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ABSTRACT

This paper examines past evidence of prolonged periods of foreign exchange reserves accumulation in the Asia-Pacific region. Several proxies for this unobserved variable are considered, including a newly proposed one based on a factor model. We focus on identifying periods of prolonged interventions and identify its key macro-financial determinants. 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. Policy implications are also drawn.

Keywords: foreign exchange reserves accumulation, monetary and financial stability

JEL Classification system: F41, F32, E44, D52

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1. Introduction

Explaining the motives for holding foreign exchange reserves continues to attract considerable research. There is, of course, a vast literature on the determinants of reserves holdings. The topic lately has garnered more attention thanks in part to the 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 over time.[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 raised awareness about foreign exchange management practices. Our interest is in investigating the determinants of the accumulation of international reserves over prolonged periods of time.

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 the precautionary motive, or by relying on principles of inventory management, research in recent years has shifted to asking why it became increasingly attractive for some central banks to accumulate reserves particularly when many evinced a tendency to adopt more flexible exchange rate regimes, occasionally alongside a form of inflation targeting.

[1] This phenomenon has spread beyond emerging markets. 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 2011. Since the announcement, Switzerland has been called the 'new China' in currency markets. See Ross (2012). The Czech National Bank followed suit in late 2013 with its decision to use the exchange rate as an additional monetary policy instrument. See https://www.cnb.cz/miranda2/export/sites/www.cnb.cz/en/monetary_policy/bank_board_minutes/2013/download/tk_07sz2013_aj.pdf.

Figure 1 reveals an upward trend in the levels of foreign exchange reserves to GDP ratio, beginning in the 1990s, in 9 of the 12 economies in the Asia-Pacific region that are examined in the present paper. Indeed, by the end of the sample in 2010, reserves exceed 40% of real GDP in 6 of 12 economies shown (China, Hong Kong, Malaysia, Singapore, Thailand) while the 20% threshold is reached in four other countries (India, Japan, Korea, Philippines). Therefore, by any metric, holdings of foreign exchange reserves are sizeable. For example, Jeanne and Rancière (2011) conclude that international reserves holdings which exceed 10% of GDP is not optimal, at least in terms of the precautionary motive. With the exception of Australia and, at times, New Zealand, this level is easily surpassed in all of the other countries of the Asia-Pacific considered in this study.

Figure 1 also highlights the period of the Asian Financial Crisis (AFC; 1997-98) and the Global Financial Crisis (hereafter GFC; dates vary, see Dominguez, Hashimoto, and Ito, 2012, Table 3). Reserves as a percent 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 characterizes the behavior of reserves accumulation in Thailand and New Zealand. Australia's reserves holdings reveal a large drop before the GFC followed by a resumption of the trend that began in the mid-1990s. The sharp depreciation of the Australian dollar assisted by an equally large fall in the Reserve Bank's policy rate likely contributed to this development.

Beyond the rise in levels of foreign exchange reserves holdings is the more intriguing observation of the incidence of episodes of prolonged reserves accumulation (PRA). This is the focus of the present study. These episodes are broadly defined as taking place when the rise in foreign exchange reserves persistently exceeds some metric that proxies a trend in reserves holdings. There is no consensus on the precise meaning of the PRA concept. As a result, several proxies have been proposed in the literature. Moreover, it is apparent that the phenomenon examined in this paper is asymmetric as one clearly observes a tendency towards the accumulation of reserves with fewer instances of reversals.[2] This phenomenon has already been observed by some (e.g., Blanchard, Faruqee, and Dias 2010; Aizenman and Sun 2010) and it has been argued that such an outcome also stems from the desire to hold a sufficiently large stocks of reserves to ward off future speculative attacks (e.g., Dominguez, Hashimoto, and Ito 2012).

The Economist (2010) refers to a 'monsoon' to describe recent patterns of reserve accumulation, particularly among emerging market economies. Table 1 illustrates the phenomenon by listing episodes when the rolling three year centered moving average of year on year changes in the reserves to GDP ratio proxy is positive in the Asia-Pacific economies in our sample.[3] Certain episodes reflect the impact of the AFC on economies such as Hong Kong and the Philippines. Elsewhere, the moving average proxy remains permanently positive, again in the aftermath of the Asian crisis of 1997-98 in countries such as Indonesia, Korea, and

[2] The asymmetry in the behavior of reserves accumulation is also reflected in the observation that central banks in emerging markets tend to respond more aggressively to prevent exchange rate appreciations but are less reluctant to stop depreciations (e.g., see Pontines and Rajan 2011).

[3] Other metrics are considered and evaluated below (also, see the Appendix). The sample is the same as depicted in Figure 1.

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 PRA and so-called 'sudden stops' wherein a sharp reversal in capital flows takes place (see, for example, Jeanne and Rancière, 2011, and Durdu et. al. , 2009).

Strikingly, the literature provides little guidance to explain why such episodes emerge. Clearly, policy makers believe that this behavior can pose economic risks, especially in emerging markets (e.g., IEO 2012, Filardo and Grenville 2012, 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. Therefore, the fact that Hong Kong, Singapore, and China, have reserves holdings that approach their annual GDP levels (see Figure 1) portend macroeconomic implications that are, as yet, not well understood.[4]

Since we do not yet fully understand the consequences of attempts at persistent reserves accumulation the present paper begins with some stylized facts and considers the role played by macroeconomic, financial, and institutional factors in determining the likelihood of observing the phenomenon of PRA.[5] To be more precise, we ask whether there are robust

[4] 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).

[5] 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

determinants of the probability of observing PRA episodes. We also touch on the question whether changes in the central bank's balance sheet resulting from prolonged interventions are reflected in the balance sheet of the private sector? (e.g., housing prices, equity prices, growth in domestic credit).

We provide a simple motivation for our empirical analysis by appealing to the usefulness of having multiple instruments when there is more than one monetary policy objective. Relatively fast-growing emerging markets, particularly ones in Asia, opted for a macroeconomic policy geared towards two objectives, namely exchange rate stability and domestic economic stability. To achieve these aims, as required by Tinbergen's principle,[6] 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.

The rest of the paper is organized as follows. In the following section we summarize the relevant literature. The data are described in section 3 and some stylized facts are also provided. The econometric specifications as well as the empirical evidence are discussed in section 4. The paper concludes with some policy implications and suggestions for further research.

2. Relevant Literature

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. See, for example, Filardo and Grenville (2012) for a discussion of the implications of foreign exchange reserves and the accumulation of 'lazy assets' on central bank balance sheets (i.e., low yielding returns in relation to available alternative asset holdings).

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

Recent research on the foreign exchange holdings practices of central banks typically identifies two principal motives.[7] They are: a precautionary desire to provide adequate foreign exchange reserves in case an economic shock might otherwise precipitate 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 demise in the early 1970s, as a system that enabled some countries to protect their export markets (e.g., Dooley et. al. 2004). More recently, 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).

As previously stated, all of these motives have implications for choosing levels of foreign exchange reserves holdings. Nevertheless, to the extent that the relevant economic shocks favoring one or more of these motives are persistent these serve as the basis for prolonging the period over which reserves are accumulated. All of the foregoing explanations also presuppose that economic fundamentals are at work to explain the reserves holdings practices of central banks. Steiner (2013a) argues that the incidence of financial crises also prompts the ramping up of foreign exchange reserves holdings.[8] Steiner (2013) highlights the fact that foreign exchange reserves accumulation is partly the result of a 'fear of capital mobility'. As a result, at least in

[7] 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.

[8] In a related vein Steiner (2014) calibrates a reserves holding model to suggest the potential for the hoarding of reserves on a global scale to potentially trigger a financial crisis. Hence, the very phenomenon such practices were intended to prevent can actually become more likely. Likewise, the decision to accumulate foreign exchange reserves creates a kind of demonstration effect that leads others to follow suit. The 'keeping up with the Joneses' phenomenon has also been supported empirically (e.g., see Pontines and Yongqiang 2011).

the short-run, there is the possibility of overcoming the restrictions imposed by the impossible trinity. Similarly, the willingness of policy makers to rely on capital controls is thought to impact the ability of central banks to effectively sterilize them since, at least in emerging markets, domestic and foreign assets are not perfect substitutes (e.g., see Bayoumi and Saborowski 2014).

Each one of the foregoing explanations 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, during the crisis which engulfed the world economy in 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. Hence, this is tantamount to evidence of a shift from a fear of floating to a fear of losing reserves (also see Aizenman and Sun 2009). Figure 1 does seem to provide some graphical support for this view.[9]

Empirically based attempts to establish whether foreign exchange holdings exceed some level deemed adequate, but not necessarily optimal, generally rely on the benchmark known as the Greenspan-Guidotti (G-G; Greenspan 1999, Guidotti et.al. 2004) rule. A level of external debt with a maturity of up to one year equal to total external debt of one ought to provide adequate protection against an economic shock that threatens the external position of the

[9] 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. These swap lines were meant to alleviate the apparent shortage of US dollars. The countries in our sample this facility was made available to are Japan, Korea, and Singapore. See Dominguez, Hashimoto, and Ito (2012). As a result, financial factors played a far greater role during the latest crisis than when the world economy was in the Great Moderation era.

domestic economy.[10] 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 how broadly the G-G rule, or some variant, is applicable across emerging markets. 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. Blanchard and Milesi-Ferretti (2011) argue that reserves holdings which appear excessive may simply 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 may reflect persistent imbalances between savings and investment. Indeed, financial imbalances are believed by some 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). IEO (2012), which reviews the policy positions of the IMF criticizes the international agency for advocating policies that "…stressed the symptom of problems rather than the underlying causes…" (op.cit., p.v) and by proposing levels of reserves adequacy that fail to consider country-specific factors and needs.

[10] 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.

The empirical literature resorts to a fairly wide broad of economic determinants to econometrically explain foreign exchange reserves holdings (e.g., see Dominguez, Hashimoto, and Ito 2011, Dominguez 2010, Hashimoto and Ito 2007, Aizenman and Lee 2005, CGFS 2009). 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).

As seen from Table 1 there are frequent episodes during which reserves accumulate for an extended period of time. However, there is little empirical guidance about whether this phenomenon can be linked to economic fundamentals (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.[11] This resulted in a sharp and prolonged change in the foreign exchange reserves holding in 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

[11] Indeed, the origins of the 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.

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, Frankel's exhaustive survey (Frankel 2010) does not allude to 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.

3. Data and Stylized Facts

In what follows we examine data at the quarterly sampling frequency for 12 economies in the Asia-Pacific region. For some key variables (e.g., GDP) the raw data are only available at this sampling frequency. Indeed, in a few cases, data are available only at the semi-annual or annual frequencies (e.g., capital mobility index, some property price data). When the raw data are not available at the quarterly frequency linear interpolation is employed to create series at the quarterly frequency.

The countries in the data set are as follows: Australia, China, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, New Zealand, Philippines, Singapore, and Thailand. The sample periods over which various econometric specifications are estimated 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 in the 1960s, 1970s, and 1980s. These are also partly motivated by data availability.

It is well-known there exist several ways to measure foreign exchange reserves adequacy including reserves to GDP, reserves to imports, or reserves to short-term external debt. All are intended to capture an economy's ability to withstand economic shocks operating through their balance of payments.[12] Moreover, the theoretical literature provides no convincing argument to support one measure over another. More often than not the literature relies on the reserves to GDP proxy because it is also the indicator available for the longest span of time.[13]

As we are interested in changes in foreign exchange reserves holdings over time, Figure 2 plots two proxies that serve as the basis for evaluating PRA episodes. They are: a rolling three year centered moving average of changes in the reserves to GDP ratio and deviations in H-P filtered reserves to GDP ratio measure.[14] There is clearly evidence of prolonged rises and declines in changes in foreign exchange reserves holding relative to some trend, relying on either proxy. Nevertheless, the PRA phenomenon is especially apparent when the moving average proxy is considered. Of course, several proxies for PRA have been proposed in the literature. Detken and Smets (2004) use a proxy that is similar to the moving average proxy defined above. Mendoza and Terrones (2008), Alessi and Detken (2010), Adalid and Detken (2007), Borio and Lowe (2002), and Gourinchas, Velde and Landerretche (2001) all employ variants of the H-P filtered proxy also included among the candidates that proxy PRA.[15]

[12] 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 contain some discontinuities.

[13] It is important to note that the variable we seek to explain is based on a classification such as the one shown in Table 1 and not the series shown in Figure 1. Plots of various proxies of the PRA proxy are relegated to the Appendix.

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

[15] The Appendix to the paper provides more precise details about the construction of PRA proxies not emphasized here.

Next, Table 2 provides some evidence on the incidence of PRA episodes considered sizeable or 'painful' in terms of their overlap with business cycle and asset price cycle related contractions. Here we follow the approach for selecting business cycle contractions of the 'sizeable' and 'painful' varieties defined by Edwards (2007). These are labeled ES and EP, respectively. Sizeable foreign exchange reserves accumulation episodes take place when the reserves to GDP measure rises (or falls) by 3% or more. This 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 instead set at ± 2%. Given that the threshold applies to data at the quarterly frequency even a 2% threshold arguably represents a sizeable change 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 PRA episodes. It is also worth highlighting, as shown in Table 2, that foreign exchange reserves change in an asymmetric manner with relatively few examples of sharp declines in reserves. Malaysia and Singapore experience drops in reserves to GDP that are greater than 2 or 3% over the sample considered. Australia experiences a sharp drop in reserves holdings but it is too brief to be recorded as sizeable. We will use the ES proxy as a benchmark of sorts against which we can compare our results that rely on alternative PRA indicators.

We then consider the joint occurrences of PRA episodes together with contractions in business cycles and asset prices. Two separate definitions of business cycle contractions are employed. First, we again follow Edwards (2007), by defining a fall in real per capita income or two consecutive periods of decline in the per capita output gap to represent business cycle

contractions. We also consider the juxtaposition of PRAs with episodes of growth recessions based on the Economic Cycle Research Institute's dating of such events (https://www.businesscycle.com/). 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 as described above.[16] 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.

Now consider the combination of PRAs with 'busts' in asset prices, where these are proxied by housing and equity prices. For this purpose we adopt the Mishkin and White (2003) definition of a 'crash' in asset prices as taking place whenever there is a 20% or more fall in equity prices on an annual basis. As seen in Table 2 these kinds of episodes emerge in most of the economies in our sample as frequently as some of the other costly events considered. Continuing in the same vein we ask whether there is some synchronicity in PRA episodes and costly output and asset price changes. 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 relying on the Mishkin and White metric. 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

[16] 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.

globalization period while stock price downturns or large negative output gaps are most highly synchronized for China, Hong Kong, Malaysia, Singapore, and Thailand.

The stylized facts considered so far do suggest that real and financial links exist with the accumulation of international reserves. In the following section we explore these via econometric estimation.

4. Econometric Specifications and Empirical Results

Since we have identified PRA episodes using a wide variety of definitions that have been used in the literature we now provide some econometric estimates of the likelihood that selected macroeconomic and financial factors will contribute to such events. A dummy variable is created set equal to 1 in any quarter when a PRA episode has been identified and zero elsewhere. Probit estimation under these circumstances is appropriate. As indicated earlier, our focus below is, first, on the ES and moving average proxies (labeled RESACC) although a new indicator is also introduced below. Define PRA_{it} as episodes of prolonged reserves accumulation, such that

$$PRA_{it} = \begin{cases} = 1 \text{ if } r_{it}^{*} > 0 \\ = 0, \text{ otherwise} \end{cases} \tag{1.1}$$

where PRA_{it}^{*} is an unobserved latent variable while PRA_{it} is the observed proxy and set equal to 0 or 1, and r_{it}^{*} is the moving average reserves to GDP ratio indicator defined earlier. Next, we posit that PRA is a linear function of a vector of macroeconomic and institutional variables, denoted by Ω_{it}, to be discussed below. The estimated specification is then written

$$PRA_{it}^{*} = \Omega_{it}\beta^{'} + \eta_{it} \tag{1.2}$$

where the index *i* identifies the country and η_{it} is a residual term assumed to satisfy the usual properties.[17] Three different proxies define PRA. By way of a benchmark we consider whether foreign exchange holdings are sizeable (ES), following Edwards. Next, we consider the three year rolling centered moving average proxy (RESACC).

As discussed previously, there is no unique or consensus measure of PRA. An alternative which, to our knowledge, has yet to be considered in the literature is to construct estimates of PRA based on a factor model where we restrict the number of factors to two since the literature suggests that two principal motives for the accumulation of foreign exchange reserves exist, namely the self-insurance/financial stability and mercantilist motives. In this case the dependent variable in equation (1.2) is replaced with one derived from estimating

$$\mathbf{Y}_{it} - \boldsymbol{\mu} = \Phi\mathbf{F}_{it} + \varepsilon_{it} \tag{1.3}$$

where **Y** is the vector of observables, namely ten different proxies for PRA,[18] Φ are the factor loadings, that is, the relative weight of each PRA proxy in constructing the two factors representing PRA (results not shown), **F** is the common factor(s) while the idiosyncratic contribution of each PRA proxy is summarized by ε. The first factor is assumed to represent the self-insurance motive since the PRA proxies are positively related to each other. If each one of

[17] 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.

[18] Details on the construction of these proxies are relegated to the Appendix. An earlier version of this paper (Filardo and Siklos 2013) also provides the details. In addition to the proxies proposed by Edwards (2007; ES, EP), the moving average indicator defined above is also included, as are the proxies of Mendoza and Terrones (2008), Alessi and Detken (2010), Adalid and Detken (2007), Borio and Lowe (2001), Detken and Smets (2004), Calvo, Izquierdo and Mejia (2004), Gourinchas, Velde, Landerretche (2001), Helbling (2005), and Mishkin and White (2003).

the proxies reflects the self-insurance motive for holding foreign exchange reserves then all of the proxies should increase (or fall) arising out of a need to forestall a surge in the demand for reserves following some negative economic shock.

The second factor is assumed to capture the mercantilist motive. A priori we do not know how strong the mercantilist motive is. Hence, depending on the central bank and the particular construction of the PRA, some policy makers may well respond by accumulating foreign exchange reserves. Alternatively, existing levels of foreign exchange reserves could serve as a buffer stock against temporary shocks to be subsequently rebuilt. Hence, 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 define PRA. Since these scores are not bounded in the [0,1] interval we can estimate this version of equation (1.2) via OLS.[19]

Turning to the potential determinants of PRA (i.e, Ω_{it}) the existing literature offers a large variety of candidates to choose from. They include: a measure of capital account openness developed by Chinn and Ito (2008), measures of exchange rate regime flexibility created by Levy-Yeyati and Sturzenegger (2005), or the alternative classification proposed by Reinhart and Rogoff (2004),[20] the rate of change in the nominal exchange rate, inflation, real per capita GDP growth or, as an alternative, the output gap, and foreign direct investment (FDI).

A series of 'gap' indicators for asset prices is also considered. The gaps were estimated by applying and H-P filter with a high smoothing parameter (λ=100,000). The justification for this

[19] 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.

[20] In the results discussed below we rely on the so-called fine classification created by Reinhart and Rogoff (2004).

choice is the same one used earlier to construct some of the proxies for the PRA indicator. 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 (West Texas Intermediate) 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.[21] Finally, to account for the possible role of the 'global' financial crisis, we also consider interaction terms with the financial variables in Ω_{it} , namely gaps in credit, real estate prices, foreign direct investment, and M2. To conserve space we only present the essential results and note how robust these are to small changes in the estimated specifications. The global financial crisis defined as a (0,1) dummy variable. The chronology of Dominguez, Hashimoto and Ito (2012) developed for each one of the countries in our data set is used to define the GFC dummy. We also include a common date (see Figure 1) for the period of the Asian Financial crisis.

Generally, speaking, one expects the following relationship between the determinants listed above and PRA. A flexible exchange rate regime (ERRFC) would make it less likely for one to observe PRA episodes. In principle, the nominal exchange rate should adjust to prevent any sudden depletion (or surge) in foreign exchange reserves. A similar argument would apply to explaining why greater capital account openness (KAOPEN) would reduce the need to continue

[21] The VIX is a widely used indicator of short-term expected volatility in equity markets derived from options on the S&P 500 index.

accumulating foreign reserves. Note, however, that if the self-insurance motive alone predominates, then fears of capital outflows may well reverse the sign of such a relationship. Similarly, greater uncertainty, proxied by a rise in the VIX, might well lead the authorities to favor the accumulation of foreign exchange reserves. It should be noted, however, that since the VIX evaluates uncertainty in U.S. financial markets this need not translate into greater uncertainty either globally or in the Asia-Pacific region. As reported in Burdekin and Siklos (2011; also see references therein), equity markets in the Asia-Pacific and the U.S. were far from being coupled over much of the sample considered in this study.

A rise in inflation (INFL) 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 monetary authorities will continue accumulating reserves. Similar arguments apply to the influence of the various asset price gaps (CREDGAP, credit gap; STMKGAP, stock market gap; RPPGAP, real estate price gap; M2GAP, gap in the M2 money stock measure) on the probability that foreign exchange reserves holdings will rise. Finally, since the market for oil is denominated in US dollars, a rise in its price (WTI) would lead to an enhanced desire to hold greater reserves, possibly as a hedge. Finally, again depending on the ability and willingness of the authorities to engage in sterilization, FDI flows can also contribute, positively or negatively, to changing international reserves holdings.

Estimates shown in Table 4 reveal that the statistical significance of the determinants of PRA is robust across definitions of the proxy shown. In particular, greater capital account mobility as well as more exchange rate flexibility reduces the likelihood of accumulating

additional foreign exchange reserves with one notable exception, namely when the self-insurance motive is the factor that drives PRAs. Next, a significant positive determinant of the desire to accumulate reserves is the VIX proxy for financial uncertainty. This highlights the role of the self-insurance motive on international reserves holding behavior. Similarly, higher oil prices are associated with a greater propensity to hold reserves. 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 GFC. 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. There is a little bit of evidence that foreign direct investment during the crisis tempers the willingness to accumulate foreign exchange reserves as well as some indications that real estate and equity market prices also significantly impact PRA. However, the results are sensitive to the particular specification and, hence, cannot be considered robust.

An interesting result concerns the separate impact of the factors meant to proxy the self-insurance and mercantilist motives on the likelihood of PRA. For example, a floating exchange rate reduces the probability of engaging in PRA when this is assumed to be driven by the self-insurance motive. This is consistent with the view that exchange rate flexibility acts as a substitute for the need to accumulate foreign exchange reserves. In contrast, if PRA is defined by the mercantilist motive then a floating exchange rate does not contribute reserves holdings. Furthermore, a credit boom raises the likelihood of a PRA when the self-insurance/financial stability motive is considered but the mercantilist motive leads to a reduction in the same probability. In particular, depending on the strength of pass-through effects, a floating

exchange rate need not completely insulate the domestic economy from external shocks. The negative response to a credit boom when the mercantilist motive predominates reflects the fact that this explanation focuses on trade in goods and services while ignoring external financial flows that are likely to be built-up during a credit boom.[22]

Table 5 presents additional results that complement the ones shown in Table 4 but this time the results are for different sample periods and country groupings.[23] Some of the country groupings are dictated by data availability and are easily identified in each table. 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 also influences data availability for some of the determinants of PRA (i.e., Ω_{it}).

For the most part, the signs reported in Table 4 carry over to the estimates shown in Table 5. However, it is interesting to consider whether some economies are more prone than others, on average, to engage in PRA. Of course, some of the results are more robust to the PRA proxy employed than others. Nevertheless, on balance, Hong Kong is prone to engaging in PRA while

[22] Hence, the interaction of a credit boom and a financial crisis raises the likelihood of a PRA as a partial response to the central bank's desire to reduce the fallout from such an event. However, this is partially offset, according to the mercantilist motive, by a desire to reduce foreign exchange level holdings (hence, the negative CREDGAP coefficient) in order to stem the pressure from an appreciating currency. Interaction effects alone are shown for the CRISES dummy (=1 during the Asian [1997Q1-1998Q4] and Global financial crises [dates vary by country; see above]). The CRISES dummy alone is highly insignificant when added. An illustration of the results is relegated to the Appendix. Space constraints also prevent a discussion of the marginal effects associate with each determinant.

[23] A referee suggested that we consider a pooled regression. We did try this and while the results for the determinants of interest remain broadly similar idiosyncracies in reserves accumulation behavior (e.g., see Table 1) argues against conditioning on fixed effects.

China, Indonesia, and India are less prone, on average, to be involved in this kind of activity. 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. In other words, the Chinese experience is sufficiently brief to suggest that PRA is not yet a firm feature of the landscape that explains their reserves holding behavior.[24]

5. Conclusions

This study has considered the economic implications of the accumulation of foreign exchange reserves that has been evident in most Asia-Pacific economies for well over a decade. The following conclusions emerge based on the stylized facts and the econometric evidence presented in this study. First, the best protection against costly reserves accumulation is a more flexible exchange rate and capital mobility. Second, the necessity of accumulating reserves as a bulwark against goods price inflation is misplaced. Moreover, 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, and assuming that the returns on international reserves is relatively low, policies pursued by several Asian economies to accumulate these reserves are potentially economically costly (e.g., Rodrik 2006, Bianchi, Hatchondo and Martinez 2012, Filardo and Grenville). In particular, such policies which lead banks to accumulate low yielding (i.e., 'lazy') assets (e.g., government securities) which may entail future exchange rate risk not to mention the risk of capital losses when interest rates

[24] Moreover, one should not confuse the size of reserves holdings with the degree to which these might be excessive according to the metrics used in this study.

rise, both of which are likely to be underwritten by the central bank or the State. 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 economic uncertainty as proxied by the VIX.

Which it is difficult to establish a direct link between prolonged reserves accumulation and their macroeconomic impact 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. 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, we find that the global financial crisis has reduced bank asset returns, consistent with the 'lazy' assets hypothesis (results not shown but see the Appendix). 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.

An important drawback with the existing metrics for foreign exchange reserves that are deemed costly is that the economically sensible thresholds indicating whether this state of affairs has been attained remain elusive. Accordingly, we propose a new metric that is

hopefully less ad hoc and 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.

Three other important extensions also await. First, it may be useful to adopt the treatment effect view of the link between exchange rate regimes and reserves accumulation. Second, we need to more carefully deal with the possible endogeneity of some of the regressors. The shortage of good instruments is a difficulty that remains difficult to overcome.

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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, 1960-2010

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, 1960-2010

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 α =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, 1960-2010

(1)

Dependent Variable: Proxy for PRA,
ES (Edwards – Sizeable)

Variable	Coeff.	SE	z-Stat	Prob.
C	-0.63	0.28	-2.20	0.03
KAOPEN	-0.14	0.07	-2.16	0.03
CREDGAP	-0.73	0.64	-1.15	0.25
CREDGAP*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: Proxy for PRA
3 year centered Moving Average, **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
CREDGAP	2.00	0.50	3.96	0.00
CREDGAP*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
WTI	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: Proxy for PRA, **Factor 1: self-insurance motive**					Dependent Variable: PRA proxy, **Factor 2 Mercantilist motive**			
Variable	Coeff.	SE	t-Stat	Prob.	Coeff.	SE	t-Stat	Prob.
C	-0.50	0.15	-3.43	0.00	0.17	0.15	1.15	0.25
KAOPEN	0.05	0.03	1.87	0.06	-0.07	0.03	-2.33	0.02
CREDGAP	0.55	0.22	2.48	0.01	0.49	0.23	2.13	0.03
CREDGAP*CRISES	-0.03	0.41	-0.06	0.95	1.86	0.43	4.36	0.00
STMKGAP	-0.07	0.15	-0.46	0.65	-0.51	0.16	-3.25	0.00
FDIGAP	-0.02	0.03	-0.64	0.53	-0.00	0.03	-0.10	0.92
FDIGAP*CRISES	-0.14	0.10	-1.51	0.13	-0.10	0.10	-1.06	0.29
RPPGAP	-0.00	0.00	-0.45	0.65	0.00	0.00	1.53	0.13
RPPGAP*CRISES	-0.01	0.01	-1.85	0.07	0.01	0.01	1.03	0.31
INFL	-0.01	0.01	-2.10	0.04	-0.05	0.01	-6.97	0.00
M2GAP	-0.00	0.00	-0.19	0.85	-0.00	0.00	-0.66	0.51
M2GAP*CRISES	-0.00	0.00	-0.90	0.37	-0.01	0.00	-2.27	0.02
PCRGDPGAP	-0.01	0.02	-0.41	0.68	-0.03	0.02	-1.75	0.08
ERRFC	0.05	0.01	5.57	0.00	-0.00	0.01	-0.27	0.79
VIX	-0.00	0.01	-0.84	0.40	0.02	0.01	2.59	0.01
WTI	-0.00	0.00	-1.32	0.19	0.00	0.00	2.50	0.01
R-squared	0.13				0.21			
Log likelihood	-553.17				9.00			
F-statistic	4.99				0.00			
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. Data are quarterly. **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. **WTI** is the rate of change in West Texas Intermediate oil price, **CRISES** is a 0,1 dummy for the Global Financial Crisis. Different dates may apply to the individual countries in the data set. See Dominguez, Hashomoto, and Ito (2012) for the dates.

Table 5 Further Probit and Factor Model Estimates of the Likelihood of Episodes of Prolonged Foreign Exchange Reserves Accumulation

(1) Data since 1960

Dependent Variable: Factor Self-insurance motive

Included observations: 668 after adjustments

Variable	Coeff.	SE	t-Stat	Prob.
CREDGAP	-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			

(2) Data since 1970

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			

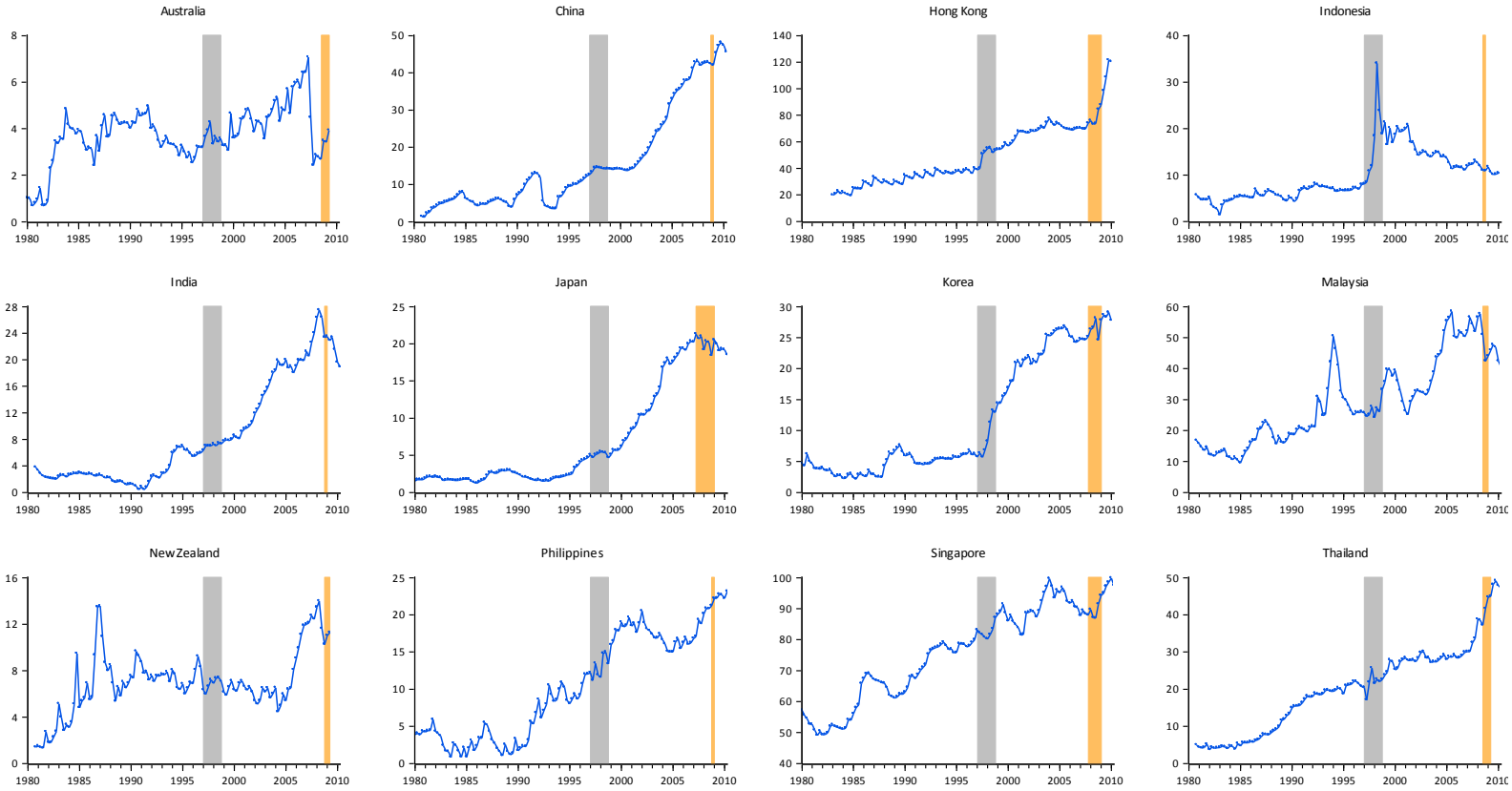
(3) Data since 1980s

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			

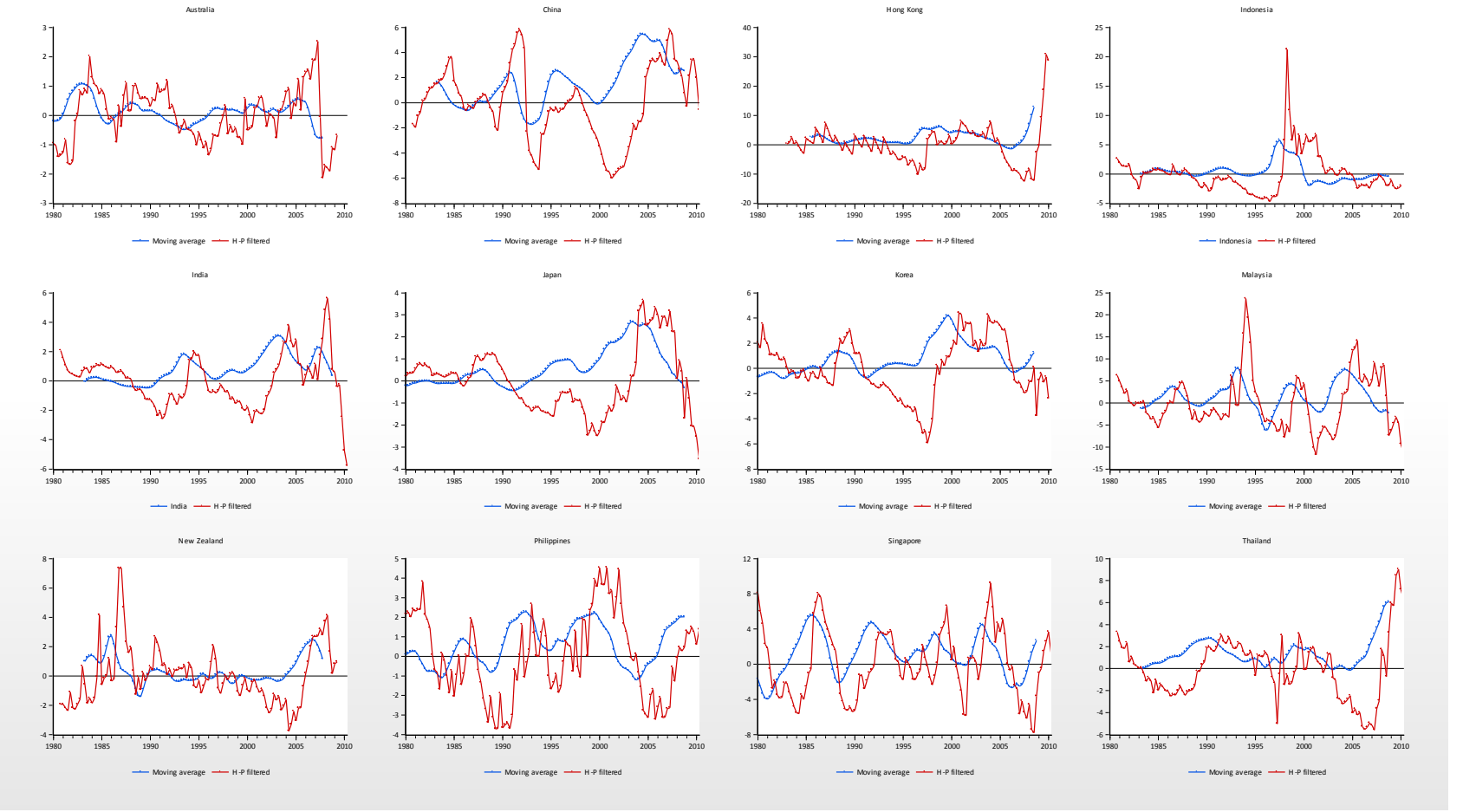
Note: See notes to Table 4. Only the self-insurance factor results are shown. Results for the mercantilist factor are available on request.

Figure 1 Reserves to GDP ratios, 1980-2010



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

Figure 2 Moving Average and H-P Filtered Reserves Holdings, 1980-2010



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.

APPENDIX

Figure A1 Proxies for Foreign Exchange Reserves Levels Adequacy, 1980-2010

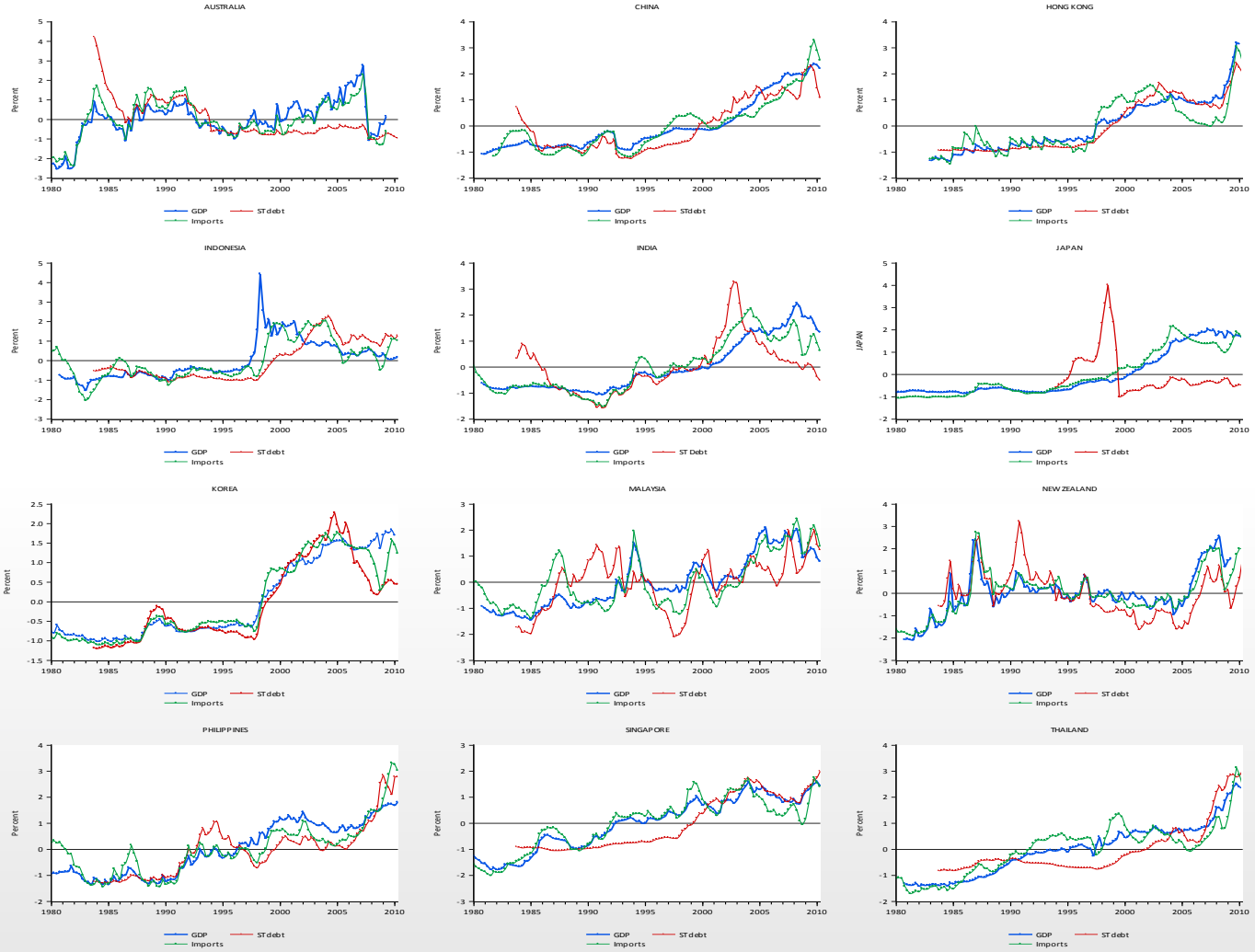


Table A1 Identifying Costly Episodes: Selection of Threshold Methods

There is no universally agreed upon method of identifying booms and busts in asset prices or in business cycle activity. Indeed, some would argue that we know a boom or a bust when we see one. Clearly then, what economists and policy makers think constitutes a boom or a bust involves some excessively large price increase or decrease. In general, the methods below rely on a deviation from some long-run trend. Typically, the long-run trend is evaluated via a version of the widely used Hodrick-Prescott (H-P) filter. Next, an assumption is made, or some estimate is hypothesized, for a threshold above which the variable in question is labeled a boom. Similarly, a fall in the same variable which exceeds a certain threshold would constitute a bust. Some of the proxies require the variable to exceed (in absolute value) the threshold over several periods (i.e., months, quarters or years) but this approach is not universally followed. An alternative approach consists in looking for benchmark episodes (e.g., the stock market crash of 1929 or 1987) and classifying all other boom and bust events in relation to this benchmark. The table below summarizes some of the proxies applied to a wide variety of macroeconomic indicators and asset prices. Finally, a distinction is sometimes made between large (small) or boom (bust) episodes versus ones that are 'painful' or 'costly' usually in terms of aggregate output. In these situations the identification of episodes of interest involves a two-stage process. We can summarize the general approach to identifying costly episodes of some kind with the expression $\%_{it} \geq \tau\sigma(\%_{it})$ where $\%_{it}$ represents the deviation from some (long-run) trend for series *i* at time *t* , τ is a threshold value and $\sigma(\%_i)$ is the sample standard deviation (S.D.) for series $\%$. The final two proxies are based essentially on an *ad hoc* (i.e., visual) estimate of rising or accelerating reserves to GDP ratio values.

Author(s)	**Acronym**	*Definition:* The 'series' in question can vary according to the specific objectives of the studies listed below. Also, the smoothing parameters can be adjusted according to the sampling frequency.
Edwards (2007)	ES EP	Series (t) ≥ 3% of real GDP(t-1), can be per capita terms: 'sizeable' Series (t) ≥ 3% of real GDP over two consecutive years (e.g., current and previous): 'painful'
Mendoza and Terrones (2008)	MT	Series (t) > recursive H-P trend + τ recursive S.D. (τ= 1.5, 1.75, or 2), λ=100,000 (smoothing parameter): 'boom'
Alessi and Detken (2010)	AD1	Series (t) > recursive H-P trend + τ recursive S.D. AND { $\%_{t+1}, \%_{t+2}, \%_{t+3}$ } < 0, $\%$ deviation from a H-P trend: 'high cost boom'
Adalid and Detken (2007)	AD2	Series (t) > recursive H-P trend + 10% over 4 quarters: 'boom', λ=100,000
Borio and Lowe (2002)	BL	Series (t) > recursive H-P trend + 5% over 12 quarters: 'boom', λ=100,000
Detken and Smets (2004)	DS	MAg (t-2, t-1, t), where MAg= moving average of growth > mean growth + 1.3 S.D.: 'boom'
Calvo, Izquierdo, Mejia (2004)	CIM	Series (t) > 2 S.D. from mean change in series
Gourinchas, Velde, Landerretche (2001)	GVL	$(L_t - L_t^{eHP}) / L_t^{eHP} > \tau$, where L_t^{eHP} is an H-P filter (λ=100,000) evaluated from some minimum starting sample for the series L and then expanded (hence, the *e*) one (or a few) observations at a time. GVL rely on a range of values for τ but 19.5 works best.
Helbing (2005)	H	Top quartile (or bottom quartile) of peak-peak increase (decrease) using the Bry-Boschan dating algorithm.
MIshkin and White (2003)	MW	20% fall in price ('bust' or 'crash') – based on Oct. 1929, 1987 benchmarks – using windows ranging from 1 day to 1 year (includes 1, 3 months)
Reserves Accumulation Reserves Acceleration	RESACC RESACCL	=1 for periods when 3 year moving average of reserves to GDP ratio rises =1 for periods when 3 year moving average of acceleration of reserves to GDP ratio rises. Both proxies based on data from Figures 1 and 2.

Table A2 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 Table A1 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 A3 Additional Probit Results: AD1 Proxy: Full Sample, 1960-2010

(1)

Dependent Variable: AD1

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: AD1

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			

(5)

Dependent Variable: AD1

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			

Note: AD1 is defined n Table A1. The remaining variables are defined below under **Data Availability.**

TABLE A4 Illustrating the Impact of the CRISES Dummy, 1960-2010

Dependent Variable: EP

Variable	Coefficient	S.E.	z-Statistic	Prob.
CRISES	**0.13**	**1.15**	**0.11**	**0.91**
KAOPEN	-0.17	0.13	-1.32	0.19
CREDGAP	-0.02	0.02	-1.34	0.18
CREDGAP*CRISES	0.11	0.11	0.98	0.33
STMMKGAP	-0.01	0.01	-0.92	0.36
RPPGAP	-0.11	0.03	-4.14	0.00
RPPGAP*CRISES	0.01	0.09	0.12	0.90
INFL	-0.14	0.09	-1.60	0.11
M2GAP	-0.01	0.01	-1.27	0.20
PCRGDPGAP	-0.07	0.06	-1.09	0.27
ERRFC	-0.23	0.07	-3.48	0.00
VIX	-0.09	0.03	-2.75	0.01
DLWTI	0.01	0.00	1.57	0.12
C	2.65	0.86	3.09	0.00
McFadden R-squared	0.35			
LR statistic	64.40			
Prob(LR statistic)	0.00			
Obs with Dep=0	277	Total obs		304
Obs with Dep=1	27			

Table A5 Asset Returns and Foreign Exchange Reserves Accumulation

Variable	Dependent Variable: Return on Assets
Constant	-7.44 (3.08)**
Reserves/GDP ratio	0.26 (0.10)*
Reserves/GDP ratio X GFC dummy	-0.07 (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.

DATA AVAILABILITY

Series[1]	Economies											
	AU	CN	HK	ID	IN	JP	KR	MY	NZ	PH	SG	TH
FDIGDP *FDI*	60.1-09.1	82.4-09.4	98.4-09.4	93.2-10.1	94.1-08.4	77.1-09.4	76.1-09.3	98.4-08.3	80.3-09.1	92.4-09.4	94.4-09.3	80.3-09.4
FAGDP *Financial account*	60.1-09.1	82.4-09.4	98.4-09.4	80.4-10.1	79.4-08.4	76.4-09.4	75.4-09.3	98.4-08.3	80.3-09.1	76.4-09.4	94.4-09.3	80.3-09.4
CAGDP *Current account*	60.1-09.1	82.4-09.4	98.4-09.4	80.4-10.1	80.3-08.4	77.1-09.4	75.4-09.3	98.4-08.3	80.3-09.1	76.4-09.4	94.4-09.3	80.3-09.4
RPP *Real property prices*	60.1-10.2	05.4-10.2	80.1-10.2	94.1-10.2	NA	60.1-10.2	86.1-10.2	99.1-09.4	79.4-10.2	NA	75.1-10.2	91.1-10.2
IP *Industrial production*	77.3-10.2	94.1-10.2	70.1-10.2	74.3-10.2	63.1-10.2	81.1-10.2	60.1-10.2	74.1-10.2	98.4-10.2	84.1-10.2	69.1-10.2	90.1-10.2
MFX *Nominal exchange rate (DCU/US$)*	60.1-10.2	60.1-10.2	60.1-10.2	67.1-10.2	60.1-10.2	60.1-10.2	60.1-10.2	60.1-10.2	60.1-10.2	60.1-10.2	60.1-10.2	60.1-10.2
STMK Equity Prices	05.1-10.2	05.1-10.2	05.1-10.2	05.1-10.2	05.1-10.2	05.1-10.2	05.1-10.2	05.1-10.2	05.1-10.2	05.1-10.2	05.1-10.2	05.1-10.2
QGDP *Real GDP*	60.1-10.2	93.1-10.2	66.1-10.2	80.2-10.2	96.4-10.2	80.1-10.2	60.1-10.2	88.1-10.2	77.2-10.2	73.1-10.2	75.1-10.2	93.1-10.2
D4 *Prolonged regime*	60.2-10.2	80.4-10.2	90.4-10.2	80.4-10.2	80.4-10.2	60.1-10.2	60.4-10.1	80.4-10.2	80.4-10.1	73.1-10.2	75.4-10.2	80.4-10.2

dummy												
D3 *Prolonged regime dummy*	60.2-10.2	80.4-10.2	90.4-10.2	80.4-10.2	80.4-10.2	60.1-10.2	60.4-10.1	80.4-10.2	80.4-10.1	73.1-10.2	75.4-10.2	80.4-10.2
D2 *Prolonged regime dummy*	62.4-07.4	83.2-08.4	93.2-08.3	83.2-08.4	83.2-08.4	60.1-08.4	63.2-08.3	83.2-08.4	83.2-07.4	75.3-08.4	78.2-08.4	83.2-08.4
D1 *Prolonged regime dummy*	62.4-07.4	83.2-08.4	93.2-08.3	83.2-08.4	83.2-08.4	60.1-08.4	63.2-08.3	83.2-08.4	83.2-07.4	75.3-08.4	78.2-08.4	83.2-08.4
FXRIM *Forex reserves to imports*	60.1-09.2	81.4-10.2	83.2-10.2	71.1-10.2	60.1-10.2	60.1-10.2	60.1-10.2	67.1-10.2	67.3-10.2	60.1-10.2	69.2-10.2	60.1-10.2
RESSTDEBT *Forex reserves to short-term debt*	83.4-10.2	83.4-10.2	83.4-10.2	83.4-10.2	83.4-10.2	93.4-10.2	83.4-10.2	83.4-10.2	83.4-10.2	83.4-10.2	83.4-10.2	83.4-10.2
CREDGAP *Credit gap*	64.4-10.2	86.3-10.3	94.3-10.2	81.3-09.4	81.3-10.2	63.4-10.2	61.3-10.2	81.3-10.2	81.3-10.2	73.4-10.1*	76.3-10.2	81.3-10.2

*There is a gap during the 1984.1-1987.2. (1) All data are quarterly

APPENDIX – DATA AVAILABILITY (cont'd)

Series	Economies											
	AU *AUSTRALIA*	CN *CHINA*	HK *HONG KONG*	ID *INDONESIA*	IN *INDIA*	JP *JAPAN*	KR *KOREA*	MY *MALAYSIA*	NZ *NEW ZEALAND*	PH *PHILIP.*	SG *SING.*	TH *THAILAND*
QMGAP *Quasi-money gap*	60.1-10.2	95.1-10.2	92.1-10.2	80.2-09.2	80.2-10.2	60.1-09.1	70.2-10.2	80.2-09.1	80.2-10.2	72.3-07.4	75.2-10.2	80.3-09.2
M1GAP *M1 gap*	60.1-10.2	95.1-10.2	92.2-10.2	80.2-09.2	80.2-10.2	60.1-09.1	70.2-10.2	80.2-09.1	80.2-10.2	72.3-07.4	75.2-10.2	80.2-09.2
BC *Business cycle dates*	83.2-10.3	84.4-10.2	NA	NA	60.1-10.3	60.1-10.3	62.1-10.3	NA	62.1-10.3	NA	NA	NA
BC1 *Business cycle growth dates*	60.1-10.2	85.1-10.2	NA	NA	60.1-10.2	60.1-10.2	66.1-10.2	NA	66.1-10.2	NA	NA	NA
WTI** *West Texas Interm.*	83.2-10.3	83.2-10.3	83.2-10.3	83.2-10.3	83.2-10.3	83.2-10.3	83.2-10.3	83.2-10.3	83.2-10.3	83.2-10.3	83.2-10.3	83.2-10.3
VIX**	90.1-10.3	90.1-10.3	90.1-10.3	90.1-10.3	90.1-10.3	90.1-10.3	90.1-10.3	90.1-10.3	90.1-10.3	90.1-10.3	90.1-10.3	90.1-10.3
EXRR *L-Y & . Exch Rate class.*	84.4-04.4	96.4-04.4	84.4-04.4	74.4-04.4	79.4-04.4	74.4-04.4	74.4-04.4	74.4-04.4	77.4-04.4	74.4-04.4	87.4-04.4	74.4-04.4
ERR *I, R&Rogoff fine exch.*	60.1-07.4	60.1-07.4	60.1-07.4	60.1-07.4	60.1-07.4	60.1-07.4	60.1-07.4	60.1-07.4	60.1-07.4	60.1-07.4	60.1-07.4	60.1-07.4

Rate class.												
CAPINC *Gross capital inflows*	60.1-09.1	05.2-10.2	98.4-09.4	05.1-09.4	NA	95.4-09.4	79.4-09.3	05.4-09.4	79.4-09.4	98.4-09.4	NA	76.1-88.4
NETCAP *Net capital flows*	60.1-09.2	98.2-10.2	99.1-10.1	05.2-09.4	NA	85.1-10.1	80.1-09.4	06.1-10.1	80.1-10.1	99.1-10.1	95.1-09.4	76.1-90.4
RESGDP *Forex reserves to GDP*	60.2-09.2	80.4-10.2	83.1-10.1	80.4-10.2	80.4-10.2	60.1-10.2	60.4-10.1	80.4-10.2	80.4-09.2	73.1-10.2	75.4-10.2	80.4-10.2
M2GAP *M2 gap*	60.1-10.2	95.1-10.2	92.1-10.2	80.2-09.2	80.2-10.2	60.1-09.1	70.2-10.2	80.2-09.1	80.2-10.2	72.3-07.4	75.2-10.2	80.2-09.2
KAOPEN *Chinn-Ito cap acct open*	70.1-08.4	84.1-08.4	70.1-08.4	70.1-08.4	70.1-08.4	70.1-08.4	70.1-08.4	70.1-08.4	70.1-08.4	70.1-08.4	70.1-08.4	70.1-08.4
INFL *Inflation rate, annual*	61.1-10.2	95.2-09.4	86.1-10.2	86.2-10.2	61.1-10.2	61.1-10.2	70.2-10.3	61.1-10.2	61.1-10.2	61.1-10.3	61.2-10.2	65.2-10.3
LR *Leverage ratio*	05.4-10.3	95.4-10.3	04.4-10.3	95.4-10.3	95.4-09.4	95.4-09.4	95.4-09.4	95.4-10.3	05.4-10.3	04.4-10.3	03.4-10.3	95.4-10.3

**Single value indicator, the same for all economies in the dataset. (1) All data are quarterly. The lightly shaded series represent raw data at the monthly frequency converted to quarterly data via arithmetic averaging. The darker shading represents data that are originally either at the semi-annual or annual frequencies converted to quarterly data via linear interpolation. NA signifies that no data were available.

Notes to the data:

Variables Worksheet Notes (in **bold** the variable names used in reporting the results)

Reserves / imports **ResIM** Foreign exchange reserves / Imports c.i.f.; in per cent.

Reserves / short-term debt **ResSTDebt** Foreign exchange reserves / short-term external debt; in percent.

Reserves / GDP **ResGDP** Foreign exchange reserves / GDP; in percent.

D1: Level of Reserves/GDP greater than 0.5 SD of HP trend = 1; otherwise = 0.

D2 for level of Reserve/GDP algorithm; Peak-to-trough period = 0; trough-to-peak = 1.

D3 3-year moving average of year-on-year change of Reserves/GDP; 1 indicates change >=0; otherwise 0.

D4 Based on 3-year centered moving average of year-on-year change of Reserves/GDP; peaks and troughs identified by Bry and Boschan algorithm; peak-to-troguh period = 0; trough-to-peak = 1.

Real GDP **realGDP** in billions of national currency; annualised data for Japan; seasonally adjusted for Australia and New Zealand.

[Per capita real GDP is real GDP deflated by annual population etimates cpnverted to the quarterly frequency via linear interpolation]

Equity index **STMK** 3 Jan 2005 =100 (in the case of AU and NZ the extension _d signfies a version derived from daily data; a longer sample was obtained from quarterly data from IFS)

Foreign exchange **FX** national currency per USD; monthly average

Industrial production growth **ProductionGrowth** year-on-year pecentage change of real industrial production

Real housing price **HousingPrice** real housing price index; 2005=100.

Current account/GDP **Current Acct** in per cent; current account balance / annualised GDP (note: current account balance is flow data while GDP is stock data)

Financial account/GDP **FinancialAcct** in per cent; financial account balance / annualised GDP (note: financial account balance is flow data while GDP is stock data)

Others **VIX** and **WTI**

Capital flows **CAPINFLOWS** gross captial inflows

Credit gaps **CREDGAP** credit/gdp - Hpfilter trend (1600 for quarterly data)

Money gaps **M1GAP,M2GAP,QMGAP** dlog(m) - dlog((p*y)/m)
Dummies for spikes in these series are **MDM1, MDM2, MDQM**

Business cycle dates **BCYCLE** only a few countries from businesscycle.com ECRI

Exchange rate regimes **EX_REGIME** Levy-Yeyati & Sturzenegger 2005 - no change assumed after sample ends
Alternate exchange rate regime classification from Dataset for Ilzetzki, Reinhart and Rogoff (2008), fine classification.

The financial account and the current account are related through a balance of payments identity:

current account + capital account +(Non-reserves capital inflows + reserves inflows [sales])* + errors and omissions = 0

* = financial inflows

A financial account contraction and a current account reversal differ by (i) the capital account, (ii) reserves sales or purchases and (iii) errors and omissions. The capital account is usually dominated by migrants' capital transfers, which are typically small. Ideally, errors and omissions are small. As current account measurement is generally thought to be more accurate than financial account measurement, errors and omissions are more likely to reflect financial account than current account measurement error.

LR Leverage ratio = Total assets divided by total equities, weighted by asset size of 10 largest banks. Raw data are annual.

Aggregate asset prices = only for Australia, New Zealand and Japan.

Foreign direct investment/GDP **FDI** in per cent; direct investment abroad / annualized GDP (note: direct investment abroad is flow data while GDP is stock data)

KAOPEN Capital account openness = Chinn-Ito de jure measure of financial openness, from http://web.pdx.edu/~ito/Chinn-Ito_website.htm

INFL Inflation = CPI inflation, year over year log difference multiplied by 100, from IFS.