneity to the level of reserves. That is, higher level of reserves, specifically higher than that of the minimum benchmark, allows for investment in less liquid assets which works to lower opportunity cost and in turn allows for more accumulation of reserves (IMF 2001b).

III. RESERVES ADEQUACY

Before moving on, it is important to understand the general ideas behind reserve holding. Reserves are held for several reasons depending upon the economy's needs. Key rationale for holding reserves can be summarized according to Nugee (2000) as follows.

1. Formal backing for the domestic currency.
2. Tool of exchange rate or monetary policy.
3. Servicing foreign currency liabilities and debt obligations.
4. Source of funds to pay for government expenditure overseas.
5. Defence against emergencies or disaster.
6. Investment fund.¹

Among the six reasons for holding reserves mentioned above, two that have become most common and prominent in the context of modern central banking are the second and the third reasons: as tool for conducting exchange rate or monetary policy, and the servicing of foreign currency liabilities and debt obligations. However, the use of reserves as a tool of exchange rate policy will become less vital as a country moves toward floating exchange rate regime. It is worth a mention that even under a clean floating regime, there is still always a positive *option* value of maintaining reserves. This reflects the possibility that the exchange rate regime may revert to a fixed program.² As

¹ Investment fund refers to holding reserves for financial gain. This, however, does not constitute as rationale behind reserves holding for most countries.

² However, this is not taken into account when determining the optimal level of international reserves as it subjectively depends on the central bank preference and is beyond the scope of this policy analysis paper.

Box1. Standard Approaches to Reserve Adequacy*1. Reserves to import ratio

Reserves to import ratio can be called the ‘traditional’ benchmark on reserves adequacy. It tells how many months of imports a country will be able to service given no other forms of foreign exchange inflows. This ratio is especially useful for countries whose current account plays a major role in overall external account (Glennester 2002).

2. Reserves to short-term debt ratio

In response to the new integrated international financial environment, the ratio of reserves to short-term debt has been adopted widely. Such level of reserves buffers the economy against ‘anticipated’ outflows resulting from a shock (IMF 2001b). It can be characterized as *first moment policy* in the sense that it captures the average loss if a shock does occur.**

3. ‘Augmented’ reserves to short-term debt ratio

Often times, the severity of the problems is much larger than that anticipated. In reality, adverse external shocks often worsen the magnitude of the problems. This calls for *second moment policy*.** That is, not only the *average* loss or cost, capital outflows in this case, but also the *standard deviation* of the problem itself has to be addressed. Therefore, in addition to simply considering reserves to short-term debt as measurement of reserve adequacy, some papers have suggested using volatilities of the capital flows (IMF 2001b) or standard deviation of the ratio reserves to broad money--reflecting possible capital flight (Wijnholds and Kapteyn 2001)—to augment the basic reserves to short-term debt.

* Summarized from the policy memorandum for BGP-460 (2003).

** Professor Hausmann asserts that there are two types of policies: (1) First moment policy focuses on the expected value of the variable in study and (2) second moment policy focuses on the standard deviation, the volatility, of the variable (Hausmann 2003).

for managed floating regime, it may take more reserves to stabilize the exchange rate when it is more volatile.³

More and more, however, the focus is on the issue of servicing foreign currency liabilities and debt obligations. It is very important to stress at the outset that this does not mean reserves will be used as an insurance against borrowing abroad. It does, however, imply that in times of credit-*cum*-liquidity crunch, reserves provide a device for absorbing the tension in the foreign exchange market to avoid excessive volatility (Nugee 2000). Reserves serve as a crisis prevention mechanism for the economy.

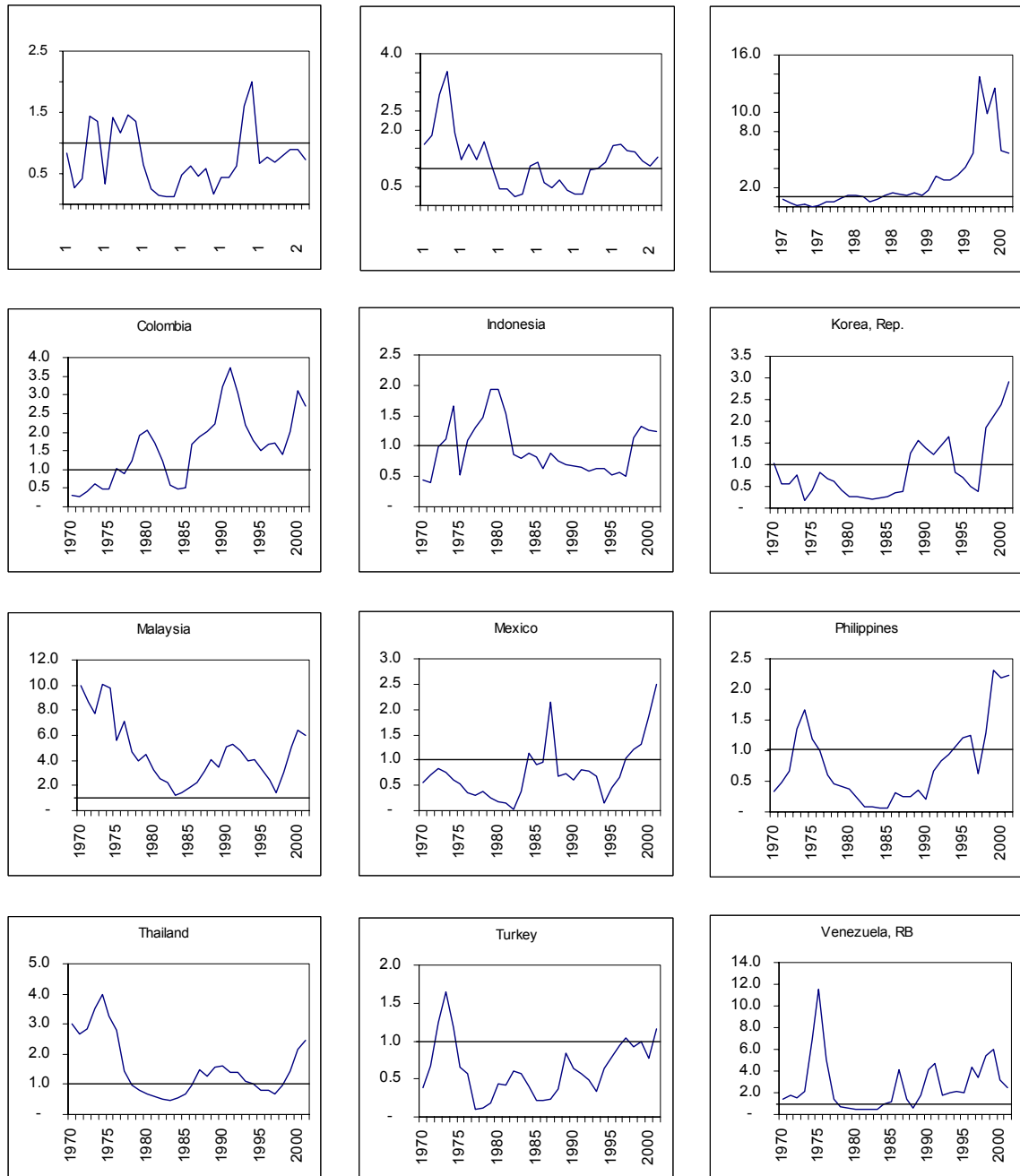
It is, therefore, crucial to determine the level of reserves adequate to absorb such risks. The IMF suggests that a good 'reserve adequacy assessment with a focus on the capital account' is the ratio of international reserves to short-term external debt by remaining maturity (IMF 2001b, p.3). Unfortunately, the external debt data by remaining maturity is usually not readily available and, often times, the short-term external debt by contract is used instead. The standard approaches to the reserve adequacy ratio are briefly summarized in **Box1**.

According to the IMF, a coverage ratio of reserves to short-term debt seems to be a good indicator of reserve adequacy in terms of crisis prevention, especially for emerging markets that have a significant portion of capital account in their balance of payments. Thailand fits into this category. **Figure3** shows how crisis-hit countries have been accumulating reserves above that of short-term debt, except for Argentina which has only recently been hit. In calculating the adequacy level of reserves, a normal rule-of-thumb of a coverage ratio of reserves to short-term debt equal to *one* is usually used.

³ I would like to thank Professor Frankel for the suggestion of this issue.

Simply put, this coverage ratio ensures that reserves must be large enough to cover for any capital outflows that might take place during the next one year.

[Figure3. Reserve/Short-term Debt: Selected Crisis-Hit Countries]



Source: International Financial Statistics (International Reserves) and Global Development Finance (External Debt)

A very interesting study done by Mulder and Perrelli (2001), estimating the determinants of credit ratings of Moody's and Standard&Poor's, suggest that since the Asian financial crisis, the ratio 'short-term debt to reserves' has become increasingly important as a determinant of credit ratings. The paper observed that 'they (i.e. Fitch IBCA analysts) began to pay greater attention to the ratio of short-term debt to reserves following the crisis.' This certainly confirms the significance of this reserve ratio.

Thus, in assessing the minimum reserves adequacy for Thailand, the short-term debt coverage ratio will be used.

Before moving on, there are two issues worth noting as regards the role of reserves in Thailand. First, part of the international reserves holding of Thailand constitutes formal backing for the domestic currency, i.e. requirement 1, as per Nugee (2000). Therefore, when discussing the optimal level of reserves for Thailand, it is important to note that there is a legally-defined minimum amount that needs to be held.

Second, the reserves holding discussed here refers to *gross*, as opposed to *net*, international reserves. After the crisis, Thailand entered an IMF adjustment program. Part of the increase in reserves after the crisis therefore reflect obligation to the IMF, so that the net reserves are somewhat smaller than gross reserves.

IV. OPTIMAL LEVEL OF RESERVES: CUSHION VS COST [BASED ON BEN-BASSAT AND GOTTLIEB (1992) MODEL]

As seen earlier in the graphs, emerging market economies tend to hold huge amount of reserves, far beyond that of the short-term debt coverage ratio. This serves as better cushion against any unanticipated external volatility; it allows greater flexibility for

the economy to adjust especially under severe economic shocks (IMF 2001b). In addition to that, it serves as a build-up of a country's creditworthiness. In this sense, holding reserves increases the confidence, and thus creditworthiness, of a country (Nugee 2000). Or, as the IMF puts it that "one of the principal aims of reserve adequacy" is to "to promote and sustain internal and external market confidence in a nation's economic policies."(IMF 2001b, p.8)

IV.1. Optimal Reserves Holding: Concepts

Given the aforementioned benefits, it makes sense to consider holding reserves beyond the minimum adequacy level. The key question is *to what extent* should the central bank hold above this minimum level, if any. As much as holding more reserves provide greater buffer, it also entails opportunity cost, the forgone earnings that could have been earned if the reserves had been put into higher return investments (Ben-Bassat and Gottlieb 1992). Since reserves must be invested in safe, liquid assets, they tend to earn low return, relatively to either the cost of acquiring these reserves of the financial as well as social returns that could be earned otherwise.

Thus, in deciding what level of reserves to hold, the central bank must consider these two aspects: (1) the marginal benefit of holding reserves and (2) its marginal cost, namely the opportunity cost (Hamada and Ueda 1977). The optimal level of international reserves will be a level that will balance these two forces.

The next question is how to measure these benefits and cost of holding reserves. The benefit arises from the ability of the central bank to avoid large economic loss due to fluctuations in balance of payments and/or exchange rate. The benefit to the central bank will be large if the perceived losses from reserves run down is large or if the central bank

is highly risk-averse to this loss as discussed by Flood and Marion (2002). As for the cost, this depends on the productivity of capital prevailing for the private sector as well as government projects. This also depends on the management strategy of the central bank, i.e. how reserves assets are being invested.

Reserves assets are usually invested in assets that are highly liquid since the purpose of holding reserves is to serve as a buffer against any economic fluctuations. However, as the level of reserves become higher, not all of them have to be invested in extremely liquid assets, which return relatively low yields (IMF 2001b). This arises from two reasons: (1) As more reserves are held, it is less likely they would be called upon as there tends to be more confidence in the economy and (2) reserves held above that of a minimum level, i.e. a coverage ratio of reserves to short-term debt, serves more as confidence buildup and less as precautionary backup.

Thus, in optimizing the level of reserves holding, it is then suggested that three factors need to be taken into account: (1) probability and severity of a crisis (2) opportunity cost of holding reserves and (3) the investment strategy which is endogenous to the optimal level of reserves.

IV.2 Optimal Reserves Holding: The Mechanics

It will be helpful to have a framework that can quantify, at least suggestively, how much the optimal level of reserves the central bank should hold taking into account the marginal benefit and marginal cost of holding these reserves. This is an optimizing problem, minimizing the objective total cost function of the central bank, i.e. the cost of output loss from reserves rundown (the mirror image of the benefit from holding reserves) and the opportunity cost of holding reserves.

Before moving on, it is worth reminding that the optimal level of reserves should not be allowed to decrease below the minimum reserve adequacy benchmark, mentioned in the previous section. In other words, the ratio of reserves to short-term debt serves as a constraint on this optimization problem.

A useful framework set forth by Ben-Bassat and Gottlieb (1992) allows the calculation of the optimal reserves. The idea of this framework is that central bank faces two major costs related to reserves holding. The first cost relates to the output loss associated with reserves run down and the second cost relates to opportunity cost of holding reserves. Central bank will want to hold a certain level of reserves such that these two costs are minimized. This will depend crucially on the weight that the central bank puts on each cost. Ben-Bassat and Gottlieb (1992) estimated the weight on the cost of output loss to be the probability that sovereign will default on their debt (and thus force the central bank to run down on its reserves.) The higher the probability is, the larger the weight will be put on the cost of output loss to the economy.

The level of reserves enters the equation at three points. First, reserves affect the probability of default. The magnitude of the probability of default depends largely on the soundness of the macroeconomic variables, one of them being the level of international reserves. Simply stated, higher reserves level lower the probability of default, implying that the cost of output loss (reserves depletion) contributes less to the total expected cost of holding reserves.

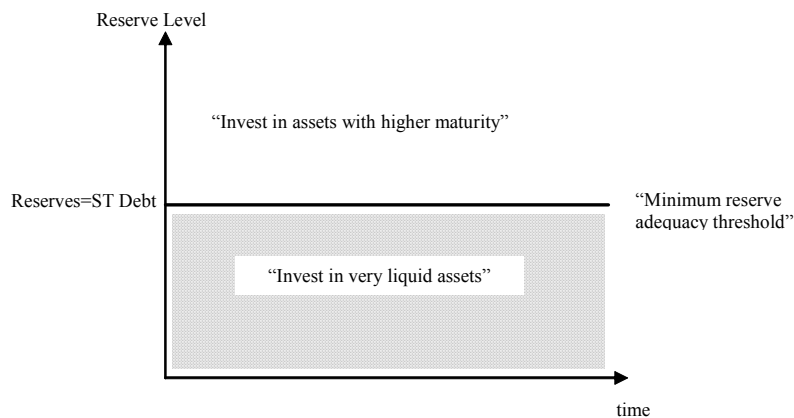
Second, reserves level affects the total opportunity cost. This opportunity cost is basically the difference between the return on reserve assets and the return on other investments, which are more profitable or productive.

V. INVESTMENT STRATEGY

Although investment strategy is beyond the scope of this policy analysis paper, one aspect of it deserves much attention relating to optimal reserves level.

As mentioned earlier on the reserves investment strategy suggested by the IMF, if reserves holdings are large enough to cover anticipated external vulnerabilities, ‘investment strategies may put greater emphasis on seeking higher returns over medium to longer runs.’ (IMF 2001b, p. 13) That is, adequate level of reserves is first determined. This is the amount of reserves that central bank must hold to buffer against anticipated outflows from external shock. Thus, this amount of reserves must be invested in safe, liquid assets. However, as discussed in the previous section, central bank may consider holding reserves beyond this benchmark, based on the cost and benefit of holding reserves. This mark-up amount, thus, serves as an additional to the ‘necessary’ buffer and can arguably be invested in something less liquid, mainly assets with higher maturity which yield higher return. Therefore, opportunity cost is endogenous to the level of reserves (as a step function of the level of reserves.)

Figure4. Investment Strategy⁴

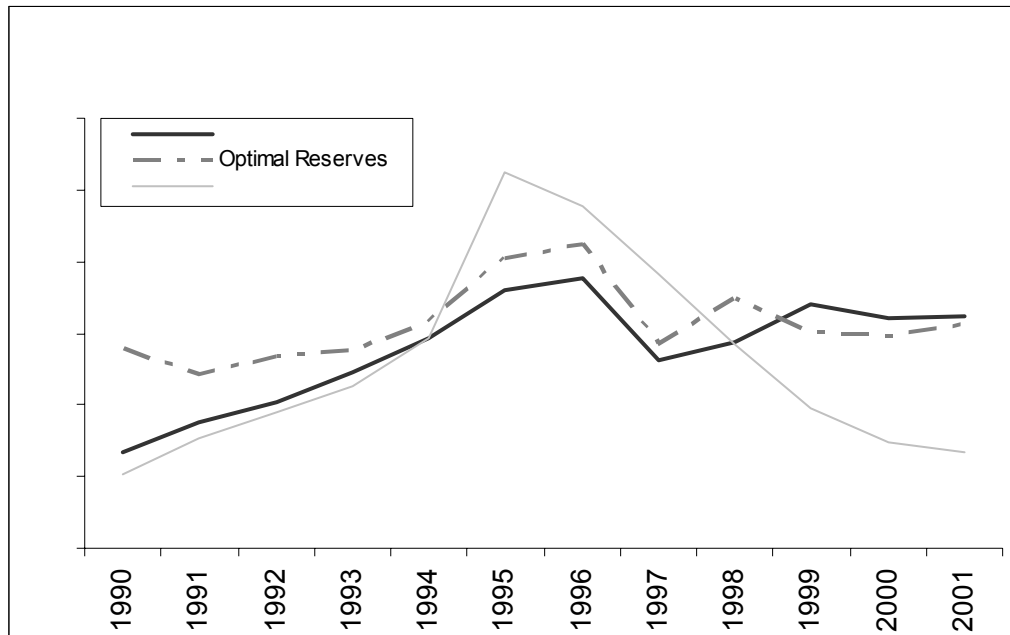


⁴ I am grateful to Dr. Titanun Mallikamas, for various valuable comments and insights, especially on the discussion of the investment strategy.

VI. RESULT

Based on the above mechanics, the optimal level of reserves is one that satisfies the first order condition of the total expected cost function.⁵

[Figure 5. Optimal VS Actual Level of Reserves]



The optimal reserve appears to move closely with the actual reserve.

Following the liberalization in the early 1990s, short-term debt has increased rapidly.

⁵ The first order condition of the total expected cost can be written as (Ben-Bassat and Gottlieb 1992):

$$EC_R = \pi_R (C_0 - rR_{opt}) + (1 - \pi)r = 0$$

where EC_R = first derivative of expected cost function with respect to reserves

R_{opt} = optimal reserves

r = opportunity cost of holding reserves (a step function of R)

C_0 = cost of default

π = probability of default

π_R = first derivative of probability of default with respect reserves.

$$\text{Given that } \pi = \frac{e^f}{(1 + e^f)} \text{ and } f = a_0 + a_1 \log\left(\frac{R}{M}\right) + a_2 e^{\frac{STD}{R}} + a_3 m + a_4 y + a_5 fix.$$

Details can be found in the appendix.

Optimal level of reserves thus rose in line, in order to maintain market confidence. The optimal level of reserves shows some levelling off after the crisis, due mainly to a sharp decline in short-term debt. In terms of the actual level of reserves, during the crisis in 1997, there was a huge run-down in reserves from defending the fixed value of the baht, an attempt that failed to succeed and later followed by the abandonment of the fixed exchange rate. (It needs to be noted here that the actual level of reserves shown here is gross reserves. In 1997, Thailand engaged in forward obligation and thus the *net* international reserves was lower than that shown.) The following few years, however, have shown a sharp accumulation of the actual level of reserves, to a point where it actually exceeds the optimal level of reserves. However, this upward trend seems to have stabilized and the actual reserves and optimal reserves actually show some convergence toward the end of the period of study.

A thin line representing the ratio of reserves to short-term debt that equals one (which is basically the short-term debt level) is included in **Figure 5**. This is to show the connection between the reserves adequacy benchmark (the ratio of reserve to short-term debt) and the optimal reserve calculated based on the standard cost-minimization approach.

According to the framework discussed earlier, the central bank of Thailand have to hold a minimum level of reserves equal to that of the short-term debt, i.e. the level of reserves should not go below the thin line. Any additional reserves beyond this benchmark has to taken into account the opportunity cost of holding reserves, which is reflected by the broken line. Two issues can be drawn from this figure:

1. Based on this approach, the actual level of international reserves appears to be very close to optimal. The gap between the two decreases over time, at least since the 1997 crisis.

2. Shortly before the crisis, the minimum reserves adequacy level exceeds that of the optimal level. This implies that the level of short-term debt is so high that the central bank of Thailand might have to disregard the opportunity cost and try to accumulate reserves that will suffice to cover short-term debt. Or looking from a different perspective, the short-term debt accumulation was not sustainable. It was too high to be sensibly covered by reserves. With the benefit of hindsight, the approach to deal with such increase in short-term debt back in the mid 1990s might not be for the central bank to accumulate more reserves, but rather, to deal directly with decreasing the level of short-term debt.

VII. CONCLUSIONS

Taking all these into account all these, a framework can be set up for determining the level of international reserves that the Bank of Thailand should hold. The framework has designed:

1. the minimum reserve adequacy benchmark
2. the extent to which reserves holding can increase above this minimum benchmark, taking into account the opportunity cost of holding reserves
3. the investment strategy which relates closely to the level of reserves holding.

It is worth noting that there are other crucial factors that must be considered when deciding on the appropriate level of reserves. One important issue is the 'subjective' loss

aversion of the Bank of Thailand itself as suggested by Aizenman and Marion (2002). This will play an important role in determining the optimal level of international reserves and how the central bank perceives risk. In addition to that, stakeholder analysis will have to be taken into account as well. Please see **Box3** for further details on this.

In conclusion, this framework serves as a guideline for the Bank of Thailand in reserves management. It provides a range of reserve level that is in line with the prevailing economic situation.

Box3. Stakeholder Analysis

Key stakeholders' interests need to be addressed as follows:

1. Minister of Finance: In general, the Minister of Finance is unlikely to say that the country now has 'too much' international reserves at hand. In the case of Thailand, however, the Minister of Finance is in quite a restrained position to make any critical remarks on the management of the international reserves of the Bank of Thailand. The substantial public debt burden as a result of the government's guaranteed deposits of the closed financial institutions following the financial restructure plan is being financed by the issues of domestic saving bonds, and the Bank of Thailand has agreed to use the annual net profits from the holding of international reserves to pay for the amortization of the bonds.* This has been finalized after quite a few rounds of negotiations between the Ministry of Finance and the Bank of Thailand. Since the Bank has now compromised on the use of its profits, interference from the Minister of Finance in the Bank's reserves management can be expected to be at minimum.

2. Commercial Banks and other private borrowers: The interest of international reserves accumulation on commercial banks and other private borrowers can be two-fold. On the one hand, from the market liquidity perspective, the Bank's outright acquire of the foreign exchange as part of its reserves build-up can put pressure on the exchange rate, unless this is done in a gradual process or when exchange rate is appreciating. On the other hand, from the market confidence perspective, reserves build-up will presumably lead to higher credit rating which should lower the borrowing cost of the commercial banks and private borrowers.

3. IMF: One of the early warning system indicators that the IMF advocates is the ratio of international reserves to short-term debt. The IMF will incline to be more concerned on the 'floor' of the level of international reserves and less on the 'ceiling.'

* It is worth noting that the Bank of Thailand has argued that this is not to be 'construed as monetization as it is the normal practice for central banks to remit their profit flows back to governments.' The Bank has further confirmed that this will not affect the level of international reserves.

APPENDIX

CALCULATION OF OPTIMAL RESERVES

In calculating the level of optimal reserve for Thailand, this paper will follow the framework by Ben-Bassat and Gottlieb (1992) who has introduced sovereign risk into the standard cost-benefit model. *This appendix briefly summarizes their model and elaborates on the modifications made to make the model more suitable to the Thai experience.*

In choosing an optimal level of reserves, a central bank needs to balance the two types of cost. On the one hand, holding more reserve means entailing more opportunity cost which can be roughly measured as the forgone earning that the central bank, or the country, could have produced if fund were invested elsewhere rather than in safe liquid assets that yield low return. On the other hand, holding more reserves means increasing country's creditworthiness, reassuring investors' confidence and, thus, reducing the chance of capital flight resulting in economic crisis and a huge, persistent output loss. Therefore, central bank needs to minimize the expected cost of holding reserves, taking these two types of costs into consideration.

$$EC = \pi C_0 + (1 - \pi)C_1$$

where π = probability of default

C_0 = cost of default (or output loss as a result of reserves rundown)

C_1 = (total) opportunity cost of holding reserves, where $C_1 = rR$

r = (marginal) opportunity cost of holding reserves

R = reserves

Minimizing this expected cost function yields:

$$EC_R = \pi_R(C_0 - rR) + (1 - \pi)r = 0$$

where EC_R = first derivative of expected cost function with respect to reserves

π_R = first derivative of probability of default with respect to reserves

Solving for R from this first order condition will yield an optimal level of reserves. However, as will be explained hereafter, the probability of default (π) is a function of reserves and thus reserves cannot be solved explicitly. An iterative process must be used to solve simultaneously for reserves and the probability of default.

Before trying to solve for the optimum level of international reserves, the three key determinants will need to be estimated:

- (1) the cost of default, C_0
- (2) the probability of default, π
- (3) the opportunity cost of holding reserves, C_1

1. Cost of Default

Ben-Bassat and Gottlieb (1992) measure the cost of default as a function of a country's openness or import propensity. They calculate the cost of default--measured as 'the present value of the difference between the actual GNP after default, Y_t , and potential GNP, Y_t^p '--of 13 countries that defaulted between 1960 and 1982. Then they estimate a log-linear relationship between the cost of default and the openness in the year before default. Finally they use this estimated equation to approximate each year cost of default for the case of Israel.

As Thailand has witnessed output loss from the financial crisis in 1997, experiencing a negative growth rate in 1997 and 1998, this paper approximates each year cost of reserves rundown for Thailand based on the actual output loss from the 1997 crisis, instead of using the equation estimated by Ben-Bassat and Gottlieb. Potential output is first estimated based on Hodrick- Prescott filter technique. The result is an average growth rate of about 2 percent per year over a five-year period 1995-2000.⁶ Assuming that without the crisis the economy will be able to grow according to this smoothing trend, output loss is then measured as the difference between this potential output and the actual output. This difference is calculated for the four years following the crisis (1998-2001).

$$C_0 = \sum_{t=0}^n (Y_t^p - Y_t) \delta^t$$

where C_0 = cost of default

Y_t^p = potential output

Y_t = actual output

δ = annual discount factor

For simplicity, this paper will assume that this output loss will remain constant throughout the period of study. It is worth noting that the equation estimated by Ben-Bassat and Gottlieb (1992) is not used to estimate the cost of default in this case because the relationship between the real-side openness measured by the average propensity to import and the cost of default is inclined to change from the time the equation was estimated. There are two remarks regarding this. First, the speed of recovery from

⁶ This corresponds with the work by Barro (2001), who estimate the 'baseline' growth rate of per capita Thai GDP for the same period to be 3.1 percent per year.

output loss can differ greatly among countries, and, second, the measurement of openness of an economy is directed more towards the financial-side openness, basically the liberalization of capital account.

2. Probability of Default

Probability of default plays the key role in taking into account the creditworthiness role of reserve level. It traces out how the reserve adequacy affects the creditworthiness of the country which is captured in the probability of default. This probability implies how risky is a country and how likely that it will default on its debt and go into a crisis.

2.1 The model for the probability of default

Ben-Bassat and Gottlieb (1992) have assumed a logistic probability function for the default probability as a function of the key reserve-related economic variables. They base their equation on the idea that sovereign risk bears stable relationship with economic variables that reflect the problem of external liquidity and solvency as well as other economic variables reflecting the effectiveness of macroeconomic policies. Their equation can be written as

$$\pi = \frac{e^f}{(1 + e^f)},$$

where f is a function of the economic variables. In their paper, Ben-Bassat and Gottlieb (1992) specify f to be,

$$f = a_0 + a_1 \log\left(\frac{R}{M}\right) + a_2 e^{\frac{D}{X}} + \sum a_i z_i.$$

where R = international reserves

M = import

$$D = D_n + R$$

D_n = External debt, net of international reserves

X = export

M = import

z_i = other economic variables, namely propensity to import (m) and per capita income (y)

The non-linear specification of the liquidity ratio and solvency ratio is based on the assumptions of their marginal effects. Creditworthiness increases at a diminishing rate with the liquidity ratio while decreases at an increasing rate with the debt ratio. Thus, the model specifies the logarithm for the reserve to import ratio and an exponent for the debt to export ratio.

In order to calculate the probability of default, π , as a function of all the key macroeconomic variables, the equation for f has to be estimated. To regress f on the right-hand side economic variables, the values of f itself must first be calculated.

Ben-Bassat and Gottlieb (1992) approaches this by assuming that the odds of default, $\frac{\pi}{(1-\pi)}$, are equal to the discounted risk premium in a perfect capital market, by

citing the work of Feder and Just (1977):

$$\frac{\pi}{(1-\pi)} = \frac{(i_D - i)}{(1+i)}$$

where i_D = rate offered by risky borrower

i = safe rate

Since $f = \log\left(\frac{\pi}{1-\pi}\right)$, $f = \log\left(\frac{i_D - i}{1+i}\right)$, or f is equal to the log of the discounted risk premium. Thus, the equation for f can be estimated by regressing discounted risk premium on the macro economic variables.

This paper first follows this exact same specification. However, the ratio of short-term debt to reserve has become increasingly crucial, as mentioned earlier. Wijnholds and Kapteyn (2001) conclude that the reserve adequacy measured in terms of imports have become relatively less important particularly in countries that rely heavily on capital inflows. The level of reserves to the size of short-term external debt, on the other hand, has become more significant. In their work, they have modified this ratio further to allow for possible capital flight and taking into account differences in country risk and exchange rate regime. Therefore, in order to update the model, this paper will attempt to estimate the probability of default function that also incorporates the ratio of short-term debt to reserve ratio, although only the simple ratio and not the modified one will be employed here.

2.2 The estimation

Three equations are estimated. First the original specification by Ben-Bassat and Gottlieb (1992) is estimated. Then it is modified by using a dummy variable to capture the exchange rate regime change. Finally, an equation incorporating the ratio of reserves to short-term debt is estimated.

1. Original specification:

$$f = a_0 + a_1 \log\left(\frac{R}{M}\right) + a_2 e^{\frac{D}{X}} + a_3 m + a_4 y$$

where m = ratio of imports to GDP

y = per capita income

2. Original specification modified to capture the change exchange rate regime:

$$f = a_0 + a_1 \log\left(\frac{R}{M}\right) + a_2 e^{\frac{D}{X}} + a_3 m + a_4 y + a_5 \text{fix}$$

where fix = dummy variable for fixed exchange rate regime

3. Liquidity specification, introducing the ratio of reserves to short-term debt:

$$f = a_0 + a_1 \log\left(\frac{R}{M}\right) + a_2 e^{\frac{STD}{R}} + a_3 m + a_4 y + a_5 \text{fix}$$

where STD = short-term debt

The estimation of f will then yield the values for the probability of default. Recall that the probability of default can be written as:

$$\pi = \frac{e^f}{(1 + e^f)}$$

Ben-Bassat and Gottlieb (1992) suggest that the method of two-stage least square is preferred over OLS since the probability of default (π) and reserve (R) are determined simultaneously. *Opportunity cost* of reserves and *total external debt* are then used as instruments. Based on the two-stage least square estimation on (annualized) quarterly data for Thailand for the period of 1994:1 to 2001:4, the following results are obtained.

Equation 1, which follows Ben-Bassat and Gottlieb (1992) specification exactly, is insignificant. Since this can be a result of a structural break during the period of crisis, a dummy variable 'FIX' is added to the equation to yield Equation 2. That improves the significance of the estimated coefficients. Most coefficients are significant at a 25 percent level.

Box.4 Two-stage Least Square Estimated Results: Discounted risk premium (f) as dependent variable				
		Specification		
		1. Original	2. Original with dummy	3. Liquidity
constant		-5.58	3.58	6.27
	<i>(t-statistic; probability)</i>	<i>(-1.48; 0.15)</i>	<i>(1.26; 0.22)</i>	<i>(1.46; 0.16)</i>
log (reserves/imports)	log (R/M)	-0.49	-3.27	-5.93
		<i>(-0.14; 0.88)</i>	<i>(-1.79; 0.08)</i>	<i>(-2.18; 0.04)</i>
exp (short-term debt/ reserves)	$e^{(STD/R)}$	-	-	0.99
				<i>(2.92; 0.01)</i>
exp (total debt/exports)	$e^{(D/X)}$	0.04	0.03	-
		<i>(1.35; 0.18)</i>	<i>1.83; 0.08)</i>	
average imports	m	-0.17	-18.87	-15.75
		<i>(-0.03; 0.97)</i>	<i>(-3.97; 0.00)</i>	<i>(-2.37; 0.03)</i>
per capita income	y	0.000021	-0.000044	-0.00017
		<i>(0.32; 0.75)</i>	<i>(-1.16; 0.26)</i>	<i>(-2.35; 0.03)</i>
dummy for fixed regime	fix	-	2.06	0.99
			<i>(5.78; 0.00)</i>	<i>(1.59; 0.12)</i>
R-squared		0.1072	0.6312	0.2801

The signs of the coefficients are as expected, corresponding to the results obtained by Ben-Bassat and Gottlieb. The liquidity ratio, reserve to import, has a negative effect on risk premium while the *insolvency* ratio, debt to export, has a positive effect. An increase in the openness of a country (m) and per capita income (y) reduces risk premium. Finally, under fixed exchange rate regime, the risk premium is higher. Price distortion of exchange rate constitutes one explanation for this positive dummy coefficient. Another explanation for the positive sign is that, under the fixed exchange rate regime, Thailand needs to maintain high level of interest rate in order to attract capital inflows and maintain its fixed rate. However, under the flexible exchange rate regime, such constraint can be relaxed. Also, it can be argued that under a fixed rate, there is less scope for inflation tax (seignorage) under a fixed rate, so public debt financing is more of a problem.⁷

In Equation 3, a new variable, (the exponent of) the ratio of the short-term debt to reserve, is introduced, in place of the solvency ratio. The introduction of this short-term

⁷ I am grateful to Professor Frankel for pointing this out.

debt to reserve ratio is done partly to evaluate if this new variable warrants much of the attention that has been paid to it. Inclusions of other variables reflecting a country's creditworthiness such as the solvency ratio, debt to export, and debt to GDP ratios, are constrained by the problems of multicollinearity. (The same problems prevented Ben-Bassat and Gottlieb (1992) from incorporating these ratio as well.) However, as discussed earlier, the ratio of short-term debt to reserve is becoming important in gauging country's risk. In the interest of seeing how this ratio will influence the holding of reserves, this equation is left with only the liquidity ratio, instead of having both the solvency and liquidity ratio. The signs are as expected. Most coefficients are significant at a 20 percent confidence level, better than that of the second specification, although the R-squared is relatively low.⁸

Given these estimated parameters, the role of reserves holding to strengthen creditworthiness can be traced out through the risk premium and probability of default. These estimated parameters will be used in the calculation of the optimal level of reserves.

3. Opportunity Cost

The opportunity cost is calculated in terms of the return that accumulation of foreign exchange could have produced if not withheld by the central bank. This is the cost many critics of reserve accumulation have been discussing. Many countries have been accumulating very high levels of reserves, especially those countries that have witnessed currency crisis, as implied by **Figure1** earlier. Because reserves serve as international liquidity, their investment is limited to short-term safe liquid investment,

⁸ Caution must be exercised when interpreting R-squared under a two stage least square method as R-squared also can take negative value. (Woolridge 2000)

which yield very low rate of return. This capital could have been invested elsewhere, for example government projects or private investments, which may yield higher social or private return rate than holding as reserve. However, as the level of reserves increases beyond a certain benchmark, reserves are allowed to be invested in medium to long-term investments which yield higher return accordingly (IMF 2001b). These forgone earnings are calculated according to Ben-Bassat and Gottlieb (1992) as follows:

$$C_1 = rR$$

where r = marginal productivity of capital – return on assets (which varies from US Treasury bill rate to 3-year government bond yield depending on reserves level)

DATA DEFINITIONS AND SOURCES OF VARIABLES

- Y = GDP deflated by consumer price index. *Source:* International Financial Statistics (IFS)
- M = total imports of goods and services deflated by the unit value of imports (1995=100). *Source:* IFS
- X = total exports of goods and services deflated by the unit value of imports (1995=100). *Source:* IFS
- R = international reserves minus gold, converted into Baht using at end exchange rate and deflated by the unit value of imports (1995=100). *Source:* IFS
- D = total external debt (BoT), converted into Baht using at end exchange rate and deflated by the unit value of exports (1995=100). *Source:* Bank of Thailand (BoT) and IFS.
- STD = short-term external debt (BoT), converted into Baht using at end exchange rate and deflated by the unit value of exports (1995=100). *Source:* BoT and IFS.
- i_D = Thai government bond yield adjusted by Thai inflation rate (CPI). *Source:* IFS
- i = US government bond yield adjusted by US inflation rate (CPI). *Source:* IFS
- r = lending rate – US Treasury bill rate. *Source:* IFS. (OR)
 = lending rate – US government bond yield. *Source:* IFS.
- FIX = 1 under fixed exchange rate regime, 0 otherwise.

Note:

1. Since quarterly data on stock of external debt are not available for the period 1994:1-1998:4, they have to be interpolated using the proportion of quarterly debt flows.
2. Quarterly data on population are not available throughout the period. For simplicity, population is assumed to grow linearly.

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