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**Working Paper**

# Prolonged reserves accumulation, credit booms, asset prices and monetary policy in Asia

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Andrew J. Filardo and Pierre L. Siklos

# Prolonged reserves accumulation, credit booms, asset prices and monetary policy in Asia

Bank of Finland, BOFIT
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Andrew J. Filardo and Pierre L. Siklos

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## Abstract

This paper examines past evidence of prolonged periods of reserve accumulation in Asian emerging market economies and the direct and indirect implications for monetary stability through the potential impact of such episodes on financial stability. The empirical research focuses on identifying periods of prolonged interventions and correlations with key macro-financial aggregates. Related changes in central bank balance sheets are also examined, especially in periods when the interventions are linked to strong capital inflows. In particular, we consider whether changes in the central bank's balance sheet from prolonged intervention lead to spillovers to the balance sheet of the private sector. We explore the possible forms of the spillovers and the consequences on asset prices (e.g., housing prices, equity prices, the growth in domestic credit). Policy implications are drawn. Finally, we propose a new indicator of reserves adequacy and excessive foreign exchange reserves accumulation based on a factor model. Two broad conclusions emerge from the stylized facts and the econometric evidence. First, the best protection against costly reserves accumulation is a more flexible exchange rate. Second, the necessity to accumulate reserves as a bulwark against goods price inflation is misplaced. Instead, there is a strong link between asset price movements and the likelihood of accumulating foreign exchange reserves that are costly.

Keywords: foreign exchange reserves accumulation, monetary and financial stability
JEL Classification system: F41, F32, E44, D52

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# 1 Introduction

Foreign exchange reserves accumulation has been a striking development in the global economy over the past two decades. The potential impact of foreign exchange reserves holdings on real economic performance and, more importantly, to the implications for economic performance when such holdings keep rising for prolonged periods of time has been largely ignored. While there is a vast literature on the determinants of reserves holdings we are unaware of any study of economies that accumulate foreign exchange reserves on a prolonged basis. Interest in the consequences of economies attempting to manipulate their currencies, in part through foreign reserves management, is not new. However, the topic lately has garnered more attention thanks to the growing prominence of China in international economic affairs, and the seemingly concerted attempt by emerging markets more generally to accumulate vast amounts of foreign exchange reserves.[1] The emergence of the G20 as a force for dealing with the cooperative measures necessary to reform the current international monetary system is also a factor that is raising awareness about foreign exchange management practices.

Whereas the early literature in this area (e.g., Heller 1966, Frenkel and Jovanovich 1981) sought to determine optimal levels of foreign exchange reserves, either based on precautionary motives, or by relying on principles of inventory management, research in recent years has shifted to asking why it became increasingly attractive for central banks, notably in emerging markets, to accumulate reserves particularly when many evinced a tendency to adopt more flexible exchange rate regimes, occasionally alongside a form of inflation targeting. As levels of reserves holdings soared, spurred by the Asian crisis of 1997-98, and again following the more recent financial crisis of 2007-9, the question whether reserves accumulation are, in a sense, 'excessive',[2] has once again attracted the attention of policy makers. Politicians, notably in the U.S. and China, have also raised questions about the macroeconomic implications of inherent imbalances reflected in the growth of foreign exchange reserves (e.g., see Morrison and Lebonte 2011).

[1] More recently, the Swiss National Bank decided to set a floor on the EUR/CHF exchange rate at 1.20CHF in view of the "…acute threat to the Swiss economy …" posed by the massive overvaluation of the Swiss franc." (see press releases of the SNB (www.snb.ch), 6 September 2010. Since the announcement, Switzerland has been called the 'new China' in currency markets. See Ross (2012).
[2] Given fundamentals of the economy in question and the global economy more generally.

Figure 1 reveals an upward trend in the ratio of foreign exchange reserves to GDP, beginning in the 1990s, in 9 of the 12 economies in the Asia-Pacific region that are the focus of the present paper.[3] Indeed, by 2010, reserves exceed 40% of real GDP in 6 of 12 economies shown (China, Hong Kong, Malaysia, Singapore, Thailand) and the 20% threshold is reached in four other countries (India, Japan, Korea, Philippines). While there is a fairly consistent pattern in the overall trend of reserves accumulation, the motives for doing so may well have been different if only because some of the economies in our sample face current account deficits, others wish to maintain an export growth driven policy, and still others may be reacting more strongly to the need to insure themselves against the consequences of future financial crises. Also highlighted in the figures are the periods of the Asian Financial Crisis (AFC; 1997-98) and the Global Financial Crisis (GFC; dates vary, see Dominguez, Hashimoto, and Ito (2011), Table 3). While reserves, as a fraction of GDP, rose slightly in India and Indonesia and more so in the Philippines, Singapore, Thailand, Australia, and New Zealand, only China, Malaysia and Japan experienced a modest decline. Visual comparisons with the AFC suggest a similar pattern with the exception of China and Korea, which saw increases while volatility characterized the experiences of Thailand and New Zealand.

Arguably, the most salient development in recent years is not only the apparent the rise in levels of foreign exchange reserves holdings but, perhaps more importantly, the incidence of episodes of prolonged reserves accumulation. In other words, episodes when the rise in foreign exchange reserves exceeds a variety of metrics that proxy trends in reserves holdings have, at times, been persistent or prolonged. This type of behavior also suggests an asymmetry of sorts in the practices of foreign exchange holdings with a clear tendency towards the accumulation of reserves with fewer instances of drawing down on these reserves. This phenomenon has already been observed by some (e.g., Blanchard, Faruqee, and Dias 2010; Aizenman and Sun 2010) and it has been argued (e.g., Dominguez, Hashimoto, and Ito 2011) that such an outcome can be interpreted as reflecting a desire to hold sufficiently large stocks of reserves to ward off future speculative attacks thereby obviating the need to reduce them, much like the lender of last resort function of a central bank is activated only in exceptional circumstances.

[3] The accumulation of foreign exchange reserves is especially noticeable in some economies in the Asia-Pacific region. Nevertheless, the phenomenon studied in this paper is also found elsewhere in the world such as in some economies in Latin and South American, Central and Eastern Europe, and Russia.

*The Economist* (2010) refers to a 'monsoon' to describe recent patterns of reserve accumulation, particularly in emerging markets. Table 1 illustrates the phenomenon by listing episodes when the three year moving average year on year changes in the reserves to GDP ratio is positive in the 12 economies in our sample.[4] Certain episodes reflect the impact of the AFC on economies such as Hong Kong and the Philippines. Elsewhere, the moving average proxy remains positive, again in the aftermath of the Asian crisis of 1997-98 in countries such as Indonesia, Korea, and Singapore. Finally, there is widespread reaction to the financial crisis of 2008-9 as evidenced by the reserves build-up in Hong Kong, Malaysia, Thailand, India, Australia, and New Zealand. Interestingly, there is almost no overlap between the episodes of prolonged reserves accumulation and so-called 'sudden stops' wherein a sharp reversal in capital flows takes place (see, for example, Jeanne and Rancière (2006), Table 1, and Durdu et. al. (2009), Table 1).

Strikingly, the literature provides little guidance to explain why these episodes emerge. Clearly, policy makers believe that such behavior can pose economic risks, especially in emerging markets (e.g., Mohanty and Turner 2006, Genberg et.al. 2005). More recently, Obstfeld (2011) has highlighted the fiscal implications arising from the accumulation of foreign exchange reserves. Moreover, sterilization is likely imperfect (e.g., see Lavigne 2008, Disyatat and Galati 2005, Siklos 2000, for the experience of emerging markets), while other macroeconomic indicators such as credit growth and asset price developments, albeit useful, provide noisy signals. Surely, the fact that Hong Kong, Singapore, joined soon perhaps by China, have reserves that approach their annual GDP levels (see Figure 1) portend macroeconomic implications that are, as yet, not well understood.[5] Moreover, it is possible that by examining periods when central banks increase their holdings of foreign exchange on a sustained basis we can glean additional insights not apparent from other methods used to ascertain the stance of monetary policy.

While textbook models posit that an increase in reserve money would lead to a boost in credit through a multiplier effect, which then spills over into the macroeconomy, this ignores the response of the authorities who change reserve requirements to at least par-

[4] Other metrics are considered and evaluated below.
[5] Nevertheless, these developments reflect persistent imbalances at the global level that would translate into an "… intensification of pressures on international monetary, financial and trading systems." (Haldane 2010).

tially close this channel among other policy responses that have recently implemented.[6] Similarly, another consequence of the accumulation of foreign exchange reserves may also be reflected in interest rate changes but this channel may function poorly if considerable financial repression is present or the authorities prefer, on balance, to operate with a loose monetary policy. Finally, another avenue may well be through asset prices unless the central bank offers relatively attractive yields to investors. Otherwise, the kind of risk-taking behavior that led to asset price bubbles in the past may well once again be encouraged.[7]

Since we do not yet fully understand the consequences of attempts at persistent reserves accumulation the present paper is an attempt to provide some stylized facts and estimates of the role played by macroeconomic, financial, and institutional factors in determining the likelihood of observing this kind of phenomenon.[8] To be more precise, we consider the following questions:

(1) To what extent is foreign exchange reserve accumulation a response to perceived financial instability?
(2) Can foreign exchange reserve accumulation be characterized as 'excessive'? If so, can we define episodes of prolonged accumulation? Is there a connection between such episodes and notions of 'financial fragility'? And, are output effects linked to reserve accumulation behaviour?
(3) Are changes in the central bank's balance sheet resulting from prolonged intervention reflected in the balance sheet of the private sector? In what form and with what consequences? (e.g., housing prices, equity prices, the growth in domestic credit).

Prolonged foreign exchange reserves accumulation has not, to our knowledge, been empirically studied. We provide a simple motivation by appealing to the usefulness of having multiple instruments when there is one than one monetary policy objective. Essentially, relatively fast-growing emerging markets, particularly ones in Asia, opted for a macroeco-

[6] These used to be referred to as monetary policy tools but, in response to the crisis if 2007-9 and the shift away from the interest rate as the predominant instrument of monetary policy, they are now called 'macroprudential tools'. In this connection, see Ishi, Stone, and Yehoue (2009).
7 If the resulting investment behavior leads to 'malinvestment' then there exists another avenue through which the accumulation of foreign exchange reserves can be economically costly.
8 We do not address the issue whether this kind of behaviour represents a deliberate choice by policy makers in the economies considered or a failure to suitably cooperate in managing international economic conditions. Also not considered are the financial costs of holding and managing such reserves, especially in an era of historically low yields, and the foregone opportunities from not investing these funds in more profitable, if not more productive, endeavours.

nomic policy geared towards two objectives. They are: exchange rate stability and domestic economic stability which can be thought of in terms of financial stability. To achieve these aims, as required by Tinbergen's principle,[9] two policy instruments were deployed, namely a policy rate (or a related monetary policy instrument such as changes in bank reserves requirements) and prolonged foreign exchange reserves accumulation. Nevertheless, there are consequences to accumulating vast amounts of foreign exchange reserves and these entail economic costs that can be measured vie output effects, asset prices, or both.

The rest of the paper is organized as follows. We begin with a summary of the relevant literature. The data are described in section 4 before outlining the empirical evidence in section 5. The paper concludes with some policy implications and suggestions for further research.

# 2 Background literature

Research on the practice of holding foreign reserves, particularly among emerging market economies, typically identifies three motives. They are: a precautionary desire to provide adequate foreign exchange reserves in case an economic shock might otherwise precipitates a crisis (e.g., Aizenman and Marion 2003); a mercantilist view, revived by those who believe that the original Bretton Woods exchange rate system lived on in a fashion, after its apparent demise in the 1970s, as a system that enabled some countries to protect their export markets (e.g., Dooley et. al. 2004); and, finally, a financial stability motive, essentially a variant of the precautionary motive wherein the ability to limit the damage following the onset of a financial crisis and, hence, any threats to financial instability, can be thwarted by ensuring that a sufficiently large 'buffer stock' of reserves is available (e.g., Jeanne and Rancière 2006).

Concerns over the foreign exchange reserves practices of some countries sometimes rest on the concept of the 'impossible trinity', also called the policy trilemma, wherein domestic policy making is constrained by the degree of capital mobility, the ability to set a domestic interest or policy rate, and the choice of exchange rate regimes. Nations must choose a between a fixed exchange rate or an autonomous monetary policy, but

[9] Namely, that the number of policy instruments should be at kleast as large as the number of policy objectives.

not both. Exchange rate regimes that limit movements in the exchange rate may give up to some degree autonomy in the realm of monetary policy, depending upon their willingness and ability to engage in sterilized interventions.

The desire to accumulate foreign exchange reserves, and the willingness of countries to face exchange rate pressure, will be dictated by a whole range of factors that influence macroeconomic conditions and policymakers' preferences for autonomy in setting the stance of policies. This gives rise to a variety of intervention practices in foreign exchange markets beyond sterilizing foreign exchange transactions. For example, Aizenman and Hutchison (2010) report that, in the crisis that engulfed the world economy during 2008-9, the emerging markets they examined allowed the exchange rate to bear much of the adjustment over the alternative of allowing foreign exchange reserves to be depleted. In their view, this represents evidence of a shift from a fear of floating to a fear of losing reserves (Aizenman and Sun 2009). Figure 1 does seem to provide some graphical support for this view. In related work, Aizenman, Lee, and Sushko (2010) also point out that the fear of losing reserves may well have been exacerbated by the fact that, unlike many industrial economies, emerging market economies did not have access to the swap lines with the U.S. Fed.[10] As a result, financial factors played a far greater role during the latest crisis than when the world economy was in a period of the Great Moderation.

These policy choices, however, are not without private and social costs.[11] Central banks, as agents for the government, must define a set of objectives to guide reserves management.[12] For the private sector, the desire to hold large quantities of foreign exchange may well influence how quickly the domestic financial market matures leading to a form of financial repression if there is excessive reliance on foreign exchange holdings as a matter of policy. China is a case in point, at least according to Lardy (2008). Moreover, as Pihlman and van der Hoorn (2010) argue, abrupt shocks to the banking system, combined with prudent risk management practices, could well indirectly contribute to creating finan-

[10] These swap lines were meant to alleviate the apparent shortage of US dollars. The countries in our sample this facility was made available to were Japan, Korea, and Singapore. See Dominguez, Hashimoto, and Ito (2010).

[11] Rodrik (2006) defines these as the difference between the yield on liquid reserve assets and the external cost of funds, that is, the private sector's cost of borrowing from abroad. These can represent up to 1% of GDP according to some of his estimates. Against these costs are the potential benefits from a reduction in the incidence of financial crises. We return to this issue below.

[12] IMF (2001) outlines the following general principles: "Reserves management should seek to ensure that (1) adequate foreign exchange reserves available for meeting a range of objectives; (2) liquidity, market, and credit risks are controlled in a prudent manner; and (3) subject to liquidity and other risk constraints, reasonable earnings are generated over the medium to long term on the funds invested."

cial instability due to pro-cyclical behavior in the investment practices of foreign exchange reserves. This may also go part way to explain the composition of foreign exchange reserves. Beck and Weber (2010) find a link between foreign exchange reserves holdings and the proportion invested in safe assets. They argue that the critical factor is the role played by risk aversion, which is proxied by the capital account openness index developed by Chinn and Ito (2008).

In recent years empirically based attempts to establish whether foreign exchange holdings exceed some level deemed adequate, but not necessarily optimal, often rely on the benchmark known as the Greenspan-Guidotti (G-G; Greenspan 1999, Guidotti et.al. 2004) rule. This rule stipulates that, if the ratio of external debt with a maturity of up to one year to total external debt equals one, this ought to provide adequate protection against an economic shock that threatens the external position of the domestic economy.[13] Why such a rule would apply to economies that either do not borrow from abroad or do so modestly, is unclear. Nevertheless, the rule does indicate a level of concern about insuring against adverse capital outflows. Moreover, since so many countries exceed this rule, often by a wide margin (e.g., see ECB 2006), the practice of accumulating large quantities of foreign exchange holdings is regarded as something of a puzzle.

It is worth underscoring the fact that there is no agreement about whether the G-G rule, or some variant, applies equally to any emerging market. For example, while the September 2003 *World Economic Outlook* (IMF 2003) recommended that Asian economies cut back on their policy of building up foreign exchange reserves, the data in Figure 1 suggest that most countries did not heed their advice. Perhaps, as recently pointed out by Blanchard and Milesi-Ferretti (2011), reserves holdings that appear in excess of what is deemed adequate for the purposes of crisis prevention may simply also reflect the role played by capital controls that limit the ability of domestic residents to acquire foreign financial assets. However, if this interpretation is correct, then periods of prolonged reserves accumulation could represent an indicator of persistent imbalances between savings and investment. Indeed, the resulting imbalances are thought to have contributed to the recent U.S. housing bubble as well as providing the necessary fuel for its subsequent bust (Bernanke et. al. 2011). It is conceivable then that the accumulation of foreign exchange re-

[13] Jeanne and Rancière (2006) specify a model whose aim is to quantify the size of foreign exchange reserves holdings needed to satisfy precautionary motives. They conclude that the G-G rule is plausible under certain circumstances and, hence, they provide a theoretical rationale for this type of rule.

serves can, indirectly, create a global shock. Therefore, whereas the extant literature typically considers the home grown consequences of foreign exchange reserves policies there exists the potential for this kind of behavior to actually induce a crisis resulting in real economic consequences.

The empirical literature has relied on a large set of economic determinants to econometrically explain foreign exchange reserves holdings (e.g., see Dominguez, Hashimoto, and Ito 2011, Dominguez 2010, Hashimoto and Ito 2007). Typically, the focus has been on the short-run, although a few studies have also considered whether determinants of reserves holdings and the quantities of foreign exchange reserves held are attracted to each other, in a statistical sense, thereby raising the possibility that there are also long-run determinants of foreign exchange reserves holdings (e.g., Gosselin and Parent 2005), many of which are the same ones as the ones that appear in short-run studies of the determinants of foreign exchange reserves. Variables believed to influence reserves holdings run the gamut from the exchange rate regime to the state of domestic fiscal policy. Only recently have studies begun to consider the implications of recurring financial crises on reserves behavior (e.g., Gourinchas, Rey, and Govillot 2010).

While there is no general consensus about the candidates for the most important variables that can explain the rapid growth in foreign exchange reserves holdings, trade openness and a country's exposure to financial shocks appear to loom large (e.g., Aizenman and Lee 2005, CGFS 2009). Another important trigger for reserves accumulation comes from the desire to prevent the next crisis from spilling over onto the domestic economy (i.e., the crisis prevention motive). Rather than dampen the desire to accumulate reserves the reverse may actually take place leading to even greater incentives to maintain what appears to be an excessive reliance on reserves.

As noted in the introduction, beyond the factors that can explain levels or changes in reserves holdings, is the observation that episodes during which reserves accumulate are prolonged. However, there is effectively no empirical guidance about whether this phenomenon can be linked to fundamentals that are typically used in assessing aggregate economic performance (i.e., output and inflation performance, the behavior of asset prices, and so on). This is surprising. Poole (1992), for example, documents how the Plaza-Louvre Accords of 1985-1987 impacted the U.S. economy as well as the economies of the U.K.,

Germany, and Japan.[14] This resulted in a sharp and prolonged change in the foreign exchange reserves holding of all of these countries that lasted several years (op. cit., Figure 3). As a result, the real economic implications for the U.S. were clear to Poole: "This classic monetary-policy cycle was accompanied by a classic cycle in real activity. Industrial production first rose in response to higher money growth and then fell as inflation rose and money growth declined." (op. cit., p. 75) Just as important, there were real economic effects on the other major economies as well. Indeed, not even Frankel's exhaustive survey (Frankel 2010) mentions this phenomenon apparent in several emerging market economies preferring instead to highlight disagreements over whether amassing foreign exchange reserves can largely be explained by precautionary or mercantilist motives.

Of course, the real impact of accumulating foreign exchange reserves may operate indirectly through its impact on financial stability. Frankel and Saralevos (2010) report a reliable and strong link between reserves holdings and the incidence and severity of a financial crisis.

# 3 Data and stylized facts

In what follows we rely on data at the quarterly sampling frequency to examine the determinants of prolonged reserves accumulation in 12 economies in the Asia-Pacific region. They are: Australia, China, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore, and Thailand. The sample periods employed in the empirical analyses to follow vary owing to differences in data availability and coverage. In addition, as the motives for holding reserves may well have evolved over time (e.g., see Obstfeld 2011) we also provide estimates for different country groupings for samples that begin on the 1960s, 1970s, and 1980s. The raw data were not always available at the quarterly frequency. If the original data are monthly then arithmetic averaging is used to convert them to the quarterly frequency. When the raw data are annual, or semi-annual, linear interpolation is used to create a quarterly equivalent time series. An appendix provides details about data availability and variable definitions.

It is well-known there exist several ways of measuring the size of foreign exchange reserves adequacy including the reserves to GDP ratio, reserves to imports, and re-

[14] Indeed, Japan's 'lost decade' may well have been triggered in part because of the appreciation of the yen that followed these two agreements. See, however, IMF (2011, Box 1.4) for a different interpretation.

serves to short-term external debt. All are intended to capture an economy's ability to withstand economic shocks operating through their balance of payments.[15] Moreover, the theoretical literature provides no convincing argument to support one measure over another. In what follows, results rely on the reserves to GDP indicator not only because it is the one typically adopted in the literature but it is also available for the longest span of time.[16]

Figure 1, briefly discussed earlier, plots a frequently used measure of reserves adequacy for each one of the 12 economies in the sample. At the risk of oversimplifying matters one can identify two categories of reserves management behavior based on their overall time series characteristics. The ratio of foreign exchange reserves to GDP is largely stationary for Australia and New Zealand. Both countries, of course, have targeted inflation since the early 1990s, although the behavior of the reserves to GDP ratio pre-dates the adoption of this monetary policy regime. Inflation targeting alone cannot explain the behavior of any measure of reserve adequacy since, for example, Korea also adopted the same monetary policy strategy. In spite of this, Korea's experience suggests that perhaps it belongs to the group of economies, along with China, Hong Kong, India, Japan, Singapore, Thailand and the Philippines, that show a steep upward trend in reserves accumulation especially in the 2000s.[17] The group spans the range of exchange rate regimes from China's pegged exchange rate through Singapore basket peg approach and Korea's managed floating regimes. We also consider below the connection between episodes of prolonged accumulation of reserves and the choice of exchange rate regimes over time.[18]

[15] Another measure that is occasionally used is the ratio of foreign exchange reserves to some monetary aggregate. A practical difficulty with this measure is that monetary aggregates are frequently redefined or can contain some discontinuities.

[16] The choice of proxies would perhaps matter less if there was a long run relationship between the series in the cointegration sense. Unfortunately, tests (not shown) for a sample from 1985-2010 suggest either that the various measures are independent random walks or that, at most, a linear combination of two of the three indicators referred to above appear to be cointegrated. An obvious alternative, to our knowledge, not considered to date is to estimate a factor model that exploits the predictive content of each measure of foreign exchange reserves holdings. We return to this possibility below. We constructed such measures but the resulting indicators did not alter our conclusions (results not shown).

[17] Korea adopted inflation targeting in 1998, Thailand in 2000, and the Philippines in 2002.

[18] For reasons to be made more explicit later on, the data do not appear to support the notion that, over the entire available span of data, a 'keeping up with the Joneses' phenomenon can explain movements in reserves holdings. There is effectively one common trend between the 12 series shown in Figure 1. Moreover, 'contagion' type tests (e.g., see Dungey, Fry, and Martin 2009), conducted over the full sample as well as covering a shorter sample since 1990, rejects in many cases contagion type effects from either China or Japan. Nevertheless, there are a few exceptions. For example, the null hypothesis of contagion from either China or Japan to the 10 remaining economies cannot be rejected for Hong Kong and Korea, for either sample considered. When the shorter sample is examined one can add Singapore and Thailand to the list. How-

While Figure 1 gives a sense of the evolution of reserves holdings, and as we are also interested in changes in these holdings over time, Figure 2 plots two proxies for foreign exchange reserves movements. They are: a three year centered moving average of changes in the reserves to GDP ratio and deviations from a H-P filtered reserves to GDP ratio measure.[19] While there is clearly evidence of prolonged rises and declines in changes in foreign exchange reserves holding relative to some trend, this finding is especially apparent for the moving average proxy. As a result, in the empirical analysis presented below, our indicator of prolonged reserves accumulation will be measured based on the three year moving average benchmark.

Next, we turn to a description of the incidence of prolonged episodes of foreign exchange reserves accumulation. Table 2 provides some evidence on the incidence of episodes of reserves accumulation considered sizeable or 'painful' in terms of their overlap with business cycle and asset price cycle related contractions. For this purpose we adopt the approach for selecting business cycle contractions of the 'sizeable' and 'painful' varieties elaborated in Edwards (2007).[20] Sizeable foreign exchange reserves accumulation episodes take place when, for example, the reserves to GDP measure rises (or falls) by 3% or more. As shown in Table 2 such a threshold implies that Australia, Japan, New Zealand, and the Philippines experienced no such events. Since the threshold is somewhat *ad hoc* the Table also shows the case when the threshold is set at ± 2%. Given that the threshold applies to data at the quarterly frequency even a 2% threshold arguably represents a sizeable rise in the reserves to GDP ratio. In addition, since the resulting proxy is based on a three year centered moving average (see Figure 2), it seems reasonable to refer to them as episodes of prolonged reserves accumulation (hereafter PRA). It is also worth highlighting, as also shown in Table 2, that changes in foreign exchange reserves move in a highly asymmetrically manner with relatively few examples of sharp declines in reserves. Only Malaysia and Singapore experience drops in reserves to GDP that are greater than 2 or 3% over the sample considered.

Next, we consider the joint occurrences of episodes of prolonged reserves accumulation episodes together with contractions in business cycles and asset prices. Two sepa-

ever, it is relatively more difficult to reject the null that there is no contagion from both China and Japan to the remaining 10 economies considered in this study.

[19] A smoothing parameter of 100000 is applied to the data shown in Figure 1.

[20] Also, see the Box 'Identifying Costly Episodes: Threshold Models' which describes other metrics used to identify episodes of prolonged reserves accumulation.

rate definitions of business cycle contractions are employed. First, we adopt the definition in Edwards (2007), such that a fall in real per capita income or two consecutive periods of decline in the per capita output gap. We also consider the juxtaposition of PRAs with episodes of growth recessions based on the Economic Cycle Research Institute's (http://www.businesscycle.com/) dating of such events. Assuming that the PRA definition is based on the 3% threshold described above half the economies in the sample experience both a PRA episode and a 'painful' business cycle contraction.[21] The number of economies with the joint occurrences rises to 7 when relying on the output gap indicator while only two economies experience both PRAs and growth rate recessions, namely China and Korea.

We next consider the combination of PRAs with 'busts' in asset prices, where these are proxied by housing and equity prices. Here we adopt the Mishkin and White (2003) definition of a 'crash' in asset prices as taking place whenever there is a 20% or greater fall in equity prices on an annual basis. As seen in Table 2 these kinds of episodes take place across most of the economies in our sample as frequently as some of the other costly events considered.

Now that we have established some stylized facts concerning unusually large changes in the series of interest we next ask whether there exists some synchronicity in episodes of PRA and costly output and asset price changes, among other determinants to be considered. This is evaluated by estimating the concordance index due to Harding and Pagan (2002) between PRAs and large negative movements in equity prices and output defined above. The results are shown in Table 3 for both the full sample and a sample when either the Great Moderation prevails or when globalization is believed to take hold (1986-2007). If PRAs were perfectly synchronized with either one of the paired variables the index would be equal to one; a zero value for the index is indicative of a counter-cyclical relationship between the series. Synchronicity is enhanced during the globalization period while stock price downturns or large negative output gaps are most highly synchronized for China, Hong Kong, Malaysia, Singapore, and Thailand.

[21] If we consider a 2% threshold then 8 of 12 economies experience both a PRA and an economic contraction defined in terms of changes in real per capita GDP.

# 4 Econometric specifications and empirical evidence

Since we have identified episodes of prolonged accumulation using a wide variety of definitions that have been used in the literature we now proceed to provide some econometric estimates of the likelihood that macroeconomic and financial factors will contribute to such events. While the empirical evidence consists in using each one of the measures defined in the accompanying BOX, a common standard is used to define the dependent variable of interest. If we set equal to 1 the quarters when a prolonged reserves accumulation episode has been identified and zero otherwise then the dependent variable becomes a binary time series. Probit estimation under these circumstances is appropriate. Define $PRA_{it}$ as episodes of prolonged reserves accumulation, such that

$$PRA_{it} = \begin{cases} = 1 \text{ if } r_{it}^{*} > 0 \\ = 0, \text{ otherwise} \end{cases} \tag{0.1}$$

where $PRA_{it}^{*}$ is an unobserved latent variable while, as previously defined, $PRA_{it}$ is observed and set equal to 0 or 1, and $r_{it}^{*}$ is the foreign exchange reserves to GDP ratio that serves as the basis for selecting episodes consistent with PRA. Next, we posit that episodes of prolonged reserves accumulation, as we have defined them, are a linear function of a vector of macroeconomic and institutional variables, denoted by $\Omega_{it}$ so that we can write the estimated specification as follows

$$PRA_{it}^{*} = \Omega_{it}\beta^{'} + \eta_{it} \tag{0.2}$$

where the index *i* identifies the country and $\eta_{it}$ is a residual term assumed to have the usual properties.[22] Although we have created up to 10 proxies for the dependent variable defined in equation (1.1) Table 4 presents the results for three selected cases.[23] As previously discussed there is considerable variation in the number of episodes identified by each approach. For example, the AD (see the box for the source and legend) method finds no epi-

[22] We also considered one period lags for all of the variables that displayed some persistence. However, all of our conclusions are unaffected by this change. Hence, the results reported below omit lags.
[23] We discuss the robustness of the results while a separate Table in the Appendix provides fuller details of the estimates for each one of the threshold indicators considered.

sodes of PRA in any of the economies examined while the BL approach returns well over 200 instances when $PRA > 0$.

An additional challenge is that data availability for the economic and institutional determinants considered differs widely (see the Data Appendix for the details). Hence, Table 5 reports results for three versions of equation (1.2) as the elimination of some of the series can boost considerably the number of usable observations. In this case there is greater emphasis on reporting whether certain economies in the various samples are more or less prone to PRA, conditional on data available for the complete sample.

Finally, since there is no consensus measure of PRA we construct estimates of PRA based on a factor model where we restrict the number of factors to two since the literature suggests that both the self-insurance/financial stability and mercantilist motives generally explain the desire to accumulate foreign exchange reserves. In this case the dependent variable in equation (1.2) is replaced with one derived from estimating

$$\mathbf{Y}_{it} - \boldsymbol{\mu} = \Phi \mathbf{F}_{it} + \varepsilon_{it} \tag{0.3}$$

where $\mathbf{Y}$ is the vector of observables, here the various proxies for PRA defined in the accompanying BOX, $\Phi$ are the factor loadings, that is, essentially the relative importance of each PRA proxy in constructing the two factors representing PRA, $\mathbf{F}$ is the common factor(s) while the idiosyncratic contribution of each PRA proxy is summarized by $\varepsilon$. Table 6 provides the factor loadings for the various combinations of PRA proxies considered. The various permutations are dictated by data availability. The first factor is assumed to represent the self-insurance motive, so that each of the PRA proxies ought to be positively related to each other, while the second factor is believed to capture the mercantilist motive. In the latter case there is no reason, *a priori*, for the PRA proxies to be positively related to each other as domestic considerations will dictate the sign of the factor loadings. The resulting scores then proxy PRA. However, since these scores are not bounded in the [0,1] interval we can estimate this version of equation (1.2) via OLS.[24]

Data were collected for the following for the determinants of $\Omega_{it}$. They are: a measure of capital account openness developed by Chinn and Ito (2008), measures of ex-

[24] It is conceivable that some of the determinants of PRA are endogenous. However, experimentation also suggests that instrument quality is a potential concern making instrumental variable estimation (e.g., GMM) unreliable under the circumstances.

change rate regime flexibility introduced by Levy-Yeyati and Sturzenegger (2005), as well as a richer alternative proposed by Reinhart and Rogoff (2004), the rate of change in the nominal exchange rate, inflation, real per capita GDP growth, as well as a series of 'gap' indicators for asset prices. The methodology used to generate the gaps were previously defined and were applied to domestic credit, equity returns, foreign direct investment, real property prices, and the M2 money stock measure. The rate of change in the WTI oil price index is added to account for the role of commodity prices in influencing the desire to hold foreign exchange reserves. As a proxy for uncertainty, and the role this might play in influencing the choice to engage in a prolonged period of foreign exchange reserves accumulation, we also added the VIX as a potential determinant of the likelihood that such an episode takes place. Finally, to account for the possible role of the 'global' financial crisis, we added interaction terms to the financial variables in $\Omega_{it}$ , namely gaps in credit, real estate prices, foreign direct investment, and M2.

It was pointed out above that a well developed theory of the relationship between macro determinants of prolonged reserves accumulation and the likelihood of such episodes emerging does not exist. However, one would expect, for example, that the more flexible the exchange rate the less likely one would observe prolonged foreign exchange reserves accumulation. A similar argument would apply to explaining why greater capital account openness would reduce the need to continue accumulating foreign reserves.[25] Similarly, greater uncertainty, proxied by a rise in the VIX, might well lead the authorities to favor the accumulation of foreign exchange reserves. A rise in inflation ought to result in a depreciation of the domestic currency thereby raising the value of existing reserves and possibly leading to a decline in the likelihood that the authorities will want to continue accumulating reserves. Essentially, similar arguments apply to the influence of the various asset price gaps on the probability that foreign exchange reserves will rise. Finally, since the market for oil is denominated in US dollars, a rise in its price would lead to an enhanced desire to hold greater reserves, possibly as a hedge.

It should be noted that the results shown in Table 4 are not, strictly speaking, directly comparable to each other. The choice of specifications is motivated in part by a desire to establish the degree to which the estimates are robust to changes in the estimated model.

[25] Ultimately, the link between inflation and reserves will also depend on authorities' ability to sterilize inflows of foreign exchange.

The estimates shown in the Table suggest some robust features in the determinants of episodes of prolonged reserves accumulation. First, greater capital account mobility as well as more exchange rate flexibility reduces the likelihood of adding to the stock of foreign exchange reserves. Next, a significant positive determinant of the desire to accumulate reserves is the VIX proxy for financial uncertainty. Similarly, higher oil prices lead to greater reserves holdings, as previously hypothesized. The only impact from the global financial crisis comes from the interaction between excessive credit growth, that is, a positive credit to GDP gap, and the dummy for the crisis. Finally, it is generally found that domestic inflation reduces the desire to engage in PRA as does a booming economy, proxied here by a positive output gap. While there is a little bit of evidence that foreign direct investment during the crisis tempers the willingness to add to the stock of foreign exchange reserves, as well as some indications that real estate and equity market prices also significantly impact PRA, the results do not emerge in a sufficiently consistent fashion to be labeled as robust.

An equally interesting result is the finding that estimating two factors to proxy the self-insurance and mercantilist motives for accumulating reserves affects the sign of the likelihood that PRA will take place. For example, while a floating exchange rate will reduce the probability of engaging in PRA in the case of the self-insurance motive, the mercantilist explanation actually has an offsetting effect. Furthermore, a credit boom will raise the likelihood of a PRA when the financial stability motive is considered but the mercantilist motive leads to a reduction in the same probability.

Table 5 presents additional results that complement the ones shown in Table 4. In this case the country groupings are largely dictated by data availability. Hence, data since the 1960s is used to generate estimates of equation (1.2) for Australia, Japan, Korea, New Zealand and Singapore, while data for the next group of economies, consisting of Hong Kong, Malaysia. Philippines and Thailand begin sometime during the 1970s. The final group of countries, which include China, Indonesia, and India, rely on a sample that begins in the 1980s. This particular way of organizing the data does limit the number of determinants (i.e., $\Omega_{it}$) that can be used. Nevertheless, for the most part, the signs reported in Table 4 carry over to the estimates shown in Table 5. Of interest here, however, is whether some economies are more prone than others, on average, to engage in PRA. On this score the evidence can be quite sensitive to one's preferred proxy for PRA. This is clearly the

case for the group of economies whose data stretches back to the 1960s and the 1970s. Nevertheless, in a few instances, the results are robust to the PRA proxy employed. As a result, Hong Kong is prone to engaging in PRA while China, Indonesia, and India are less prone on average. While the result for China may appear at first glance to be surprising, the period of PRA is a relatively recent one, as both Figures 1 and 2 suggest.

# 5 Conclusions

This study has considered the economic implications of the accumulation of foreign exchange reserves most notable in Asia-Pacific economies for well over a decade. We have found considerable variations in the degree to which this kind of behavior takes place depending on the metric employed. Nevertheless, the following conclusions emerge from the stylized facts and the econometric evidence. First, the best protection against costly reserves accumulation is a more flexible exchange rate and capital mobility. Second, the necessity to accumulate reserves as a bulwark against goods price inflation is misplaced. Indeed, there is also a previously under-explored link between asset price movements and the likelihood of accumulating foreign exchange reserves for prolonged periods. Third, there is a clear and robust trade-off between output and the accumulation of foreign exchange reserves. Therefore, policies pursued by several Asian economies to accumulate these reserves are economically costly. Finally, while above trend economic growth serves to lessen the desire to hold reserves, the opposite is true in response to commodity price movements and volatility.

Since it is difficult to establish a direct link between prolonged reserves accumulation and their macroeconomic effects it is worthwhile asking about the implications of these episodes for the financial sector. A plausible scenario involves banks loading up on government securities, that is, acquiring sovereign debt with a low risk weighting and low returns. Of course, a possible reaction of banks, depending upon the quality of the regulatory environment, is to move up the risk curve as they seek to maintain stable asset or equity returns. In either case, the accumulation of foreign exchange reserves has the potential to influence financial markets and, thereby, impact macroeconomic performance via distortions in the credit allocation process. Mohanty and Turner (2006) argue that a rise in bank credit is the consequence of the accumulation of foreign exchange reserves since these have the effect of enhancing the liquidity position of the banking industry.

Unfortunately, the necessary data to investigate the effects of growing foreign exchange reserves holdings on bank performance is hard to come by. Nevertheless, based on data from Bankscope for China, Hong Kong, South Korea, and Thailand, Table 7 finds that the global financial crisis has reduced bank asset returns, consistent with the 'lazy' assets hypothesis. Moreover, there is also some evidence that reserves accumulation has a positive effect on asset returns which is consistent with the notion that such policies may well lead banks to also take on more risky assets.[26]

An important drawback with the existing metrics for foreign exchange reserves that are deemed costly is that the thresholds indicating whether this state of affairs has been attained are somewhat *ad hoc*. Accordingly, we propose a new metric that is hopefully less ad hoc but takes advantage of the information content of the various indicators of the intensity with which foreign exchange reserves are held. We estimated factor models based on all the proxies for reserves accumulation considered in this study and we conclude that this approach broadly supports our conclusions based on select individual proxies.

Obvious extensions to our work include applying the proposed specifications to data from other regions of the world. Also potentially useful is to investigate whether economies that undergo PRA episodes are also more likely to experience booms and busts in asset prices. These extensions are left for future research.

[26] Shrestha (2012) does not find an effect from reserves accumulation to bank credit for Thailand, South Korea, Malaysia, and the Philippines over the 1986-2009 period.

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Table 1 Episodes of prolonged reserves accumulation, 1960-2010

| Economy | Sample | Episodes | Duration | % of sample |
|---|---|---|---|---|
| **AUSTRALIA** | 1960.4-2010.2 | 1961.2-1962.1 | 2 | 40.3 |
| | | 1963.4 | 1 | |
| | | 1971.1-1974.1 | 13 | |
| | | 1982.2-1986.2 | 15 | |
| | | 1986.4-1991.4 | 21 | |
| | | 1999.4 | 1 | |
| | | 2000.4 | 1 | |
| | | 2001.2-2001.3 | 2 | |
| | | 2003.2-2004.2 | 5 | |
| | | 2004.4 | 1 | |
| | | 2005.2 | 1 | |
| | | 2005.4-2010.1 | 18 | |
| **CHINA** | 1980.4-2010.2 | 2003.2-2008.4 | 23 | 22.7 |
| | | 2009.2-2010.1 | 4 | |
| **HONG KONG** | 1990.4-2010.2 | 1997.3-1998.1 | 3 | 10.1 |
| | | 2009.2-2010.2 | 5 | |
| **INDONESIA** | 1980.4-2010.2 | 1997.3-2010.1 | 51 | 42.9 |
| **INDIA** | 1980.4-2010.2 | 1994.1-1995.1 | 5 | 26.9 |
| | | 2002.1-2005.3 | 14 | |
| | | 2006.2 | 1 | |
| | | 2007.1 | 1 | |
| | | 2007.3-2010.1 | 11 | |
| **JAPAN** | 1960.1-2010.2 | 1971.3-1972.2 | 4 | 21.8 |
| | | 1972.4 | 1 | |
| | | 2000.3-2010.1 | 39 | |
| **KOREA** | 1960.4-2010.2 | 1998.2-2010.1 | 48 | 24.2 |
| **MALAYSIA** | 1980.4-2010.2 | 1992.3 | 1 | 21.8 |
| | | 1993.3-1994.3 | 5 | |
| | | 1999.2 | 1 | |
| | | 2004.1-2005.4 | 8 | |
| | | 2006.2 | 1 | |
| | | 2007.2 | 1 | |
| | | 2008.1-2010.1 | 9 | |
| **NEW ZEALAND** | 1980.4-2010.1 | 1983.1 | 1 | 17.8 |
| | | 1984.4 | 1 | |
| | | 1986.3-1987.2 | 4 | |
| | | 2005.4-2008.3 | 12 | |
| | | 2009.1-2009.2 | 2 | |
| | | 2010.1 | 1 | |
| **PHILIPPINES** | 1973.1-2010.2 | 1991.2 | 1 | 41.3 |
| | | 1991.4-1992.1 | 2 | |
| | | 1992.3-1994.3 | 9 | |
| | | 1996.2-1997.1 | 4 | |
| | | 1997.3 | 1 | |
| | | 1998.2-1998.3 | 2 | |
| | | 1999.1-2001.2 | 10 | |
| | | 2002.1-2010.1 | 33 | |
| **SINGAPORE** | 1975.4-2010.2 | 1985.4-1986.4 | 5 | 54.7 |
| | | 1992.3-2010.1 | 71 | |
| **THAILAND** | 1980.4-2010.2 | 2008.1 | 1 | 6.7 |
| | | 2008.4-2010.2 | 7 | |

Note: The sample represents the period for which the reserves data are available. The column labeled 'episodes' represents the samples when the 3 years year over year moving average of reserves to GDP ratio is positive. Duration is measured in quarters while the % of sample is the number of quarters as a percent of the total number of observations when the moving average measure exceeds zero.

Table 2 Incidence of sizeable and painful episodes of prolonged reserves accumulation

| Economy | Foreign exchange reserves | | | | Real GDP | | | | Painful equity (1) | Painful equity (2) |
|---|---|---|---|---|---|---|---|---|---|---|
| | Sizeable increase 3% | Sizeable increase 2% | Sizeable decrease -3% | Sizeable decrease -2% | Painful real per capita (1) | Painful real per capita (2) | Painful output gap | Painful growth | | |
| AU | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| CN | 19 | 38 | 0 | 0 | 0 | 0 | 12 | 6 | 3 | 8 |
| HK | 32 | 45 | 0 | 0 | 11 | 14 | 14 | 0 | 6 | 7 |
| ID | 10 | 12 | 0 | 0 | 6 | 6 | 4 | 0 | 5 | 5 |
| IN | 3 | 14 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| JAP | 0 | 13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| KR | 9 | 16 | 0 | 0 | 2 | 4 | 5 | 4 | 2 | 8 |
| MY | 34 | 42 | 5 | 10 | 5 | 5 | 17 | 0 | 7 | 7 |
| NZ | 0 | 9 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| PH | 0 | 14 | 0 | 0 | 0 | 8 | 0 | 0 | 0 | 3 |
| SG | 29 | 43 | 5 | 16 | 9 | 13 | 20 | 0 | 5 | 8 |
| TH | 7 | 23 | 0 | 0 | 1 | 2 | 0 | 0 | 1 | 2 |

Notes: the figures in the table refer to the number of quarters consistent with episodes as defined in the text. The definitions of 'sizeable' and 'painful' follow those of Edwards (2007). For foreign exchange reserves a 'sizeable' change represents a quarter when the 3 year moving average of reserves to GDP exceeds the threshold shown above. For output and asset prices the 'painful' episodes are ones where the moving average of reserves to GDP ratio exceeds +3% and there are two consecutive quarters of negative output gaps ('painful' output gap), or real per capita real GDP growth is negative ('painful' real per capita). 'Painful' equity periods are defined as ones where the 3 year moving average of reserves growth exceeds either 3% (1) or 2% (2) and the rate of change in stock prices exceeds -20%. 'Painful' growth are the number of quarters when there is a growth recession combined with sizeable reserves accumulation. See the appendix for the country code details. A smoothing parameter of 1600 is used to estimate the output gap.

Table 3 Synchronicity of prolonged reserves accumulation and costly equity or output gap cycles

| Economy | Sizeable vs equity (2) full | Sizeable vs equity (3) global | Sizeable vs equity (4) full | Sizeable vs output (5) global | Sizeable vs output (6) full | Sizeable vs output (7) full |
|---|---|---|---|---|---|---|
| AU | .09 | .03 | .09 | .05 | .07 | .07 |
| CN | .18 | .36 | .13 | .34 | .16 | .09 |
| HK | .23 | .40 | .18 | .39 | .30 | .27 |
| ID | .12 | .20 | .11 | .15 | .07 | .07 |
| IN | .13 | .27 | .09 | .16 | .07 | .03 |
| JP | .17 | .32 | .13 | .16 | .08 | .03 |
| KR | .11 | .22 | .14 | .14 | .21 | .22 |
| MY | .24 | .43 | .20 | .42 | .20 | .17 |
| NZ | .13 | .19 | .08 | .15 | .10 | .05 |
| PH | .18 | .26 | .14 | .19 | .16 | .12 |
| SG | .20 | .34 | .16 | .35 | .22 | .19 |
| TH | .18 | .36 | .11 | .31 | .16 | .09 |

Note: Sizeable in columns (2), (3), (5) and (6) refers to the foreign exchange reserves variable defined in defined in Table 2, column (2). Sizeable in columns (4) and (7) refers to the foreign exchange reserves variable defined in defined in Table 2, column (3). Equity refers to the painful equity variable (1) also defined in Table 2. Output refers to a binary variable created by setting output equal to 1 whenever the output gap is -2% or greater. Synchronicity refers to the coincident index of Harding and Pagan (2002) between two series α and β defined as: $\frac{1}{N}\sum_{t=1}^{T}\{\alpha_t\beta_t + (1-\alpha_t)(1-\beta_t)\}$ where $\alpha, \beta = \begin{cases} 0 \\ 1 \end{cases}$ are binary variables such that $\alpha$ =1 whenever the economy in question is in a PRA episode, and $\beta = 0$ whenever the output gap is -2% or larger or the economy in question is in a painful equity drop period.

Table 4 Probit and factor model estimates of the likelihood of episodes of prolonged foreign exchange reserves accumulation

(1)

Dependent variable: ES

| Variable | Coeff. | SE | z-Stat | Prob. |
|---|---|---|---|---|
| C | -0.63 | 0.28 | -2.20 | 0.03 |
| KAOPEN | -0.14 | 0.07 | -2.16 | 0.03 |
| CREDYGAP | -0.73 | 0.64 | -1.15 | 0.25 |
| CREDYGAP*CRISES | 4.15 | 1.06 | 3.91 | 0.00 |
| STMKGAP | -0.37 | 0.35 | -1.06 | 0.29 |
| FDIGAP | 0.12 | 0.07 | 1.80 | 0.07 |
| FDIGAP*CRISES | -0.24 | 0.19 | -1.24 | 0.21 |
| RPPGAP | -0.02 | 0.01 | -2.59 | 0.01 |
| RPPGAP*CRISES | 0.02 | 0.02 | 1.12 | 0.26 |
| INFL | 0.02 | 0.01 | 1.30 | 0.19 |
| M2GAP | -0.00 | 0.00 | -0.44 | 0.66 |
| M2GAP*CRISES | -0.00 | 0.01 | -0.17 | 0.86 |
| PCRGDPGAP | -0.06 | 0.03 | -1.76 | 0.08 |
| ERRFC | -0.17 | 0.02 | -8.33 | 0.00 |
| VIX | 0.04 | 0.01 | 3.55 | 0.00 |
| DLWTI | 0.01 | 0.00 | 3.09 | 0.00 |
| McFadden R-squared | 0.33 | | | |
| LR statistic | 153.94 | | | |
| Prob(LR statistic) | 0.00 | | | |
| Obs with Dep=0 | 494 | Total obs | | 575 |
| Obs with Dep=1 | 81 | | | |

(2)

Dependent variable: RESACC

| Variable | Coeff. | SE | z-Stat | Prob. |
|---|---|---|---|---|
| C | 0.19 | 0.25 | 0.76 | 0.45 |
| KAOPEN | -0.38 | 0.06 | -6.40 | 0.00 |
| CREDYGAP | 2.00 | 0.50 | 3.96 | 0.00 |
| CREDYGAP*CRISES | 5.41 | 1.04 | 5.19 | 0.00 |
| STMKGAP | -0.62 | 0.28 | -2.21 | 0.03 |
| FDIGAP | -0.03 | 0.05 | -0.62 | 0.54 |
| FDIGAP*CRISES | -0.37 | 0.18 | -2.09 | 0.04 |
| RPPGAP | 0.01 | 0.01 | 2.13 | 0.03 |
| RPPGAP*CRISES | -0.00 | 0.01 | -0.18 | 0.85 |
| INFL | -0.25 | 0.03 | -9.45 | 0.00 |
| M2GAP | -0.00 | 0.00 | -0.69 | 0.49 |
| M2GAP*CRISES | -0.02 | 0.01 | -2.41 | 0.02 |
| PCRGDPGAP | -0.07 | 0.03 | -2.10 | 0.04 |
| ERRFC | 0.06 | 0.02 | 3.20 | 0.00 |
| VIX | 0.02 | 0.01 | 2.75 | 0.01 |
| DLWTI | 0.01 | 0.00 | 2.17 | 0.03 |
| McFadden R-squared | 0.27 | | | |
| LR statistic | 214.37 | | | |
| Prob(LR statistic) | 0.00 | | | |
| Obs with Dep=0 | 277 | Total obs | | 581 |
| Obs with Dep=1 | 304 | | | |

(3)

Dependent variable: Factor 1: self-insurance motive

| Variable | Coeff. | SE | t-Stat | Prob. |
|---|---|---|---|---|
| C | -0.50 | 0.15 | -3.43 | 0.00 |
| KAOPEN | 0.05 | 0.03 | 1.87 | 0.06 |
| CREDYGAP | 0.55 | 0.22 | 2.48 | 0.01 |
| CREDYGAP*CRISES | -0.03 | 0.41 | -0.06 | 0.95 |
| STMKGAP | -0.07 | 0.15 | -0.46 | 0.65 |
| FDIGAP | -0.02 | 0.03 | -0.64 | 0.53 |
| FDIGAP*CRISES | -0.14 | 0.10 | -1.51 | 0.13 |
| RPPGAP | -0.00 | 0.00 | -0.45 | 0.65 |
| RPPGAP*CRISES | -0.01 | 0.01 | -1.85 | 0.07 |
| INFL | -0.01 | 0.01 | -2.10 | 0.04 |
| M2GAP | -0.00 | 0.00 | -0.19 | 0.85 |
| M2GAP*CRISES | -0.00 | 0.00 | -0.90 | 0.37 |
| PCRGDPGAP | -0.01 | 0.02 | -0.41 | 0.68 |
| ERRFC | 0.05 | 0.01 | 5.57 | 0.00 |
| VIX | -0.00 | 0.01 | -0.84 | 0.40 |
| DLWTI | -0.00 | 0.00 | -1.32 | 0.19 |
| R-squared | 0.13 | | | |
| Log likelihood | -553.17 | | | |
| F-statistic | 4.99 | | | |
| Prob(F-statistic) | 0.00 | | | |

(4)

Dependent variable: factor 2 mercantilist motive
Sample (adjusted): 1990Q1 2007Q3
Total panel (unbalanced) observations: 521

| Variable | Coeff. | SE | t-Stat | Prob. |
|---|---|---|---|---|
| C | 0.17 | 0.15 | 1.15 | 0.25 |
| KAOPEN | -0.07 | 0.03 | -2.33 | 0.02 |
| CREDYGAP | 0.49 | 0.23 | 2.13 | 0.03 |
| CREDYGAP*CRISES | 1.86 | 0.43 | 4.36 | 0.00 |
| STMKGAP | -0.51 | 0.16 | -3.25 | 0.00 |
| FDIGAP | -0.00 | 0.03 | -0.10 | 0.92 |
| FDIGAP*CRISES | -0.10 | 0.10 | -1.06 | 0.29 |
| RPPGAP | 0.00 | 0.00 | 1.53 | 0.13 |
| RPPGAP*CRISES | 0.01 | 0.01 | 1.03 | 0.31 |
| INFL | -0.05 | 0.01 | -6.97 | 0.00 |
| M2GAP | -0.00 | 0.00 | -0.66 | 0.51 |
| M2GAP*CRISES | -0.01 | 0.00 | -2.27 | 0.02 |
| PCRGDPGAP | -0.03 | 0.02 | -1.75 | 0.08 |
| ERRFC | -0.00 | 0.01 | -0.27 | 0.79 |
| VIX | 0.02 | 0.01 | 2.59 | 0.01 |
| DLWTI | 0.00 | 0.00 | 2.50 | 0.01 |
| R-squared | 0.21 | | | |
| F-statistic | 9.00 | | | |
| Prob(F-statistic) | 0.00 | | | |

Note: All specifications were estimated via probit via maximum likelihood except when factors are used as the dependent variable in which case panel OLS is used. KAOPEN is the index of capital account openness, CREDGAP is the domestic credit gap, STMKGAP is the gap in equity market prices, FDIGAD is the gad in foreign direct investment, RPPGAP is the gap in real property prices, INFL is CPI inflation, M2GAP is the gap in the M2 money stock measure, PCRGDPGAP is the output gap measured in terms of real per capita income, VIX is the proxy for uncertainty, and ERRFC is the Reinhart-Rogoff exchange rate regime indicator. Also, see BOX for dependent variable definitions.

Table 5 Further probit and factor model estimates of the likelihood of episodes of prolonged foreign exchange reserves accumulation

(1)

Dependent variable: ADD

| Variable | Coeff. | SE | z-Stat | Prob. |
|---|---|---|---|---|
| CREDGDPGAP | -1.59 | 0.69 | -2.32 | 0.02 |
| INFL | -0.13 | 0.03 | -5.05 | 0.00 |
| ERRFC | -0.21 | 0.04 | -5.70 | 0.00 |
| Australia | 2.57 | 0.51 | 5.05 | 0.00 |
| Japan | 3.08 | 0.51 | 6.03 | 0.00 |
| Korea | 1.86 | 0.43 | 4.31 | 0.00 |
| New Zealand | 4.13 | 0.56 | 7.39 | 0.00 |
| Singapore | 1.62 | 0.48 | 3.40 | 0.00 |
| Obs with Dep=0 | 395 | Total obs | | 708 |
| Obs with Dep=1 | 313 | | | |

(2)

Dependent variable: Factor self-insurance motive
Included observations: 668 after adjustments

| Variable | Coeff. | SE | t-Stat | Prob. |
|---|---|---|---|---|
| CREDGDPGAP | -0.92 | 0.38 | -2.45 | 0.01 |
| INFL | -0.07 | 0.01 | -6.94 | 0.00 |
| ERRFC | -0.10 | 0.02 | -5.98 | 0.00 |
| Australia | 1.57 | 0.23 | 6.95 | 0.00 |
| Japan | 1.83 | 0.23 | 7.90 | 0.00 |
| Korea | 1.09 | 0.22 | 5.07 | 0.00 |
| New Zealand | 2.14 | 0.26 | 8.24 | 0.00 |
| Singapore | 0.90 | 0.23 | 3.93 | 0.00 |
| R-squared | 0.17 | | | |

(3)

Dependent variable: ADD

| Variable | Coeff. | SE | z-Stat | Prob. |
|---|---|---|---|---|
| INFL | 0.17 | 0.09 | 1.85 | 0.06 |
| KAOPEN | -3.84 | 0.88 | -4.37 | 0.00 |
| CREDGDPGAP | -0.67 | 0.99 | -0.67 | 0.50 |
| PCRGDPGAP | -0.17 | 0.09 | -1.88 | 0.06 |
| FDIGDPGAP | -0.01 | 0.11 | -0.13 | 0.90 |
| Hong Kong | 7.94 | 2.24 | 3.54 | 0.00 |
| Malaysia | -1.46 | 0.45 | -3.27 | 0.00 |
| Philippines | -1.15 | 0.65 | -1.77 | 0.08 |
| Thailand | -1.75 | 0.50 | -3.53 | 0.00 |
| Obs with Dep=0 | 137 | Total obs | | 191 |
| Obs with Dep=1 | 54 | | | |

(4)

Dependent variable: Factor 1 self-insurance motive
Included observations: 264 after adjustments

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| INFL | 0.00 | 0.01 | 0.05 | 0.96 |
| KAOPEN | -0.30 | 0.20 | -1.50 | 0.14 |
| CREDGDPGAP | -0.75 | 0.37 | -2.04 | 0.04 |
| FDIGAP | -0.01 | 0.04 | -0.21 | 0.83 |
| Hong Kong | 0.38 | 0.54 | 0.70 | 0.48 |
| Malaysia | 0.37 | 0.22 | 1.67 | 0.10 |
| Philippines | -0.13 | 0.18 | -0.72 | 0.47 |
| Thailand | -0.27 | 0.15 | -1.75 | 0.08 |
| R-squared | 0.06 | | | |

(5)

Dependent variable: ADD

| Variable | Coeff. | SE | z-Stat | Prob. |
|---|---|---|---|---|
| INFL | 0.06 | 0.04 | 1.43 | 0.15 |
| ERRFC | -0.02 | 0.10 | -0.21 | 0.84 |
| CREDGDPGAP | 3.43 | 0.65 | 5.26 | 0.00 |
| FDIGAP | -0.08 | 0.04 | -1.69 | 0.09 |
| China | -0.20 | 0.51 | -0.40 | 0.69 |
| Indonesia | -1.42 | 0.94 | -1.50 | 0.13 |
| India | -0.75 | 0.80 | -0.94 | 0.35 |
| Obs with Dep=0 | 143 | Total obs | | 231 |
| Obs with Dep=1 | 88 | | | |

(6)

Dependent variable: Factor self-insurance motive
Included observations: 211 after adjustments

| Variable | Coeff. | SE | t-Stat | Prob. |
|---|---|---|---|---|
| INFL | 0.01 | 0.01 | 1.06 | 0.29 |
| KAOPEN | -0.77 | 0.51 | -1.50 | 0.14 |
| ERRFC | 0.07 | 0.10 | 0.69 | 0.49 |
| CREDGDPGAP | 2.80 | 0.49 | 5.70 | 0.00 |
| FDIGAP | -0.10 | 0.03 | -3.88 | 0.00 |
| China | -0.32 | 0.40 | -0.79 | 0.43 |
| Indonesia | 0.25 | 1.78 | 0.14 | 0.89 |
| India | -1.64 | 0.39 | -4.18 | 0.00 |
| R-squared | 0.33 | | | |

Note: See notes to Table 4. Only the self-insurance factor results are shown.
Results for the mercantilist factor are available on request.

Table 6 Factor loadings

| PRA | Factor model 1 | | Factor model 2 | | Factor model 3 | | Factor model 4 | | Factor model 5 | | Factor model 6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ES | .68 | -.64 | .38 | .30 | .30 | .28 | .71 | -.63 | .43 | .28 | .36 | .25 |
| EP | .65 | -.67 | | | | | .09 | -.66 | | | | |
| MT15 | .80 | .21 | | | | | 79 | .31 | | | | |
| MT175 | .83 | .24 | | | | | .83 | .39 | | | | |
| MT2 | .76 | .13 | .45 | .18 | | | .77 | .28 | .45 | .16 | | |
| ADD | .45 | .36 | .64 | -.36 | .67 | -.29 | | | | | | |
| BL | .27 | .38 | .48 | -.45 | .54 | -.41 | .18 | .18 | .27 | -.21 | .25 | -.21 |
| DS | .35 | -.01 | .39 | .32 | .29 | .18 | .33 | -.02 | .35 | .09 | .34 | .17 |
| CIM | .05 | .05 | .16 | .20 | | | | | | | | |
| GVL | .02 | .09 | .04 | -.09 | | | | | | | | |
| RESACC | .40 | .04 | .49 | .19 | .61 | .17 | .38 | -.004 | .54 | -.07 | .61 | -.16 |
| RESAXEL | .45 | .28 | .61 | .01 | .50 | .36 | .41 | .20 | .55 | -.24 | .61 | .004 |

Note: See BOX for an explanation of PRA. The combinations considered above are dictated by data availability as well as a test of the robustness of the results.

Table 7 Asset returns and foreign exchange reserves accumulation

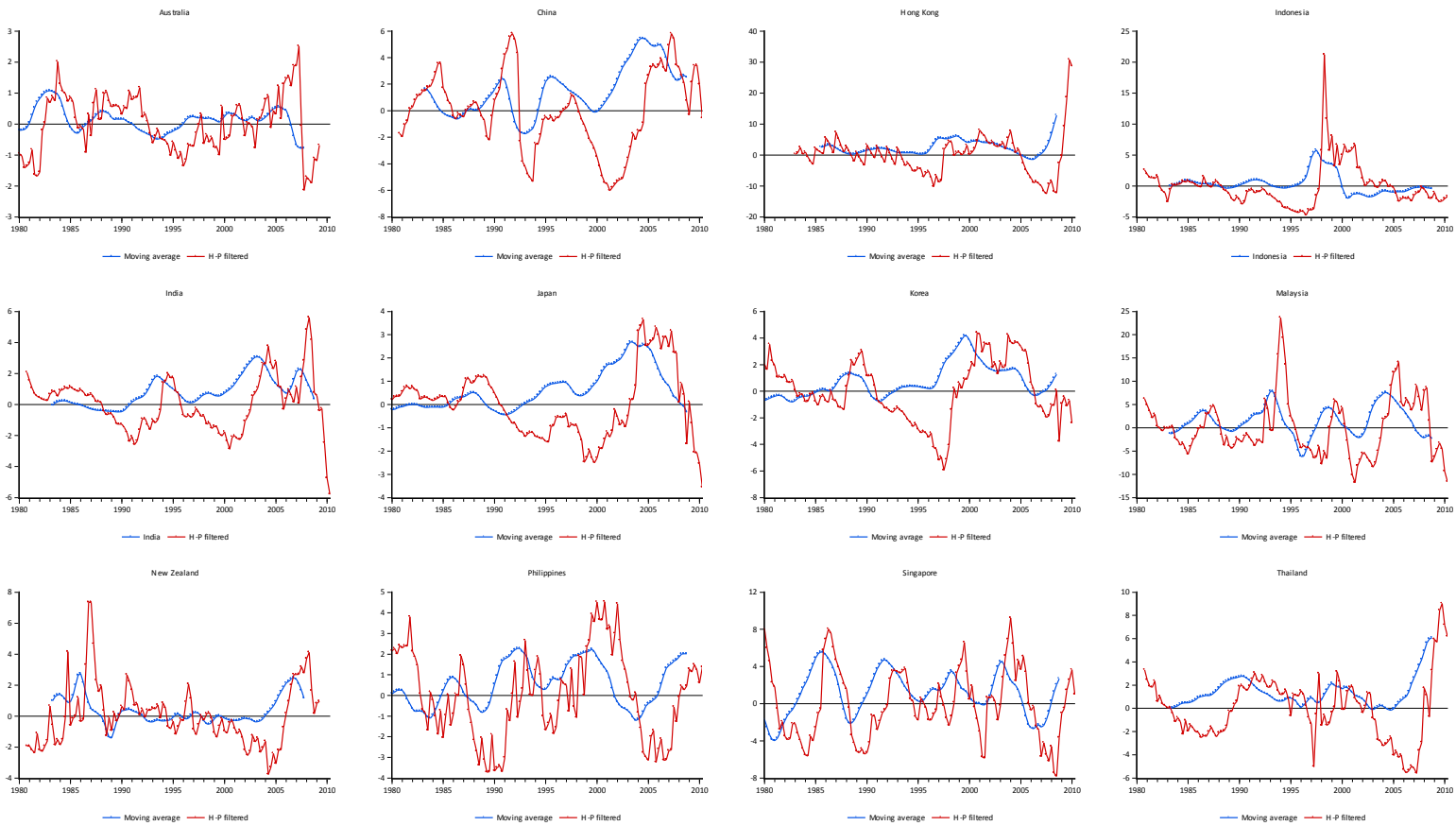
| Variable | Dependent variable: Return on assets |
|---|---|
| Constant | -7.44<br>(3.08)** |
| Reserves/GDP ratio | 0.26<br>(0.10)* |
| Reserves/GDP ratio X GFC dummy | -0.07<br>(0.03)** |
| *Fixed effects* | |
| China | 1.47 |
| Hong Kong | -9.29 |
| S. Korea | 2.44 |
| Thailand | 0.38 |
| *Summary Statistics* | |
| $R^2$ | 0.49 |
| F-statistic (p-value) | 3.87 (0.01) |

Note: Dependent variable defined in the text. Also, see Figure 1. GFC dummy is a global financial crisis dummy set equal to 1 after 2007Q3, and 0 otherwise. Data on return on assets are from Bankscope. Two stage least squares estimation is used with lagged asset returns, exchange rate regime type, capital account openness index, constant and GFC dummy are the instruments.

Figure 1 Reserves to GDP ratios

Note: The vertical axis is in percent. Data are quarterly.

Figure 2 Moving average and H-P filtered reserves holdings




Note: The moving average is over a three year horizon for the annual change (i.e., *t* less *t-4* in the reserves to GDP ratio (see Figure 1). For the H-P filtered series a smoothing parameter of 100,000 is applied to the reserves to GDP ratio series.

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