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accumulation: new international
evidence

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The economic policy of foreign reserve accumulation: new international evidence*

Martín Redrado Jorge Carrera Diego Bastourre Javier Ibarlucia

Abstract

This paper aims at identifying the underlying reasons for substantial accumulation of foreign reserves, a strategy currently followed by a large number of countries.

To this end, it first studies international liquidity conditions and individual country demand for reserves. It then analyses reserve hoarding by different country groups and its relationship with exchange rate and sterilization policies. Following this, the dynamics of reserves in Argentina is described. Additionally, several adequacy indicators for emerging economies are calculated. After discussing alternative econometric strategies, the paper estimates reserve determinants in a panel of 139 countries employing a generalized method of moments estimator (System GMM). This methodology considerably changes prevailing results. It is found that inertia, regional imitation, both trade and financial openness and income levels are important factors driving reserve hoarding. It is concluded that in the context of asymmetric financial integration, reliance on international liquidity is a feasible way of guaranteeing the stability of monetary and exchange rate policies when real and financial shocks hit an economy.

As a policy recommendation, exchange rate flexibility does not turn out to be a substitute for reserve accumulation. Emerging economies combine high international reserve levels with greater exchange rate flexibility as a strategy to face increasing exposure to external shocks.

JEL Codes: C23, F30, F33

Key Words: international liquidity, international reserves, exchange rate regimes, panel data

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Executive summary

In the last ten years the international monetary economy has been witness to a notable phenomenon: the explosive growth at global level of international reserves. During this period they reached a record level of 3.8 trillion dollars. This accumulation process was driven mainly by emerging economies.

Faced by this behavior, old doubts have arisen once again, and other new questions are being asked. Why do most emerging countries decide to follow a reserve accumulation strategy? Is it a case of convergence of individual motives, or are there global impulses that drive countries to adopt such a policy? What are its benefits and costs? What is the role currently played by reserves? Is there such a thing as an optimum level for this variable?

Guided by these questions, various aspects of the problem have been analyzed. The first part of this paper examines both the supply of global liquidity and the demand for reserves in each country. Particular attention is paid to the recent matter of global imbalances and the role of external central bank assets in the organization and sustainability of the international macroeconomic system. The latter represents an improvement with respect to other studies, because it is usually assumed that reserve accumulation decisions taken by each economy are independent from international liquidity conditions.

In the case of demand for reserves, a detailed analysis is made of the various theoretical models that rationalize their determinants. A review is made both of traditional contributions, stressing the role of a limited group of variables, and more recent literature that underlines the precautionary and insurance aspects of international liquidity. The idea that reserve dynamics can be determined or influenced by other relevant macroeconomic variables is also discussed. Additionally, the extent to which the demand for reserves could derive from the specific objectives of each exchange rate regime is analyzed.

This analytical structure constitutes the reference framework for the empirical research. This part of the paper covers four analytical instances.

First, compared experiences of groups of countries are analyzed, with special emphasis on the behavior of emerging economies. This has shown the existence of various patterns. In particular, there was a notable acceleration in the rates of accumulation during the nineties, led by emerging countries. Within this group, the Asian economies adopted this policy in a persistent and systematic manner. As one important aspect has to do with the implementing of a coherent monetary policy through the accumulation strategy, this section also studies the role of the monetary and exchange rate systems and sterilization policies. As a main conclusion, it has been found that in economies that have accumulated large quantities of reserves over a long period, a significant portion of the increase in the external asset is sterilized. Accumulation through sterilization is furthermore a strategy pursued under different exchange rate and monetary systems.

Second, various reserve adequacy indicators have been calculated, apart from pointing out their advantages and limitations, as a guide for economic policy. There are different variants such as "commercial criterion," "financial criterion," and "additive criterion," the latter being the sum of the two previous criteria. According to the additive criterion, four of the five Latin

American economies considered are below appropriate levels. On the other hand, Asian countries are mostly above the adequacy thresholds.

Next, a specific analysis of reserves in Argentina is presented, with a brief description of their unstable history. Then, work is performed on simple crossed correlations between reserves and other macroeconomic indicators such as inflation, output, current account or nominal and real volatility. It has been determined that 2003-2005 was the only significant period in the last thirty years during which positive current account balances coexisted with reserve accumulation at the Central Bank. Last, an analysis is included of recent Central Bank policy that explains how prudential accumulation has been implemented in Argentina as from the re-monetization of the economy and the absorption of liquidity via various sterilization channels, with the aim of ensuring compliance with the established monetary program.

The econometric section completes the explanation for the main question on the cause of reserve accumulation using a panel data model. In this chapter, various methodological improvements have been adopted in relation to recent research by incorporating the dynamic specification of reserve demand and controlling the possible effects of endogenous factors in the estimation. In first place, the methodological discussion justifying the final decision to use the GMM System methodology is presented.

Results highlight that inertial behavior, imitation of the policies of neighbors, trade levels and capital flows are relevant in explaining reserve accumulation. In contrast, individual country exchange rate policy, the opportunity cost of reserves, and volatility of trade and financial flows are not statistically significant variables. Moreover, an inverted "U" relationship is established between the reserves to GDP ratio and the level of economic development.

Consideration of inertial behavior is a very significant improvement, as is consideration of regional imitation. This is a strong indication that decisions on accumulation are neither sporadic nor erratic.

Relevant conclusions include the following:

Self-insurance by means of reserve accumulation could be considered a second-best solution, even when disregarding the composition dilemma. It would be better to take part in a global system forming a pool to exploit all the potential for risk diversification. Nevertheless, multilateral institutions, and the IMF in particular, have not been capable in recent years of playing the role of pool administrators. For this reason, their functions within global financial architecture need to be reviewed.

As a summary of the lessons learnt from the analysis performed on the behavior of countries, it can be argued that :

- 1) Financial and commercial integration generates a highly volatile context for emerging economies;
- 2) There is a less than nil probability of sharp adjustments in the international economy to correct current imbalances;
- 3) There is a lack of a reliable global financial structure that includes a lender of last resort;
- 4) The effects of competitive imitation in accumulation by the various regions is relevant;

5) The increased importance of reserve accumulation during the intermediate stage of development

are key elements in understanding why emerging countries have accelerated their rate of reserve accumulation.

In conclusion, the lack of relevance of exchange rate systems in explaining the reserve dynamic indicates that the complementary (rather than substitution) relationship between reserve accumulation and greater exchange rate flexibility appears to be the appropriate policy combination to reduce external risk and long-term volatility in emerging economies.

Introduction

In the last ten years the international monetary economy has been witness to a notable phenomenon: the explosive growth at global level of international reserves, largely driven by emerging economies. During this period external assets held by central banks increased by 220%, reaching a record level of 3.8 trillion dollars.

Faced by this behavior, old doubts have arisen once again, and other new questions are being asked. Why do most emerging countries decide to follow a reserve accumulation strategy? Is it a case of convergence of individual motives, or are there global impulses that drive countries to adopt such a policy? What are its benefits and costs? What is the role currently played by reserves? Is there such a thing as an optimum level for this variable? Do the theoretical or empirical models developed to date explain the reasons for such accumulation?

This study takes a dual approach to the subject, one analytical and the other empirical. Given the segmented nature of the evidence available to date, a sequential study is advisable, with an integrating perspective.

The first part examines both the supply of global liquidity and the demand for international reserves for each country. All the studies on the matter concentrate on the individual aspect, considering the supply of reserves as infinitely elastic, which implies assuming that the individual accumulation decision taken by each country is independent from the liquidity production conditions. Just as when discussing whether a positive current account balance is caused by excess saving or lack of investment, a country's reserve accumulation can be the result of a decision of "individual demand," or it could be influenced by what is happening with "global liquidity supply".

To understand how the process of generation and injection of liquidity works during the era of the dollar as the reserve currency, a long-term approach has been adopted to explain how the monetary leader has developed its relations with the remaining reserve-demanding countries.

A detailed analysis is performed of the various theoretical models that rationalize the determinants of the demand for reserves. This analytical framework constitutes the benchmark for the econometric research.

The empirical section of the paper consists of four separate parts.

First, work has been carried out on the compared experiences of groups of countries, with special emphasis on the behavior of emerging economies. This has shown the existence of several significant patterns.

Next, Argentine reserves have been considered, stressing both the reasons for their unstable history and their relationship to other macroeconomic variables.

Third, reserve adequacy indicators have been calculated for the emerging countries group, pointing out their advantages and limitations, as a guide for economic policy.

The econometric section completes the explanation for the main question on the cause of reserve accumulation using a panel data model. In this chapter, various methodological

improvements have been adopted in relation to recent research, by incorporating the dynamic specification of reserve demand to the analysis. It is shown that by ignoring the inertial aspect of reserve demand, as in the case of earlier studies, significant problems of bias and inconsistency arise in the coefficients estimated. This demonstrates the advisability of switching from the estimate of fixed effects by the least squares method to the GMM System, with a significant change in the range of results determined up to the present time.

The last section of the document reports the conclusions and discusses the economic policy recommendations arising from the analysis performed.

1. International liquidity supply and global reserve dynamics

The role of reserves has changed drastically in the last one hundred years. During the time of the gold standard, and well into the 20th century, they played a leading role in each country's monetary system, as the counterpart to money emission. They thus represented the guarantee that conferred credibility on national currencies.

Since Bretton Woods, reserves ceased to be directly linked to emission, only providing the degrees of freedom needed to avoid sharp adjustments to the level of national income in the event of external shocks, in a global context of exchange rate and capital controls. For the first time, one country's currency (the dollar) replaced gold as the main instrument of international liquidity, and thus as a reserve currency.

The move towards floating reserves that began in 1971 removed, in theory at least, some of the incentive for holding international reserves. It was assumed that the exchange rate was capable of isolating countries, lessening the impact of shocks on the economic cycle. Nevertheless, the demand for reserves continued to grow.

During the nineties there was a widespread increase in the rate at which such assets were accumulated, a phenomenon led by developing economies.

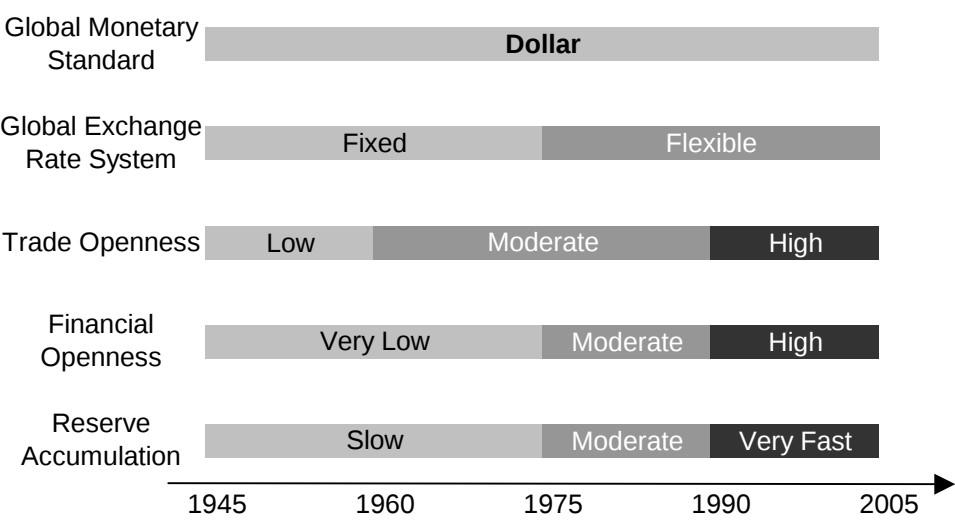
This reserve accumulation phenomenon can be approached from two complementary angles: from a structural standpoint, and from a macroeconomic standpoint. The latter conceives the demand for reserves as based on the decision of a country's central bank, taken on the basis of certain domestic determinants. The former, on the other hand, concentrates on matters of global liquidity, and defines the reserve accumulation decision of each country in terms of the operation of the international monetary system. In this case, the passive aspect of the decision to hold reserves is emphasized: the behavior of a country in relation to this variable would be largely determined by global events over which it would have little influence.

A review of the literature on this matter shows that there are almost no studies on reserves that make an effort to establish a context for demand within the international monetary order. At the same time, those works that do deal with this last aspect rarely delve deeply into aspects such as the benefit, accumulation dynamic, or the optimum level of reserves. The purpose of this work is precisely to integrate the two approaches. This chapter begins by describing the main characteristics of the global system.

The hypothesis discussed in this section assumes that, in essence, the basic manner in which liquidity is created and injected into the international economy has not changed in the

last 50 years. That is why it is necessary to begin the study of the global system as from Bretton Woods. Understanding the era of the dollar standard (in its fixed and floating variants), its changes and its crises, is necessary for a correct evaluation of the decisions by the international monetary system players in relation to their reserve assets. Changes to the dollar standard system contribute the nuances that will be studied, as they have altered the level of demand for reserves, the rate of their accumulation and their composition. They form the nucleus of the first section of the paper, and can be summarized in the graphic representation of the development of the four key variables shown in Figure 1: i) the global exchange rate system; ii) the degree of openness to trade; iii) the mobility of capital; and iv) reserve accumulation.

Figure 1. Global determinants of reserve dynamics

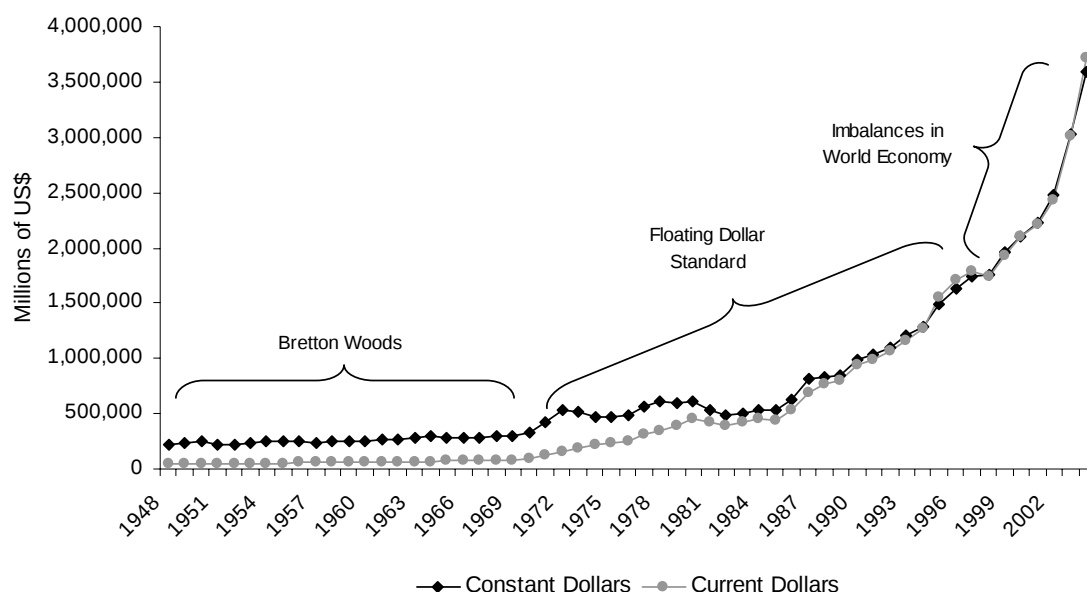


Before analyzing each stage of the dollar standard, to be able to identify the main features of the behavior of the variable under consideration Graph 1 shows the historical series for total world reserves between 1948 and 2004.¹

The reserve series trend in both constant and current dollars has followed a steady upward path, although there have been changes in the velocity of accumulation.

¹ Total world reserves are calculated regularly by the IMF. The series in constant dollars has been constructed deflated by the US export price index. The resulting measurement provides an indication of the purchasing power of reserves in terms of tradable goods produced by the country issuing the currency that is the vehicle for international transactions. Graph 1 does not alter significantly when deflated by the US wholesale price index.

Graph 1. International reserves (world total) in current and constant dollars, 1948-2004



Source: Prepared on basis of IMF data (IFS)

There are three clearly-defined periods: i) that of Bretton Woods (or fixed dollar standard), 1948-1970; ii) the floating gold standard, 1974-1998;² and iii) that of world trade imbalances in 1998-2004. The third of these periods could be interpreted as a sub-stage of the more general global system defined as the floating dollar standard. Nevertheless, as it has certain distinctive features, it would be advisable for it to be analyzed separately.³

Significant contrasts can be found when calculating the reserve accumulation rate in each of these three stages. Table 1 shows the average growth rates for this variable for each historical phase, and a measure of their volatility (the coefficient of variation).

² There is a time between the end of 1970 and 1973 that is not included within any specific period. That stage took place between the collapse of the Bretton Woods system and the birth of a new system, a moment that cannot be assigned a precise date. The end of Bretton Woods technically began on August 15, 1971, with the order by President Nixon to halt the gold convertibility of the dollar. Towards the end of that year new fixed parities were negotiated between the main economies. Nevertheless, the new agreement was soon broken. During 1972 the pound sterling began to float against the dollar. This decision was copied by Japan in February 1973, and by the six members of the European Community in March of that year.

³ Indeed, there is considerable academic discussion (to be detailed later in this section) as to whether a new international monetary system is in fact developing.

Table 1. Growth rates (in annual average) and volatility of reserves

Period	Current dollars		Constant dollars	
	Average growth	Coefficient of variation	Average growth	Coefficient of variation
1948-1970	3.09	1.31	1.75	2.54
1973-1998	9.47	0.93	5.02	1.82
1998-2004	13.47	0.57	12.74	0.48

Source: Prepared on basis of IMF data (IFS)

It can be seen that the growth rate has accelerated, achieving very considerable volumes. It is hard to find global economic variables that have shown such notable and systematic growth in real terms over a period as lengthy as that considered here. Significantly, the volatility of such growth has lessened, raising a question as to whether the increased stability in accumulation in the latest stage is a fortuitous phenomenon, or the result of a deliberate policy.

Now that the main features of the global reserve dynamic have been identified, the following sections indicate in greater detail the characteristics of each of the stages through which the international monetary regime has evolved in the last 50 years.

1.1. The rules of the game under the fixed dollar standard and the role of reserves

The design of a global solution for the reconstruction of the economy in the period after the Second World War required that the errors made in the period between the wars should not be repeated. A significant increase in liquidity was needed to keep pace with a steady expansion in output and international trade.

Memories of the traumatic return to the gold standard during the twenties and the competitive devaluations during the Great Depression tilted the balance among academics and policymakers in favor of a fixed parity scheme. The United States was the only country in a position to tie the value of its currency to gold. It held approximately 70% of international gold reserves in 1945. Additionally, this country was a major creditor of the rest of the allied economies as a result of the economic and military assistance it had provided.

This situation gave birth to a system whereby all currencies were linked to the dollar. Parities could be adjusted within certain margins in the face of specific structural balance of payments imbalances.⁴ The United States in turn held the dollar at a value of US\$ 35 per troy ounce.⁵

⁴ The International Monetary Fund, also created as part of the Bretton Woods agreement, was the institution responsible for authorizing the devaluation and financing transition under structural adjustment agreements. In practice, this adjustment mechanism did not work as originally intended (McKinnon, 1996).

⁵ As there was a cost involved in transporting and insuring the precious metal, the intervention threshold was slightly above US\$35 per ounce.

The other significant commitment arose from the desire of the United States to extend the convertibility of transactions, and the insistence by Great Britain that controls be maintained. The solution was the prompt restoring of current account convertibility that took place in Europe in 1959 and in Japan some years later, combined with authorization to preserve restrictions on the capital account indefinitely (Eichengreen, 2004). Rigid controls were also maintained on domestic financial markets.

Away from the Federal Reserve, the remaining central banks ensured the stability of the nominal exchange rate in each country by intervening (with dollars) in their currency markets. By taking on the nature of an intervention currency, the dollar was transformed into the source of liquidity and the basic reserve asset of the international monetary system. The revolutionary impact of Bretton Woods in relation to the gold standard was that for the first time in history, world liquidity supply began to be determined not by a random exogenous factor such as the overall availability of precious metals, resulting instead from the balance of payments position of the United States.⁶

To some extent, part of this new order in international finance reflected the ideas of Keynes himself, who diagnosed that the central flaw in the global balance of payments system in force until 1945 was its inability to correct persistent current account deficits among partners without restricting growth in world output.⁷

In the initial stages the United States maintained a commitment to remedy global imbalances by means of a Marshall Plan and other assistance mechanisms, as Europe needed US exports to rebuild its stock of capital. Had it followed the alternative tried after the First World War, Europe and Japan would have had to restrict their imports to the level of their exports, delaying the recovery. This initial period is defined as one of “dollar scarcity” as European currencies and those of the rest of the world were not convertible to gold. Nevertheless, by 1958 the balance of payments had improved sufficiently in Europe for the convertibility of external transactions to be restored, a measure that was effectively adopted in the following year (McKinnon, 1979).

Despite the success of the new international regime in the reconstruction, voices were raised warning that it was unsustainable. It was Triffin (1960) who first outlined the dynamic inconsistency of the global system. In view of the growing and persistent balance of payments deficit in the United States, this author identified just two possibilities for the future: i) the elimination of the deficits, an event that would restrict the creation of international liquidity to the new net supply of gold; or ii) continued deficits, a process that would lead to a

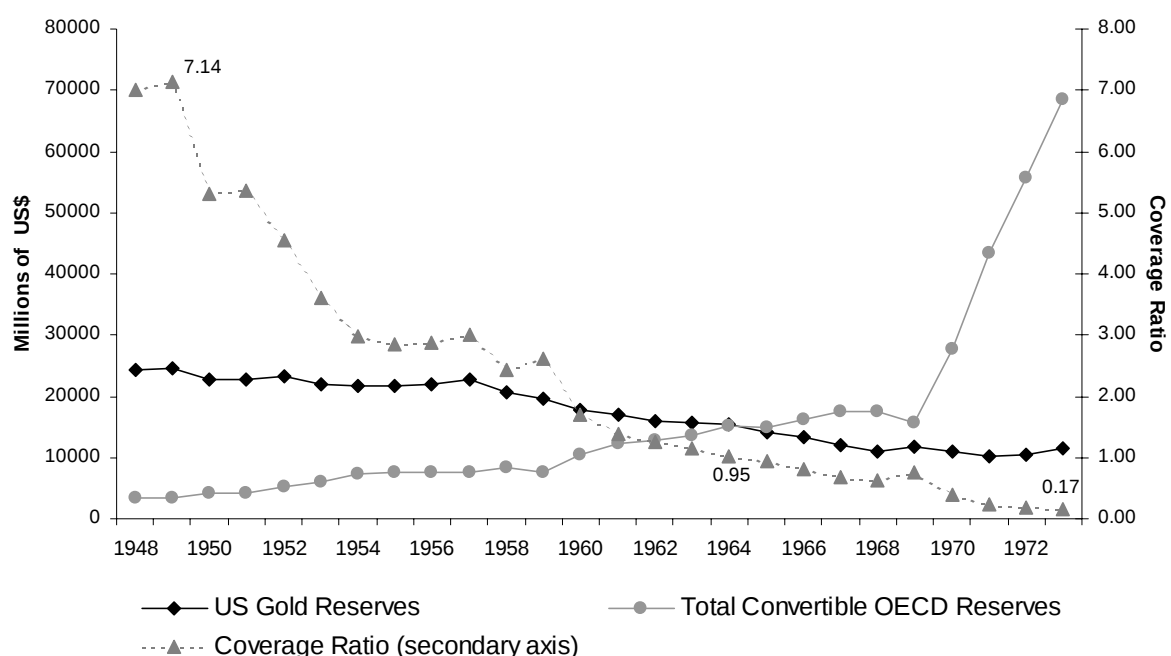
⁶ In fact, this statement is based on the classic idea of Triffin (1960), the most accepted in literature, that represents a “supply side” vision on the theory of international liquidity. On the other hand, Johnson (1964), Kindleberger (1965) and McKinnon (1969), among others, suggested an alternative view that posited that the deficit of the United States was a residual determined by the reserve accumulation wishes of the rest of the world. Any US effort to reduce the deficit would be offset by adjustment policies by other countries to restore the target accumulation rate (Williamson, 1973). As will be seen later, some current discussion has strong links to this early debate in literature on the subject.

⁷ Keynes thus concluded that the substantial change that needed to take place in the new regime was the transfer of responsibility for the adjustment from the debtor country running the current account deficit to the creditor country with a surplus. For a detailed analysis of these Keynesian ideas in relation to the organization of the international system, see Davidson (2002).

gradual deterioration in the ratio of US gold reserves to world liquidity. The last scenario would imply less confidence in the dollar that eventually would provoke a mass attempt to convert dollars into gold that would lead to a collapse similar to that which took place in 1931.⁸ Here there was a kind of “success dilemma.” The efficient operation of the international financial system was dependent on the growth of liquidity to support the world trade growth rate. The latter could only take place however if the United States were to achieve an external deficit that would increase the rights of all other countries on its fixed reserves of precious metals.

To illustrate how the process forecasted by Triffin took place, the dynamic of US gold reserves has been charted, together with reserves in convertible assets held by the central banks of the original members of the OECD. The ratio of coverage of official holdings of dollars has also been included, this being simply the quotient of the two previous variables.

Graph 2. Backing of dollar as international reserve during Bretton Woods



Source: Prepared on basis of IMF data (IFS)

It is clear that the United States suffered a constant drain in its gold reserves, which were mainly acquired by France, Germany, Switzerland and Italy. It was not only the OECD's gold reserves that grew, as their dollar reserves also increased. The coverage ratio fell at an annual average rate of 12.6%, from a maximum of 7.14 in 1949 to 0.95 in 1965. Once convertible assets (dollars) in the portfolios of central banks exceeded the value of total gold holdings valued at US\$ 35 per ounce held by the Fed, convertibility at the official parity became dependant on the willingness of each country to keep the composition of its reserves

⁸ A formalization of Triffin's ideas can be found in Kenen (1960), which presents a simple portfolio composition (dollars and gold) for central bank reserves. It concludes that the probability of collapse in a system such as that of Bretton Woods increases when the total demand for reserves rises, when the new supply of gold is lower, and when the system allows private holdings of convertible dollars.

unchanged.⁹ With the exception of the behavior of the United Kingdom which lost gold reserves during the sixties, this theoretical possibility did not take place in practice. The system broke down even though different ad hoc measures were implemented to keep it working.¹⁰

1.2. Floating dollar standard

Despite being very traumatic, the abandoning of Bretton Woods was a change intended to overcome previous problems with a floating exchange rate system. However, as will be seen below, the dollar continued to hold an irreplaceable role as a global monetary standard.

Floating by leading currencies together with the gradual elimination of controls on both the current account and the capital account were the features that distinguished the new stage begun in 1973. In effect, the two factors are connected: once fluctuations in exchange rates became frequent, opportunities arose for quick profits from speculative movements, and the structure regulating capital flows was seriously challenged.

Under the new global system, the exchange rates between the leading currencies (dollar, yen and mark-euro) fluctuated, while small or developing countries had the possibility of choosing between fixed or flexible exchange rates or intermediate systems (crawling pegs, exchange rate bands, managed floating, etc.).

At different speeds and with different details, leading countries eliminated restrictions on capital movements and liberalized financial markets. Latin America experienced two reform stages, one at the end of the seventies and early eighties, which ended in the debt crisis, and another at the start of the nineties. This second commercial and financial liberalization was also experienced by a significant group of Asian and European economies.

⁹ Various explanations have been attempted for this at first sight inconsistent behavior by some European countries. One of them derives from traditional portfolio theory (Kenen, 1960). Mundell (1968) developed an idea known as the signaling theory. Its author claims that European portfolio composition decisions were determined by its view on the need for growth or contraction on a global scale. If it was considered to be advisable to reduce world income, a signal was sent by transforming dollars into gold. As a result, the United States had to moderate monetary expansion to restore the balance of the gold-dollars ratio. As monetary expansion affected world income, Europe thus achieved its original aim. A third line of argument can be found in Cohen (1970), who believed that the European preference for gold was essentially a political phenomenon explained by the "wish for power," the latter being explained as the ability to avoid being forced to pursue adjustment policies.

¹⁰ In particular, one of the measures related to the problem of reserves was the creation of Special Drawing Rights. SDRs were introduced following the Río de Janeiro Accords in 1968 with the aim of complementing reserves in dollars, gold and the IMF quotas. At that time it was believed that this mechanism would be a significant landmark in international finance, by ensuring ordered growth in world liquidity and lowering transaction costs (Grubel, 1972; Kelly, 1970). This measure was taken too late, however (the first issue of SDRs took place in 1970-1972) and was unable to impact significantly on the development of the Bretton Woods crisis. According to Olivera (1969) the reform planned at that time was based on the idea that the aggregate nominal amount of reserves should provide the flexible element in the adjustment between supply and demand for international liquidity. According to his reasoning, this principle implied the adoption of a system of "passive money" in the international sphere. Money ceased to be an exogenous element to which prices and wages were required to adjust, becoming an endogenous variable with an equilibrium value (see also Olivera, 1970).

As indicated, far from becoming less preponderant, the US dollar continued to constitute the de facto monetary standard in the new system. Commercial and financial flows continued to be mainly stated in that currency. International dollar reserves increased under the new system. US treasury bonds continued to gain ground as financial instruments with maximum liquidity. Prices of commodities such as gold and oil continued to be invoiced in dollars, as happened under Bretton Woods.

It was not until the end of the nineties that a highly significant event was to take place that countered the dominant trend of the dollar: the start to circulation by the euro. Nevertheless, its definitive impact on the organization of the international payments system is still unclear. For example, for Eichengreen (2005) the only risk that could lead to the dollar losing its supremacy as an international reserve would be the persistence of severe misalignment in US fundamentals.¹¹ However, the author expects the euro to gain in importance, as greater financial integration increases the desirability of shared monetary leadership, a situation that is not new in the history of international finance.¹²

Despite having made progress towards greater exchange rate flexibility, economies sharply increased their reserve accumulation rate in the 1973-1998 period (see Table 1). This is surprising, as in theory it would be expected that large quantities of external assets would not be held under flexible systems. Literature has attempted some explanations for this paradox since the end of the seventies.

Frenkel (1983) was the first author to analyze this matter. He argues on the one hand that the stability observed in the demand for reserves from Bretton Woods until the start of the eighties was due to the fact that many of the exchange rate arrangements during this phase were not “exchange rate pegs” but “adjustable parities”. On the other hand, after the breakdown of the global system, various central banks carried out “managed floating” rather than “pure floating”. Therefore, the actual behavior of the monetary authorities did not alter substantially under the new global system.

This argument, although interesting and plausible for a certain number of countries at the beginning of the eighties,¹³ cannot fully explain past history when viewed from the present time. First, because the larger developed economies have floated consistently since 1973-1974. Second, because on a growing and continuous basis, more countries have moved towards exchange rate flexibility since the eighties, although this was not a lineal process.¹⁴

¹¹ This is the conclusion that the author reaches from analysis of the process of decline by the pound sterling, the main currency for the international payments system until the beginning of the 20th century.

¹² This was the case of the pound and the dollar from the end of the 19th century until the Great Depression.

¹³ For example, for the Latin American economies that adopted stabilization policies based on the exchange rate or crawling pegs in this period.

¹⁴ There is much empirical evidence and several relevant debates on this point. One extended thesis (Fisher, 2001) indicates that there is a trend towards corner solutions in the choice of exchange rate systems. Countries opt either for hard pegs (currency boards, monetary unions or dollarization), or for flexible arrangements (independent or administered floating). Another influential idea is based on the existence of a “fear of floating” which means that countries nominally declare flexible systems but intervene regularly in exchange markets, preventing a genuine float (Calvo and Reinhart, 2002).

In another line of reasoning, Grimes (1993) builds a simple model to demonstrate the conditions under which the amount of reserves maintained during a floating or fixed rate would be similar. The underlying justification is that even though the central bank is operating a pure flexible system, there is a probability greater than zero of a future return to a fixed exchange rate or managed floating regime. If there were uncertainty regarding the possibility of gaining access to external financing, then future intervention could only be ensured by maintaining reserves during the present. If the opportunity costs of reserves were to be insignificant, or if central banks were to be extremely averse to risk, the holdings of reserves under fixed or flexible exchange rates would be identical.

Once again, the explanation proposed leaves some questions unanswered. In the best of cases, the Grimes model shows why there can be similar trends (in an extreme situation) in different systems, so that it would not be paradoxical to demand the same volume of reserves under opposing systems as regards degree of flexibility. The model does not however explain the factors that accelerated the accumulation of reserves, regardless of the system adopted. Furthermore, the opinion of theoreticians is that in reality, the opportunity cost of reserves is not low.¹⁵ Lastly, extreme risk aversion by the monetary authority seems a somewhat ad hoc assumption, requiring at least a consistent justification for this behavior.

In this paper it is suggested that the explanation for the paradox lies in the fact that progress towards floating exchange rates since the abandoning of Bretton Woods happened concurrently with financial liberalization (see Figure 1). In a world of increased volatility, sudden stops in capital flows, contagion and propensity to crisis, new uses arise for international reserves that extend beyond the exclusive sphere of the exchange rate system.¹⁶

1.3. Imbalances in international monetary economy, reserves and sustainability

A series of recent events has unleashed debate in relation to the establishing of a new system of trade and financial relations between countries. The so-called global imbalances have captured the attention of academics. Current account deficits in the United States that are larger than the GDP of a country such as Brazil, accumulated international reserves that are equivalent to 10 times the sum of the shareholding quotas of the IMF or saving rates of 45% in Asian economies¹⁷ are some of the manifestations of such imbalances. In the face of their persistence, there is a widespread impression among theoreticians and policy-makers that “something has changed” in the world, as the system’s automatic correction mechanisms are not working, or do so extremely slowly.

Reserves growth is one of the most notable aspects of these imbalances. One need only consider, as Roubini and Setser (2005) have done, that the world’s central banks financed 88% of the US current account deficit in 2003.

¹⁵ The opportunity costs of reserves are alternative investments with a greater yield than the risk-free bonds of the countries issuing reserve currencies. Rodrik (2006) for example, estimates opportunity costs in developing countries at 1% of GDP.

¹⁶ This idea will be explained in greater detail in the theoretical section.

¹⁷ In China the saving level reached 47% of GDP and in Malaysia 42% during 2003, according to World Bank indicators (WDI, 2005).

In specialized literature there is a debate between the various ways of viewing this problem that are consistent in theory but difficult to contrast empirically. In other words, various explanations coexist for these imbalances that are logically coherent. Are the current account deficits of the United States a consequence of low savings rates in that country, or are they due to the demand for low-risk financial assets by emerging Asia? Are the higher reserves in Asia a result derived from an implicit objective for the real exchange rate, or are they the result of a decision to limit the impacts of a possible financial crisis?

In this discussion on the establishing of a new international order, the most provocative position is that expressed in a series of studies by Michael Dooley and Peter Garber. Their idea is that a Bretton Woods-type system has arisen with a new periphery in Asia that follows an export-led growth strategy, and the same center, the United States. As was the case forty years ago, the core of the debate centers on the predisposition of the periphery countries to accumulate the assets of the center country (Dooley et al., 2003).

Dooley and Garber (2005) believe that this new order is destined to be maintained for at least a few more years. According to their study, the sustainability of the regime is derived from the benefits (from export led growth) that the periphery would obtain if it continues with its current strategy. There would be no incentive to diversify stocks formed mainly of US Treasuries, because that would unleash a trend towards appreciation that is precisely what it was intended to avoid. Thus, two decisions guarantee global sustainability: i) the decision to continue to accumulate reserves (acting on flows); and ii) the decision to maintain existing stock of reserves in dollars and liquid financial instruments of the United States (action on stocks).

On the matter of the composition of reserves¹⁸, it is known that if the dollar needs to depreciate to correct the imbalances, those central banks with significant stocks of US assets would be exposed to major capital losses. Why then is it that monetary authorities would not want to alter the composition of their portfolio, predicting a future weakness of the dollar, in some way repeating the history of gold at Bretton Woods?

According to Dooley and Garber (2005), this would be counterproductive for Asia. Their argument is based on the logic of the portfolio composition models. If the reserves are switched from US bonds to bonds in euros, private portfolios (which contain bonds in dollars, euros and Asian bonds in domestic currency) would be adjusted. Private portfolios would suddenly hold fewer euros and more dollars than desired, which would tend to lead to the appreciation of the euro, and to a lesser extent the Asian currencies. As the authors assume that Asia wants to avoid the appreciation of the exchange rate, there would be no point in unleashing this mechanism, altering the composition of reserves. Among other things, it would imply greater sterilization efforts than at present.

Some critical observations can be made regarding this reasoning. The most significant arises precisely from applying the underlying logic of assets models. Even though Asia as a bloc could face downward pressure on the exchange rate (of second order in relation to the euro), this does not mean that the trend towards appreciation in each country would be significant,

¹⁸ Literature exists on determinants of the world composition of reserves that investigates the factors that explain why a currency becomes international money. Krugman (1984); Matsuyama et al. (1993); Eichengreen and Frankel (1996); and Chinn and Frankel (2005) are some examples.

because most of the effect will be spread across the rest of the economies. The central bank making the change in composition does not suffer this effect in a proportionately greater manner than the bank deciding not to do so. Nevertheless, here the authors employed a three assets model (one for Asia, one for Europe and another for the United States), when it would be advisable to count on a model with as many assets as number of countries. The larger the number, the lower the internalized cost (in terms of appreciation) of the country reassigning its reserve assets.

In addition, portfolio equilibrium models show that pressures for appreciation in a given economy will be lower, the lower the share of assets issued by it in the optimum portfolio of private agents. If it is assumed that there is some positive relation between the size of the economy and the share of the country's assets in the optimum portfolio, it can be concluded the smaller the country, the lower the pressures for appreciation.

In short, pressure on the exchange rate in a country that alters composition should be of a second or third order, and will decline based on the size of the economy.

If the observations of Eichengreen (2004) on the lack of cohesion of the Asian bloc when compared with Europe are included, there would seem to be less justification to consider that there would be no changes in the composition of reserves, at least from the logic of the assets model used by Dooley and Garber to argue their case.

In this regard, a recent econometric study by Chinn and Frankel (2005) predicts that in a scenario in which the members of the European Union not currently in the Monetary Union join it,¹⁹ the euro would become the principal reserve currency by 2020, as long as the dollar continues with the depreciation trend of the last thirty years.

Flow decisions must also be evaluated, which implies discussing whether countries will continue accumulating reserves or not. Implicitly this involves investigating the consistency of such flows at global system level, and whether there is a need to correct imbalances.

Most authors do not share the opinion that global imbalances can continue for much longer. However, there are differences in the diagnosis and in the mechanisms necessary for correction.

Bernanke (2005) considers that a combination of factors in the past decade resulted in a significant increase in the global supply of savings, causing the current "saving glut".²⁰ One of the novel aspects of the current situation is the reversal of the credit flows from emerging and developing economies towards the United States. The receipt of this larger portion of funds by this latter country can be explained by the sophistication of its financial markets, which include assets of the highest liquidity and security, and by the fact that it issues the world's leading reserve currency.

¹⁹ Here the inclusion of the United Kingdom would have a strong impact, because of the size of its economy, and because London is a strategically important financial center.

²⁰ In the opinion of Roubini (2005), the position expressed in Bernanke's speech considered here is in essence very similar to that of other Fed governors and staff. For this reason he groups these ideas, describing them as "the vision of the Fed." He has also been highly critical of the "excess saving" concept, preferring to talk of "investment drought" in the real sector, radically altering the economic policy recommendations.

The most direct conclusion of an analysis such as the above for economic policy on imbalances is that a reduction in the US fiscal deficit will not correct the current account deficit, as the latter will be determined as the consequence of the saving decisions by the rest of the world.²¹

Another influential current of opinion proposes that under the present dollar standard, the appreciation of the yuan and the yen would lead to lower growth by China and Japan, and eventually to deflation, but would not offset the imbalance between saving and investment in the United States (McKinnon, 2005a). This challenges the traditional focus on trade balance elasticities (which relates exchange rates to net exports), as it ignores important effects caused by appreciation such as deflation in the country that appreciates its currency. In McKinnon (2005a, 2005b) much of the explanation of the imbalances corresponds to a saving deficiency in the United States (particularly by households and the federal government) and not to excess saving in the rest of the world. This author also indicates that the monetary policy implemented contributed to the lack of saving by encouraging negative real rates of interest that encouraged excess consumption and a real estate bubble.

Nevertheless, there are theoreticians who believe that the correction of imbalances requires a very large depreciation of the dollar, in some cases with an explicit effort by Asia and China in particular (Blanchard et al., 2005).²²

One possible way to calculate the corrections necessary in the face of imbalances is to make use of a general equilibrium model, as Obstfeld and Rogoff (2004) have done. They have determined that an abrupt return to a US current account equilibrium would imply an immediate over-reaction by the dollar, that would devalue by 40% (or even more, depending on the specific calibration of the model).

For his part, Mussa (2005) points out that it would not be necessary to take the current account balance to zero to stabilize the US net external asset position. A deficit of 2.5 or 3 points of GDP is compatible with a ratio of external assets of 50%, a level which, while high, would be sustainable. An adjustment such as the above would require a real depreciation of the dollar in relation to the remaining currencies in the order of 30%, and would have to be larger for the leading trade partners of the United States. To reach such a situation, increased international cooperation would be required on the matter of exchange rate adjustment by Asia. On the basis of the way it has been working so far, any new system *à la* Bretton Woods would not last more than four years, according to Mussa.

Perhaps the most skeptical voices regarding the chances for the continuity of “Bretton Woods II” are those of Roubini and Setser (2005), who have gone so far as to suggest that the system would not last beyond 2006. In addition, they have pointed out that it is the central banks (by accumulating reserves) and not the private sector agents that are financing the US deficit. In addition, they stress that in the case of Asia, the official purchase of reserves exceeds their current account surplus (allowing them to accumulate US\$530 billion, compared with the bloc’s US\$310 billion trade balance in 2004).

²¹ See the sixth footnote of the paper to note how current debate is not entirely original, in fact replicating the academic discussion that took place at the end of the sixties.

²² It is notable that many academics debate the adjustment by China, although Germany and Japan are the export world leaders (Obstfeld and Rogoff, 2005).

Lastly, Godley et al. (2004), making use of a consistent stock-flow model, also conclude that current trends in imbalances cannot continue for very long. Even so, they state that an automatic, spontaneous and ordered correction should not be expected, for at least two reasons: i) it is not clear how Asian economies -and various emerging economies outside that region- will be persuaded to stop accumulating reserves if they have the impression that such an action is beneficial to them; ii) the transference problem implicit in reducing the US current account deficit to zero, as it would require growth in US consumption well below the growth in its output.

As can be seen, the problem of liquidity supply is similar in essence during the entire dollar standard period: how to introduce liquidity in accordance with the requirements of economic growth without generating profound imbalances within the system. Decisions on the stock, flow and composition of each country's international reserves must be taken in the context of the global situation. Specifically, regarding the imbalance stage, it should be noted that adjustment scenario that eventually takes place in the future will have a decisive influence on three strategic decisions: how large the reserves to be held should be, in what currencies they should be maintained, and the speed at which they should be accumulated.

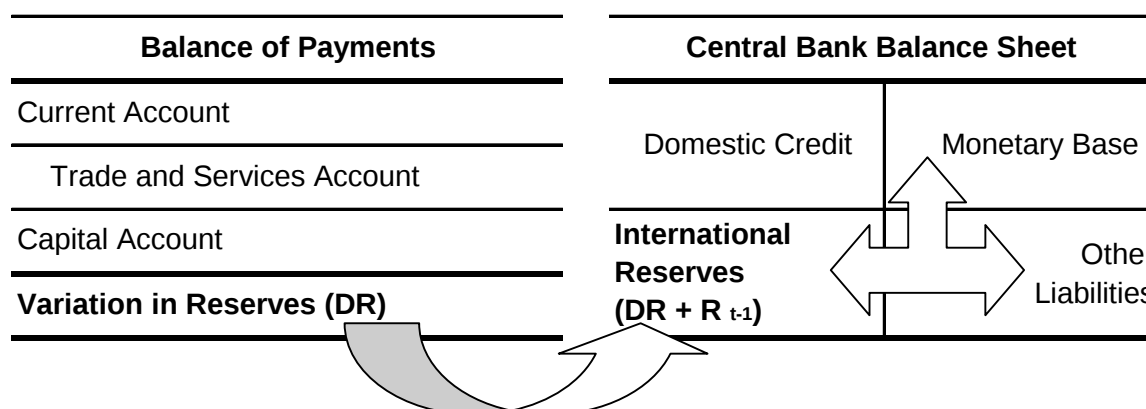
2. Why international reserves are held, and what they are used for: the theoretical reasons

Since the abandoning of the gold standard, the basic reason for a country to hold international reserves has been because it has decided to maintain some form of commercial or financial relationship with the rest of the world. An economy in autarchy has no need for reserves. In terms of theory, reserves are those assets that possess the following two qualities: i) they are accepted by external economic agents at all times for the settlement of trade and financial obligations; and ii) their value, stated in external account units, is known with certainty (Heller, 1966).²³

Once reserves have been incorporated to the domestic economic system, they act as a variable that connects the external sector to the monetary and financial sector of the economy. Figure 2 provides a simplified representation of this relationship.

²³ This definition habitually leads to the calculation of four types of asset: i) gold; ii) SDRs (described in footnote 10); iii) foreign currency; and iv) the country's reserve position at the International Monetary Fund. This is the criterion followed in this study.

Figure 2. Stylized link between the external and financial sector via international reserves



As can be seen from the illustration, the balance of payment result (a flow designated here as DR) determines the variation in the stock of international reserves that are a fundamental part of the central bank assets. The arrow on the left side of Figure 2 refers to the fact that there is a connection (which varies with the exchange rate and monetary regime) between reserves and the amount of money and other monetary liabilities.

Economic theory has developed this simple rationale for holding reserves using more sophisticated structures. Initially, an extrapolation was made between the individual demand for money of monetary theory and the demand for reserves. This gave rise to the appearance of the transaction, precautionary and speculative reasons for demanding liquid external assets.

With the passing of time a body of ideas and models took form that can be grouped under the heading of “reserve demand theory.” To detail this theory, a division should be made that observes the chronological progress of the literature on the topic, because as will be seen below, there is fairly direct link between the development of the international monetary system and the development of the ideas.

The proposed division make as distinction between: i) the traditional view centered on the sphere of trade transactions and the current account; ii) the modern view focused on prudential or precautionary demand in the face of financial crises, enabling a more specific attention to be paid to deregulation and liberalization of the capital account and its potential problems; and iii) demand derived from the operation of the exchange rate and monetary system, where the focus centers on the endogenous nature of reserves in relation to other relevant variables of the economic system. These reasons for maintaining a given quantity of reserves are in principle additive in nature.

A significant aspect is that the importance of each motive changes over time. For example, it is probable that during the fifties and sixties, when capital mobility was low, the precautionary reason was important only for the current account side, transactional demand being substantial because of the great growth in international trade. In addition, the accumulation of reserves as a result of the exchange rate system can be very variable over time, depending on the stage of the external cycle that each country is experiencing.

There is also certain accumulation linked to the fact that part of the reserves are held because of the desire to gain credibility for the domestic currency. If there is no national currency it is not possible for there to be a run on cash, thus providing one less reason to hold international hedge assets.

2.1. The traditional view of reserve demand

Towards the end of the thirties the quantitative theory of money provided the starting point for the study of reserve demand, as it did for so many other developments in macro economy. If it is assumed that i) the demand for reserves (gold at that moment in history) is proportional to the amount of money,²⁴ and that ii) demand for money is proportional to the demand for transactions, then gold reserves would be a fixed fraction of the total value of transactions. The immediate corollary of this is that the demand for reserves would increase in proportion to production and trade (Olivera, 1969).

The academic interest in the subject of international reserves grew notably under Bretton Woods. During this period the problem of external adjustment began to be frequent. To confront an external deficit, at that time countries had three choices: i) to finance it with a loss of reserves; ii) to implement expenditure-switching policies, that is to say, increases in the exchange rate, tariffs, quotas, etc.; or iii) apply expenditure-reducing policies.

Clearly, the last two types of policy represent a greater cost in terms of production, prices and employment, making the first alternative more attractive (especially when the external problem is not structural but temporary). Under Bretton Woods, international liquidity²⁵ was considered appropriate if it succeeded in ensuring that countries with balance of payment deficits could finance them without having to adopt adjustment policies.

In general, reserves allow a country to pursue its domestic economic objectives in the event of a temporary balance of payments problem, and also “buy time” to adopt the correct adjustment policies if the external deterioration proves to be permanent (Clark, 1970). In short, there is a desire by the policymaker to smooth the economic cycle that generates interest in reserve assets.

If reserves can prevent unnecessary macroeconomic adjustments,²⁶ then their setting at a level that guarantees coverage in adverse balance of payments scenarios should be a deliberate objective of prudent economic policy. Along these lines, Triffin (1947) proposed to

²⁴ Under the gold standard it was usual for a hedge margin to be maintained in precious metals for the total amount of notes and sight liabilities of central banks (Olivera, 1969).

²⁵ International liquidity and international reserves are concepts that are usually used with the same meaning, although they are not equivalent. In effect, Clower and Lipsey (1968) say that the concept of international liquidity is widespread, but little understood. To avoid confusion, literature proposes precise definitions for these terms. International reserves are financial assets that represent international purchasing power with high liquidity, and are in the hands of the monetary authorities. International liquidity is a broader term that includes both access to credit and the capacity of central banks to convert illiquid assets into liquid purchasing power via international financial markets.

²⁶ From this point of view reserves may be necessary both in the face of random events (such as for example a shock in the terms of trade), and in the case of systematic maladjustments in income and outflows from the balance of payments (for example, because the flows of funds from imports and exports are unsynchronized over time).

use the quotient between reserves and imports as a good indicator of adequacy.²⁷ According to this approach, the demand for reserves would increase *pari passu* with the growth in external transactions, reaching a conclusion similar to that of the quantitative approach, although for a different reason.

Obviously, this first intuitive theory of reserve demand suffered numerous attacks. One significant challenge derived from recognition of the fact that reserves were used to finance trade deficits and not levels of trade. As Nurske (1944) has already pointed out, variability in external imbalances alters the level of reserves necessary for their financing.²⁸ Flanders (1971) lists at least ten reasons why the ratio of reserves to imports is insufficient as a theory. These include the costs of reserves and their rates of return, the instability of exports, aversion to facing the costs of adjustment and the availability of indebtedness.

In the sixties various works appeared that enriched theory from macro and microeconomic standpoints. The macroeconomic approach applies the monetarist concept of the balance of payments to the theory of international liquidity, and is attributed to Johnson (1965). This approach, known as “global monetarism” or “global quantitative theory” (Black, 1985; Bahmani-Oskooee and Brown, 2002), maintains that the variation in reserves is equal to the change in the demand for domestic money less the variation in the supply of domestic money.

The microeconomic view displaces the nucleus of the problem towards the determination of an optimum level of reserves by means of a maximization process. This can adopt the variants of a cost-benefit calculation or an analysis on the basis of a social welfare function.

Among the developments based on the cost-benefit marginal calculation, Heller (1966) is the pioneering work. The model is very simple and clear in its conclusions, offering an explicit formula for optimum reserves. The cost of an additional unit of reserves is the difference in yield between the reserves and the benefit to society of employing the resource in a productive manner in an alternative asset. The benefit of the marginal reserve is the possibility of financing the balance of payments deficit without having to make an adjustment. The way to make adjustments is by reducing national income until the drop that is provoked in imports eliminates the deficit. Therefore, the benefit has a magnitude equivalent to the inverse of the marginal propensity to import, and takes place only in cases of a cumulative deficits process (it is probabilistic). Under the assumption of symmetry in the stochastic reserve accumulation process, the following expression of the optimum level of reserves is obtained:

$$(1) \quad R_H^* = \left[\frac{\log(rm)}{\log \frac{1}{2}} \right] \sigma_1$$

²⁷ There is a subtle difference between the need for (or adequacy of) reserves and the demand for them. Demand reflects a judgment by the policymaker which may or may not correspond with an objective criterion on the appropriate level.

²⁸ This point is also picked up by Malchup (1966) and Heller (1968), for whom trade variability is more important than its level as an element explaining the demand for reserves, unless they are both very correlated.

Optimum reserves (R_H^*) decrease with their opportunity cost (r) and with the marginal propensity to import (m) while they increase with the variability of the balance of payments (σ_1).

Hamada and Ueda (1977) and Frenkel and Jovanovic (1981) performed significant extensions of this cost-benefit approach to the demand for reserves. The first of these works resolves some of the limitations of the study by Heller (1966), in particular those referred to the possibility of exhaustion of reserves and the type of stochastic process (random walks in this case) that they follow. The relevant expression of this model is:

$$(2) \quad R_{HU}^* = \left[1 + \frac{1}{(rm)^{1/2}} \right] \sigma_2$$

Once again a negative ratio is determined for optimal reserves²⁹ regarding the opportunity cost (r) and the marginal propensity to import (m).

The study by Frenkel and Jovanovic (1981) emphasizes the role of the randomness³⁰ of external transactions and the income that “is not earned” by holding reserves. The costs of the optimum stock have two components, that of the adjustment incurred once reserves reach the lower limit³¹ and the opportunity cost of the alternative use of such resources. The optimum stock is obtained by minimizing the expected value of the sum of the two components:

$$(3) \quad R_{FJ}^* = C \sigma_3^{1/2} r^{-1/4} \quad \text{where } C = \frac{R_0}{m_0}$$

The coefficient C is a fixed cost that reflects the lower income needed to constitute the primary stock of reserves (via lower imports), m_0 is the initial marginal propensity to import, R_0 the optimum reserves for the first period, and σ_3 a measure of the variability of external transactions (which is different from that of the two previous models). The greater the variability (larger σ_3) the greater the optimum reserves. Accumulation is reduced when opportunity costs rise or when the propensity to import at the initial moment ($t = 0$) increases. This model became well-known as the buffer stock model.

The first formal developments based on a social welfare function that coincide with the utility function of the central banker correspond to Clark (1970) and Kelly (1970).³²

²⁹ The change in sub-index indicates the change of model.

³⁰ It is assumed that the equation that governs the dynamic of reserves is equal to a negative term that grows at a constant rate over time added to a Wiener process (analogous to the *random walk* in continuous time).

³¹ This model is not designed to function exclusively under a fixed parity system. Therefore, the adjustment costs are not necessarily the domestic recession that reduces imports (when there is a fixed exchange rate), but they could adopt the form of a drop in the real value of assets driven by the increase in prices that follows a devaluation (in the case of a flexible exchange rate).

³² These two models assume a fixed exchange rate.

The two authors assume that the social welfare function is positively dependant on income level and negatively dependant on its variability. Regarding the restrictions of the problem, consideration is given to the fact that balance of payments deficits can be faced with reserves or by adjustments. In the first case there will be a lower level of income from the sacrifice involved in maintaining reserves, while in the second case there will be increased real volatility. It is possible therefore to construct a trade-off between income level and its volatility that acts as a restriction on maximization. In particular, Kelly (1970) obtains the following expression for optimum demand:

$$(4) \quad R_K^* = \frac{\sigma_4}{\left(\frac{e}{c}\right)^{1/2} + \left(\frac{c}{e}\right)^{1/2} m^2 r^2 \left(\frac{a}{b}\right)}$$

The optimum level of external central bank assets is a declining function of the opportunity cost (r) and the propensity to import (m). Optimum reserves also decrease when the parameter a increases (a being the marginal disutility of income reduction). The partial derivatives of R_K^* with regard to σ_4 (variability of exogenous external shocks), to b (marginal disutility of volatility) and to e (probability that the reserves fall below a specified minimum) all have a positive sign.³³

Clark's study (1970) has the advantage of jointly formalizing the optimum demand for reserves and an endogenous adjustment variable. The latter measures the proportion of the gap between the observed reserves in the previous period and the optimum reserves that are corrected in the current period. Nevertheless, this model presents the problem of not being able to assign an explicit reduced form for the two variables of interest. However, it can be proved by means of the implicit function theorem that:

$$(5) \quad \frac{\partial R_C^*}{\partial \sigma_5} > 0; \quad \frac{\partial R_C^*}{\partial m} < 0; \quad \frac{\partial R_C^*}{\partial r} < 0; \quad \frac{\partial R_C^*}{\partial Y^*} > 0$$

The first three partial derivatives have the same signs as in the four previous models, and are therefore to be interpreted in the same manner. The variable Y^* is the full employment income level, and has a positive influence on the optimum demand.

The idea of extending the model to a dynamic context was suggested by Williamson (1971) and performed by Nyberg and Viotti (1976). Another relevant contribution to the traditional optimality approach is that of Olivera (1969) who extended the result of Baumol (1952). The author shows that precautionary demand increases by the square root of the level of commercial transactions.³⁴ This means there are economies of scale in reserve accumulation.

³³ In the case of the variable e , it will be necessary to satisfy the intuitive condition that the disutility of the reduction of income should be greater than the disutility of the volatility of income ($a > b$ in formal terms). The parameter c is a positive constant without economic interpretation.

³⁴ To avoid confusion, it must be clarified that the demand for reserves on which Olivera (1969) bases his theory is precautionary demand (as in the case of the rest of the models presented here), although the case presented by Baumol (1952) is applied to the transactional demand for money.

So far a review has been made of the traditional view of precautionary demand. Nevertheless, in so far as liquidity is required to carry out international transactions, there is also a transaction reason for holding reserves. There is consensus that means of payment should increase with the volume of foreign trade. However, there is controversy over whether such international liquidity should be public or private.³⁵

For Heller (1968) there is a transactional demand for means of payment by commercial banks that are directly involved in foreign trade. But it should be noted that the central bank acts as a lender of last resort in times of liquidity difficulties, so that it will also have to cover with its reserves some of the international transactions. Hence there is a demand of reserves for this reason.

2.2. Financial volatility and precautions in the face of crises

During the eighties and much of the nineties, academic interest in reserves waned in comparison with the two previous decades. In part this can be explained by the change in the international system. It was thought that this change would include a new adjustment mechanism (exchange rates) to confront balance of payments difficulties. Nevertheless, from the Asian crises until the present, literature on reserves has revived hand in hand with new financial problem topics arising from the opening up of the capital account.

New reasons emerged for central bankers seeking to foresee adverse scenarios to acquire external assets to act as buffers. The world changed not only because of the lower commitment to the exchange rate; the capital account is now far more open, so that abrupt interruption of financing,³⁶ contagion and volatility are currently the main sources of external uncertainty. Therefore, today the same asset is required as under Bretton Woods (reserves), and for the same reason (precaution) in the face of the same risk (external). Nevertheless, the most significant source of external risk has switched from the current account to the capital account.

Just as in the seventies reserves were studied without making a distinction between developed and developing nations, now the accent is on emerging economies. Access to the global financial market can vary drastically for an emerging country, and reserves are always freely available to the monetary authority, hence their usefulness in the event of unfavorable shocks.

For these reasons, in an environment of high capital mobility with severe and frequent crises, the idea of coverage in terms of imports stressed by traditional view is clearly insufficient (Mendoza, 2004). In fact, according to Flood and Marion (2002) a traditional model such as that of Frenkel and Jovanovic (1981) cannot provide a thorough explanation for reserve accumulation dynamic in conditions of high financial integration and exchange rate crises. Faced by such events, the traditional model assumptions are no longer realistic.

There are currently several interrelated channels through which international reserves exercise their influence as a precautionary asset on the financial side: i) as insurance in the face of disturbances in the capital account that cut access to credit markets; ii) as a

³⁵ Only in the latter case would they strictly speaking be international reserves.

³⁶ A phenomenon known in the literature as “sudden stop” (Calvo, 1998).

mechanism to prevent financial crises; and iii) as a factor that lowers the spread and default risk. In these three cases it can be seen that reserves contribute to GDP stabilization.

There are various models illustrating the insurance channel. For Aizenman and Marion (2003, 2004) the significant point is that reserves are a precautionary saving for economies that face restricted access to external financing. According to these authors, the necessary conditions for a large stock of reserves are: i) the presence of productivity shocks that create a tax base that is volatile and costly to tax, and ii) incomplete financial markets. This model is applicable to various exchange rate systems.

One novel analytical framework is that proposed by Aizenman and Lee (2005), who extend developments on bank reserves in closed economies to the demand by countries for international reserves.³⁷ It is assumed that banks act as intermediaries by taking in short-term deposits and that they finance long-lived investment projects. Such projects are decided on before macroeconomic liquidity shocks caused by sudden stops take place. As there is no credible international lender of last resort, precautionary accumulation is a form of self-insurance that saves costs from the early liquidation of productive assets.

Relevant contributions have also been made by the crisis literature (the second of the channels). Distayt (2001) describes a demand for reserves compatible with second generation crisis models³⁸. From this model it can be inferred that countries with greater risk aversion prefer to pay a premium (which is the opportunity cost) to reduce the probability of a crisis.

It is possible that high levels of reserves could play an important role as a preventive mechanism when the fundamentals are in an intermediate zone characteristic of second generation models (Kim et al., 2004). In a recent contribution, Li and Rajan (2005) have formalized the idea that these assets can partially compensate for a weak performance of key macroeconomic variables. Nevertheless, at a given point in the weakness of the fundamentals,³⁹ no level of reserves will reduce the possibility of occurrence of a speculative attack (in other words, there are corner solutions).

Following this same line of research, models have been used for inter-temporal optimization for small economies. Jeanne and Ranci re (2005) use such a framework. In that case, reserves allow a country to moderate the adjustments on domestic absorption in the face of a sudden stop, generating a reduction in the probability of a crisis and offsetting the loss of production when such an adverse event takes place.

It is notable that even though there is a certain relationship between the matter of insurance and reserves, little effort has been dedicated to providing a perspective based on the insurance theory. Lee (2004) analyzes this line of thought. His idea was to explore the

³⁷ See Bryant (1980) or Diamond and Dybvig (1983).

³⁸ The main feature of these models is that in some of the multiple possible equilibriums in the system, the fears of investors unleash episodes in which initial negative beliefs or expectations tend to be self-fulfilling.

³⁹ The fundamentals listed by Li and Rajan (2005) are the same as those postulated by the classic model of a second generation crisis by Sachs et al. (1996): i) current account deficit; ii) lending boom; iii) real exchange rate appreciation; and vi) size of the external debt.

equivalence between “self-insurance” and other financial options,⁴⁰ in particular, a put option providing the same time of hedge.⁴¹ This makes it possible to determine an optimum amount of coverage by means of reserves, and the discrepancy with levels recorded in emerging countries has led the author to conclude that there is a very limited availability of insurance provided by the market.

Feldstein (1999) argues in favor of the idea that emerging countries protect themselves from capital account problems. For this author, the recent crises have taught that these countries cannot rely on organizations such as the IMF, or wait for the global financial architecture to be reformed. In contrast, international liquidity is the best form of self-insurance, as it makes an attack on the currency less likely, improves the ability to act once it takes place, and enables a more orderly adjustment. Rodrik (2006) agrees with this general principle, but claims that it should not be the only strategy for increasing liquidity. The optimum liquidity policy for emerging countries involves a mix of reserve accumulation and short-term external debt repayment.

One last point in relation to the modern precautionary view relates to the two-way connection between reserves and risk. Ben-Bassat and Gottlieb (1992) build a model to underline the importance of the costs of default on the demand for highly liquid international assets. The idea is that insolvency damages financial relations with the rest of the world, and therefore countries that had to bear some event of this kind in the past should demand a proportionately larger amount of reserves.

The above causality (risk to reserves) could very well be inverted when it is considered that reserves are a variable that international lending agencies bear in mind when evaluating a country’s sovereign debt. As these agencies have an influence on investor decisions, there is thus a potential “demonstration effect” for reserves (Soto et al. 2004). As a result, more accumulation implies a better rating and lower sovereign risk.

There is also an opinion that postulates the existence of a kind of “battle for reserves,” in which a country demonstrates solvency to the market by holding as many or more reserves than other similar countries (Turner and Moreno, 2004). Here it is stressed that there is a practical and conceptual difficulty in establishing a universal adequacy criterion.⁴² For this reason, to avoid financial problems it may be necessary to maintain reserves at a level that is perceived as satisfactory by the market and the risk agencies (Hawkins and Turner, 2000). This is a theoretical argument that leaves open the question on the role of imitation among countries in the accumulation of reserves.

⁴⁰ Caballero and Panegas (2004) have studied the role of certain hedge instruments on central bank financial statements that could ostensibly improve the efficiency of strategies to confront sudden stops. The idea is to incorporate assets that are negatively correlated with sudden stops as a counter-cyclical policy.

⁴¹ A put option is a contract whereby the purchaser acquires the right, but not the obligation, to sell an underlying asset on a future date at a price agreed in advance.

⁴² This matter will be dealt with in depth in the fifth section of this study.

2.3. Derivative demand for reserves

It has been remarked that both the operation of the international monetary/exchange rate system and the specific exchange rate arrangement of each country impact on reserves holdings. A contrast can be seen between the type of analysis of the large global aggregates presented in the first part of the document, and the study of the demand for these assets as a phenomenon in the domestic sphere. However, as has been indicated, the world production of liquidity cannot be dissociated from individual demand for reserves.

From a structural point of view, reserve accumulation tends to be seen as a by-product of the exchange rate system, hence its “derivative” nature. The idea is that the stock achieved in various countries (particularly in Asia) is explained by the desire to prevent or moderate exchange rate appreciation, as this would not be beneficial to export growth. The argument used to oppose this idea by those who stress the precautionary motive is that export-led growth is not new to the world, and even less so in Asia, whereas the acceleration in the accumulation of reserves took place after the financial crises were unleashed in that region.

Nevertheless, this unresolved debate is complex, as reality reveals an undeniable fact (acceleration in reserve accumulation), the interpretation of which is not incompatible with the explanations proposed. In effect, thorough recent research by Genberg et al. (2005) raises exactly this unknown in the case of eastern Asia, concluding that accumulation is not the result of a deliberate policy for under-valuation of the exchange rate.⁴³

As a result, a question arises requiring greater mainly empirical analysis before reaching definitive conclusions.

It is fairly obvious that there is a need for international reserves when a fixed exchange rate (or a crawling peg system) is implemented. For example, their central role in first generation crisis models will be recalled. Krugman (1979) stresses the limitations of a government seeking to use this resource exposed to exhaustion (reserves) to provide a nominal anchor. The linear version of Flood and Garber (1984) introduces the notion of the exchange rate shadow price, which is precisely the exchange rate that would prevail if reserves were to fall to a minimum level and a free float were to be allowed.

Therefore, there is clear role of reserves as a commitment to the exchange rate in fixed or intermediate systems. The situation is different when there is a flexible exchange rate.⁴⁴ Here, there is a surprising result that has been presented by Canales-Kriljenko (2003).

⁴³ The authors maintain that recent increases in reserves are the result of greater capital flows than current account surpluses. In these circumstances, it is possible that it would be correct to intervene in currency markets to prevent sudden appreciation that could potentially cause domestic deflationary pressures. Aizenman and Lee (2005) also minimize the importance of the “mercantilist” objective in relation to the “precautionary” motive in the Asian case.

⁴⁴ It is not necessary to have a restrictive view of this regime here. For this reason it is useful to use the International Monetary Fund definitions, which make a distinction between managed float and independent float. In the case of the first variant, the monetary authority influences exchange rate movements by intervening actively in the currency market without specifying or announcing in advance any specific value or path for it. In an independent float, the exchange rate is determined exclusively by the market, and any intervention is driven by the aim of moderating fluctuations (volatility) in the price of international currencies, rather than to establish a particular exchange rate level.

According to this author, in emerging and developing economies the degree of intervention in the exchange rate market is higher in the case of flexible regimes and lower when more rigid systems are adopted.⁴⁵ This runs counter to the intuitive text-book result. However, it could be explained by the fact that private agents are those who absorb the largest part of innovations in the exchange rate market when there are a credible nominal anchor and stable expectations (Killeen et al., 2001).

In cases of independent and managed floating regimes, there is an additional reason for holding reserves.⁴⁶ Soto et al. (2004) examine the first type of regime. They note sterilized interventions do not necessarily involve the use of international reserves, although this would be the more general case. Central banks could also obtain the desired effect on the exchange rate market using both other financial instruments (currency swaps, derivatives, use of dollar credit lines) and the so-called “signal channel”.

In short, it is difficult to determine if the demand for reserves is precautionary or derives from the exchange rate system. The two motives could probably coexist. There is therefore no general criterion that summarizes the motivation that lies behind each accumulation experience. A specific evaluation for each country and moment in time would be necessary if it is intended to be thoroughly aware of the underlying reasons for each individual case.

Summing up the models surveyed, it can be seen that the theory that attempts to rationalize accumulation of reserves is segmented, considering determinants that are not always related. For the moment at least there is no consensus model that specifically lists the determinants of demand for reserves. Therefore, this work will seek an empirical response based mainly on a panel of countries that is sufficiently wide-ranging (geographically and temporally) to be able to capture the heterogeneity of the various central bank practices. In first place therefore, a comparative analysis will be made of the international experience in the next section.

3. International experience

Before carrying out a regression analysis of the demand for reserves, it is appropriate to detect the key events that arise from the statistical series in the 1973-2004 period. In particular, the intention will be to deepen understanding of behavior by country groups to determine whether accumulation is homogeneous or not.

⁴⁵ Another relevant outcome of this study is that almost all countries sterilize their exchange rate intervention. Those that float (whether in an independent or managed manner) are those that sterilize the largest part of their intervention. Those countries that never sterilize include only countries with rigid systems. Argentina during the currency board was an example of this latter behavior. Interventions tend to be sterilized in floating systems so the exchange rate objective does not come into conflict with the normal development of monetary policy.

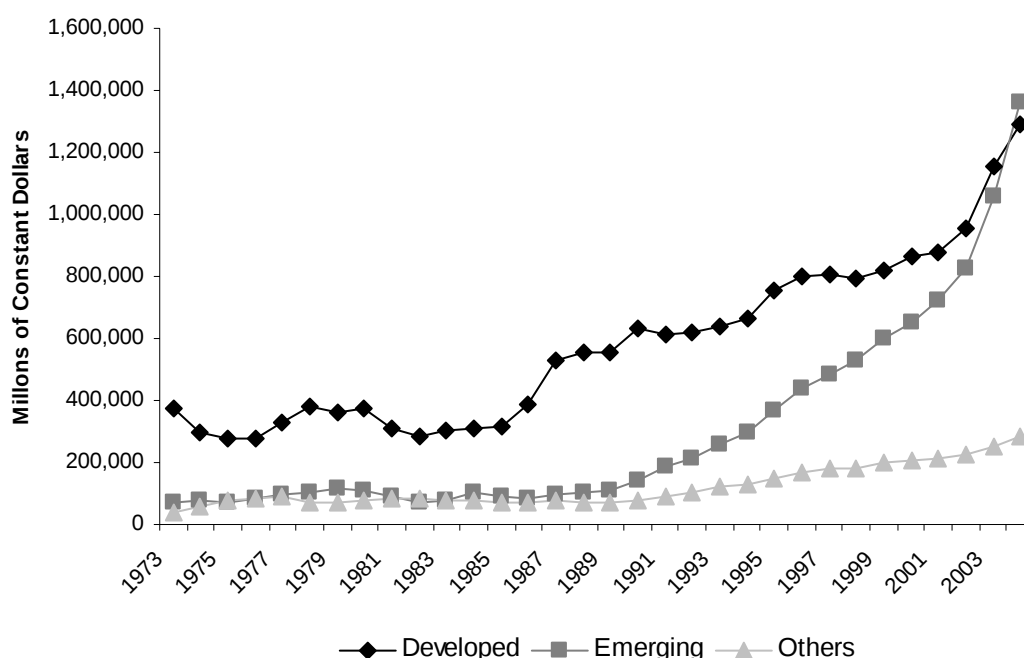
⁴⁶ Bofinger and Wollmershäuser (2002) provide an analysis of managed floating. The authors seek to detect precise, concrete experiences of such an exchange rate system. For them, the intervention activity (reflected in the changes in reserves) is the key variable that makes it possible to distinguish between the three types of float: pure, independent, and managed. The pure float term is a category often added to the Monetary Fund classification, in general with theoretical objectives, to identify situations where there is directly no intervention of any kind.

Undoubtedly, the strongest hypothesis that international evidence appears to suggest is that there is a convergence (or catching-up) process according to which the less developed nations gradually approach the level of reserves of developed countries as their standard of living improves.

From the first section of the document it can be clearly seen how ownership of the reserves changed during Bretton Woods, shifting from the United States to the economies of Europe and Japan, where income per capita was also growing at a faster rate.

From 1973 to date history is repeated, although with new leading players. The so-called emerging economies have taken the place of Europe and Japan, while the group of developed countries provides the comparison point for convergence. This is confirmed by Graph 3.

Graph 3. International reserves in millions of constant dollars by group of countries, 1973-2004.⁴⁷



Source: Prepared on basis of IMF data (IFS)

Since the end of the eighties, in consonance with the opening up of the economy, total reserve holding growth in emerging nations accelerated, until in 2004 it exceeded the stock held by the developed world.

It is reasonable to conjecture on a preliminary basis that the accumulation of reserves is a phenomenon associated with intermediate stages of development. It is probable that a large stock of liquid international assets that functions as a buffer against negative external shocks will be of greater value to a country with a medium or low level of development than it would be for a country with a high level of development. Reserves could compensate for the

⁴⁷ Section A.1 of the Appendix contains the list of countries included in each group. From here on, reference will be made to international reserve series expressed in constant dollars, except when calculating quotients between reserves and other nominal variables.

absence of certain institutions or mechanisms for self-regulation characteristic of developed countries, such as greater financial deepening, exchange rate flexibility, credibility and consistency of economic policies and the fluid access to credit by the public and private sectors.

The information on Table 2, provides further elements to support the catching up hypothesis. Table 2 shows annual average rates of growth in the stock of reserves and the volatility of the annual rate of change for different groups of countries.

Table 2. Average annual growth rates of reserves and volatility by groups of countries⁴⁸

Country Group	Period			
	1973-1998		1998-2004	
	Average Growth	Coefficient of variation	Average Growth	Coefficient of variation
Markets				
Developed	3.03	3.28	8.52	0.80
Emerging	8.28	1.52	17.20	0.50
Others	6.31	1.96	7.65	0.55
Income Level				
Low	5.74	3.00	23.94	0.33
Lower Middle	7.90	1.78	17.57	0.60
Upper Middle	6.69	2.52	7.39	1.17
High Non OECD	8.44	0.79	6.50	0.71
High OECD	3.26	3.08	9.80	0.66
Regions				
East Asia & Pacific	8.54	1.67	20.84	0.44
South Asia	7.33	2.89	27.20	0.43
Europe and Central Asia	2.51	3.99	-1.87	4.54
Latin America & Caribbean	5.61	2.70	4.45	1.76
North America	2.48	3.92	1.67	2.29
Middle East & North Africa	5.00	3.10	10.94	0.27
Sub-Saharan Africa	3.99	3.70	13.14	1.38

Source: Prepared on basis of IMF (IFS) and World Bank (WDI) data

The data for the first part, classified by type of market, only reinforces that shown on the previous graph.

Substantial differences between sub-periods can be seen in the second part of the table, where classification is based on income level. In the first, no group in particular stands out, except for the lower rate of growth in the OECD. In the second sub-period, it is very clear that accumulation has become led by the group of low and medium-low income levels. These two groups have doubled or even tripled, depending on the comparison, the rest of the groups, in addition to being the least volatile in accumulation.

⁴⁸ Again, the corresponding lists for each group can be consulted in Section A1 of the Appendix. Classification by income level is that made by the World Bank. The table took the separation criteria corresponding to 2004.

If, on the other hand, the geographical grouping is considered, it can be seen that South Asia, East Asia and the Pacific are the regions that have headed the reserve accumulation in both sub-periods, although with a far greater impulse following the financial crises that struck that area. Here Japan appears to be an exception, as it behaves like the rest of its neighbors despite being a very high income country (and thus not likely to demand large volumes of reserves). This geographical feature, which would appear to be so significant, will be evaluated with the panel data by incorporating a variable that captures the effect of regional imitation (see section 6).

The contrast with Latin America is evident, as its accumulation rates have been low even in comparison with the Middle East and Africa. Furthermore, it should be noted that accumulation in the region declined between periods (dropping from an annual 5.61% growth in 1973-1998 to 4.45% growth in 1998-2004), as happened in the case of the continents where the more developed countries are located. The contrasting behavior of Latin America compared with Asia could be due to differences in current external regimes (just as in the fifties and sixties there was a confrontation between export-led growth strategies and import substitution), or it could be due to different reactions in the face of the lessons from the financial crises in 1998.

The differences in growth rates between developed and developing countries had a significant effect on the relative participations in world reserve stocks. For this reason, leadership in the ranking of holders of reserves has seen significant changes in the last 30 years. Table 3 shows the ten countries with the highest stocks in 1973, 1980, 1990, 1998 and 2003, clarifying in each case the percentage of the world total held by each economy.

Table 3. Reserve stocks ranking and percentage of world total

Position	1973	1980	1990	1998	2003
1	Germany (18.04)	Germany (11.87)	United States (8.83)	Japan (12.06)	Japan (21.02)
2	United States (7.82)	France (6.96)	Japan (8.25)	China (8.34)	China (13.05)
3	Japan (6.66)	United States (6.15)	Taiwan* (7.57)	Taiwan* (5.06)	Taiwan* (6.61)
4	France (4.64)	Italy (5.86)	Germany (7.52)	Hong Kong** (4.99)	Korea (4.95)
5	Switzerland (4.63)	Japan (5.77)	Italy (6.68)	United States (4.65)	Hong Kong** (3.77)
6	Spain (3.68)	Saudi Arabia (5.31)	Spain (5.38)	Germany (4.44)	India (3.17)
7	Netherlands (3.56)	United Kingdom (4.82)	France (4.23)	Singapore (4.17)	Singapore (3.05)
8	United Kingdom (3.52)	Switzerland (4.35)	United Kingdom (3.81)	Spain (3.13)	United States (2.82)
9	Italy (3.50)	Netherlands (3.05)	Switzerland (3.45)	Korea (2.89)	Russia (2.35)
10	Brazil (3.49)	Libya (2.97)	China (3.13)	France (2.74)	Mexico (1.88)

*Province of China

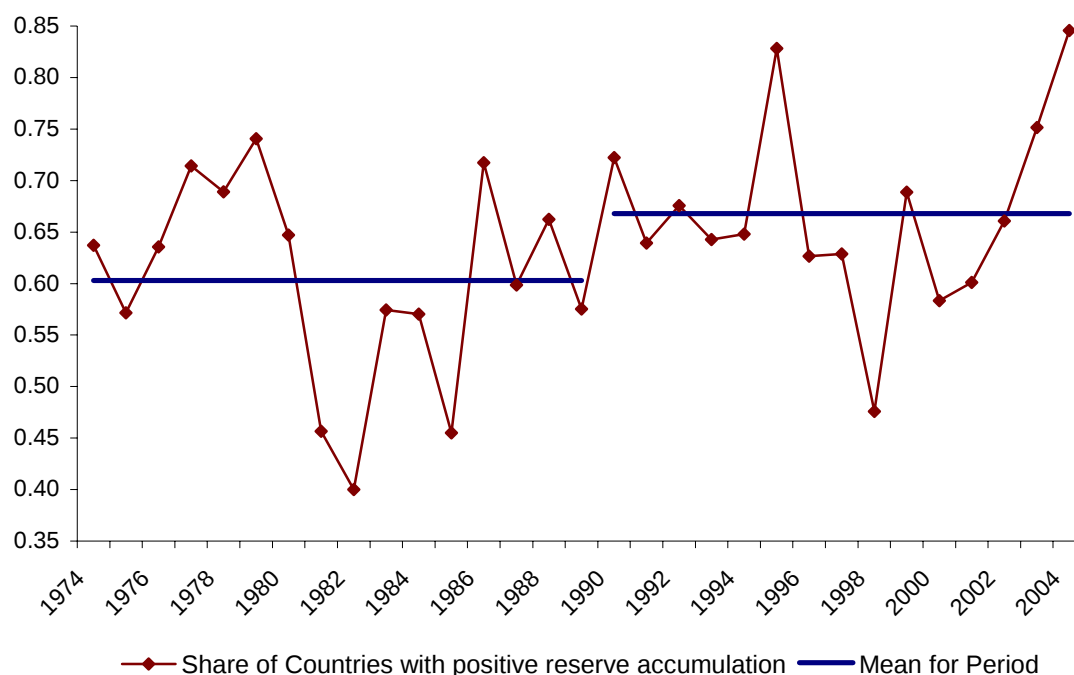
**Special Administrative Region

Source: Prepared on basis of IMF data (IFS)

It is interesting to note how, with the exception of Japan, developed countries have been losing ground to the emerging Asian economies. For example, Taiwan has become consolidated in third place of the ranking since 1990. China for its part figured in tenth place that year, subsequently rising to second. In addition, Korea has climbed from ninth to fourth place between 1998 and 2003. Of the ten top countries of the ranking in 2003, eight are emerging nations. This accelerated accumulation in Asia can be corroborated by looking at the ranking of countries ordered by their contribution to total world reserve growth (see the third section of the Appendix, Table A.1).

It is important to establish whether accumulation is extended or restricted to a limited number of economies. Below is a graph indicating the number of countries showing positive reserve accumulation (the number of cases with positive growth rates for this variable in relation to the total).

Graph 4. Share of countries with positive reserve accumulation, 1974-2004



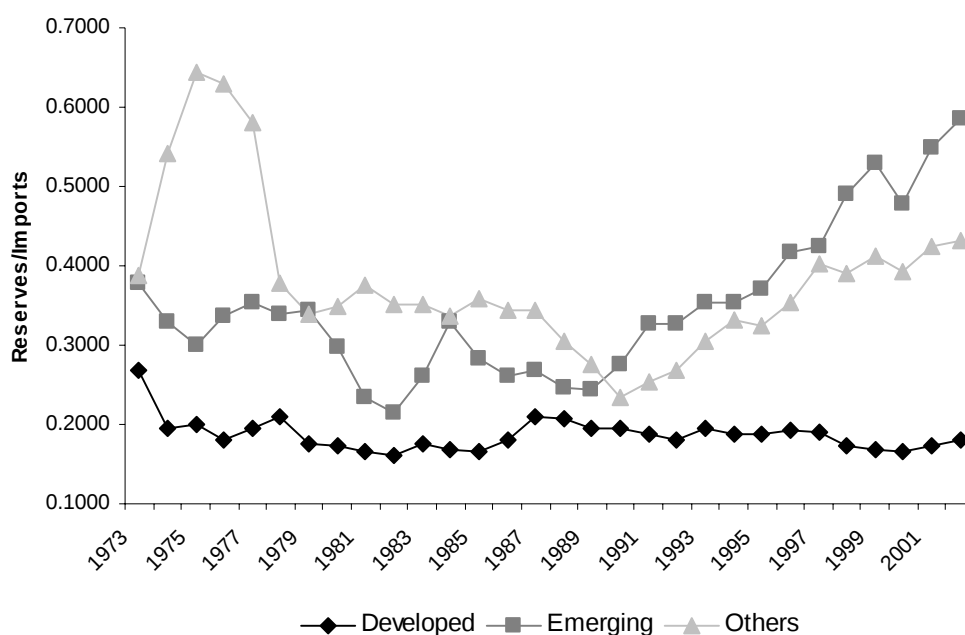
Source: Prepared on basis of IMF (IFS) and World Bank (WDI) data

In general it can be seen that with the exception of four years, over half the countries show positive rates of growth between 1974 and 2004. In 1995 and 2004 the number of economies accumulating reserves rose above 80%. Given the dynamic shown on Graph 4, it is possible to conclude that the global accumulation detailed above is the product of widespread behavior, rather than the mere reflection of a specific strategy by a few players.

3.1. Scaled reserve indicators

In this section an analysis is performed of reserves in relative terms to provide a more thorough idea of its dynamic behavior. Normally the interest variable is scaled using fundamental macroeconomic indicators such as imports, M2 or GDP. Following traditional practice, Graph 5 shows the reserves series scaled on the basis of imports.

Graph 5. Reserves-imports ratio by group of countries, 1973-2002



Source: Prepared on basis of IMF (IFS) and World Bank (WDI) data

Interpretations differ significantly in this part. In the case of the developed countries, the substantive growth seen in Graph 3 is no longer evident. On the contrary, there is a drop in the ratio and considerable stability over the whole period. As a result, international trade growth more than offsets the increase in reserves, even when including Japan in this group, one of the leading holders of reserves during the entire floating dollar stage. For this reason, if Japan were excluded from the sample, the ratio would fall more sharply for the group of developed economies.

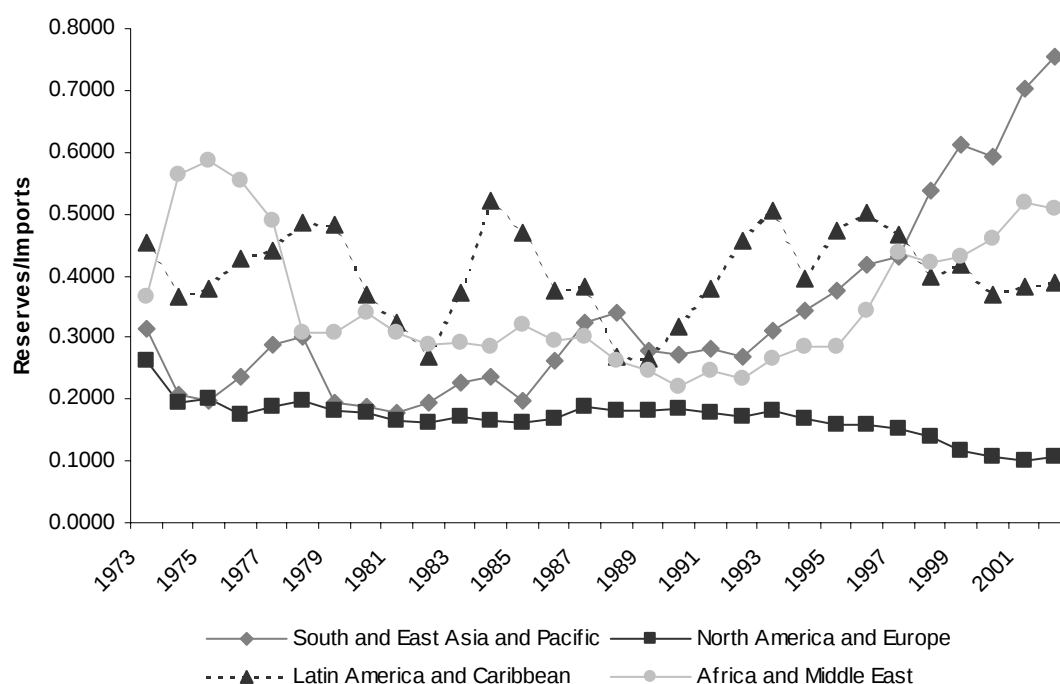
The developing world (Others and Emerging in Graph 5) contributes with the highest values of this indicator, as well as the most erratic trajectories. The reserve-import quotients always exceeds a value of 0.2, a figure that represents two and a half months of coverage of imports by reserves.

The group of countries neither developed nor emerging (named as “Others” in Graph 5) shows a first cycle of sharp ups and downs between 1973 and 1978, oscillations linked to shocks from oil prices. A more stable phase began later, which ended with four successive drops towards the end of the eighties that led to the low point for the series, in 1990. From then on, an upward trend in the indicator gained strength, as was the case for total reserves.

Among the emerging group, there has been a notable dip caused by the debt crisis in 1982-1983. Recovery followed (to levels somewhat lower than in the seventies). Additionally during the nineties this ratio grew strongly, as in the previous case.

When the regional dimension of this indicator is analyzed in Graph 6, it can be seen that the impressive accumulation (in relative terms) by the developing world is hidden behind the performance by Asia in the first place and Africa and the Middle East in the second. It can also be seen that the rise in the mid-seventies is attributable to events in the Middle East, with the oil shock as a determinant.

Graph 6. Reserves-imports ratio by region, 1973-2002



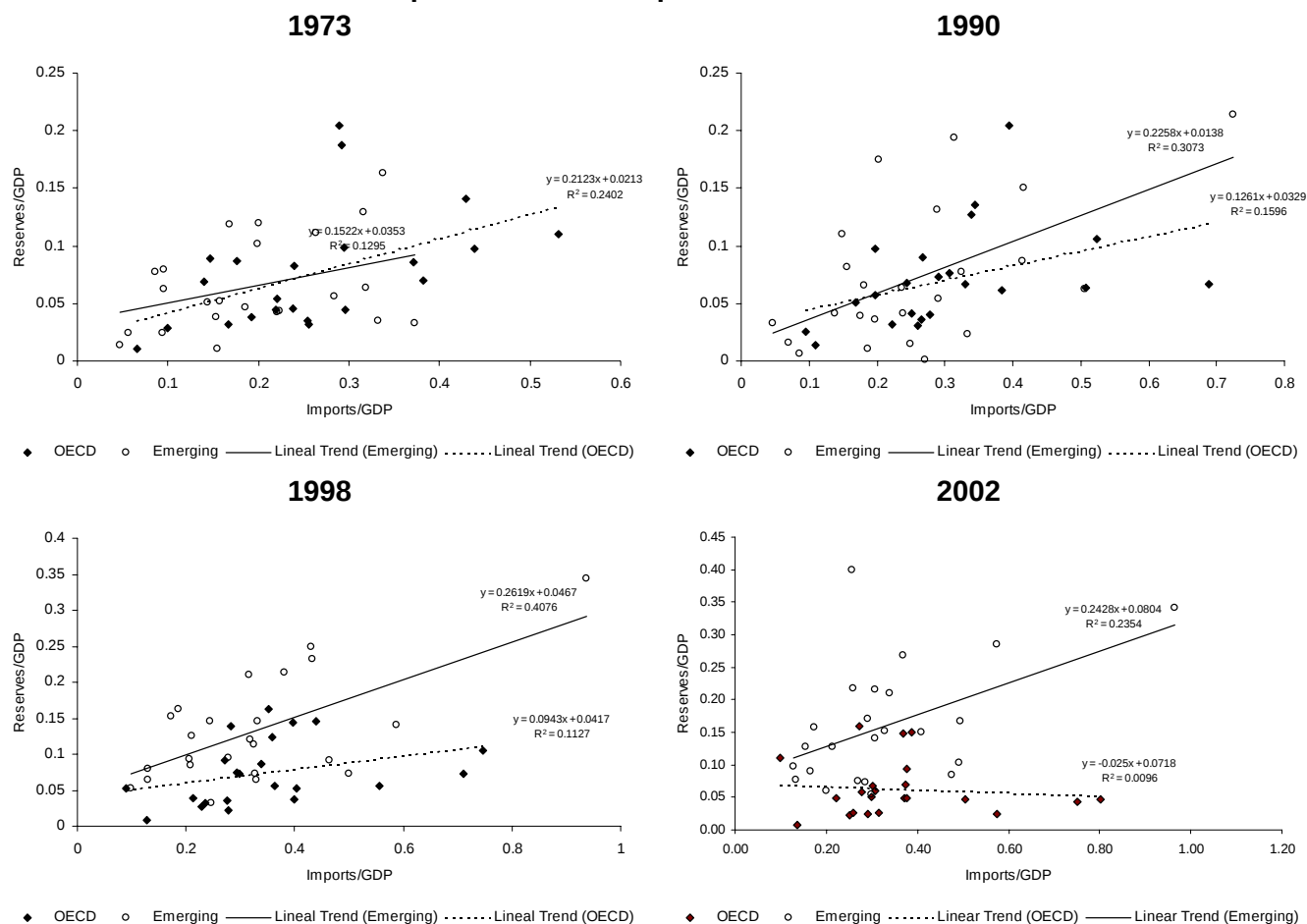
Source: Prepared on basis of IMF (IFS) and World Bank (WDI) data

It can also be seen that the decline in the ratio with an epicenter in 1982 observed on Graph 5 was more vigorous in Latin America and the Caribbean, and that its recovery in the two subsequent years took the series to its high point (Graph 6). The explanation for this is that the reserves for the region returned to their pre-crisis levels, while imports continued very weak.⁴⁹ The sharp drop in 1988 and 1989 was related to the significant expansion in purchases from the rest of the world, while the “Tequila” effect in 1994 caused a fall of over 20% in the reserves to imports ratio compared with the previous year.

If four “photographs” are taken over time of the reserves-GDP ratio, the uneven performance between developed and undeveloped countries becomes evident once again. Graph 7 performs a cross-plot for the OECD countries and emerging nations between the reserves-GDP ratio and the imports-GDP ratio for four selected years that coincide with the most significant landmarks in the international economy: 1973 (end of Bretton Woods); 1990 (financial opening-up in various emerging and developed countries); 1998 (Asian crises); and 2002 (the last year for which sufficient data is available for these measures, and which is representative of the acceleration in accumulation).

⁴⁹ No doubt explained by the poor performance by regional growth, with a GDP in dollars that fell 11% between 1982 and 1985.

Graph 7. Reserves-imports ratio over time

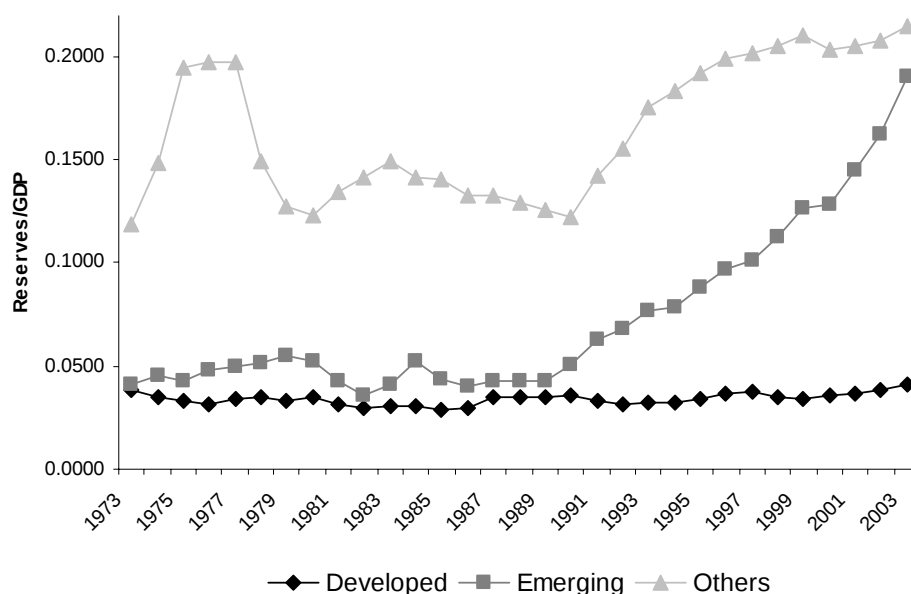


Source: Prepared on basis of IMF (IFS) and World Bank (WDI) data

The sequence formed by Graph 7 provides two valuable lessons. The first is that a positive ratio that appears to show divergence between groups of countries in 1973 has evolved over time until a change in its sign in the final period analyzed, accentuating the discrepancy between emerging and OECD countries. The second lesson has to do with the stability of the relationship in the case of emerging economies.

An alternative normalization to imports is that which arises from making use of GDP as is done in Graph 8.

Graph 8. Reserves-GDP ratio by group of countries 1973-2003



Source: Prepared on basis of IMF (IFS) and World Bank (WDI) data

This Graph corroborates the same key events that were noted in the previous analysis on the basis of the reserves to imports ratio. On this occasion, the reserves/GDP of the group named as “Others” are far (two to three times) higher than those of the other two groups. This has not happened since the end of the nineties, as the emerging countries have significantly narrowed the gap.

There are also other methods of normalization that are closely linked to the literature on adequacy indicators, the topic to be dealt with in the fifth section. Without getting ahead of that discussion, mention should be made of the fact that other variables could provide useful information, such as the monetization of the economy (approximated by M2 and representing the potential quantity of capital flight), capital flows (or the reasons detailed in section 2.2 on precautionary demand), or trade flows. To sum up the information arising from the calculation of such series, Table 4 and Table A.2.2 in the Appendix are included, showing reserves averages for different periods.

Table 4. Average value of the scaled reserves by groups of countries

Country Group	Reserves-Imports		Reserves-GDP		Reserves-M2	
	1973-1998	1998-2002	1973-1998	1998-2003	1973-1998	1998-2003
Markets						
Developed	0.19	0.17	0.03	0.04	0.03	0.05
Emerging	0.31	0.53	0.06	0.14	0.14	0.19
Others	0.37	0.41	0.15	0.21	0.36	0.27
Income Level						
Low	0.27	0.47	0.04	0.10	0.11	0.14
Lower Middle	0.30	0.58	0.06	0.15	0.13	0.16
Upper Middle	0.48	0.37	0.10	0.12	0.31	0.30
High Non OECD	0.33	0.50	0.30	0.47	0.45	0.44
High OECD	0.19	0.18	0.03	0.04	0.03	0.05
Regions						
East Asia & Pacific	0.27	0.65	0.04	0.13	0.05	0.11
South Asia	0.21	0.14	0.06	0.04	0.15	0.19
Europe and Central Asia	0.41	0.39	0.06	0.09	0.21	0.28
Latin America & Caribbean	0.42	0.53	0.14	0.17	0.32	0.25
North America	0.10	0.07	0.01	0.01	0.02	0.02
Middle East & North Africa	0.29	0.51	0.03	0.09	0.08	0.17
Sub-Saharan Africa	0.19	0.34	0.05	0.10	0.12	0.25

Source: Prepared on basis of IMF (IFS) and World Bank (WDI) data

The first conclusion is that the heterogeneity by group is not altered substantially in its proportions by changing from one scale to another, although there are certain significant exceptions. For example, it is notable that economies with a low average income were the highest accumulators in 1998-2002 when scaled by imports, but were closer to those with fewest reserves when normalized by M2. The result is repeated for the East Asia and Pacific region between 1998 and 2002.⁵⁰

The most surprising result seen on Table 4 relates to the behavior of Latin America and the Caribbean, the largest accumulator in the second stage according to the reserves to M2 ratio. Evidently, behind this lies the chronic macroeconomic instability of the region, the cause of its low monetization in relative terms.

3.2. Dynamic aspects

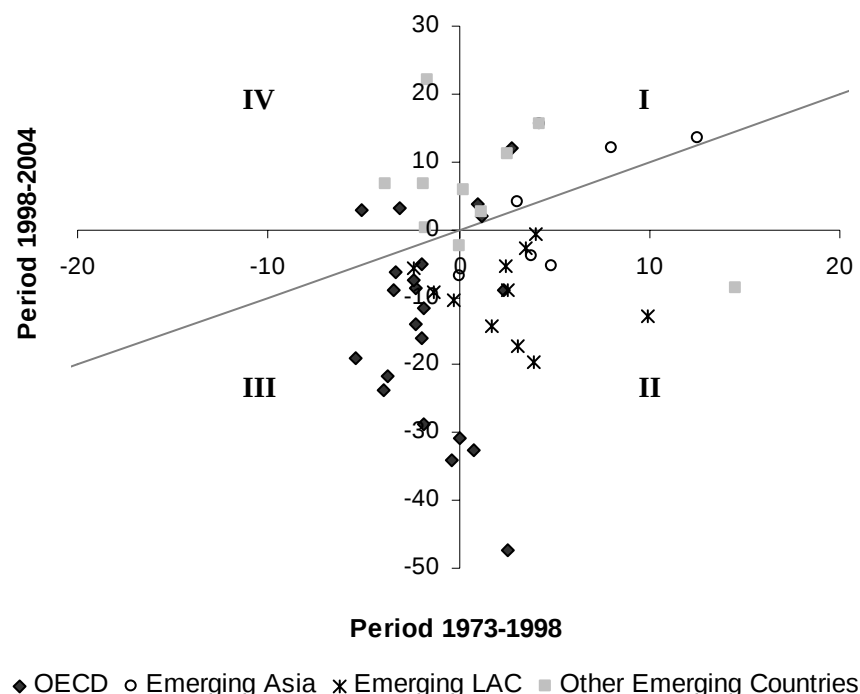
It would be useful here to stress two dynamic considerations related to international reserves.

The first of these has to do with the relative accumulation of emerging countries and those of OECD countries compared with the world average. To be able to study this ratio, calculation was made of the difference between the average annual rate of growth for each country and the corresponding rate for the world as a whole. This calculation was performed for two sub-periods: from 1973 to 1998 and from 1998 to 2004. A cross-plot was then prepared, with the

⁵⁰ The results for trade and financial flows do not significantly alter this outlook, as can be seen from the Appendix.

addition of a 45 degree line where those cases of equality (between stages) would be positioned.

Graph 9. Individual accumulation compared with world reserve accumulation, 1973-1998 and 1998-2004

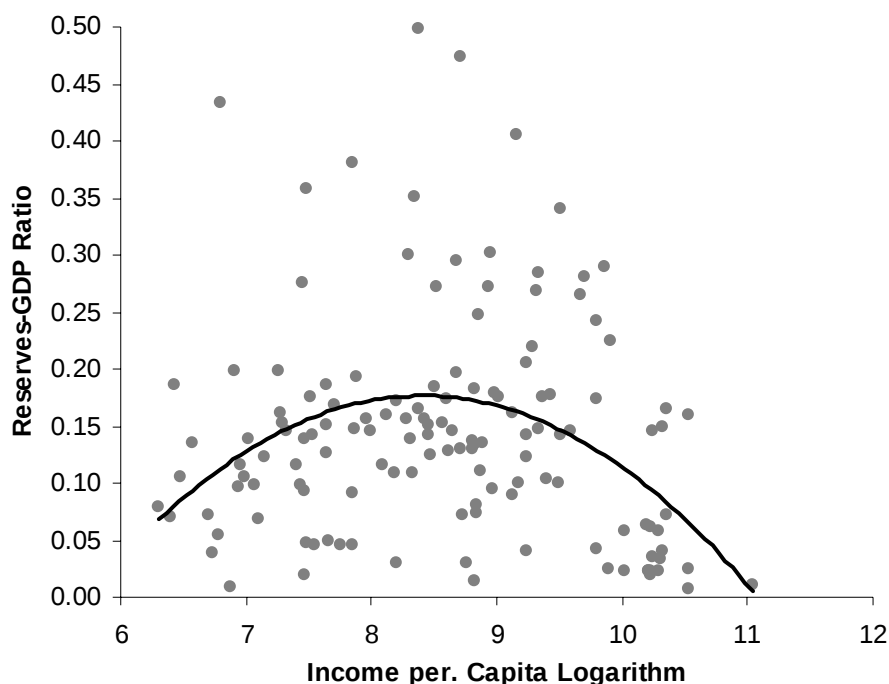


Source: Prepared on basis of IMF (IFS) and World Bank (WDI) data

Differentiation between the three groups of emerging nations and the inclusion of OECD members makes it possible to determine fairly well-defined behavioral patterns. Latin American emerging countries fall mainly into the second quadrant, indicating that they accumulated more than the world mean between 1973 and 1998 and less than the average in the subsequent period. Three emerging countries in Asia are situated above the global trend in both stages of the floating dollar standard, while three others are situated at the same level as most of the Latin American countries. In addition, most OECD member countries are positioned in the third quadrant (having declined more than the mean in both stages). Lastly, in relation to the rest of the emerging country economies, it should be noted that with two exceptions, they grew at a faster than average rate during 1998-2004, while showing no clear pattern in the 1973-1998 period.

The last point in this section returns to the matter of catching up in reserves. If international reserves were indeed to be accumulated especially in transition stages of development, then there should be a non-linear relationship, in the shape of an inverted U, between reserves (scaled by some variable) and the degree of development. This is a point that will be stressed when analyzing the data panel, but to leave established some preliminary evidence, the link between the reserves to GDP ratio and the logarithm of the income per capita has been charted for 2003.

Graph 10. Relationship between international reserves and development level, cross-country dimension in 2003



Source: Prepared on basis of IMF (IFS) and World Bank (WDI) data

The proposed quadratic adjustment generates results that appear to confirm that reserve demand is not linear in relation to level of development. Nevertheless, it would be advisable to await the regression analysis to verify the suitability of this idea and the rest of the hypotheses suggested by the evidence of this descriptive section.

3.3. Exchange rate, monetary and sterilization policies in processes of systematic accumulation

So far, an overview has been presented on the scope and depth of the reserve growth phenomenon. In this section a study will be made of the relationship that exists between monetary, exchange rate and sterilization policies in those countries in which reserve accumulation has been a central component of economic policy.

To determine whether a country is a “systematic accumulator”, a process has been implemented to identify periods of at least three consecutive years with rates of change equal or higher than the median accumulation rate for each year for the total sample.⁵¹ To eliminate erratic behavior attributable to small countries exposed to very high volatility in their reserves, a threshold of US\$ 500 million in reserves in 1990 was established to qualify for the final list of cases.

⁵¹ It was decided to use the median rate of change rather than the mean because of the strong positive bias that exists in the distribution of annual reserve growth rates. It was also considered advisable that this median rate should change year by year to establish the change over time in reserve growth.

This detection mechanism resulted in a total of 74 processes of “systematic accumulation”. The mean life of a process is approximately four years and three months. The distribution of frequency of these episodes by number of years is shown on Table 5.

Table 5. Duration of episodes of “systematic accumulation”

Duration of experience	Frequency	Percentage
3 Years	27	36.49%
4 Years	23	31.08%
5 Years	11	14.86%
6 Years	7	9.46%
7 Years	2	2.70%
8 Years	3	4.05%
9 Years	1	1.35%
Total	74	100%

Source: Prepared on basis of IMF (IFS) and World Bank (WDI) data

The complete list of countries can be found in part four of the Appendix, and once again shows the relative importance of the Asian countries. Another notable aspect is the high number of episodes in the economies of Eastern Europe and the former Soviet Union. However, it should be pointed out that unlike the Asian countries, which in 1990 already held significant stocks of liquid external assets, in Eastern Europe and Central Asia the starting point at the beginning of the nineties (when many of these new states were created) was low in relative terms.⁵²

The first relevant question to be asked in order to establish the relationship between exchange rate, monetary, sterilization and reserves policies is to identify the exchange rate regime adopted by each accumulator. For this purpose the system followed by the International Monetary Fund was used, which identifies the following categories: i) fixed regimes (which covers cases where there is no separate legal tender, currency boards and conventional pegs; ii) intermediate regimes (horizontal bands, crawling pegs or crawling bands); iii) managed floating (float without a pre-announced path); and iv) independent floating.

In analyzing each experience, it should be taken into consideration that the exchange rate arrangements are defined on an annual basis, whereas each systematic accumulation event has a duration of at least three years. It is therefore possible that there could be events for which there have been one or more changes to the exchange rate regime. For this reason and with the aim of providing an indication of the most probable regime for a systematic accumulator, the number of years is considered rather than the number of experiences in

⁵² Specifically, a total of 32 episodes correspond to Europe and Central Asia, accounting for 43% of all cases. The figures for the rest of the regions are as follows: i) East Asia, Pacific and South Asia: 21 cases (29%); ii) Middle East and Africa, 12 cases (16%); iii) Latin America and Caribbean: 8 cases (11%); and iv) North America: 1 case (1%).

which each particular scheme was observed. The frequencies and the respective percentages are tabulated below.

Table 6. “Systematic accumulators” and exchange rate regime

Exchange rate regime	Frequency	Percentage
Fixed rate	78	26%
Intermediate regime	20	7%
Managed floating	108	35%
Independent floating	99	32%
Total	305	100%

Source: Prepared on basis of IMF (IFS) data

These results lead to the conclusion that a sustained reserve accumulation strategy is possible, although not equally probable, under any exchange rate regime. A significant number of cases can be found within the two most flexible categories.

The second exercise carried out concentrates directly on changes of regime, to which end the corresponding transition matrix is constructed. This exercise has the following dynamic. The first year of each experience is considered, and the exchange rate regime is observed. Then this regime is compared with the regime in the following year. Next, the second year is compared to the regime of the third year. If the systematic reserve accumulation episode is of only three years, the process stops there. If the duration is longer, the same procedure is continued forward until completing the years making up the experience. Each case is included in a double entry matrix for which the rows indicate the regime in force at the start of the year, with columns showing the regime at the start of the following year (this represents all the possible transitions between states). The elements along the main diagonal represent the absence of changes or transition. The results of this exercise can be found in Table 7 showing both the number of cases and the corresponding probability. The latter is no more than the quotient between the frequency of a particular cell and the total (on the row) to which the cell belongs.

Table 7. Exchange rate regime transition matrix for “systematic accumulators”

		Exchange rate regime at $t + 1$				
		Fixed exchange rate	Intermediate regimes	Managed floating	Independent floating	Total
Exchange rate regime at t	Fixed exchange rate	52 94.5%	0 0.0%	3 5.5%	0 0.0%	55 100%
	Intermediate regimes	2 15.4%	10 76.9%	1 7.7%	0 0.0%	13 100%
	Managed floating	4 4.8%	5 6%	72 85.7%	3 3.5%	84 100%
	Independent floating	2 2.4%	0 0.0%	8 9.8%	72 87.8%	82 100%
	Total	60 25.6%	15 6.4%	84 35.9%	75 32.1%	234 100%

Source: Prepared on basis of IMF (IFS) data and the Annual Report on Exchange Rate Arrangements and Exchange Rate Restrictions of the IMF (various years)

As can be observed, the higher probabilities are on the main diagonal of the matrix. The first conclusion is that the most probable result at the beginning of a year is that there is no change in exchange rate regime, regardless the type of exchange rate system. In other words, most regimes are stable in processes of high reserve accumulation. A second very suggestive characteristic is that although the total number of cases outside the diagonal is low, they are mostly below it. There are twenty-one cases in the lower triangle (9% of all cases) and only seven in the upper triangle (3% of cases). From this it can be inferred that once conditioned to the occurrence of a movement in the exchange rate scheme, in 75% of cases systematic accumulators adopt a more rigid regime than they held previously.⁵³

It is difficult to obtain a systematic and uniform classification of the monetary policy implemented by the accumulators for a numerous group of countries. Comparatively, the literature on exchange rate regime classification is far more extensive. Use will be made here of the taxonomy proposed in an IMF paper (Stone and Bhundia, 2004), given its wide coverage in terms of both time period and geography.

⁵³ As can be deduced from the transition matrix, the exhaustive list of possible alternatives for the switching to a more rigid regime are: i) to apply an independent float and switch to a managed float (8 cases), to an intermediate regime (no case) or to a fixed regime (2 cases); ii) to apply a managed float and switch to an intermediate regime (5 cases) or to a fixed exchange rate (4 cases); or iii) to apply an intermediate regime and switch to a fixed exchange rate (2 cases).

These authors divide the various monetary regimes into seven categories: i) full-fledged inflation targeting; ii) inflation targeting lite;⁵⁴ iii) implicit price stability anchor (countries with annual inflation below 4% in the last ten years); iv) monetary anchor (targets for monetary aggregates and floating exchange rate); v) monetary nonautonomy (monetary unions, dollarization and currency boards); vi) weak anchors (countries with annual inflation rates of over 40%); vii) exchange rate peg (conventional pegs, bands and crawling pegs); as well as viii) a last residual category grouping all those cases not previously classified.

Table 8 shows the frequencies and the percentages of the various monetary regimes (on an annual basis) adopted by the accumulators.⁵⁵

Table 8. “Systematic accumulators” and monetary regime⁵⁶

Monetary regime	Frequency	Percentage
Full-fledged inflation targeting	16	7.1%
Implicit price stability anchor	18	8%
Monetary anchor	4	1.8%
Inflation targeting lite	77	34.4%
Weak anchor	26	11.6%
Exchange rate peg	77	34.4%
Monetary nonautonomy	21	9.4%
Total	224	100%

Source: Prepared on basis of IMF (IFS) data and Stone and Bhundia (2004)

As in the case of exchange rate policy, there is considerable variety in the monetary policies adopted by accumulators. There have even been several episodes of strong reserves growth in economies with high rates of inflation (above an annual 40%).⁵⁷ There is also a significant presence of inflation targeting countries, a reflection of the increasing international trend towards the adoption of this system. On the other hand, only the process of accumulation by Korea between 1992 and 1995 combined exchange rate flexibility with the control of monetary aggregates as an anchor for prices and expectations.

The large number of categories for monetary regimes would hinder analysis on the basis of the transition matrix such as was used for exchange rate regimes. Nevertheless, it is possible to investigate the stability of monetary policies in the universe of systematic

⁵⁴ Stone and Bhundia (2004) employ the description of *inflation targeting lite* for a broad range of transitional monetary regimes aiming at maintaining monetary stability until the implementation of the structural reforms in support of a single nominal anchor.

⁵⁵ Consideration is given to the number of years and not experiences for the same reasons given in the case of exchange rate regime.

⁵⁶ There are fewer cases than for Table 6 because of the lack of data on the monetary regime.

⁵⁷ It is notable that this group includes three Latin American experiences with structural inflation problems: Brazil (between 1992 and 1995), Uruguay (1992-1995) and Peru (1991-1993).

accumulators, by simply analyzing the number of regime changes for the total number of episodes.

Table 9. “Systematic accumulators” and monetary regime stability

Changes in monetary regime	Frequency	Percentage
No changes	40	74.1%
One change	12	22.2%
Two changes	1	1.8%
Four changes	1	1.8%
Total experiences	54	100%

Source: Prepared on basis of IMF (IFS) data and Stone and Bhundia (2004)

These figures reinforce the principal conclusion of this part of the study: countries that pursue aggressive accumulation strategies do so under different exchange rate and monetary regimes, although once the process has begun, they only occasionally change the system under which they began to develop such a prudential policy.

3.3.1. Sterilization in processes of systematic accumulation

The connection between reserves and sterilization is highly influenced by the selection of exchange rate and monetary regime. Some examples follow.

Under a hard peg sterilization should not in theory be possible⁵⁸ as monetary autonomy is lost.

With a conventional fixed exchange rate system, monetary policy possibilities increase, although the credibility of the program imposes narrow limits. There is a significant asymmetry in this case. While, depending on the circumstances, the option may be available to sterilize the purchase of reserves by simultaneously reducing domestic credit or increasing non-monetary liabilities, the opposite situation would tend to deteriorate the quality or backing of the peg.

With greater exchange rate flexibility other types of contrast arise. A system under which the central bank remains entirely aloof from the exchange rate market by definition eliminates the possibility of sustained accumulation of reserves.⁵⁹ The fact that countries that claim to

⁵⁸ If a restricted concept of sterilization is not adopted, and consideration is given to a broad spectrum of actions that shrink the monetary base, such as the purchase of currency with the fiscal surplus, or financial system regulations, then the mentioned affirmation becomes relative. According to Frankel (1994) a limited definition of sterilization would be restricted to policy actions or open market operations so as to leave the monetary base unchanged. For Reisen (1993) there is a wide view of sterilization that includes other types of measures such as the administration of minimum liquidity requirements.

⁵⁹ It could be argued that a central bank could borrow abroad to increase its reserves. However, it seems unlikely that there would be a strong and systematic growth in reserves based exclusively on the use of external debt.

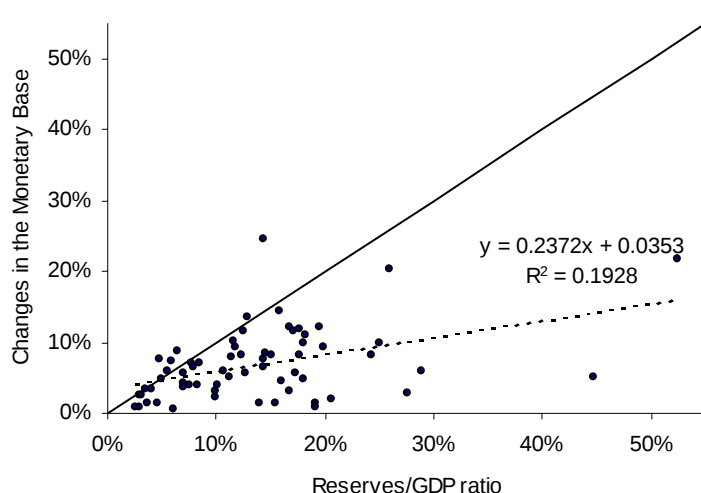
practice independent flotation accumulate significant volumes of external assets suggests that such a category is only an ideal theoretical entity that is not observed in practice.⁶⁰

In the relevant case of intervention in the exchange rate area (allowing for varying intensity) there are basically two views of monetary policy.

Under a monetary policy that defines quantitative targets for the growth of aggregates, sterilization will absorb the excess over monetary demand generated ex-post.⁶¹ If, on the other hand, monetary policy is targeted at control of interest rates as a tool (whether in the case of an *inflation targeting* system in its various forms or of multiple policy objectives), sterilization could condition the range set for them. It is harder to predict a clear link to monetary aggregates as these become determined by the demand for money.

The study of the sterilization policy in the cases of systematic accumulation performed here is based on the construction of a measure for this variable, which consists in studying the overall variation of reserves during the accumulation stage and comparing it with the corresponding variation in the monetary base. As a preliminary exercise, the mentioned variations have been charted, normalized by the level of GDP for each country at the end of their respective experiences.

Graph 11. Changes in scaled reserves and changes in the monetary base



Source: Prepared on basis of IMF (IFS) data

As can be seen from Graph 11, a clear majority of cases are located below the bisector. To some extent, this suggests a preference for partial sterilization of the increase in external assets. In this graph, the vertical distance from one point to the 45° line could be interpreted as the sterilization effort made in terms of GDP.

⁶⁰ In this regard, see footnote fourteen.

⁶¹ If in addition to monetary aggregate targets an explicit objective is set for the accumulation of reserves, sterilization could be determined in the system once the quantity of external assets to be acquired during the course of the year has been defined. Obviously this is not the case when the expansion programmed for the monetary base is lower than that required to purchase the currency needed to meet the reserve target.

In order to construct a proxy for sterilization for each experience, the following indicator has been adopted:

$$(6) \quad \text{Degree of sterilization} = \frac{\Delta \text{Reserves} - \Delta \text{Monetary base}}{\Delta \text{Reserves}}$$

Where Δ is the change in the levels of the respective variables for each experience. The coefficient is negative when the base expands more than reserves. A value between zero and one means that the increase in external assets is partially neutralized. The sterilization index is higher than one if the purchase of reserves is accompanied by a monetary contraction.

Below is a calculation of the degree of sterilization that the various groups of accumulators recorded on average, the exchange rate and monetary regimes being alternatively the variables determining each grouping. This enables conjecture as to whether the theoretical differences in sterilization for each regime take place or not according to the data.

Table 10 calculates the average value of this index according to the exchange rate regime for the experiences identified, its volatility (the coefficient of variation between the various episodes) and its maximum and minimum values.

Table 10. Sterilization by groups of experiences: exchange rate regime

Exchange rate regime	Level of Sterilization	Volatility of Sterilization	Minimum	Maximum
Fixed exchange rate	0.47	0.59	0.02	0.95
Intermediate regime	0.56	0.62	0.22	0.91
Managed float	0.40	1.18	-0.70	1.04
Independent float	0.36	0.97	-0.59	0.90
One change of regime	0.32	1.25	-0.57	0.90
Two changes of regime	0.80	0.89	0.10	1.93
Weighted average	0.42	0.98	-0.70	1.93

Source: Prepared on basis of IMF (IFS) data

The table shows that the difference in the degree of sterilization between regimes is kept within a narrow interval. A certain linear negative relationship can also be observed with regard to flexibility. Accumulators with fixed and intermediate exchange rates sterilize 47% and 56% respectively of the increase in their reserves, and in addition present a lower variability. On the other hand, the index for floaters is set in a lower range (between 36% and 40%).

This exercise is repeated below, considering the monetary regime as the grouping variable.

Table 11. Sterilization by groups of experiences: monetary regime

Monetary regime	Level of Sterilization	Volatility of Sterilization	Minimum	Maximum
Full-fledged inflation target	0.91	1.02	0.13	1.93
Implicit price stability anchor	0.52	0.76	0.13	0.89
Monetary anchor	0.18	-	0.18	0.18
Inflation targeting lite	0.54	0.56	0.07	1.04
Weak anchor	0.10	4.46	-0.34	0.55
Exchange rate peg	0.49	0.60	-0.10	0.95
Monetary nonautonomy	0.44	0.72	0.02	0.81
One change of regime	0.30	1.14	-0.70	0.91
Weighted average	0.45	0.91	-0.70	1.93

Source: Prepared on basis of IMF (IFS) data and Stone and Bhundia (2004)

Sterilization is at its highest under full-fledged inflation targets. In that situation, the degree of neutralization practically doubles that of a second group made up of the implicit price stability anchor, inflation targeting lite, pegged and hard pegged exchange rate regime categories. There is even the atypical experience of the Czech Republic, which shrank its monetary base by 50% at the same time as it sharply increased its reserves. In addition, the low frequency of experiences with a monetary anchor inhibit the extracting of conclusions (there is only one event with that monetary policy). Lastly, in the case of weak anchors (annual inflation rates in excess of 40%), the lowest sterilization indexes are recorded. The index is also low when changes of regime have taken place.

Although indicative, a global index such as that proposed does not enable determination of the specific manner whereby accumulation and sterilization policies are articulated. Central banks possess individual characteristics that hinder a unified and systematic treatment. For this reason the matter tends to be dealt with by means of case studies.⁶² Following this practice, the fifth section of the Appendix includes analysis of four recent experiences in which the accumulation of reserves is complemented by a prudent handling of monetary policy: India, Korea, China and Russia. From this analysis it can be concluded that in these four countries “fine tuning” of monetary policy instruments has required a very active and coordinated policy to be able to accumulate reserves with price stability, high growth rates and a reduction in external vulnerability.

⁶² See conventional contributions from Calvo et al. (1993) and Reinhart and Reinhart (1998). For a more recent treatment, see Ho and McCauley (2005) and Terada-Hagiwara (2005).

4. Reserves in Argentina

4.1 Summary of historical development

Having reviewed international trends, this section now tackles the issue of reserves in Argentina. The purpose is to place the forces that drove accumulation in Argentina in a world context, and investigate whether there was any link to the global dynamics.

Few of the available works analyzing recent monetary and financial history have paid attention to the subject of reserves.

Table 12 calculates average annual growth rates for reserves and the coefficient of variation for the annual rates of changes for two periods: before and after the fall of Bretton Woods.

Table 12. Annual average growth rates for reserves and volatility of the rates of change in Argentina

Period	Current dollars		Constant dollars	
	Average growth	Coefficient of variation	Average growth	Coefficient of variation
1948-1972	-1.70	4.30	-1.50	4.44
1973-2004	8.87	2.77	5.15	3.18

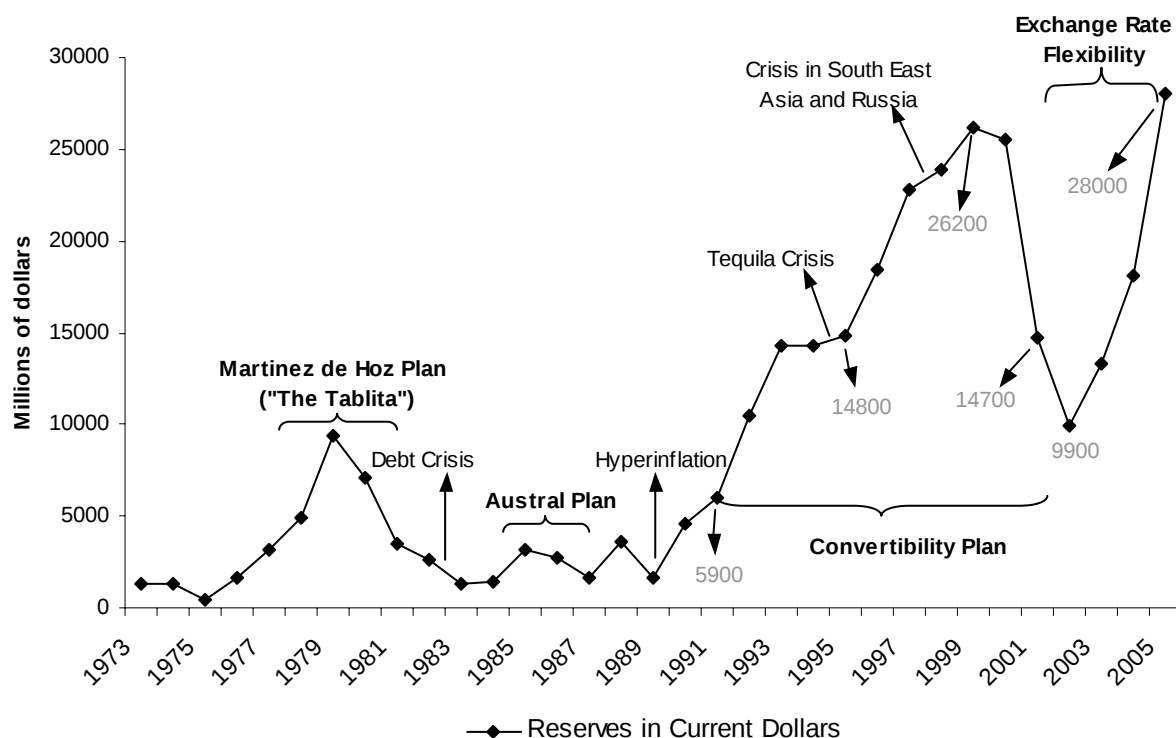
Source: Prepared on basis of IMF (IFS) data

Until 1975, Argentina was a partially closed economy as were the rest of the economies of Latin America. Over the period of twenty-five years between 1948 and 1972, current reserves fluctuated sharply, dropping to a low of US\$97 million in 1958 and a high of US\$760 million in 1968. High volatility and a significant drop between ends, which on an annualized basis resulted in an average annual reduction of 1.7% were the two main features of this first stage.

The behavior of the external assets held by the Central Bank reflected both the changes in the global regime and in the specific international insertion scheme of Argentina. The declining trend from the Bretton Woods period reversed. On the basis of the information provided in the third section, it can be claimed that Argentina behaved like the rest of Latin America during the floating dollar phase. The average growth rate in constant dollars of 5.15% for the 1973-2004 period is comparable with the figure for Latin America as a region (5.61% for 1973-1998 and 4.45% for 1998-2004) shown in Table 2.

After having analyzed these aggregate figures, Graph 12 shows the course followed by reserves from 1973 to date.

Graph 12. The unstable course of reserves in Argentina, 1973-2005⁶³



Source: Prepared on basis of IMF (IFS) and Banco Central de la República Argentina data

At the beginning of the seventies the series shows a low stock of reserves that reflects the limited degree of freedom that economic policy could count on at that time. The greatest difficulty was to close the external “gap” that arose during the stop and go model.⁶⁴ The low point for the series took place in 1975 (US\$460 million).

In the latter part of December 1978, a program of pre-announced exchange rate guidelines was established that relied on exchange rate appreciation as an anchor for price levels.⁶⁵ With this attempt at opening of the economy, a cyclical behavior began to be seen in reserves that was to manifest itself with greater intensity, over a broader time-frame, during the Convertibility period. Driven mainly by capital flows, reserves reached a peak of US\$ 9.3 billion.

In 1980 the current account deficit reappeared, as a result of increased external competition, encouraged by trade openness and appreciation of the real exchange rate, which, together with the collapse of the country’s leading financial institution, had a negative impact on expectations. Even though the public sector increased its indebtedness to preserve the level of reserves and lower tension in the financial system,⁶⁶ capital flight accelerated, and in

⁶³ Information for 2005 was obtained from the BCRA and corresponds to the end of December 2005. For the remaining years the source is the IMF (IFS).

⁶⁴ Nevertheless, 1973 in particular ran counter to the trend of chronic weakness in Argentine external accounts, as it ended with a trade surplus of US\$1.03 billion that doubled the previous record set in 1949 (Gerchunoff and Llach, 2000).

⁶⁵ See a detail of the theory behind this policy in Rodríguez (1979).

⁶⁶ Damill and Frenkel (1987)

February 1981 the program was abandoned with reserves at one third of the level held in 1979. There followed a period of disorderly adjustment, and the reserves drain continued until 1983.

Graph 12 reveals a significant rebuilding of Central Bank external reserves in 1985,⁶⁷ coinciding with the introduction of the Austral Plan and a return to a current account surplus. This plan did not lead to substantial capital inflows, however, and the level of reserves remained low.

During the hyperinflation that took place between April and June 1989, reserves reached a new low (US\$1.13 billion, of which 84% was maintained in gold and SDRs). The premature change of government was followed by a failed attempt at stabilization and a second period of hyperinflation that happened between January and March 1990. Meanwhile, reserves began an upward path.

It is significant that even though 1990 and 1991 were difficult years from a macroeconomic standpoint, reserves continued at a high level in comparison with their recent past. This was partly due to the policy of the Central Bank, which set tight limits on financial institution indebtedness and forced the liquidation of part of their dollar holdings, helping to partially control speculation. But overall, it was the implementation of a managed float system and the policy of preventing the appreciation of the exchange rate (once the run had been controlled) that added large sums of dollars to Central Bank reserves. Between April and December 1990, reserves rose from US\$1.8 billion to almost US\$4.8 billion, and the exchange rate remained at between 5,000 and 6,000 australes per dollar.

In April 1991 the Convertibility Plan was introduced. It has been pointed out by a number of academics that this plan was able to count on several very favorable conditions at the outset. The relatively comfortable reserve situation was precisely one of the pre-requisites that were to guarantee the success of the program.⁶⁸ The holding of a sufficiently high stock of external assets to cover a very high percentage of cash in circulation provided a greater basis of credibility compared with previous exchange rate pegs.

As a result of the arrival of large volumes of capital and the operation of the currency board, Argentina reserves rose at a dizzying speed between 1991 and 1993. They then leveled off in 1994-1995 because of the Tequila crisis, which nevertheless concealed a very significant intra-year dynamics. Between December 1994 and March 1995 Central Bank external assets dropped from US\$14.5 billion to US\$8.6 billion, but by December that year they had returned to their starting-point (US\$14.55 billion). A significant portion of this recovery was due to the financial assistance granted by the IMF in the context of the extended facilities agreement that was renewed in April 1995.

After this crisis, the country once again entered into an upward cycle, with abundant capital inflows and rising indebtedness. Reserves reached their highest point under Convertibility in 1999 (US\$26.2 billion), when the recession had already begun.

⁶⁷ The increase in reserves in 1985 compared with 1984 was 120%.

⁶⁸ Other favorable elements contributing to the success of the currency board as a stabilization program included the extraordinary fiscal revenue contributed by the early privatizations, the discipline of certain price formers, encouraged by the trade openness, and the fact that the program was implemented at a time of significant increase in capital flows to emerging markets.

The collapse of the exchange rate regime was obviously reflected in the behavior of the external assets of the Central Bank. The reserves drain during the whole of 2001 was continuous, despite the partial execution of the contingent credit program (with participation by international financial institutions and multilateral agencies) and a specific IMF loan for the purpose of rebuilding them.⁶⁹

The first part of 2002 was marked by the need to stabilize expectations, and in particular those relating to the exchange rate. Reserves reached a low point for the year in July (US\$6.8 billion), at which time the main real and financial variables steadied. Compared with previous exchange rate crises, the freeing of the exchange rate at the same time as reserves were at a record high prevented the fulfillment of the more negative currency devaluation and hyperinflation predictions.

From then on, Central Bank external reserves returned to a growth path, keeping pace first with the recovery and then with the growth of the economy. The distinctive feature of the post currency board period has been that it is the first stage in recent times in which in a medium-term horizon, significant increase in reserves have coexisted with trade balance and current account surpluses.

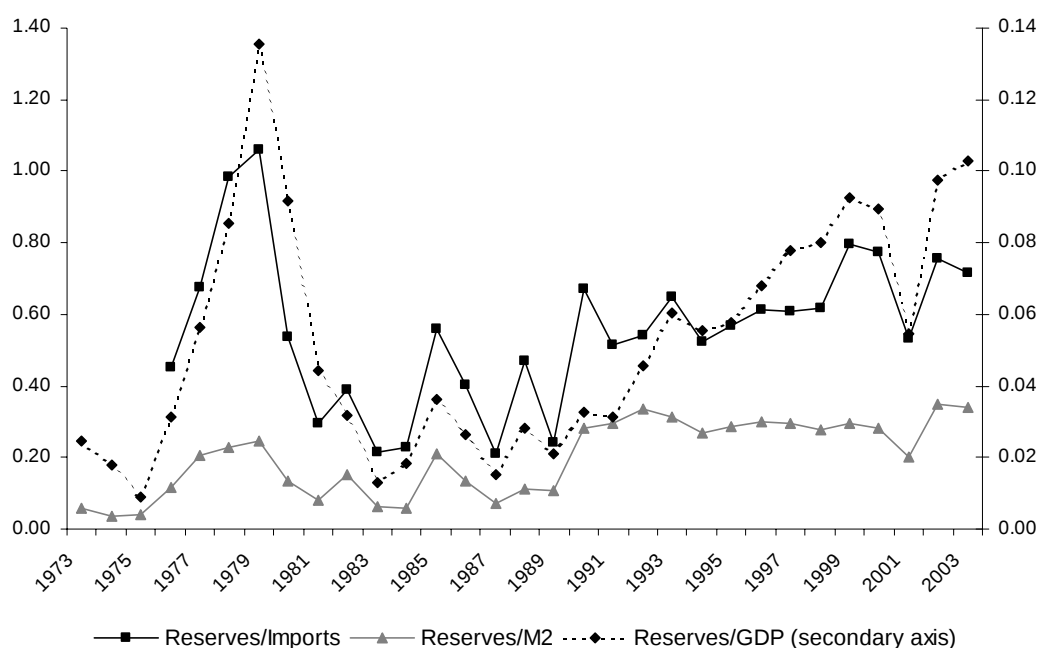
4.2. Reserves in relation to other macroeconomic variables

Detailed analysis of the relationship that exists between reserves and other macroeconomic variables in Argentina would require a special study. For this reason, in this brief section only the basic outlines will be presented, acting as a guide for future research.

To begin with, scaled reserves are analyzed. Graph 13 shows the reserve series normalized by imports, GDP and M2.

⁶⁹ As a result of both these actions, reserves rose from US\$14.5 billion in August to US\$21.55 billion in September 2001.

Graph 13. Scaled reserves in Argentina, 1973-2003



Source: Prepared on basis of IMF (IFS) and World Bank (WDI) data

This clearly shows the massive capital inflows in the period prior to the debt crisis in the eighties. This can be seen both with regard to imports and with regard to GDP, as the historical maximum was recorded in 1979 in both cases.

Examination of Graph 13 also shows the following: i) the behavior of reserves scaled by imports and by GDP is almost identical -obviously bearing in mind their different level- until 1990, as from when the second series grows at a far faster rate than the former; ii) the rise in the reserves-M2 ratio was not as high either during the “Tablita” period or during the currency board period, compared with other scaled measures, probably due to monetization of capital inflows; and iii) reserves normalized by GDP and M2 were higher in 2003 than during the currency board period.

The link between reserves and other significant macroeconomic variables can be seen from the analysis of contemporaneous correlation in Table 13. This includes the following variables: growth and level of GDP, inflation rate and volatility (measured by the standard deviation of the intra-year inflation rate), result of the current account and level and volatility of the bilateral real exchange rate in relation to the United States⁷⁰ (the latter estimated by the coefficient of variation for the intra-year levels). It should be clarified that no type of conclusion or interpretation is proposed on the underlying causality between the variables.

⁷⁰ Constructed using the respective consumer price indexes.

Table 13. Contemporaneous correlation of reserves and selected macroeconomic variables, 1973-2004

Variable	Correlation	
	Coefficient Value	Statistical Significance (P Value)
GDP level	0.955	0.000***
Growth	0.162	0.374
Inflation	-0.344	0.053*
Inflation Volatility	-0.371	0.036**
Current account	-0.554	0.001***
Real Exchange Rate (RER)	-0.440	0.011**
RER Volatility	-0.711	0.000***

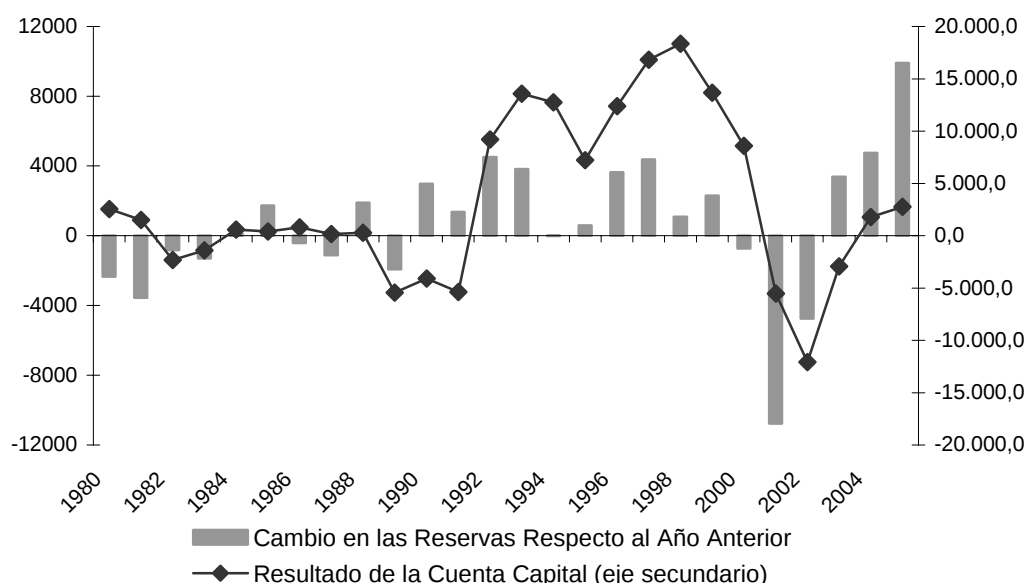
Source: Prepared on basis of IMF (IFS) and Banco Central de la República Argentina data

Note: *significant at 10%, **significant at 5%, ***significant at 1%

A negative relation can be observed between reserves and both level and volatility of inflation rates. The same happens with RER level and its volatility. The only positive and significant association is with GDP.

The negative correlation between reserves and the current account is striking, as 2003-2005 is the only period in which positive current account balances have coexisted with the accumulation of external assets at the Central Bank. This negative association leads to the inference that the hoarding of reserves in Argentina was historically governed by the pendulum movements of capital flows. Graph 14 confirms this intuition, comparing the evolution of the capital account with the changes in the stock of reserves from one period to another.

Graph 14. Capital account and changes in reserves, 1980-2005 in millions of dollars



Source: Prepared on basis of IMF (IFS), Central Bank of Argentina and INDEC data

Accumulation during the currency board period was accompanied by a capital account surplus and a current account deficit. In the 2001-2002 crisis there was a sharp change in the capital account balance, with a record loss of reserves. Nevertheless, in 2003-2005 the latter variable rose again significantly, while the level of external exposure declined from the settlement of debt with the rest of the world.

4.3. Differences between the current reserve accumulation cycle and the currency board: sterilization and prudent monetary policy

As mentioned in the previous section, Argentina has experienced different periods of reserve accumulation. There have been three stages showing very high rates that are of particular interest: two cycles during the currency board and another after that program was abandoned, under a flexible exchange rate regime. It is interesting to note that in these stages very different monetary policies were implemented.

The first expansive cycle of reserves during Convertibility lasted for forty-five months from the beginning of the program (in April 1991) to December 1994. During that period, Central Bank external assets rose fivefold, from US\$2.56 billion to US\$14.55 billion. The second accumulation stage under the currency board ran from January 1996 to July 2000. In those fifty-five months, reserves practically doubled, from US\$13.23 billion to US\$26.05 billion.

With the abandoning of the exchange rate parity, reserves peaked in July 2002. That date marks the start of a new rising phase, which by December 2005 had lasted for forty-two months. Accumulation in this period totaled almost US\$20 billion, three times the initial stock.⁷¹

⁷¹ Reserves increased from US\$ 8.98 billion in mid-2002 to US\$28.07 billion at the end of 2005.

Capital inflows were the principal source of reserves during Convertibility. The operation of the currency board allowed unlimited monetary expansion as long as it was backed by dollars. As a result, the possibility of sterilizing the monetary effect of the rising stock of foreign assets was restricted. Table 14 shows the rate of change of reserves, the monetary base and M2 for each of the stages mentioned. Also shown are the coverage ratios for the base by international reserves, that is, the quotient between reserves and broad monetary base.⁷²

Table 14. Changes in reserves, monetary aggregates and coverage ratios in Argentina

Period	1991-1994	1996-2001	2002-2005
Variation in Reserves	450%	97%	212%
Variation in Broad Monetary base	230%	64%	104%
Variation in M2	272%	37%	146%
Initial coverage ratio	0.53	0.83	1.15
Coverage ratio at end of period	0.88	0.99	1.52

Source: Prepared on basis of IMF (IFS) and Banco Central de la República Argentina data

At the start of the currency board period, growth in external assets higher than the increase in the monetary base led to an improvement in the coverage ratio. In the second accumulation phase, which also took place under the same regime, the phenomenon was repeated, although in a lesser intensity. The most recent stage, when the exchange rate flexibility was greater, at the end of 2005 shows a coverage ratio even higher than during the currency board stage. This has happened even though the monetary authority has not assumed an explicit commitment in relation to the exchange rate.

During Convertibility the monetization of capital inflows was not questioned, based on the assumption that there was an underlying genuine demand for money. Currently, control of the monetary aggregates is the nominal anchor by means of which the Central Bank influences prices and expectations. Therefore, having abandoned the passive monetary policy that characterized the currency board, it is necessary to sterilize liquidity in excess of the established monetary program.

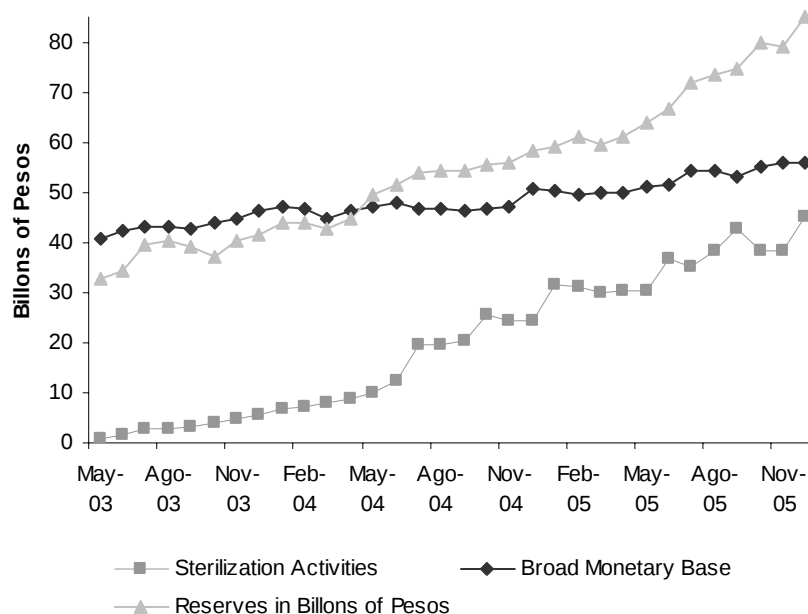
S terilization policy, like the accumulation strategy, sends a clearly prudential signal by imposing a quantitative limit on the growth of aggregates. Unlike during Convertibility, quantitative targets are established through a monetary program. In addition, the current behavior of the BCRA is not conditioned by the monetization of the fiscal deficit, as was the

⁷² The broad monetary base is defined as the sum of notes and coins, quasi-currencies and bank reserves.

case of the sterilization carried out during the eighties. On the contrary, a context of twin surpluses exists for the current account and fiscal accounts.

In general terms, in the last three years four channels can be identified through which the BCRA implements its sterilization policy. In the first place, there is the placing of short and medium-term bills (LEBAC and NOBAC). A second channel is the settlement of debt incurred by banking institutions following the financial crisis of 2001-2002 (rediscount channel). In addition, repo transactions have systematically been carried out. Lastly, of secondary importance in relation to the previous ones, is the sale of government securities in the BCRA's portfolio. This latter contraction factor has been used only occasionally.⁷³ Graph 15 shows the series for international reserves and broad monetary base together with a measure of the main sterilization activities. This latter variable is defined as the sum of the total stock of bills (LEBAC and NOBAC), sales of government securities in portfolio and the accumulated total for repos and settlement of rediscounts by financial institutions.

Graph 15. Reserves, monetary base and sterilization, 2003-2005⁷⁴



Source: Prepared on basis of Banco Central de la República Argentina data

The trends for these series indicate a significant sterilization activity as a complement to the reserve accumulation strategy. From May 2003 to mid-2004, reserve accumulation was combined with a successful remonetization of the economy after the Convertibility crisis. As

⁷³ Lavoie (2001) presents evidence in support of the idea that in developing countries the regular sterilization channel is that of open market transactions using government securities. Reinhart and Reinhart (1998) underline that the main advantage of using this method for sterilization is that it offers a channel for containing monetary growth and credit without imposing a greater tax burden on the financial system (inducing financial disintermediation), as happens when bank reserve requirements are raised.

⁷⁴ The choice of May 2003 is due to the fact that it is the moment when the stock of rediscounts begins to shrink systematically (so that the sum of sterilization activities generates a contraction effect on the aggregates).

can be seen from the graph, the resulting sterilization remained at a low level, although its increase was systematic.

This policy can also be interpreted from a counter-cyclical angle. During the currency board period there was a limited capacity for carrying out corrective actions on monetary aggregates. This meant that money and credit cycles originating in the instability of capital flows and financial markets were very pronounced, providing the real sector with excessive volatility. For sterilization to function effectively in a counter-cyclical manner, it should rise and fall (depending on the phase of the business cycle) at rates that could seem high. It should not be forgotten, however, that the purpose is to prevent such violent fluctuations from taking place from other variables that should be targeted by a Central Bank (quantity of money and reserve accumulation, in this case).

As has been pointed out by various authors,⁷⁵ there could be significant quasi-fiscal costs derived from the implementation of reserve accumulation and sterilization policies (rate differentials between reserves and bills). Nevertheless, as has been emphasized in other sections of this document, to be able to count on instruments that reduce the probability of a crisis, transmit confidence and increase solvency are benefits that, although difficult to quantify, should be considered in the cost-benefit equation. In the current Argentine context, the financial cost is more than offset by income derived from the operations of the Central Bank, which overall result in a fiscal surplus position. In particular, the yield on external and internal assets (bonds and rediscounts) during 2003, 2004 and 2005 exceeded disbursements on the BCRA bills and notes, as well as the cost of other liabilities.

5. Reserves adequacy indicators

So far an analysis has been made of the global dynamics, theoretical models and comparative international evidence on reserves. In both current and following sections an attempt will be made to answer the question about the volume of reserves that a central bank should hold, depending on particular characteristics of the economy.

Literature has followed two alternative ways to answer that question. The first is the use of reserves adequacy indicators. For the second, econometric techniques are employed. The latter is known as an “optimal reserves analysis” because it assumes that actual reserves holding is proportional to the optimal holding plus an error term which is uncorrelated with other explaining variables.⁷⁶ In the present section the first strategy will be developed.

Adequacy indicators have evolved in parallel with the advances in theory. They are more commonly used by policymakers because in comparison with econometrics, they compensate for their excess simplicity with greater transparency.

Initially, under a conventional precautionary approach, it was believed that reserves were sufficient if they ensured that an arbitrary number of between three and six months of imports could be financed. This adequacy criterion will henceforward be known as the “commercial criterion”, and is closely linked to pioneering models on reserve demand reviewed in the theoretical framework.

⁷⁵ See second section of this paper.

⁷⁶ Aizenman and Marion

As has been seen, the opening up of the capital account added new used for reserves. As a result the use of the commercial criterion alone fell into disuse in empirical works on the floating dollar standard, especially after the crises in emerging economies in the second half of the nineties.

It was therefore proposed to use an indicator that would take into account liquidity status, and that in some way could predict the probability of a crisis.⁷⁷ Specifically, it was decided to consider as adequate a stock of reserves that covered external debt⁷⁸ falling due within a year or less (Greenspan, 1999; De Beaufort Wijnholds and Kapteyn, 2001; Soto et al., 2004). Some empirical works on adequacy use an additive logic, adding together the reserves derived from the commercial and financial criteria.⁷⁹

One important point to be mentioned is that even though the short-term external debt gives an indication of the potential external drain in the event of a liquidity crisis, it does not enable the internal drain associated with capital flight by residents to be evaluated (Soto et al., 2004; Kim et al., 2005). This risk is better reflected by the reserves-M2 ratio that measures to what extent banking system liabilities are covered by international reserves (Li and Rajan, 2005).

5.1. Implementation of adequacy indicators in selected emerging countries

To perform adequacy calculations it is necessary to select one of the above-mentioned alternatives. Therefore, it was decided to consider three measures much used in literature, two of which were proposed by De Beaufort Wijnholds and Kapteyn (2001) in a paper published by the IMF.

In first place, adequacy is evaluated according to the commercial criterion, taking as a basis four months of imports. Thus,

$$(7) \quad R_{adequate}^1 = \frac{M}{3}$$

where M represent annual imports.

The second is an adequacy measure concentrating on the financial aspect and the capital account openness. The idea is that the reserves of a country are considered to be adequate if they cover the short-term external debt plus a percentage that varies according to the exchange rate regime, of M2 multiplied by a country-risk indicator taken from the *Economist Intelligence Unit* (EIU).⁸⁰

⁷⁷ Empirically, a very strong link has been found between short-term debt and exchange rate crises. See for example Rodrik and Velasco (1999), Bussière and Mulder (1999) or Willett et al. (2004).

⁷⁸ Public and private debt, although there is some discussion as to whether both should be included in the adequacy standard, or just the former. (Soto et al., 2004).

⁷⁹ See among others, the calculations of De Beaufort Wijnholds and Kapteyn (2001) or Kim et al. (2005). The Central Bank of Russia presents an adequacy indicator based on short-term debt, imports and the drop in M2 in crisis periods (Shcherbakov, 2002). Also, Genberg (2005) uses an additive indicator similar to that used here to analyze the case of Korea.

⁸⁰ This country risk indicator from *The Economist* takes into account seventy-seven different indicators ranging from monetary and fiscal policies to measures of political stability.

In the indicator developed by De Beaufort Wijnholds and Kapteyn (2001) a difference is established according to the exchange rate regime flexibility: with a fixed exchange rate an M2 coverage of 20% is assumed, while in the case of floating arrangements, the necessary coverage is 5%.⁸¹

Nevertheless, after reviewing historical data in relation to the increase in demand for reserves during floating period, it does not seem advisable to establish such a marked difference between exchange rate regimes.

For this reason, it was decided to use a coverage of 12.5% of M2 regardless of the exchange rate arrangement to perform the calculations on Table 15 and to include a sensitivity analysis in the Appendix. The latter does indeed take as bands the rates of 5% and 20% of M2, respectively. As a consequence, all the possible cases according to the methodology of De Beaufort Wijnholds and Kapteyn (2001) are within the bands laid down.

The analytical form of the financial indicator is:

$$(8) \quad R_{adequate}^2 = DECP + 0.125 * M2 * RP$$

where *DECP* is the external debt that falls due within a year and *RP* is the average country risk coefficient for the year, ranging between 0 and 1 as the perceived risk grows.

The third index takes into account both financial and commercial prudential aspects and consists simply of the linear sum of the measures resulting from equations (7) and (8). The corresponding expression is:

$$(9) \quad R_{adequate}^3 = DECP + 0.125 * M2 * RP + \frac{M}{3}$$

Table 15 shows the indicators for a group of emerging countries, with a preponderance of economies in Asia and Latin America .

⁸¹ Curiously, the mentioned work makes an exception for currency boards such as that which functioned for over ten years in Argentina, suggesting that they should have an M2 coverage level similar to that of flexible regimes.

Table 15. Reserve adequacy indicators in selected emerging countries, 2004

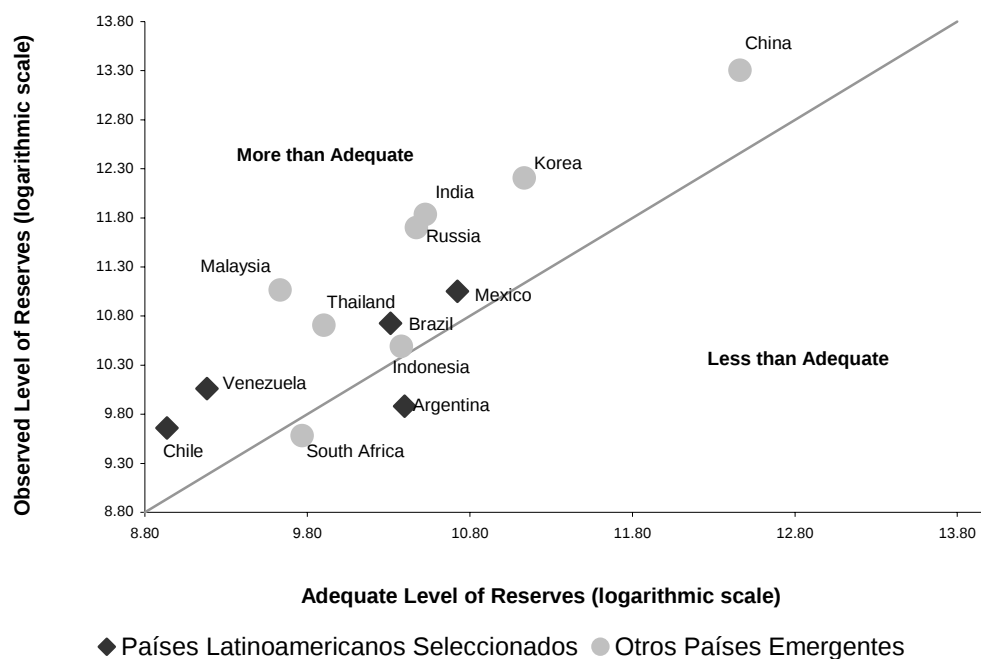
Country	Observed Level	Commercial criterion		Financial criterion		Commercial and financial criterion	
		Adequate	Dif. %	Adequate	Dif. %	Adequate	Dif. %
Argentina	19.600	8.691	55.66	32.836	-40.31	41.527	-52.80
Brazil	45.500	27.673	39.18	30.091	51.21	57.764	-21.23
Chile	15.700	10.053	35.97	7.602	106.53	17.655	-11.07
Mexico	63.000	69.348	-10.08	45.447	38.62	114.795	-45.12
Venezuela	23.400	6.462	72.38	9.725	140.62	16.187	44.56
China	600.800	206.505	65.63	258.571	132.35	465.076	29.18
Korea	200.100	81.856	59.09	68.585	191.75	150.441	33.01
Malaysia	64.000	38.792	39.39	15.254	319.57	54.046	18.42
Thailand	44.600	31.79	28.72	19.991	123.10	51.781	-13.87
Indonesia	36.000	23.561	34.55	32.188	11.84	55.749	-35.43
India	138.000	42.795	68.99	37.285	270.12	80.080	72.33
Russia	120.800	42.982	64.42	35.321	242.01	78.303	54.27
South Africa	14.500	19.56	-34.90	17.484	-17.07	37.044	-60.86

Source: Prepared on the basis of data from the IMF (IFS), World Bank (WDI), JPMorgan, Goldman Sachs and Economist Intelligence Unit (EIU)

There are three relevant observations. In first place, there is a notorious discrepancy between the countries of Latin America and the rest of the cases included. Based on the financial criterion, in 2004 only Argentina presented a level lower than that of the reference indicator, whereas according to the additive criteria, except for Venezuela, the four other Latin American economies were below the levels considered appropriate. On the other hand, Asian countries were mainly situated above the adequacy thresholds.⁸² The differential behavior between regions is illustrated on Graphs 16 and 17.

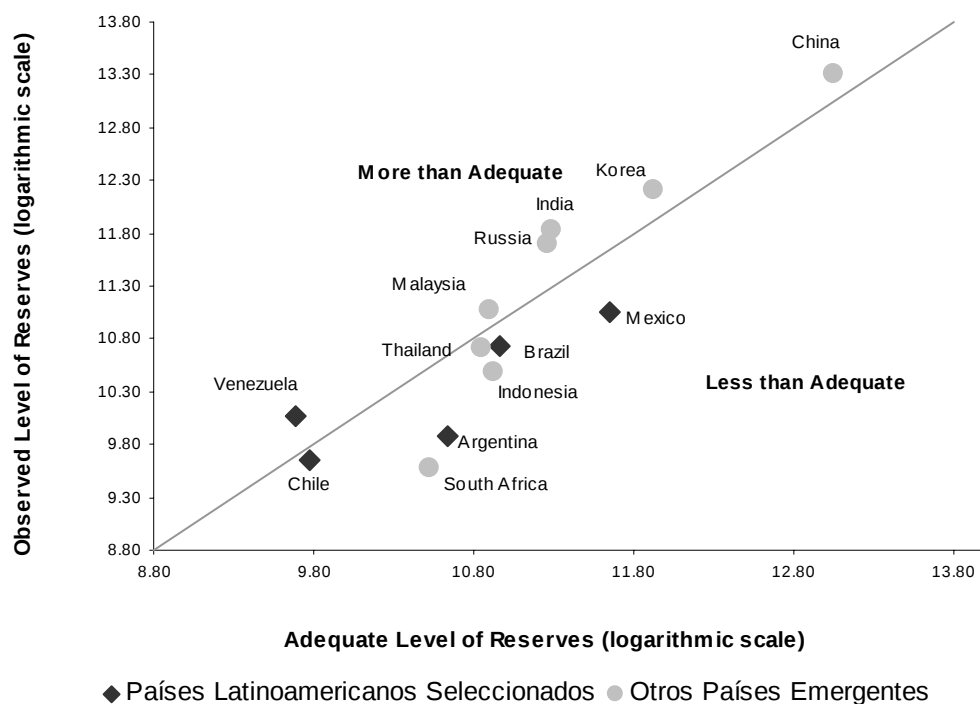
⁸² The percentage differences between the level observed and the adequate level according to each criterion are included in the fourth, sixth and eighth columns of Table 15.

Graph 16. Reserve adequacy according to financial criterion in selected emerging countries



Source: Prepared on the basis of data from the IMF (IFS), World Bank (WDI), JPMorgan, Goldman Sachs and Economist Intelligence Unit (EIU)

Graph 17. Reserve adequacy according to commercial and financial criteria in selected emerging countries



Source: Prepared on the basis of data from the IMF (IFS), World Bank (WDI), JPMorgan, Goldman Sachs and Economist Intelligence Unit (EIU)

Secondly, it can be appreciated that in all cases the actual reserves are far from adequacy by a very high margin (never below 10% in the case of the additive criterion).

Lastly, a comment on the figures for Argentina. The calculation of the short-term debt is strongly influenced by a portion of the public debt in default in 2004, hence the magnitude of certain values on Table 15. Calculations have been based on preliminary data for 2005, so that the restructuring at the beginning of that year can be included. In that case, the financial criterion determines an appropriate amount of reserves of US\$22.36 billion, while commercial and financial criteria suggest that an adequate level would be approximately US\$32.53 billion.

6. Econometric analysis of reserve level determinants

From the study of the global reserve accumulation dynamic, the discussion of theory and the comparative analysis of the international experience performed in the first three sections of this work, a series of hypotheses have arisen. The empirical validity of these hypotheses will be evaluated by means of econometric tools. It should be noted that only some of them have received specific treatment in the literature on international reserves.

First, from the global focus on production and injection of international liquidity, it can be determined that it is important to investigate whether there has indeed been a significant change in the demand for reserves during the floating dollar standard. *A priori*, the possible break points would be the opening of the capital account by numerous countries at the beginning of the nineties and the Asian crises of 1997-1998.

Later, the theory framework proposes various relevant factors to explain the demand for reserve assets. From a more conventional standpoint, note is taken of the importance of the propensity to import, the opportunity costs and the variability of external transactions. From a more modern view, the role of the opening of the capital account as a determinant of accumulation is stressed. The possibility is also raised that part of the demand for reserves could be a phenomenon derived from the functioning of the exchange rate regime.

Lastly, comparative analysis of the international experience suggests that it is probable that there could be a sort of “Kuznets curve” for reserves, that is to say, an inverted “U” relationship between the reserves to GDP ratio and the level of development. Thus, countries with an intermediate level of development would be those recording the highest value for this quotient. In addition, international evidence shows that there is significant heterogeneity between geographical regions that could be an indication of a certain component of imitation between neighbors in the demand for reserve assets.

The econometric evaluation of the characteristics of the hypotheses proposed requires a sample with temporal length and cross-section heterogeneity enough to detect (or discard) the above phenomena. The empirical strategy will therefore be to work with a panel data that covers the whole floating dollar standard (from 1973 onward), including within it both developed and developing countries.

Nevertheless, this is not the general case among recent studies. Several have preferred to restrict one of the two dimensions, working either with short periods or with specific groups of countries. Among the most wide-ranging are the works of Aizenman and Marion (2003,

2004) who, despite covering over 125 countries in each case, restrict their consideration to the undeveloped countries. Soto et al. (2004) analyze the 1990-2001 period for 31 emerging countries. On the other hand, Aizenman and Lee (2005) consider OECD and developing countries, although using a not very large number of cases (53). Lane and Burke (2001) employ 102 countries (industrialized and non-industrialized) but lose the temporal dimension by estimating a “between” model⁸³. Mora and Plazas (2004) use quarterly data for 23 economies (developed and undeveloped), but only from 1990 onward. García (1999) includes 47 countries with heterogeneous characteristics, reaching only as far as 1998. Also considering economies with differing degrees of development, Flood and Marion (2002) construct a panel with 36 cases for the period 1988-1997.⁸⁴

It should be noted that in none of these works does the temporal horizon extend beyond 2000, so they do not consider the recent stage of greatest acceleration in reserve accumulation, led by the emerging countries.

6.1. Econometric model

For the reasons indicated previously, to determine the empirical validity of the hypotheses presented, a demand for reserves will be estimated for a non-balanced panel data of 139 countries (including industrialized and developing economies) for the 1973-2003 period using annual data.

As the main aim is to explain the different levels of external assets held by central banks, the dependent variable is the logarithm of the ratio of international reserve stock to gross domestic product (R/GDP).⁸⁵

The group of explanatory variables⁸⁶ includes those that capture the exposure of the economy to external shocks: the level of trade openness (measured by the imports to GDP ratio) and the level of financial openness (measured by the flow of capital, also in relation to GDP). According to the theoretical framework, a positive relationship between these determinants and the R/GDP ratio can be expected.

⁸³ That is, for each country they take the average value of the variables for the period 1981-1995, estimating a cross-section model with such data.

⁸⁴ There is a first set of evidence that is prior to the collapse of Bretton Woods that evaluated more or less sophisticated versions of the conventional theoretical models reviewed in the second section. These classic studies include: Kenen and Yudin (1965), Malchup (1966), Heller (1968) or Kelly (1970). A second wave of empirical studies took place at the beginning of the eighties, with notable works by Frenkel and Jovanovic (1981), Frenkel (1983), Edwards (1983, 1985) and Lizondo and Mathieson (1987). A detailed survey of this literature can be found in Bahmani-Oskooee and Brown (2002).

⁸⁵ Use of a scaled measure for reserves is the most common practice for empirical works. Studies that specifically normalize using GDP include Lane and Burke (2001), Aizenman and Marion (2003), Aizenman and Lee (2004) and Aizenman et al. (2004). Other studies use more than one variable. Soto et al. (2004) for example, also work with the following dependent variables: ii) reserves over M2; iii) reserves over direct foreign investment ; and iv) reserves over short-term external debt.

⁸⁶ Section A.6 of the Appendix describes in detail the manner in which the variables used in the regressions were constructed and the source of the data.

The coefficients of variation of exports and capital inflows are included to capture the effect of the volatility of the shocks faced by the economy on the demand for reserves. Theory suggests that the greater the volatility, the more reserves countries will wish to hold.

As a measure of the opportunity cost of holding these assets, the interest rate on 10-year US Treasuries is used. With reference to this variable, it should be mentioned that it is very difficult to obtain a good empirical proxy. Ideally a yield differential (r) should measure the discrepancy between the best-yielding alternative investment of the funds used to acquire reserves (i) and the external rate at which they are effectively invested (i^*), so that $r = i - i^*$. Nevertheless, it is not so easy to find an alternative return measure. Various solutions have been tried, for example by using product per inhabitant (Kenen and Yudin, 1965), interest rates paid on government bonds (Frenkel and Jovanovic, 1981), or the marginal productivity of capital (Edwards, 1985). In view of the shortfalls in the series of these variables, Soto et al. (2004) opt for considering only one of the components of opportunity cost: the external rate of interest. This is the strategy adopted in this document, as the problems with the measuring of alternative returns are aggravated in a panel that covers such a lengthy period and wide geographical area. Therefore, all things being equal, it could be expected that this factor would have a positive effect on the level of reserves. In other words, for a given value of alternative yield, an increase in effective remuneration of reserves increases the incentive to accumulate them.

To test the hypothesis of a quadratic relationship between reserves and level of development, GDP per inhabitant is included (in relation to average world GDP for each year) and its level squared. If this hypothesis is confirmed, a positive coefficient should be determined for the linear term, and a negative one for the quadratic term.

The existence of the regional imitation phenomenon is evaluated by means of a variable that calculates the quotient between the number of countries in a region that increased their reserves during the previous year and the total number of countries in the corresponding geographical zone. Thus it is a variable that changes over time and by region.

On the basis of the matters discussed in the section on the global context, to identify a possible structural change or displacement in the demand for reserves at the beginning of the nineties and its acceleration after the Asian crises, two dummies have been incorporated: one that takes the value of one as from 1990, and another that does so as from 1998.

As the exchange rate regime is identified by the theoretical literature as a very important conditioner of reserve levels, on the basis of the methodology of Coudert and Dubert (2005) a *de facto* classification⁸⁷ has been made of the regime adopted by each country in each year (pure float, managed float, crawling peg or fixed peg) and the binary variables that identify them have been incorporated as regressors.⁸⁸ The aim is to determine if the exchange rate arrangement is neutral or not for the reserve accumulation dynamic, and in particular, if greater flexibility implies lower levels of such assets.

⁸⁷ It was opted to evaluate the *de facto* regime shown by each country in relation to the dollar (as the main reserve currency), ignoring the *de jure* categorization.

⁸⁸ The exchange rate regimes of those countries that could not be classified because of a lack of data were identified as indeterminate. For details of the methodology followed, see the corresponding section in the Appendix.

Due to the purpose of the study, reserve demand is estimated on the basis of a stock, and because of that characteristic, it could be expected that it would change slowly over time. In this dynamic process, adjustment to the long-term level takes place gradually, with inertia being an inevitable component at each moment in time. As a result, past accumulation would tend to be closely related to current accumulation. Nevertheless, recent empirical studies using panel data have omitted the dynamic issue in the estimation. This aspect was not ignored by the pioneering works mentioned in the theoretical framework such as those of Kenen and Yudin (1965), Heller (1966) or Clark (1970). On the contrary, there the emphasis has been precisely in the discussion of the underlying stochastic process for reserves, the dynamic of which in the final instance determined the “optimum” level for this variable.

As to the economic interpretation of this behavior, it has been seen how many countries embarking on asset accumulation processes do so on a continuous basis for relatively prolonged periods. It has also been mentioned that in the more advanced stages of development there is considerable stability in the volume of reserves in relation to GDP, for example. In both cases, awareness of the past history of the dependent variable provides valuable information on current behavior. This means that the degree of inertia should not be omitted in the specification of all reserve demand. To evaluate the existence or not of this phenomenon, neglected by the empirical studies carried out to date, inclusion is made of the lagged dependent variable as a regressor.

6.2. Econometric methodology

The paper makes two relevant contributions in relation to the empirical study of the determinants of the demand for reserves. The first is the dynamic specification of the equation, and the second, the econometric methodology used in the estimation.

Papers on reserves with panel data have been based almost exclusively on estimates of static models with fixed effects by Ordinary Least Squares (OLS) or Generalized Least Squares (GLS), when a correction is made for autocorrelation and/or heteroscedasticity.

Nevertheless, by ignoring the inertia that potentially characterizes reserve demand, the equations of the previous research are incorrectly specified, and as a result, the corresponding estimates show problems of bias and inconsistency. An adequate specification is provided by the following model:

$$(10) \quad y_{i,t} = \gamma_{i,t-1} + x'_{i,t}\beta + \eta_i + \varepsilon_{i,t}$$

where $x_{i,t}$ is a vector for variables that for the moment will be assumed to be exogenous (in the sense that $E(x_{i,t}, \varepsilon_{j,s}) = 0 \quad \forall i, t, j, s$), η_i captures the unobservable heterogeneity among countries and $\varepsilon_{i,t}$ is a random error without autocorrelation and heteroscedasticity ($E(\varepsilon_{i,t}, \varepsilon_{j,s}) = 0 \quad i \neq j \text{ or } t \neq s$) and uncorrelated with the specific individual effect ($E(\eta_i, \varepsilon_{j,s}) = 0 \quad \forall i, j, s$).

However, inclusion of the lagged dependent variable on the right side of the equation to capture the dynamic and correct the specification error raises a question regarding the appropriate econometric technique for estimation. As noted by Bond (2002), addition of the

dynamic is crucial, even when the coefficient of lagged dependent variable is not the main focus of interest, as it makes it possible to obtain consistent estimates of the remaining regressors.

One alternative is to estimate a model of dynamic fixed effects by *OLS (DFE)*. However, the inclusion of $y_{i,t-1}$ causes biased and inconsistent estimators even with errors that are in principle not auto-correlated.⁸⁹ Nickell (1981) shows that even when there are no exogenous regressors, the DFE underestimates the impact of $y_{i,t-1}$ if $\gamma > 0$ and that the bias tends towards zero if $T \rightarrow \infty$. This result was applied by Kiviet (1995) in cases where there are also exogenous explanatory variables.⁹⁰

In addition, Hsiao (1986) notes that estimating equation (10) by *OLS* ignoring the unobservable heterogeneity would give the γ coefficient an upward bias, given the correlation that exists between the lagged dependent variable and the specific effect η_i . As a result, a consistent estimation of γ should be situated between the *DFE* and the *pooled OLS*.

Anderson and Hsiao (1981) was the first study that provided an estimator to resolve these difficulties through an instrumental variables procedure. The idea was to remove the fixed effect differentiating equation (10) to obtain:

$$(11) \quad (y_{i,t} - y_{i,t-1}) = \gamma(y_{i,t-1} - y_{i,t-2}) + (x_{i,t} - x_{i,t-1})' \beta + (\varepsilon_{i,t} - \varepsilon_{i,t-1})$$

As in this equation in differences the errors $(\varepsilon_{i,t} - \varepsilon_{i,t-1})$ are correlated by construction with the variable $(y_{i,t-1} - y_{i,t-2})$, those authors proposed using as instruments either $y_{i,t-2}$ or $(y_{i,t-2} - y_{i,t-3})$, alternatively. Arellano (1989) demonstrates that the use of the lagged difference results in an estimator with a very high variance. Subsequently, Arellano and Bond (1991) and Kiviet (1995) confirmed the superiority of $y_{i,t-2}$ as an instrument.

Nevertheless, the Anderson-Hsiao (AH) estimator is a special case in the family of estimators within the generalized method of moments (*GMM*). Other members of this family, such as that proposed by Arellano and Bond (1991), are superior for at least two reasons. On the one hand, they gain efficiency by exploiting restrictions of additional moments and using as instruments all the available lags of the regressors. On the other, they enable control of the endogeneity of variables other than the lagged dependent.

The estimator developed by Arellano and Bond (1991), known as the “difference GMM” (*Dif. GMM*), instruments the equation (11) with all the available lags for the levels of the

⁸⁹ This happens because by making the transformation within, $(y_{i,t-1} - \bar{y}_i)$ it is linearly related to $(\varepsilon_{it} - \bar{\varepsilon}_i)$, as by construction $y_{i,t-1}$ and $\bar{\varepsilon}_i$ are correlated. The estimator of fixed dynamic effects is inconsistent when $N \rightarrow \infty$ (where N is the cross-section dimension) and T (the number of periods) is fixed (Hsiao, 1986). It is only consistent if $T \rightarrow \infty$ (Baltagi, 1995).

⁹⁰ That paper also provides an equation for the bias of the complete vector of coefficients for the dynamic fixed effects model.

endogenous variables (as from $t - 2$ for $y_{i,t-1}$).⁹¹ This estimator, which is consistent for $N \rightarrow \infty$ and fixed T , allows two variants: one-step and two-step.

Two-step *Dif. GMM* improves on one-step because it possesses greater asymptotic efficiency, but its standard errors in small samples have a strong downward bias (Arellano and Bond, 1991). Windmeijer (2005) resolved this difficulty by developing a correction for the variance matrix in finite samples.

Because of these virtues, two-step *Dif. GMM* would appear to be the appropriate econometric methodology to study the determinants of the demand for reserves. Nevertheless, one problem still remains. When the dependent variable presents a high level of persistence, lagged levels are weak instruments of the first subsequent differences (showing a very low correlation with the endogenous variable). As a result, estimated coefficients could show a strong bias in finite samples because of the problem of weak instruments (Blundell and Bond, 1998).

To resolve this problem, Arellano and Bover (1995) and Blundell and Bond (1998) propose the estimator known as *System GMM*. The strategy followed by those authors consists in adding to the equation (instrumented with levels) a regression in levels (instrumented with the lagged differences for the corresponding variables). The basic idea is to exploit additional moment conditions that arise from the assumption that the specific effect is not correlated with the first lag of the difference in the dependent variable.⁹² When this is combined with the rest of the assumptions of the Arellano and Bond methodology (1991),⁹³ moment conditions arise that establish that the error term is not correlated with the difference of the explanatory variable lagged by one period, and therefore it is allowed to instrument an equation in levels.

The strength of the *System GMM* is based on taking advantage of an optimum linear combination between the *GMM* estimators of the equations in levels and differences. In this linear combination with variable weightings, the weight of the estimator in levels rises as long as $\gamma \rightarrow 1$, that is to say, as long as the problem of weak instrumentation becomes more important because of high persistence.⁹⁴

The techniques presented so far have not been the only strategies implemented to confront the problem of bias induced by the dynamic specification of the equation (10). Kiviet (1995) highlights the fact that although estimators based on *GMM* are consistent they tend to present high variance. On the other hand, the *DFE* is more efficient, although biased. In his work, Kiviet finds an expression for this bias and uses it to correct the *DFE* estimates, thus taking advantage of its greater efficiency. This procedure is known as *Dynamic Fixed Effects Corrected (DFEC)*. However, this methodology considers that the remaining regressors are exogenous.

⁹¹ The levels of the explanatory exogenous variables (both contemporary and lagged) are also used as instruments.

⁹² It can be demonstrated that this condition is satisfied under mean stationarity of the $y_{i,t}$ process (Blundell et al., 2000).

⁹³ Ahn and Schmidt (1995) demonstrated that the base assumptions of Arellano and Bond (1991) imply $T - 1$ restrictions of non linear moments that could potentially result in efficiency gains.

⁹⁴ This weighting grows as the variance of the unobservable heterogeneity grows in relation to the variance in the error term.

As has been pointed out, appropriate study of reserve demand requires a satisfactory and simultaneous solution to the problems imposed by its dynamic specification, the potential endogeneity of the regressors and its characteristic strong inertial component. In view of all this, the *System GMM* estimator is the most appropriate econometric methodology.

6.3. Results

There follows a sequential series of estimates beginning with a static specification and ending with a dynamic model estimated by *System GMM*. This sequence evidences the limitations of previous empirical works and the consequences that they have on the interpretation of the determinants of reserve demand.

Table 16 presents a static fixed effects model estimated by *OLS* (*within* transformation). Very similar regressions (in terms of significant variables and values of the corresponding coefficients) constitute the empirical core of more recent literature on the demand for international reserves.

Table 16. Static OLS estimation with fixed effects⁹⁵

Dependent Variable: Log. Reserves to GDP			
Explanatory variables	Coefficient	Standard error	P value
<i>GDP PPP per inhabitant</i>	0.0064392 ***	0.0020826	0.002
<i>GDP PPP per inhabitant ^ 2</i>	-0.0000166 ***	4.43E-06	0.000
<i>Imports / GDP</i>	0.5270873 ***	0.0664021	0.000
<i>Capital inflows / GDP</i>	0.0085130	0.0185583	0.646
<i>Volatility of Exports</i>	0.0462896 **	0.0182322	0.011
<i>Volatility of Capital Inflows</i>	-0.0683953 ***	0.0200440	0.001
<i>Opportunity cost</i>	-0.3216272 ***	0.0833705	0.000
<i>Regional imitation</i>	0.0031897 ***	0.0009093	0.000
<i>Pure float</i>	0.0648807	0.0550261	0.238
<i>Managed float</i>	-0.1387258 ***	0.0492013	0.005
<i>Crawling Peg</i>	-0.0332071	0.0532703	0.533
<i>Indeterminate exchange rate regime</i>	-0.4313096 ***	0.1285942	0.001
<i>Dummy Displacement 1990</i>	0.1704095 ***	0.0425443	0.000
<i>Dummy Displacement 1998</i>	0.1377914 ***	0.0466449	0.003
<i>Constant</i>	-2.035131 ***	0.2743489	0.000
Number of countries			139
Number of observations			2646
R ²			0.296
F Test (P value)			0.000

Note: *significant at 10%, **significant at 5%, ***significant at 1%

In principle, several of the expected signs would be confirmed for this new broader sample in both number of countries and number of years. In addition, the model would have a high explanatory capacity (R² totals 0.78 when the fixed effects are included). Nevertheless, as

⁹⁵ The variables for reserves to GDP, imports over GDP, financial openness, export volatility, financial openness volatility and opportunity cost are expressed in logarithms.

was noted in the methodological section, all these interpretations lack the necessary econometric support for two reasons: i) they ignore the dynamic, which provokes bias and inconsistency; and ii) they ignore the endogeneity of various of the regressors, which also causes inconsistency.

The next step was to modify the specification including the lagged dependent variable. Estimating the pooled OLS model, an autoregressive coefficient value of 0.8989 is obtained which, as has been pointed out, has an upward bias. When the model of fixed effects by OLS is calculated, the inertial coefficient, which has a downward bias, is 0.7601. Both estimates lead to the inference that the value of the coefficient calculated consistently should be situated between these limits.

One alternative is to estimate a model of dynamic fixed effects corrected for bias as proposed by Kiviet (1995).⁹⁶ Implementing this methodology, which as in the case of the previous ones also does not control by endogeneity, shows how the introduction of the dynamic “absorbs” the significance of other explanatory variables. It can therefore be deduced that inertia should not be omitted from the analysis.

Table 17. Estimate of dynamic fixed effects corrected for bias

Dependent Variable: Log. Reserves to GDP			
Explanatory variables	Coefficient	Standard error	P value
<i>Inertia (Reserves-GDP in t-1)</i>	0.8304086 ***	0.0223638	0.000
<i>GDP PPP per inhabitant</i>	0.0009350	0.0020753	0.652
<i>GDP PPP per inhabitant ^ 2</i>	-3.49e-06	4.17e-06	0.403
<i>Imports / GDP</i>	0.0436693	0.0539556	0.418
<i>Capital inflows / GDP</i>	0.0335939 **	0.0150123	0.025
<i>Volatility of Exports</i>	-0.0039469	0.0138601	-0.28
<i>Volatility of Capital Inflows</i>	-0.0088826	0.0160733	0.581
<i>Opportunity cost</i>	-0.0674186	0.0650216	0.300
<i>Regional imitation</i>	0.0041529 ***	0.0006776	0.000
<i>Pure float</i>	0.0503772	0.0395364	0.203
<i>Managed float</i>	0.0738806 **	0.0355597	0.038
<i>Crawling Peg</i>	0.0136130	0.0381041	0.721
<i>Indeterminate exchange rate regime</i>	0.0638411	0.1021953	0.532
<i>Dummy Displacement 1990</i>	0.0843338 **	0.0331894	0.011
<i>Dummy Displacement 1998</i>	0.0087109	0.0383472	0.820
Number of countries			139
Number of observations			2638

Note: *significant at 10%, **significant at 5%, ***significant at 1%

In this new specification, the lagged dependent variable becomes significant at 1%, while the rest of the variables lose explanatory power in relation to the results on Table 16. In addition, the value of the autoregressive coefficient is very high (being situated between the bands provided by the pooled OLS and the static fixed effects models, as could be expected),

⁹⁶ Bias induced by omission of the dynamic in the static specification should not be confused with bias from estimating by OLS the fixed effects model that includes the lag for the variable dependent. See previous methodological discussion.

indicating that in principle, the inertial component of the accumulation decision is of crucial importance.

Moreover, the calculations shown on Table 17 evidence the type of omission in previous studies on reserve demand, and are an indication that the results of such studies should be evaluated with caution. For example, this comment is valid in the case of the estimates by García (1999), Aizenman and Marion (2003, 2004), Aizenman and Lee (2004) and Soto et al. (2004), which rely exclusively on the static fixed effects models. If the lagged variable dependent is omitted (and if it is persistent), then it is possible that other series that are also persistent could erroneously capture the dynamic effect, and thus the coefficients could be biased.

However, the previous methodology does not adequately deal with the potential endogeneity of the other regressors different from the lagged dependent variable. For this reason, Table 18 shows the estimates consistent with the *Dif. GMM* methodology developed by Arellano and Bond (1991), which does take this aspect into account. Two-step estimates were used as they are more efficient. To eliminate the problem of downward bias in finite samples in the estimate of standard asymptotic errors, the correction proposed by Windmeijer (2005) has been used.

Table 18. Estimate of Dif. GMM (two-step estimation)

Dependent Variable: Log. Reserves to GDP			
Explanatory variables	Coefficient	Standard error	P value
<i>Inertia (Reserves-GDP in t-1)</i>	0.5895869 ***	0.0550884	0.000
<i>GDP PPP per inhabitant</i>	-0.0098288	0.0099876	0.327
<i>GDP PPP per inhabitant ^ 2</i>	4.51e-06	0.0000167	0.788
<i>Imports / GDP</i>	0.2283528	0.1677821	0.176
<i>Capital inflows / GDP</i>	0.0440503	0.0270239	0.105
<i>Volatility of Exports</i>	-0.0343942 **	0.0166820	0.041
<i>Volatility of Capital Inflows</i>	-0.0158001	0.0251338	0.531
<i>Opportunity cost</i>	-0.1433024 **	0.0673646	0.035
<i>Regional imitation</i>	0.0038641 ***	0.0007902	0.000
<i>Pure float</i>	0.0343588	0.0322533	0.289
<i>Managed float</i>	0.0484225	0.0337872	0.154
<i>Crawling Peg</i>	-0.0044458	0.0295389	0.881
<i>Indeterminate exchange rate regime</i>	0.2156254	0.2009608	0.285
<i>Dummy Displacement 1990</i>	0.0842409 *	0.0455636	0.067
<i>Dummy Displacement 1998</i>	-0.0432136	0.0384614	0.263
Number of countries			138
Number of observations			2469
Number of instruments			231
Hansen Test (P Value)			1.000
First order autocorrelation Test (P Value)			0.000
Second order auto-correlation Test (P Value)			0.930

Note: *significant at 10%, **significant at 5%, ***significant at 1%

Endogenous variables: Inertia, GDP PPP per Inhabitant, Square of GDP PPP per Inhabitant, Imports over GDP, Financial openness, Export volatility, Financial openness volatility, Regional imitation.

In first place, it should be determined whether the theoretical assumptions of the methodology are satisfied. To do so, the Hansen test is used to examine the moment condition under the null hypothesis that they are valid (that is to say, that the instruments used are not correlated with the error term). The result in this case is that the validity of the instruments cannot be rejected. The two remaining tests refer to the autocorrelation pattern. It is expected that because of their construction, errors will have serial correlation of the first order but not the second, so as not to violate the moment condition. In this particular case, as can be seen on Table 18, the null hypothesis of no first order autocorrelation is rejected, while the null hypothesis of no second order serial correlation cannot be rejected.

Once these requirements have been confirmed, it should be possible to analyze the results. Nevertheless, what is happening with the instrumentation must still be considered. As was mentioned previously, a consistently-estimated model should generate a coefficient for inertia within the bands provided by the fixed effects model and the pooled OLS, that is to say, between 0.7601 and 0.8989. Therefore, a coefficient of 0.5756 in the calculation of *Dif. GMM* (well below the estimate of uncorrected fixed effects) is a very strong sign of weak instruments (Bond *et al.*, 2001). As noted by Alonso-Borrego and Arellano (1999) and

Blundell *et al.* (2000) among others, when the series are very persistent and the number of temporal observations is relatively low, it can be seen that the *GMM* estimator in differences has a very significant bias in finite samples.

In view of the problems created by the inclusion of the dynamic, endogeneity and the high persistence in the dependent variable, the *System GMM*⁹⁷ methodology has been implemented, having proved to be a satisfactory tool for their simultaneous solution.

Table 19. Estimate of System GMM (two-step estimation)

Dependent Variable: Log. Reserves to GDP			
Explanatory variables	Coefficient	Standard error	P value
<i>Inertia (Reserves-GDP in t-1)</i>	0.8529464 ***	0.0256205	0.000
<i>GDP PPP per inhabitant</i>	0.0016251 *	0.0009036	0.074
<i>GDP PPP per inhabitant ^ 2</i>	-5.98e-06 **	2.76e-06	0.032
<i>Imports / GDP</i>	0.0829643 *	0.0491948	0.094
<i>Capital inflows / GDP</i>	.0428755 *	.0219807	0.053
<i>Volatility of Exports</i>	-0.0226167	0.018692	0.228
<i>Volatility of Capital Inflows</i>	-0.0123594	0.0227256	0.587
<i>Opportunity cost</i>	-0.0422273	0.0641736	0.512
<i>Regional imitation</i>	0.0041718 ***	0.0008114	0.000
<i>Pure float</i>	0.0001283	0.0299053	0.997
<i>Managed float</i>	0.0243429	0.0312476	0.437
<i>Crawling Peg</i>	-0.0054370	0.0281226	0.847
<i>Indeterminate exchange rate regime</i>	0.0750048	0.1309026	0.568
<i>Dummy Displacement 1990</i>	0.0711959 **	0.0285057	0.014
<i>Dummy Displacement 1998</i>	-0.0142478	0.0275846	0.606
<i>Constant</i>	-0.4902925 ***	0.1621275	0.003
Number of countries	139		
Number of observations	2638		
Number of instruments	462		
Hansen Test (P Value)	1.000		
First order autocorrelation Test (P Value)	0.000		
Second order auto-correlation Test (P Value)	0.807		

Note: *significant at 10%, **significant at 5%, ***significant at 1%

Endogenous variables: Inertia, GDP PPP per Inhabitant, Square of GDP PPP per Inhabitant, Imports over GDP, Financial openness, Export volatility, Financial openness volatility, Regional imitation.

As in the previous case, the results of the Hansen test and the autocorrelation test for residuals do not invalidate assumptions, so that it is possible to thoroughly analyze the results.

⁹⁷ Once again, this involves two-step estimates calculating the robust correction of the standard errors by Windmeijer (2005).

6.4. Discussion of results

The first point to be noted has to do with the inertial coefficient. This variable is significant at 1% and the value of the coefficient is between the bands mentioned in the estimate by pooled OLS and by fixed effects, which is at least an indication of consistency. Moreover, the 0.842 value for this coefficient is very close to that determined by the method of corrected fixed effects of Kiviet (1995). This finding confirms the suspicion of the weak instrumentation in the *GMM* in differences.

The economic interpretation is that accumulation (and disaccumulation) decisions are not erratic processes that change abruptly from one year to the next. Reserves are a stock, and as such are subject to the inertia for which this type of variable is noted. Adjustments towards desired levels take place slowly, with a trend for the predominance of past behaviors. In addition, it should be considered that although the mentioned coefficient marks the importance of inertia, it gives no reason for it. Nevertheless, as can be determined from the first three sections of this study, a large part of such behavior is explained by the deliberate (non-exogenous) decision by a relatively large number of central banks to adopt an aggressive accumulation strategy.

Placed in the context of the remaining conclusions, the inertia coefficient supports a view that is not exclusively centered on the classic micro-determinants of accumulation.

This proposition is further reinforced when analyzing the results obtained for two other variables that are also not considered within standard determinants: regional imitation and the quadratic adjustment to the level of development, which possess the expected signs. Regional imitation is significant at 1%. The quadratic term for GDP per inhabitant is significant at 5%, and the linear one is significant at 10%. It is thus confirmed that once controlled by other relevant factors, the greater ratios of reserves to product belong to those countries in an intermediate state of development. This means that the “U”-shaped relationship introduced in the third section is corroborated.

Specifically in relation to regional imitation, it is possible to conjecture that its positive effect is partially explained by a strategic game in which no neighbor wishes to lose ground in reserve accumulation because of the benefits it provides.

As mentioned in the first part of the document, this strategic behavior could have two interpretations. In first place, the theory of the “battle for reserves” (Turner and Moreno, 2004) would suggest that a country should not possess fewer reserves (in relative terms) than its neighbors, as its credit rating and capital inflows could be negatively impacted. Alternatively, from the “derived demand” approach, it could be argued that the accumulation of reserves is the result of tempering exchange rate appreciation *vis a vis* the other members of the region.

Therefore, the first conclusion of the econometric section is that it is past decisions themselves, and the decision to imitate neighbors, that determine the volume of reserves to be held, in the context of the economic growth stage being experienced by each country.

Two other variables significant at 10% are the degrees of trade and financial openness, both of which with positive signs as could be expected on the basis of the theory analyzed. This is

a sign that precautionary behaviors tend to be more important as external exposure becomes more pronounced.

Nevertheless, results for the volatility of both commercial and financial flows are not statistically significant, indicating that, together with the foregoing, the explanatory factor to be considered could be exposure to shocks and not their specific magnitude. The reasoning thus would be that open countries seek self-insurance knowing that by being exposed to external risk they are very vulnerable, despite the fact that in the past the size of the shocks they have faced may not have been very significant.

Here the positive and statistically significant coefficient for the shift dummy variable in the nineties also points in the same direction, as it will be recalled that at that time there was a structural break in the financial openness in the countries of America, Europe and Asia. Perhaps this variable is reflecting in part the effect of the greater volatility of external shocks.

On the other hand, the coefficient for the shift variable subsequent to the crisis in Asia is not statistically significant. Possibly there is no additional precautionary lesson to be learnt from the Asian crises, the relevant lesson being to be prepared in the event of financial openness.

Another two determinants that are not significant are opportunity cost and exchange rate regimes. The first of these results has already been documented in various earlier empirical studies, and is confirmed when applying a robust methodology on a dynamic specification.

There are two possible explanations. The first is based on the mentioned measurement problems for the opportunity costs. The second is that the benefits of prudent behavior would have a greater weight on the decision to accumulate than strictly financial costs. In fact, in the research by Soto *et al.* (2004), for example, a negative statistically significant coefficient is determined for this variable in some of its estimates, as in the case of the static specification in Table 16. The robust estimators of the *System GMM* indicate absence of statistical relationship, which is at least not contrary to the theoretical intuition.

In the case of the result for exchange rate regimes, it should be mentioned that it is included within the paradox explained in the theory framework, and is no more than confirmation of its validity, despite having been enunciated over twenty years ago: exchange rate arrangements do not have an impact on the dynamic of reserve assets. For this reason, the increased exchange rate flexibility towards which the emerging world has evolved appears to complement accumulation. Indeed, if both policies were to be substitutes, a significant negative sign should be found for the most flexible categories.

Once again, the finding shows that while the accumulation of reserves cannot in theory be entirely divorced from the exchange rate regime, it should not be related on a linear basis to it. It also suggests that it is possible to adopt effective policies for increasing (or reducing) reserves under alternative regimes. This explains, for example, how it is possible for emerging countries with such dissimilar exchange rate and monetary policies (and that are so variable over time) such as China, Korea, Brazil, Russia or Argentina, should have simultaneously increased their stocks of such assets.

7. Conclusions

The aim of this paper is to provide a comprehensive response to the question as to what determines a country's reserve levels. In particular, it attempts to explain why the accumulation of reserves accelerated in the last fifteen years, led by the emerging countries.

To this end, a sequential analytical approach is adopted from different complementary angles. In first place, a study is made of the links between accumulation of reserves and global liquidity production. In second place, various theoretical models are detailed on the reasons for reserve demand. Next, a comparative analysis is provided of the international experience, in search of key events. In fourth place, the details of the Argentine reserve accumulation case are presented. In the fifth section the problem of defining the appropriate volume of such assets is dealt with, calculating adequate indicators for a group of emerging countries. Lastly, an econometric model is presented for the determinants of reserves, on the basis of a panel of 30 countries and 30 years.

From the discussion on the global monetary regime, it emerges that the manner in which liquidity is generated and injected on a worldwide scale cannot be ignored when analyzing the demand for reserves. In effect, demand has been far more active in times of global imbalances, where the injection of liquidity has been much more pronounced than, for example, in certain specific moments of the Bretton Woods regime. Events such as the "dollar scarcity", flows of gold from the United States to Europe, or the creation of sophisticated mechanisms such as the SDRs, made it clear that it was not easy to create international means of payment. Discussion has also taken place on how at present global liquidity is linked to the action of a central player with a large deficit on the international scene.

Another conclusion reached in this first part concerns the paradox that arises when contrasting the global exchange rate regime and the reserve accumulation dynamics. The collapse of Bretton Woods meant a switch from the fixed dollar standard to that of a floating dollar, at the same time as a rising trend for the adoption of more flexible exchange rate systems began to be seen. Nevertheless, the demand for reserves, far from declining, increased. This indicates that there are other factors that could be even more important than flexibility in explaining the behavior of central banks. These factors are both increased financial and commercial integration, which raised interdependence and limited the potential for isolation in the face of external crises.

Although the entire floating dollar standard is analyzed in detail, after 1998 a special scenario emerged characterized by imbalances. There are authors who predict a disorderly and abrupt adjustment in the short term, while others consider that existing imbalances will be maintained and adjusted gradually. Experience since 1973 indicates that every time there is an adjustment in exchange rate parities between countries leading the monetary system, there could be strong negative repercussions in developing economies.

A disorderly adjustment to global imbalances would generate a decline in long-term growth prospects because of increased protectionist pressures, reductions in trade and less willingness to finance productive investment in emerging economies. Therefore, the scenarios that have been discussed in the global context seem to produce strong incentives

to maintain precautionary accumulation in developing countries.⁹⁸ The most debatable matter could concern not so much the level of reserves but their optimum composition.

Domestic demand for reserves was analyzed from the microeconomic perspective of the countries, investigating the development of theoretical explanations intended to rationalize the changes occurred in the dynamics of individual accumulation. .

Theory always underlined a fundamental reason for holding such assets: their precautionary role as a mechanism to soften the impact of external shocks. Nevertheless, over time the principal source of external disturbances has shifted: from trade openness (current account) to problems with financing, sudden stops and the volatility of credit flows (capital account).

Specifically, numerous models discuss the role of reserves as a self-insurance mechanism in the face of a crisis. This characteristic has gained strength with the mass opening up of emerging countries to capital flows in the nineties and the proliferation of crises during this stage. The possibility was also analyzed that the demand for reserves could be “derived” from the way the exchange rate and monetary systems functioned.

Having reviewed the theory, it has been concluded that so far a unifying or consensus model has not been developed, with each study being circumscribed to one particular aspect. Therefore, interaction between the portion of reality expressed by each model for national demand and global variables has developed various of the determinants to explain, in the empirical model, the reasons for the dynamics observed in reserves.

Comparative evaluation of the development of reserves in the last 30 years, grouping countries alternatively according to their access to financial markets, region and level of development, results in significant findings.

First, the accumulation phenomenon is widespread, covering almost all the regions of the world, although heterogeneous as to magnitude. Classifying countries according to whether they are advanced, emerging or developing, it can be seen that during 1998-2003 emerging countries doubled the annual rate of accumulation of other groups. This process has been led by East and South Asia, with annual average growth of approximately 24%. Latin America, on the other hand, has grown far more slowly, at only an annual 4.5%. The low propensity to accumulate reserves by this latter region compared with Asia is a pattern that persisted during the last three decades. At the other extreme, Europe and North America have recorded very low growth for the entire period. An analysis is also made of reserves scaled by imports, GDP and M2. There is a notably high ratio of reserves to M2 in Latin America, clearly explicable by its historically low level of monetization.

Regarding the behavior of systematic accumulators, a series of key events have been detected that deserve specific treatment in future studies. It has been established that episodes of high accumulation can take place under any type of exchange rate or monetary regime, although floating regimes account for the majority. On the other hand, once the process of systematic accumulation has begun, it is unlikely that there will be any change in the exchange rate and monetary conditions at the outset.

⁹⁸ There is a paradox here: the same accumulation of reserves carried out to soften the impact of future adjustments contributes to the financing of current imbalances.

One complementary finding is related to the strategy for sterilization of the issue of money that tends to accompany processes of sustained growth in external assets held by central banks. In particular, it has been possible to establish that the neutralization in monetary terms of increases in reserves is the general rule, although the intensity with which this policy is applied is fairly variable. When the degree of sterilization is grouped by type of experience it can be seen that there is no difference between accumulators in terms of their exchange rate and monetary regimes, with the possible exception of those that operate full-fledged inflation targets, a group noted for its high rates of sterilization, and those with weak anchors, where the exact opposite is the case.

As far as Argentina is concerned, its long-term behavior did not differ from that of the region to which it belongs. Between 1948 and 1972 reserves declined, while during the floating dollar stage, they rose at a rate similar to that for Latin America, although showing high volatility. When reserves are linked to other macroeconomic variables through a correlation analysis for the 1973-2004 period, it can be seen that they maintained a positive association with the level of GDP and a negative one with the current account, inflation (level and volatility) and the RER (level and volatility). As regards recent accumulation policy, it is clear that the passive monetary policy of the currency board period has been abandoned, and that the need arose for the sterilization of excess liquidity derived from the reserve accumulation strategy by means of various mechanisms.

Calculation of adequacy indicators once again confirms the regional discrepancy pattern. According to these practical criteria, Asia would be situated above its adequacy level, while Latin America is below it.

Study of the global dynamics of reserve accumulation, discussion on theory and comparative analysis of international experience performed in the first three sections, gave rise to a series of hypotheses, the empirical validity of which was evaluated with robust econometric tools.

Notable methodological progress has been made in relation to the current state of research into the matter. The econometric section shows that ignoring the inertia characteristic of reserve demand generates bias and inconsistency. The methodology eventually proposed (*System GMM*) jointly resolves the problems of dynamic model specification, regressor endogeneity and weak instrumentation in high persistence contexts. Its application significantly changes the panorama of results known to date. Specifically, many conventional determinants lose significance at the same time as new explanatory variables become relevant.

One very significant result is that an inverted U-shaped relationship has been determined between the reserves-GDP ratio and the level of economic development. Often, less advanced countries are closed from both a trade and financial point of view, and therefore do not need to allocate such a large portion of their resources for insurance purposes. Furthermore, in those countries, the benefit from the alternative use of this resource would also be high in comparative terms, thus leading to the assumption that the demand for reserves will also tend to be low. At the other extreme, OECD economies tend to be more open, possess access to financial markets, and are not affected by “fear of floating.” This enables them to make use of a mix of borrowing and exchange rate flexibility in the event of adverse disturbances, without the need for an explicit precautionary buffer. Emerging countries, on the other hand, are asymmetrically integrated to goods markets, and in a

segmented manner to capital markets. The shocks they experience are generally large, and often they are unable to rely exclusively on exchange rate flexibility and external financing. Therefore, higher levels of reserves than in the past offer an alternative solution in the face of the risks of growing external openness.

Inertial behavior, imitation of policies of neighbors, levels of both trade and capital flows are all relevant in explaining the accumulation of reserves. On the other hand, the exchange rate regime adopted by each country, the opportunity cost of reserves, the volatility of both trade and financial flows are not statistically significant variables.

Consideration of the inertial aspect is a very important improvement, as is consideration of the phenomenon of regional imitation. The significance of the former variable constitutes a strong sign that the processes of accumulation and disaccumulation are not erratic. Behind the demand for reserves there is a stock variable that as such does not alter abruptly, indicating that adjustments to the desired level in the long term take place over prolonged periods, rather than instantly. In addition, those adopting deliberate accumulation policies in general do so over several years, at a rate that changes slowly. The regional imitation variable indicates that attention is also paid to how neighbors act when establishing the volume of external assets that should be held in the central bank. There would therefore be typical behavior of strategic games in the case of economic policy on reserves.

The statistically significant determinants that demonstrate the importance of openness are imports, capital inflows -in both cases in relation to GDP- and the shift dummy variable as from 1990, because of a significant interruption in financial openness.

Reserve accumulation does not appear to be determined by the manner in which each particular exchange rate regime operates. Indeed, it has been determined that the variables classifying *de facto* arrangements are not statistically different from zero. This corroborates the paradox of a world that advances towards greater exchange rate flexibility while at the same time accumulating reserves. Countries may possibly be unable (or unwilling) to confront all the exchange rate volatility necessary to smooth the shocks that external openness brings with it.

It should be noted that on the matter of insurance in the face of disturbances, the role of the government is irreplaceable because of the economies of scale and externalities that exist from creating a pool, instead of leaving coverage decisions to the judgment of each individual agent. This is valid even when there is potentially a moral hazard problem.

It is true that self-insurance through reserve accumulation could be considered a second-best solution, even when the dilemma of composition is ignored. It would be better to participate in a global system that could form a pool to exploit all the potential for risk diversification. Nevertheless, multilateral institutions, particularly the IMF, seem unable in recent years to assume the role of manager of such a pool. Uncertainty regarding their role as lenders of last resort could have generated doubts as to the advantage of such an option. Indeed, if the evolution of the overall ratio of IMF quotas to reserves is considered, the preference by countries for self-insurance is evident. Between 1993 and 2004, total international reserves grew by more than 200% and the mentioned ratio dropped from 17% to 8%. As a possible intermediate alternative, the idea for regional reserve funds has still not reached a sufficient level of maturity.

The importance of self-insurance makes it possible to understand the lack of relevance of opportunity cost as a determinant of reserve accumulation. Possibly, as some recent theoretical models have suggested, the relevant opportunity cost for countries would be the expected size of the crises. This cost is not independent of the existence of reserves itself, as has been pointed out in the literature. In effect, higher reserve levels tend to be associated with lower levels of country risk and better credit ratings, all things being equal.

One hypothesis to be tested in future studies is whether the high levels of reserves recorded by some countries are explained by the desire to grant greater credibility to the monetary supply. Financial liberalization favored portfolio dollarization and facilitated the substitution of currencies. It is possible that part of the volume of reserves in some countries could be justified by the need to ensure the credibility of the currency, over and above any explicit exchange rate commitment. To a certain extent, holding a high level of reserves returns us in part to the role that these assets performed under the gold standard: to back monetary aggregates, not just external trade. In a context of high capital mobility and potential for currency substitution, for there to be a demand for money, some governments had to demonstrate high levels of backing by external assets.

To summarize the lessons learnt from the analysis on country behavior, it can be concluded that:

- The context of high volatility implicit for emerging economies in financial and commercial integration;
- The non null probability of sudden changes in the international economy to correct current imbalances;
- The lack of reliable global financial architecture with a lender of last resort;
- The relevance of the effects of competitive imitation in accumulation in the various regions; and
- The increased importance of reserve accumulation during intermediate development stages

are key elements in understanding why emerging countries have speeded up their reserve accumulation rate.

Lastly, the lack of relevance of exchange rate regimes in explaining the dynamics of reserves indicates that complementarity (rather than substitution) between reserve accumulation and greater exchange rate flexibility appears to be the appropriate policy combination to reduce external risk and long-term volatility in emerging economies.

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Appendix

A.1. List of countries according to classification

A.1.1. Classification by markets

Developed Countries

Germany, Australia, Austria, Belgium, Canada, Denmark, Spain, United States, Finland, France, Greece, Netherlands, Ireland, Iceland, Italy, Japan, Luxembourg, Norway, New Zealand, Portugal, United Kingdom, Sweden, Switzerland.

Emerging Countries:

Algeria, Argentina, Bolivia, Brazil, Bulgaria, Czechoslovakia, Chile, China, Colombia, Korea, Ivory Coast, Costa Rica, Croatia, Philippines, Hungary, India, Indonesia, Jordan, Malaysia, Morocco, Mexico, Nigeria, Panama, Peru, Poland, Czech Republic, Slovakian Republic, Russia, South Africa, Thailand, Tunisia, Turkey, Uruguay, Venezuela.

Others:

Afghanistan, Albania, Angola, Antigua and Barbuda, Netherlands Antilles, Saudi Arabia, Armenia, Aruba, Azerbaijan, Bahamas, Bahrain, Bangladesh, Barbados, Belize, Benin, Bhutan, Botswana, Burkina Faso, Burundi, Cambodia, Cameroon, Chad, China, R.P.:Hong Kong, China, R.P.:Macao, Cyprus, Comoros, Djibouti, Dominica, Ecuador, Egypt, El Salvador, Arab Emirates, Slovenia, Estonia, Ethiopia, Fiji, Gabon, Gambia, Georgia, Ghana, Grenada, Guatemala, Guinea Equatorial, Guinea-Bissau, Guyana, Haiti, Honduras, Iran, Iraq, Solomon Islands, Israel, Jamaica, Kazakhstan, Kenya, Kuwait, Laos, Latvia, Lesotho, Lebanon, Liberia, Lithuania, Libya, Macedonia, Madagascar, Malawi, Maldives, Mali, Malta, Mauricio, Mauritania, Micronesia, Moldavia, Mongolia, Myanmar, Namibia, Nepal, Nicaragua, Niger, Oman, Pakistan, Papua New Guinea, Paraguay, Qatar, Central African Republic, Republic of Congo, Democratic Republic of Congo, Dominican republic, Romania, Rwanda, Samoa, San Marino, St. Vincent and Grenadines, St. Lucia, Sao. Tomé and Príncipe, Senegal, Seychelles, Sierra Leone, Singapore, Syria, Somalia, Sri Lanka, St. Kitts and Nevis, Sudan, Surinam, Swaziland, Taiwan Prov. of China, Tanzania, Togo, Tonga, Trinidad and Tobago, Ukraine, Uganda, Vanuatu, Yemen, Zambia, Zimbabwe.

A.1.2. Classification by income level

Low income:

Afghanistan. Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Cameroon, Chad, Comoros, Ivory Coast, Ethiopia, Gambia, Ghana, Guinea Equatorial, Guinea-Bissau, Haiti, India, Solomon Islands, Kenya, Laos, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Moldavia, Mongolia, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Papua New Guinea, Central African Republic, Republic of Congo, Democratic Republic of

Congo, Rwanda, Sao Tomé and Príncipe, Senegal, Sierra Leona, Somalia, Sudan, Tanzania, Togo, Uganda, Yemen, Zambia, Zimbabwe.

Middle low income:

Albania, Algeria, Armenia, Azerbaijan, Bolivia, Brazil, Bulgaria, Colombia, Djibouti, Ecuador, Egypt, El Salvador, Fiji, Georgia, Guatemala, Guyana, Honduras, Iran, Iraq, Jamaica, Jordan, Kazakhstan, Macedonia, Maldives, Morocco, Micronesia, Namibia, Paraguay, Peru, Dominican Republic, Romania, Russia, Samoa, Syria, Sri Lanka, South Africa, Suriname, Swaziland, Thailand, Tonga, Tunisia, Turkey, Ukraine.

Middle high income:

Malaysia, Croatia, Czech Republic, Hungary, Poland, Slovakia, Argentina, Chile, Costa Rica, Mexico, Panama, Uruguay, Venezuela, Estonia, Lithuania, Antigua and Barbuda, Barbados, Belize, Dominica, Grenada, St. Kitts and Nevis, St. Lucia, St. Vincent and the Grenadines, Trinidad and Tobago, Lebanon, Libya, Oman, Saudi Arabia, Botswana, Gabon, Mauritius, Seychelles.

High income non OECD:

Netherlands Antilles, Aruba, Bahamas, Bahrain, China, R.P.:Hong Kong, China, R.P.:Macao, Cyprus, United Arab Emirates, Slovenia, Israel, Kuwait, Malta, Qatar, San Marino, Singapore, Taiwan, Prov. of China.

High income OECD:

Germany, Australia, Austria, Belgium, Canada, Korea, Denmark, Spain, United States, Finland, France, Greece, Holland, Ireland, Iceland, Italy, Japan, Luxembourg, Norway, New Zealand, Portugal, United Kingdom, Sweden, Switzerland.

A.1.3. Classification by regions

East Asia and Pacific:

Australia, Cambodia, China, China, R.P.:Hong Kong, China, R.P.:Macao, Korea, Fiji, Philippines, Indonesia, Solomon Islands, Japan, Laos, Malaysia, Micronesia, Mongolia, New Zealand, Papua New Guinea, Samoa, Singapore, Thailand, Taiwan, Prov. de China, Tonga.

South Asia:

India, Afghanistan, Bangladesh, Bhutan, Nepal, Pakistan, Maldives, Sri Lanka.

Europe and Central Asia :

Albania, Germany, Armenia, Azerbaijan, Austria, Belgium, Bulgaria, Cyprus, Croatia, Denmark, Slovenia, Spain, Estonia, Finland, France, Georgia, Greece, Holland, Hungary, Ireland, Iceland, Italy, Kazakhstan, Lithuania, Luxembourg, Macedonia, Moldavia, Norway, Poland, Portugal, United Kingdom, Czech Republic, Slovakia, Romania, Russia, San Marino, Sweden, Switzerland, Turkey, Ukraine.

Latin America and Caribbean:

Antigua and Barbuda, Netherlands Antilles, Argentina, Aruba, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominica, Ecuador, El Salvador, Grenada,

Guatemala, Guyana, Haiti, Honduras, Jamaica, México, Nicaragua, Panama, Paraguay, Peru, Dominican Republic, St. Vincent and the Grenadines, St. Lucia, St. Kitts and Nevis, Surinam, Trinidad and Tobago, Uruguay, Venezuela.

North America:

United States, Canada.

Middle East and North Africa:

Saudi Arabia, Algeria, Bahrain, Djibouti, Egypt, United Arab Emirates, Iran, Iraq, Israel, Jordan, Kuwait, Lebanon, Libya, Malta, Morocco, Oman, Qatar, Syria, Tunisia, Yemen.

Sub-Saharan Africa:

Angola, Benin, Botswana, Burkina Faso, Burundi, Cameroon, Chad, Comoros, Ivory Coast, Ethiopia, Gabon, Gambia, Ghana, Equatorial Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauricio, Mauritania, Namibia, Niger, Nigeria, Central African Republic, Republic of Congo, Democratic Republic of Congo, Rwanda, Sao Tomé and Príncipe, Senegal, Seychelles, Sierra Leona, Somalia, South Africa, Sudan, Swaziland, Tanzania, Togo, Uganda, Zambia, Zimbabwe.

A.2. Complementary analysis of international experience

Table A.1. Ranking by contribution to world growth in reserves between periods

Position	1973-1980	1980-1990	1990-1998	1998-2003
1	France (8.51)	Taiwan* (14.40)	Japan (18.39)	Japan (34.20)
2	Germany (7.76)	United States (11.43)	China (14.26)	China (19.75)
3	Saudi Arabia (7.44)	Japan (10.65)	Hong Kong** (7.77)	Taiwan* (8.81)
4	Italy (7.44)	Spain (7.88)	Singapore (5.64)	Korea (7.88)
5	United Kingdom (5.70)	Italy (7.83)	Korea (4.44)	India (5.48)
6	Japan (5.19)	China (5.48)	Brazil (4.19)	Russia (5.03)
7	United States (5.05)	Singapore (4.22)	India (3.07)	Hong Kong** (2.04)
8	Libya (4.18)	Germany (3.32)	Poland (2.73)	Mexico (2.03)
9	Switzerland (4.17)	Australia (2.95)	Mexico (2.61)	Algeria (2.01)
10	Nigeria (3.63)	Sweden (2.92)	Austria (2.57)	Denmark (1.65)

*Province of China

**Special Administrative Region

Source: Prepared on basis of IMF (IFS) data

Table A.2. Average value of reserves scaled by group of countries

Group	Reserves-Trade flows		Reserves-Financial flows	
	1973-1998	1998-2002	1973-1997	1998-2003
Markets				
Developed	0.10	0.09	0.33	0.17
Emerging	0.16	0.25	0.86	1.47
Others	0.18	0.21	0.95	0.90
Income Level				
Low	0.15	0.25	0.99	1.94
Lower Middle	0.15	0.29	1.01	1.37
Upper Middle	0.22	0.18	0.87	1.18
High Non OECD	0.17	0.26	0.91	1.80
High OECD	0.10	0.09	0.33	0.18
Regions				
East Asia & Pacific	0.13	0.31	0.62	1.32
South Asia	0.11	0.07	0.41	0.12
Europe and Central Asia	0.20	0.20	0.70	0.73
Latin America & Caribbean	0.19	0.25	0.93	1.05
North America	0.05	0.04	0.17	0.08
Middle East & North Africa	0.17	0.27	1.38	2.41
Sub-Saharan Africa	0.09	0.17	0.68	0.82

Source: Prepared on basis of IMF (IFS) and World Bank (WDI) data

A.3. Sensitivity analysis of reserve adequacy indicators

Table A.3. Upper (20% of M2) and lower (5% of M2) limits of the adequacy indicators in selected emerging countries 2004

Country	Level observed	Financial criterion		Commercial and financial criteria	
		Upper Band	Lower band	Upper Band	Lower band
Argentina	19.600	35.378	30.294	44.069	38.985
Brazil	45.500	35.846	24.337	63.519	52.010
Chile	15.700	8.203	7.001	18.256	17.054
Mexico	63.000	51.475	39.419	120.823	108.767
Venezuela	23.400	10.820	8.630	17.282	15.092
China	600.800	355.934	161.208	562.439	367.714
Korea	200.100	76.556	60.614	158.412	142.470
Malaysia	64.000	18.046	12.461	56.839	51.254
Thailand	44.600	24.425	15.556	56.216	47.347
Indonesia	36.000	36.860	27.515	60.422	51.077
India	138.000	51.376	23.194	94.171	65.989
Russia	120.800	41.633	29.008	84.615	71.990
South Africa	14.500	22.334	12.634	41.895	30.194

Source: Prepared on the basis of data from the IMF(IFS), World Bank (WDI), JPMorgan, Goldman Sachs and Economist Intelligence Unit (EIU)

A.4. List of “systematic accumulation” experiences

Albania (1994-2001), Algeria (2000-2004), Argentina (1991-1993), Argentina (1996-1998), Armenia (1993-1998), Azerbaijan (1994-1997), Azerbaijan (1999-2001), Bahrain (1999-2001), Bangladesh (1991-1994), Bangladesh (2002-2004), Brazil (1992-1996), Bulgaria (2000-2004), Cambodia (1994-2002), Canada (1998-2001), China,P.R.: Mainland (1994-1997), China,P.R.: Mainland (2000-2004), China,P.R.: Hong Kong (1991-1993), China,P.R.:Macao (1991-1995), China,P.R.:Macao (1999-2001), Korea (1992-1995), Korea (1998-2004), Croatia (1993-1998), Croatia (2000-2003), Denmark (1995-1997), Denmark (2001-2003), Egypt (1991-1993), El Salvador (1992-1999), United Arab Emirates (1998-2001), Slovenia (1992-1998), Slovenia (2000-2003), Estonia (2002-2004), Hungary (1991-1993), Hungary (1998-2000), India (1991-1994), India (1997-2004), Indonesia (1998-2000), Iceland (2002-2004), Israel (1995-1998), Japan (1993-1996), Japan (1999-2004), Kazakhstan (1994-1997), Kazakhstan (2000-2004), Kuwait (1998-2001), Latvia (1996-1999), Lebanon (1991-1996), Liberia (1993-1995), Liberia (2001-2004), Lithuania (1993-1995), Lithuania (2000-2003), Macedonia, FYR (1997-1999), Malaysia (1991-1993), Morocco (2001-2004), Mexico (1995-1998), Moldova (1993-1997), Mongolia (1993-1995), Mongolia (1999-2002), Peru (1991-1996), Poland (1994-1998), Qatar (1997-1999), Qatar (2001-2004), Czech Republic (2000-2002), Slovakia (2002-2004), Romania (1991-1994), Romania (2000-

2004), Russia (2000-2004), San Marino (2002-2004), Singapore (1991-1995), Thailand (1991-1993), Taiwan, Prov.of China (2001-2003), Trinidad and Tobago (1996-2001), Turkey (1995-1997), Ukraine (1994-1997), Ukraine (1999-2004), Uruguay (1992-1995).

A.5. Analysis of experiences of systematic accumulation and policies of sterilization

A.5.1. India

During 2002-2005 India's international reserves have grown significantly. In March 2002 they totaled US\$54.1 billion, gradually rising to US\$141.5 billion in the same month of 2005.

The recent increase in external assets has been exclusively explained by the capital account surplus, with a notable role being played by foreign direct investment, which in 2004-2005 totaled US\$5.8 billion. The current account has been negative in the last two years.

The exchange rate has remained relatively stable in the period analyzed, with a slight tendency to appreciate. Whereas in December 2002 the exchange rate was 48 rupees per dollar, in December 2005 the rate was 45 rupees.

There are two mechanisms whereby the Reserve Bank of India implements its active liquidity management policy through open market transactions known as LAF (*Liquidity Adjustment Facility*) and MSS (*Market Stabilization Scheme*). By means of the first mechanism introduced in June 2000, the Central Bank of India controls liquidity and exercises its influence on short-term interest rates in a manner consistent with its monetary policy objectives. According to the Reserve Bank of India (2005), the terms of these instruments are short, and transmission seeks mainly to act via signals. Nevertheless, given the major capital inflows that India was experiencing, the system was modified at the end of March 2004. As from that time the importance of the second instrument, the MSS, began to grow. The feature of these instruments are their longer term (from 90 days to two years) and in relative terms their use now exceeds that of the LAF.

Total liquidity absorbed by MSS and LAF in October 2005 amounted to approximately US\$18 billion. As a result, the ratio of reserves to stocks of sterilization instruments was 7.8 (Reserve Bank of India, 2006).

Lastly, liquidity in the banking sector is controlled by means of the direct channel of the cash-deposits ratio (Reserve Bank of India, 2006).

A.5.2. Korea

In the period between 2002 and 2005, the international reserves of the Central Bank of Korea rose from US\$121 billion to US\$210 billion.

The origin of this growth lies in the twin surpluses of external accounts, with a greater relative weight in the case of the current account. The latter reached US\$16.6 billion at the end of 2005. Although the capital account remains in surplus, it has been showing a declining trend. In the exchange rate market, the won/US\$ rate has shown an inclination to appreciate. Whereas at the beginning of 2002 it stood at 11300 won per dollar, at the beginning of 2006 the rate was 970 won per US\$1.

The sterilization system used by the Central Bank of Korea relies heavily on adjustments to liquidity by means of open-market transactions using Monetary Stabilization Bonds (MSB) and Repos. These bonds offer 11 alternative maturities from 14 days to two years. The total stock of this instrument was US\$137 billion at the end of 2004 and US\$4158 billion the following year. As a result, the ratio between stock of reserves and stock of bills in 2005 was 1.33. In that year interest payments on MSBs totaled US\$6.1 billion (Bank of Korea, 2006).

Repos are used in this case to regulate short-term liquidity over periods of no more than 90 days and an average maturity of 15 days.

Lastly, as a result of the gradual opening up of financial markets in Korea during the nineties, the use of minimum liquidity requirements has gradually declined (Bank of Korea, 2003; Terada-Hagiwara, 2005).

A.5.3. China

Between 2002 and 2005 China's international reserves rose strongly, from US\$286.4 billion to US\$818.9 billion.

This growth is backed by the significant current account and capital account surpluses, although the latter has shown certain signs of weakening.

In managing its monetary policy, the People's Bank of China monitors various indicators such as the exchange rate, changes in reserves, fiscal accounts, monetary circulation and bank liquidity. On the basis of these indicators, it pursues an aggressive sterilization policy for purchases of reserves, attempting to maintain domestic interest rates at low levels. It implements this policy mainly through open market operations, with a broad range of financial instruments with different maturities.

Towards the end of 2005, the stock of notes issued by the Bank of China totaled US\$ 255.6 billion, which translates into a reserves-bills ratio of 3.2. Repos represented another important sterilization tool, with a volume in 2005 of US\$91.3 billion. Taking transactions with notes and repos together, the net shrinking of the monetary base in 2005 was US\$171 billion, more than twice the amount for the previous year (People's Bank of China, 2005).

The sterilization task carried out by means of these open market operations is complemented by the action of credit directing policies on the financial system that adopt different reserve ratio requirements according to the purpose of the loans, affecting bank liquidity.

A.5.4. Russia

Russia's international reserves increased almost fourfold between 2002 and 2005, rising from US\$ 47.8 billion to US\$182.2 billion.

This increase is explained almost entirely by the strong current account surplus (during the period its balance rose from US\$30 billion to US\$92.5 billion) as a result of the high prices of energy product exports. In contrast, the capital account has systematically recorded negative balances (in the order of US\$11.2 billion in 2002 and US\$34.8 billion in 2005) The nominal exchange rate appreciated by 4.5% during the same period.

This large increase in reserves generates the need to be able to count on instruments to keep the monetary expansion under control. A key role in this task is played by the Stabilization Fund of the Russian Federation made up of resources derived from the extraordinary gains from the production and export of oil, gas and other energy products (Bank of Russia, 2005a). By the end of February 2006 this fund totaled US\$ 52 billion, equivalent to 27% of the stock of reserves held by the Bank of Russia (Bank of Russia, 2005b).

Although in the most favorable scenarios the Stabilization Fund is inadequate to absorb the volume of money supply generated by the purchase of reserves, it lowers the pressure faced by conventional sterilization policy.

The principal instruments of the latter are the Bank of Russia Bonds (for terms of between 3 and 6 months). To discourage inflows of short-term capital, which increases the need for sterilization, the Bank does not agree to yields on these instruments that are higher than the interest rates in force on international markets (Bank of Russia, 2005b).

The accumulation of government funds in accounts at the Central Bank, including the Stabilization Fund, plays a very important role in control of the short-term money supply.

Complementing the action of these instruments, the Bank of Russia includes the possibility of implementing drastic measures in relation to minimum bank liquidity requirements as an additional sterilization action (Bank of Russia, 2005b).

A.6. Construction of variables and data sources

This part of the Appendix indicates how the variables used in the third and sixth section were constructed, and the sources of data.

Total reserves:

Use was made of the Total Reserves series “.1..SZF” from the *International Financial Statistics* (IFS).⁹⁹ This includes the sum of the holdings of foreign currency, SDRs and gold (valued at 35 SDRs per ounce) and the position at the IMF. For its expression in dollars, the SDR rate at the end of each period was used (series “111..SA.ZF”).

The series for reserves in real terms was obtained by considering as deflator the US export price index (base 2000=100) (series “111.74..DZF”).

Scaled reserves analysis:

To scale Total Reserves the following series obtained from the *World Development Indicators* 2005 (WDI) CD-ROM were used.¹⁰⁰

- GDP: Gross domestic product in current dollars (“NY.GDP.MKTP.CD” series).
- Imports: Imports of goods and services in current dollars (“NE.IMP.GNFS.CD” series).

⁹⁹ IFS figures are those published in the CD-ROM for July 2005.

¹⁰⁰ Except for the variable that measures capital flows, for which the source of data is the IFS.

- M2: The “FM.LBL.MQMY.CN” series stated in local currency was used, and then converted into current dollars using the average exchange rate for each year (“PA.NUS.FCRF” series).
- Trade flows: Imports and exports of goods and services in current dollars were totaled (“NE.EXP.GNFS.CD” series).
- Capital flows: Formed by the sum of the absolute values of capital inflows (lines “.78BEDZF” –foreign direct investment–; “.78BGDZF” –portfolio investment–; “.78BIDZF” –other investment–), capital outflows (lines “.78BDDZF” –direct investment abroad–; “.78BFDZF” –portfolio investment –; “.78BHDZF” –other investment–) and errors and omissions (line “.78CADZF”). The IFS is the source of these figures.

Econometric analysis:

For the econometric analysis the dependent variable selected was reserves scaled by GDP. The explanatory variables introduced in the model were:

- GDP PPP per inhabitant: use was made of the GDP PPP per capita at constant prices for 2000 (the WDI’s “NY.GDP.PCAP.PP.KD” series).
- Imports over GDP: this ratio was constructed using the WDI series already referred to.
- Financial openness: This variable derives from the quotient for capital inflows and GDP. The numerator was constructed adding the absolute value for the three items reported by the IFS: foreign direct investment (“.78BGDZF” line) and other investments (“.78BIDZF” line). Countries and years including with data for the three items was considered.
- Volatility of exports: the above-mentioned export series was used. The volatility of year t was constructed taking the coefficient of variation for the exports of 3 years: t , $t-1$ and $t-2$ (“rolling window” calculation).
- Volatility of capital inflows: capital inflow volatility (numerator of the financial openness variable) was calculated the same way as its equivalent for exports.
- Opportunity cost: the annual yield on 10-year US Treasury Bonds was taken. Source is the IFS (“111.61...ZF” series).
- Regional imitation: this variable calculates the quotient between the number of countries in a region that increased their reserves during the previous year and the total number of countries making up the corresponding geographical region.
- Exchange rate regime dummies: the exchange rate regime for each country was classified each year following the methodology of Coudert and Dubert (2005). The regression included the binary variables corresponding to the systems of pure float, managed float, crawling peg and indeterminate, the omitted category being the exchange rate peg system. A more detailed explanation can be found in the following section of the Appendix.
- *Shift dummies variables*: the 1990 shift binary variable takes the value 1 from 1990 to 2003. That corresponding to 1998 takes the value of 1 from that year and through to the end of the sample.

A.7. Methodology for the classification of exchange rate regimes

In this paper the methodology proposed by Coudert and Dubert (2005) has been followed to identify the de facto exchange rate regime that the countries in the sample adopted in each year.

The classification process consists of three steps and is based on analysis of the behavior of two variables: the nominal exchange rate in relation to the dollar (NER) and reserves. In the first step, the annual NER level trend is estimated (on the basis of monthly data), to differentiate crawling pegs from fixed pegs. The second step is aimed at differentiating rigid systems (crawling peg and fixed exchange rates) from flexible (pure and managed floats) by means of a test comparing the variance in the monthly change in the NER for each country vis a vis that of a benchmark of currencies that are considered to float. Lastly, within the flexible system, a separation is made between pure and managed floats. To do so, a test is performed comparing for each country the variance in the monthly change in reserves in relation to the benchmark.

The methodology classifies exchange rate systems into four categories:

- Pure float: high variance in NER and low volatility in reserves.
- Managed float: high volatility in both NER and reserves.
- *Crawling peg*: annual positive trend for the NER higher than a given threshold α and low NER volatility.
- Peg: Null annual trend or lower than the given NER threshold α and low volatility of such variable.

Each of these steps is detailed below.

Step 1: Determination of the annual NER trend

For each country and year, the following regression for the monthly NER data is run:

$$(A.1) \quad \ln e_t = \alpha + \gamma t + \varepsilon_t$$

where e_t is the monthly NER against the dollar, t is the time trend ($t = 1, 2, \dots, 12$) and ε_t is the error term. The annual trend of year j is designated β_j and is obtained on the basis of the following expression:

$$(A.2) \quad \hat{\beta}_j = (1 + \hat{\gamma})^{12} - 1$$

where $\hat{\gamma}$ is the OLS estimator of coefficient γ .

If $\hat{\beta}_j$ is positive, then the series in logarithms of the monthly NER for year j is stripped of its trend ($\ln \tilde{e}_t$). If it is negative, its absolute value is matched to an arbitrary threshold (α). Following Coudert and Dubert (2005) this threshold is set at an annual 2%.

Step 2: Comparison of the variance of changed in NER to the benchmark

Three currencies make up the floatation benchmark: the yen, the pound sterling and the deutschemark.¹⁰¹ For each of these currencies the variance in the monthly change in NER is calculated. The average of these variances constitutes the annual variance of the NER of the benchmark (s_B^2).

Next, for each country i the same volatility measure (s_i^2) is calculated. If the NER shows a positive trend during the year, it is calculated on the variation in the series without trend ($\ln \tilde{e}_t$).

Lastly, variances are compared by means of a Fisher test. To do so, it is assumed that the annual variances are distributed normally with a theoretical σ_i^2 variance for country i and σ_B^2 for the benchmark. As a result, the quotient

$$(A.3) \quad \frac{s_B^2 / \sigma_B^2}{s_i^2 / \sigma_i^2}$$

follows a distribution F with n_B degrees of freedom in the numerator and n_i in the denominator. As in this case work is performed with monthly data, the degrees of freedom are 35 and 11 respectively.

The test performed has a null hypothesis that for each year the variance in the change in NER for country i is lower than that of the benchmark. That is to say:

$$(A.4) \quad H_0 : \sigma_i^2 < \sigma_B^2$$

Then, if it is determined that

$$(A.5) \quad s_i^2 < \left(\frac{1}{2.54} \right) s_B^2$$

the null hypothesis at 5% of significance is not rejected¹⁰² and it is considered that the variance of country i is low. On the other hand, if

$$(A.6) \quad s_i^2 \geq \left(\frac{1}{2.54} \right) s_B^2$$

the variance of i is considered high.

¹⁰¹ As from 1999 the mark is replaced by the euro in the benchmark.

¹⁰² The critical value at 5% of significance of a distribution $F(35,11)$ is 2.54.

Step 3. Comparison of the variance of the changes in reserves with the benchmark

Here, the same test as in step 2 is applied, this time to the variance in the change in reserves. The annual variance in the benchmark (calculated as the average of the annual variances for each of its components) is designated as $\tilde{S}_B^2$, and that of country i as $\tilde{S}_i^2$.

Repeating the assumption that the monthly changes in the stock of reserves follow a normal distribution, another F test is performed. In this case the null hypothesis for a given year that the annual variance in the change of reserves for country i ($\tilde{\sigma}_i^2$) is greater than that of the benchmark ($\tilde{\sigma}_B^2$) is contrasted:

$$(A.7) \quad H_0 : \tilde{\sigma}_i^2 > \tilde{\sigma}_B^2$$

Under H_0 , the ratio

$$(A.8) \quad \frac{\tilde{S}_i^2 / \tilde{\sigma}_i^2}{\tilde{S}_B^2 / \tilde{\sigma}_B^2}$$

has a distribution $F(35,11)$.

If it is found that

$$(A.9) \quad \tilde{S}_i^2 > 2.54 \tilde{S}_B^2$$

the null hypothesis at 5% of significance is not rejected and it is considered that the variance in country i is high. On the other hand, if

$$(A.10) \quad \tilde{S}_i^2 \leq 2.54 \tilde{S}_B^2$$

the variance of i is considered low.

Once these steps have been concluded, the exchange rate systems are classified according to the results obtained for the estimate of the trend, and for the two variance tests.

Table A.4. Final scheme for the classification of exchange rate regimes

Annual trend	Variance in change in NER	Variance in change in reserves	Exchange rate regime
$\hat{\beta} \geq 0$	High	Low	Pure float
$\hat{\beta} \geq 0$	High	High	Managed float
$\hat{\beta} \geq 0$ y $\hat{\beta} \leq x$	Low	–	Peg
$\hat{\beta} \geq 0$ y $\hat{\beta} > x$	Low	–	Crawling Peg
$\hat{\beta} < 0$ y $ \hat{\beta} > x$	–	Low	Pure float
$\hat{\beta} < 0$ y $ \hat{\beta} > x$	–	High	Managed float
$\hat{\beta} < 0$ y $ \hat{\beta} \leq x$	Low	–	Peg
$\hat{\beta} < 0$ y $ \hat{\beta} \leq x$	Low	Low	Pure float
$\hat{\beta} < 0$ y $ \hat{\beta} \leq x$	High	High	Managed float

The series used have been obtained from the IFS (IMF) and their codes are “1L.DZF” (reserves) and “AE.ZF” (NER).