NBER WORKING PAPER SERIES

FINANCIAL STABILITY, THE TRILEMMA, AND INTERNATIONAL RESERVES

Maurice Obstfeld
Jay C. Shambaugh
Alan M. Taylor

Working Paper 14217
http://www.nber.org/papers/w14217

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
August 2008

Financial support from the Fondation Banque de France through a grant administered by the CEPR is gratefully acknowledged. We also thank Sara Friesen and Seema Sangita for excellent research assistance. We thank Sebastian Edwards for providing us with his data on financial openness (which update the indicator described in Edwards 2007); we thank Ross Levine for directing us to data on bank quality; and we thank Ugo Panizza for providing data on "original sin." For helpful comments we thank Sebastian Edwards, Kenneth Froot, Olivier Jeanne, Ross Levine, and Dani Rodrik; scholars in workshops at the Banque de France, Kansas, Manchester, Warwick, Brown, and UCLA; participants at the 10th Annual International Economics Conference at UC Santa Cruz, the NBER IFM Program Meeting, the Darden-State Street Emerging Markets Finance conference, the 2nd annual CEGE conference at UC Davis, the 2008 IEA World Congress in Istanbul; and especially discussants Michael Devereux, Kathryn Dominguez, and Sebnem Kalemli-Ozcan. All errors are ours. The views expressed herein are those of the author(s) and do not necessarily reflect the views of the National Bureau of Economic Research.

Financial Stability, the Trilemma, and International Reserves
Maurice Obstfeld, Jay C. Shambaugh, and Alan M. Taylor
NBER Working Paper No. 14217
August 2008
JEL No. E44,E58,F21,F31,F36,F41,N10,O24

ABSTRACT

The rapid growth of international reserves---a development concentrated in the emerging markets---remains a puzzle. In this paper we suggest that a model based on financial stability and financial openness goes far toward explaining reserve holdings in the modern era of globalized capital markets. The size of domestic financial liabilities that could potentially be converted into foreign currency (M2), financial openness, the ability to access foreign currency through debt markets, and exchange rate policy are all significant predictors of reserve stocks. Our empirical financial-stability model seems to outperform both traditional models and recent explanations based on external short-term debt.

Maurice Obstfeld
Department of Economics
University of California, Berkeley
549 Evans Hall #3880
Berkeley, CA 94720-3880
and NBER
obstfeld@econ.berkeley.edu

Jay C. Shambaugh
Department of Economics
Dartmouth College
6106 Rockefeller Hall
Hanover, NH 03755
and NBER
jay.c.shambaugh@dartmouth.edu

Alan M. Taylor
Department of Economics
University of California, Davis
One Shields Avenue
Davis, CA 95616
and NBER
amtaylor@ucdavis.edu

1 Introduction

Over the past decade, the international reserves held by monetary authorities have risen to very high levels relative to national outputs. More rapid reserve accumulation, primarily attributable to relatively poor countries, is thought to have affected the global patterns of exchange rates, of capital flows, and of real interest rates. Foreign official purchases of dollars have also financed an unprecedented level of external borrowing by the world's biggest economy, that of the United States. The upsurge in global reserve growth confronts economists with an important puzzle. What has driven it, and is it likely to endure?

The facts to be explained can be summarized as follows. Starting from the end of the Bretton Woods era, global international reserve holdings as a fraction of world GDP grew dramatically—up by a factor of 3.5 from less than 2 percent in 1960 to 6 percent in 1999—despite the supposed global shift toward more flexible exchange rate arrangements in 1973. Since 1999, reserve accumulation has accelerated sharply. Asian and some Latin American emerging markets, Japan among the industrial countries, and oil exporters, notably Russia, have been the primary drivers of this trend. Since 1990, the average advanced country ratio of reserves to GDP has held steady at about 4 percent, but the emerging markets' average reserve ratio has more than quintupled, from 4 percent to over 20 percent of GDP.[1] These data present both a theoretical and an empirical challenge, but as yet there is little consensus and only modest success on either front. Indeed some have suggested that the current level of reserves is excessive—and hence, implicitly, beyond the explanatory powers of a rational economic framework.[2]

We argue that reserve accumulation is a key tool for managing domestic financial instability as well as exchange rates in a world of increasing financial globalization. We therefore build on the view—certainly not a new one—that a primary reason for a central bank to hold reserves is to protect the domestic banking sector, and domestic credit markets more broadly, while limiting external currency depreciation.[3] The need for such protection increases given the multiplication of risks in more financially open economies, where potential currency mismatches and a combination of internal drains (runs from bank deposits to currency) and external drains (flight to foreign currency or banks) can place extraordinary demands on a central bank's foreign exchange reserves. In the empirically prevalent scenarios of "twin" internal and external drains (Kaminsky and Reinhart 1999), reserve backing falls when the central bank attempts to ease domestic illiquidity by acting as a lender of last resort (LLR). Especially for an emerging market in which domestic bond markets are thin and large-scale of-

[1]Figures are from Flood and Marion (2002) and Jeanne (2007).

[2]See, for example, Summers (2006). Bird and Rajan (2003) and Rodrik (2006) make the second-best argument that, rather than self-insuring against domestic economic vulnerabilities by incurring the costs of holding more reserves, countries should attack the sources of the vulnerabilities directly. We return to this point below. Levy Yeyati (2006) offers a critique of standard measures of reserve holding costs.

[3]See, inter alia, Feldstein (1999) and Calvo (2006). Later in this paper we trace the argument back to the seminal work of Thornton (1802).

ficial bailouts may spark fears of public insolvency, no practical short-run means of influencing the exchange rate other than reserve sales may be available.

We first present a simple theoretical framework for understanding this mechanism. We then investigate the empirical determinants of reserve growth in a broad panel of developing, emerging, and advanced countries. We pursue a systematic empirical investigation to show that there has been a statistically robust and economically significant correlation of reserve levels (reserves/GDP) with financial openness (a measure of cross-border capital mobility), financial development (proxied by M2/GDP), and exchange rate policy (using peg indicators). The three factors are all important and they multiplicatively compound each other as a determinant of reserve/GDP ratios in our specification. This result again highlights the role of the trilemma, albeit in a different context. In previous papers we have emphasized how open capital markets and an exchange-rate target limit monetary policy autonomy measured by interest rate independence (Obstfeld, Shambaugh, and Taylor 2004, 2005). In this paper we show how the same policy environment may dictate a large war chest of reserves for LLR purposes when there is a risk of capital flight.

These findings do not necessarily deny a role to more traditional determinants of reserve holdings, such as openness to international merchandise trade. In our simple conceptual framework, these other determinants may well act as complementary factors affecting the demand for reserves, and in our empirical work we are careful to control for them. As a matter of statistical significance, some of these traditional factors appear to matter (e.g., trade) but others do not (for example, foreign debt). Of course, the channels through which traditional variables such as trade influence reserve demand can be quite "nontraditional" in a financially globalized world.

As a matter of quantitative significance, however, we show through counterfactual analysis that the key to understanding the evolution of reserves, especially in recent years, is to include measures of financial openness and financial development. With the spread of globalization and the growth of banking systems and financial markets, these variables have shifted profoundly in emerging markets since the early 1990s. By accounting for those shifts, we can much more successfully explain the changing patterns of reserve holdings. For example, we can show (using out of sample predictions) that there was no major deviation in this pattern after 1997. We can even go a long way toward explaining alleged outliers such as China. By this historical yardstick, current reserve holdings are neither inexplicable nor excessive—we find no major underprediction, at least not systematically, and not for the usual emerging-market suspects. China and most of emerging Asia hold reserves at levels close to those predicted by the model, and only in the last years of our sample (2003–04) does China start to leave a substantial fraction of reserves unexplained. Among the very big reserve holders, Japan does appear to hold more reserves than the model suggests are necessary.

2 Earlier thinking on the demand for international reserves

A long literature has, at different times, emphasized various motives for holding international reserves.

2.1 From the trade-based Bretton Woods view to sudden stops and precautionary accumulation

The modern study of optimal international reserves begins with Heller (1966), who viewed the demand for reserves by a monetary authority as reflecting optimization subject to a tradeoff between the benefits of reserves and the opportunity cost of holding them. Heller's work and the work that soon followed envisioned the benefits as relating to the level and variability of balance of payments flows, primarily imports and exports. Basically, reserves could buy time for more gradual balance of payment adjustment, so the demand for them was viewed as a positive function of both the cost of adjustment (through demand compression, devaluation, and so on) and the likelihood that such adjustment measures might become necessary at a low level of reserves. While such adjustment-based variables met with some empirical success, the proxies for reserve costs showed no robust relationship to reserve holdings, at least when countries were pooled.[4]

The collapse of the Bretton Woods regime after 1973 shifted the ground under the arguments about reserve holdings. At least in the advanced countries, a new resolution of the trilemma emerged—a move to a different "vertex" with capital mobility and floating exchange rates. But it was unclear what this move meant for reserve holdings. On the one hand, a truly floating regime needs no reserves and a liberalized financial account would minimize the need for reserve changes to absorb a given set of balance-of-payments shocks. On the other hand, governments are far from indifferent to the exchange rate's level and a liberalized financial account might in and of itself generate more balance-of-payments instability, possibly augmenting reserve needs.

As if to support an array of confounding theoretical arguments, global international reserves did not decline noticeably relative to output after the shift to floating exchange rates. The exigencies of the 1980s debt crisis did lead to a decline in the growth rate of developing-country reserves during the 1980s. But the new wave of rich-to-poor capital flows starting in the 1990s led to new thinking on the role of international reserves in a financially globalized world, one in which currency crises originating in the financial account could inflict major reserve drains. An important study in this vein is that of Flood and Marion (2002). They showed that a parsimonious but successful specification

[4]See Williamson's (1973) magisterial survey of the literature up to the close of the Bretton Woods system. More recent surveys include Wijnholds and Kapteyn (2001) and Bahmani-Oskooee and Brown (2002). Because proxies for reserve costs have generally performed so poorly in pooled samples, we do not include them in our empirical analysis below; one notable exception, however, was Edwards (1985) who used long-term sovereign spreads rather than short-term money market spreads.

based on earlier work by Frenkel and Jovanovic (1981) remained robust, and they reinterpreted the balance-of-payments variability regressor central to that specification in terms of the "shadow floating exchange rate" concept from the theoretical crisis literature. However, their work left open the possibility that variability in reserves is a proxy for more fundamental financial variables that generate reserve (or shadow exchange rate) variability.

Perhaps the most influential view has been one based on the role of short-term external debts as drivers and predictors of emerging-market currency crises. Wijnholds and Kapteyn (2001, n. 13) recount that in December 1997, after the Korean crisis erupted, the IMF board discussed a rule of thumb for reserve adequacy incorporating short-term foreign-currency debt. It came to be known as the Guidotti-Greenspan rule after policymakers Pablo Guidotti and Alan Greenspan both explicitly proposed the idea in 1999 (see Greenspan 1999).

The proposal came at a time of mounting concern about "sudden stops" in capital inflows (Calvo and Reinhart 2000), periods when access to foreign financing can dry up. A country may be able to pay interest on external debt, but lack the wherewithal to repay a principal balance that it had expected to roll over. Guidotti suggested a rule of thumb whereby emerging markets should have sufficient reserves to cover full amortization for up to one year without access to foreign credit. The idea was supported by empirical research showing that short-term external debt appears to be a potent predictor of currency crises. It is not much of an exaggeration to say that on this view, the economy *itself* is a bank, and monetary (as opposed to credit) considerations are inessential.

Despite its recent notoriety, the Guidotti-Greenspan rule has a hallowed history going back at least a century. In the second volume of his *Treatise on Money* (1930), John Maynard Keynes discussed his view of the then-accepted principles governing the optimal level of free gold reserves. Because it is so very explicit and so clearly in line with current discussion (including consideration of financial integration), the relevant passage is worth quoting at length (Keynes 1971, pp. 247–8):

> The classical investigations directed to determining . . . the appropriate amount of a country's free reserves to meet an external drain are those which, twenty years ago, were the subject of memoranda by Sir Lionel Abrahams, the financial secretary of the India Office, who, faced with the difficult technical problems of preserving the exchange stability of the rupee, was led by hard experience to the true theoretical solution. He caused to be established the gold standard reserve, which was held separately from the currency note reserve in order that it might be at the unfettered disposal of the authorities to meet exchange emergencies. In deciding the right amount for this reserve he endeavoured to arrive at a reasoned estimate of the magnitude of the drain which India might have to meet through the sudden withdrawal of foreign funds, or through a sudden drop in the value of Indian exports (particularly jute and, secondarily, wheat) as a result of bad harvests or poor prices.

> This is the sort of calculation which every central bank ought to make. The bank of a country the exports of which are largely dependent on a small variety of crops highly variable in price and quantity—Brazil, for example—needs a larger free reserve than a country of varied trade, the aggregate volume of the exports and imports of which are fairly stable. The bank of a country doing a large international financial and banking business—Great Britain, for example—needs a larger free reserve than a country which is little concerned with such business, say Spain.

Notice that Keynes here focuses exclusively on external drains, and does not mention the causal influence of internal drain on external drain that would surely have appeared more important to him upon witnessing the global financial crisis that broke out in 1931, the year after the *Treatise*'s publication. In this respect his prescriptions mirror the Guidotti-Greenspan perspective, which likewise concentrates on external drains, largely ignoring the possible role of domestic residents' financial decisions.

In more recent writing, Aizenman and Marion (2003) suggest a precautionary demand for reserves as a cause of the rising international reserves in East Asia following the Asian crisis. Aizenman and Lee (2006) estimate an empirical panel model in which precautionary factors, represented by dummy variables marking past crises, play an important role in explaining desired reserve levels. Like us, Aizenman and Lee (2007) find that China is not an obvious outlier. However, while the authors motivate their regression tests in terms of a theoretical model of insurance against sudden stops, their econometric results actually say nothing about the mechanism through which past crises have influenced subsequent reserve holdings.

How does the Guidotti-Greenspan precautionary prescription hold up in practice? Jeanne and Rancière (2006) and Jeanne (2007) estimate optimal international reserves in a model where the latter serve the role of allowing national consumption smoothing in the face of random sudden stops.[5] Consistent with Summers' (2006) observation, they find that countries hold reserves that are excessive relative to the Guidotti-Greenspan benchmark—in some cases multiples of short-term external debt. Were it not for this predictive failure, there would perhaps be no great puzzle over "excessive" reserves.

2.2 An alternative view based on the double drain

What then has been driving reserve accumulation since the late 1990s? To resolve the puzzle we consider the concerns of a government facing simultaneous currency and banking crises, with potential foreign reserve losses that are magnified by its domestic interventions as the lender of last resort. In this context the failure of trade and debt criteria to explain reserve holdings is more understandable. Trade and debt arguments for reserve holdings emphasize that

[5] Durdu, Mendoza, and Terrones (forthcoming) likewise focus on potential sudden stops as a motivation for reserve demand.

a negative (capital outflow) balance-of-payments shock can emanate from the financial account when the *export of home assets to foreigners suddenly stops.* But we think it important to recall that similar shocks can arise when the *import of foreign assets by domestic residents suddenly starts.*[6]

Some illustrative calculations can illuminate the point. A typically "bad" trade deficit in a developing country might be, say, 5% of GDP, but if this had to be financed out of reserves in a sudden stop, the implied drain would only be about $\frac{1}{10}$% of GDP per week, a slow leak. To ratchet this drain up we might consider that an imminent crisis could lead to speculative arbitrage even on the current account side, either via "leads and lags," or even the outright hoarding of all hard-currency export receipts offshore. In that case, suppose exports and imports are, say, a not unreasonable 26% of GDP, so trade is balanced. A sudden stop (with no export receipts repatriated in the worst-case scenario) implies that a reserve drain of $\frac{1}{2}$% of GDP per week will ensue. Given current levels of emerging market reserve holdings, this faster drain would be a concern, but would not exhaust reserves very quickly.

What about the next rationale for reserves, short-term debt? If we suppose there is also a short-term debt equal to a not atypical 26% of GDP rolling over continuously, this could add a further $\frac{1}{2}$% of GDP in weekly financing needs, getting the reserve drain up to 1% of GDP a week. Conventional drains of this order of magnitude might be potentially worrying, but to rationalize current reserve holdings we think it is important to keep in mind the even more catastrophic double drains that can result from capital flight.

In the case that we focus on, domestic capital flight is financed through a drain of domestic bank deposits—so domestic financial stability is inescapably a central consideration in reserve management policy. To continue with intuition based on representative estimates, suppose M2 is 20% of GDP. If half of M2 decides to flee the country in a panic, this could happen in the space of a week or two, and hence reserves equal to 5%–10% of GDP per week might start to drain out of the country. That flow would be an order of magnitude larger than those likely to be triggered in a sudden stop by the trade or debt financing channels noted above. It is the threat of this type of drain that most worries emerging market policymakers. Absent speedy and credible help from an international lender of last resort, rapid ouflows of this type would be difficult to manage without a large war chest.

In the new era of financial globalization, these flows are not just hypothetical. A good example of this kind of dynamic is provided by the events in Argentina. We look first at 1994–95, and developments in the wake of the Mexican "Tequila Crisis." Just before the crisis started in December 1994, Argentina's central bank reserves were about 11 billion pesos, out of a total money base (M0) of 15 billion pesos (with 1 peso equal to 1 U.S. dollar). M2 was about 50 billion pesos, or 20 percent of a GDP of roughly 250 billion pesos.

[6] For example, sudden stops and current account reversals are often classified using net balance of payments flow data, but this may obscure the underlying cause of the flow. However, as Rothenberg and Warnock (2006) note, many "sudden stop" episodes would be better described as "sudden flight" events of the kind we have in mind here.

After the crisis, a sudden stop occurred in emerging markets including Argentina. For the first few weeks no great problem arose in the Argentine domestic banking sector. But in early 1995 a bank run steadily developed. During this time, demand for money base or M0 held steady at about 14 to 15 billion pesos until mid-1995. However, the demand for M2 collapsed; bank depositors took their money to Miami or Montevideo in search of a safe haven. As they rushed for dollar liquidity in February and March the central bank's reserves bled away, falling to a level of just 5 billion pesos by April 1995, meaning that about one eighth of M2 had been exchanged for central bank reserves (worth two fifths of M0) in the space of a few weeks.

If this kind of drain had continued, Argentina's existing reserves would have been quickly depleted and convertibility would have ended within weeks or even days. Yet the plan survived. Despite a 1994 statement that it would tolerate no more fiscal laxity from Argentina, the IMF (fearing global contagion) rolled out new loans as the bank run grew to critical proportions in early 1995. The new injection of dollars kept the plan afloat and was thought to have served a "catalytic" role in encouraging fresh inflows of private capital. A currency collapse was narrowly averted.[7]

What would have happened without IMF intervention in 1995? It is likely that the 1995 counterfactual, with no IMF support, would have looked something like the actual events of 2001–02, when the withdrawal of IMF support in late November 2001 (in much tougher macroeconomic and fiscal circumstances) triggered a massive bank run. Already the year 2001 had seen a steady double drain, with the country losing 11.5 billion dollars of deposits and 10.9 billion in reserves from January to November. But in the two days after the IMF withdrew its backing, the drain intensified by an order of magnitude. On the single day of November 30, 1.4 billion dollars were withdrawn from the banking system; fully ten percent or 1.7 billion dollars of reserves were lost in the space of twenty four hours.[8]

The convertibility plan died a quick death. First, the "temporary" capital controls of the *corralito* were imposed within a couple of days of the IMF's departure, and starting in January the trilemma was resolved more definitively when the peso was allowed to depreciate (it was soon hovering around 4 pesos per dollar, before steadying at 3). And along the way Argentina suffered an historic economic and political meltdown.

In our view, emerging market policymakers now have exactly this type of double drain in mind, a rapid portfolio shift by domestic depositors which threatens to overwhelm the reserves of a central bank, even one that could be mistaken for a currency board. As large fractions of M2 decided to leave Argentina, it was clear that having near-complete backing of M0 would be of little help.

Based on this line of reasoning, and much more theory and evidence to follow, we think capital flight is at least as important, and perhaps more important than sudden stops as a crisis trigger. We agree with Wijnholds and Kapteyn (2001,

[7]The Argentine experiences in 1994–95 and 2001–02 are recounted in great in detail Paul Blustein's (2005) book *And the Money Kept Rolling In (and Out)*.

[8]Figures from Levy Yeyati, Schmukler, and Van Horen (2004).

pp. 10–11), who argue that even the recent debt-based approaches to reserve demand, while considering financial globalization, have missed a vital element. We adopt this broader view of the financial stability concerns of a central bank faced with a double drain risk, and we and find that the broader view better fits the data.

Our conceptual framework therefore builds on crisis-inspired discussions of banking problems such as those of Velasco (1987), Calvo (1996, 2006), Calvo and Mendoza (1996), Sachs (1998), and Chang and Velasco (2001), in which a flight from domestic bank deposits into foreign exchange—a scenario of simultaneous internal and external drain that occurred in many of the 1990s crises—brings foreign reserves and the exchange rate under extreme pressure by putting the banking system into meltdown and activating the central bank's LLR role.[9]

Several papers have highlighted the double drain within the context of the historical gold standard. In a classic paper, Dornbusch and Frenkel (1984) employ a standard model of the money multiplier to derive a dynamic model of gold flows and reserves in a world of imperfect capital mobility. The risk of a double drain arises when the "confidence effect" is at work and higher interest rates cause a flight to cash rather than into deposits.[10] In an extension of this model, della Paolera and Taylor (2002, 2003) show that the model predicts a crisis outcome when a national bank, say, the "banking department" of a gold standard currency board or a parastatal bank, acts as a lender of last resort (loosening credit as its reserves fall in a credit crunch).

Even for present-day currency arrangements, we also emphasize that a drain which *originates* as purely an internal matter may spread to the exchange market if it sparks fears of government fiscal distress following a banking-sector rescue.[11] As Viner (1939, p. 263) puts it: "A drain ... which is distinctly of one type in its origin, may imperceptibly become a drain of another type, or may, by causing alarm, give rise to another type of drain as well." Following up on this view, we see M2, the quasi-liquid deposits of the banking system, as the variable most naturally tracking the potential pressure on reserves resulting from a flight out of domestic-currency bank deposits.[12]

This broader view of the utility of reserves also has a hallowed history—one that goes back at least to the British currency turbulence of the late eighteenth and early nineteenth centuries. Writing in his classic *Paper Credit of Great Britain* (1802) during Britain's 1797–1821 suspension of gold convertibility, Henry Thornton argued that gold reserves were necessary not only to meet fluctuations in the trade balance (external drains); they also were important

[9]More recent theoretical contributions to the "twin crisis" literature include Goldstein (2005) and Shin (2005), both of whom focus on the decisions of foreign bank creditors.

[10]For a related analysis, see Miller (1996).

[11]Miller (2000) sketches a scenario in which banking crises lead to currency crises.

[12]Keynes (1971, p. 247), again seeming to ignore the possibility of *domestic* financial instability, argues that the maximal sizes of the external shocks necessitating free foreign exchange reserves are not "likely to bear any stable relationship to the volume of money within the country, which will depend partly on the national income and partly on the national habits. They are governed, rather, by the magnitude and variability of the country's international business as traders, investors and financiers."

for positioning the Bank of England to head off or respond to internal drains without collapsing the home economy. He argued explicitly that at a time of domestic economic distress, attempts to attract gold by shrinking the Bank of England's note issue would be self defeating—gold can be accumulated only ex ante, not ex post.

Like Keynes, Thornton is worth quoting at length. After pointing out that some "interchange of gold for paper" is needed to regulate the real value of paper money, he states (Thornton 1939, pp. 111–2):

> In order to ensure that this interchange shall at all times take place, it is important that, generally speaking, a considerable fund of gold should be kept in the country, and there is in this kingdom no other depository for it but the Bank of England. This fund should be a provision not only against the common and more trifling fluctuations in the demand for coin, but also against the two following contingencies. First, it should serve to counteract the effects of an unfavourable balance of trade, for this infallibly will sometimes occur, and it is what one or more bad harvests cannot fail to cause. It is also desirable, secondly, that the reserve of gold should be sufficient to meet any extraordinary demand at home, though a demand in this quarter, if it should arise from great and sudden fright, may undoubtedly be so unreasonable and indefinite as to defy all calculation. If, moreover, alarm should ever happen at a period in which the stock of gold should have been reduced by the other great cause of its reduction, namely, that of a call having been recently made for gold to discharge an unfavourable balance of trade, the powers of any bank, however ample its general provision should have been, may easily be supposed to prove insufficient for this double purpose.

Later in *Paper Credit* Thornton spells out further his thinking on the role of reserves in supporting domestic financial markets along with the currency's foreign exchange value (Thornton 1939, p. 153):

> The more particular examination of this subject of an unfavourable exchange, brings us, therefore, to the same conclusion to which we were led in the former Chapter; namely, that the [Bank of England] ought to avoid too contracted an issue of bank notes. The absence of gold, though itself an evil, may prevent other evils of greater moment.... It should farther be remembered, that gold is an unproductive part of our capital: that the interest upon the sum exported is so much saved to the country: and that the export of gold serves, as far as it goes, to improve the exchange, by discharging the debt due on account of an unfavourable balance of trade; and to prevent the depreciation of our own paper currency, as compared with the current money payments of other countries.

Thornton's perspective affirms the close interplay between internal and external drains, and thus the interplay between domestic financial stability and currency stability.[13]

The credit-market turbulence that erupted in the summer of 2007 has vividly illustrated that in a world of deeply intertwined financial markets, the potential need for reserves to counter domestic financial instability is not limited to poorer countries. For example, a French bank operating in multiple currencies but lacking access to Federal Reserve lending facilities may well experience a need for dollar liquidity that the European Central Bank cannot directly meet by supplying euros.

If the ECB nonetheless supplies euro credit when dollars are wanted, the euros will be sold for dollars in the foreign exchange market, depressing the euro's dollar price and, contrary to the classical case of LLR support in a closed economy, incipiently raising euro-zone inflation. The ECB can avoid these pressures by purchasing the euros it has lent out with dollar reserves—in effect, carrying out a sterilized sale of dollars. But to do so readily, in the amounts that may be necessary, it may need to hold substantial dollar reserves. Recognizing such needs, the Federal Reserve's Open Market Committee, at its December 11, 2007 meeting, authorized the extension of substantial dollar credits to major foreign central banks.

This rationale for reserve holding even by developed countries is not entirely new, though it has been neglected in the recent discussion of reserve levels, perhaps because emerging-market crises have been much more frequent and salient than crises in the industrialized world. Writing more than two decades ago, Guttentag and Herring (1983, pp. 20–21) expressed concern about "banks located in countries that have adequate LLR facilities for banking activities denominated in domestic currencies but inadequate facilities for coping with foreign-currency difficulties. This category . . . may . . . include banks headquartered in countries with convertible currencies but meager foreign-exchange reserves."[14]

[13]Years later, Bagehot (1873) famously expanded on Thornton's themes. He observed, "Very large loans at very high rates are the best remedy for the worst malady of the money market when a foreign drain is added to a domestic drain. Any notion that money is not to be had, or that it may not be had at any price, only raises alarm to panic and enhances panic to madness...." Later still, Johnson (1958, p. 157) argued that a larger money supply would necessitate larger reserves, but he based his analysis on the monetary approach to the balance of payments rather than on the central bank's LLR role vis-à-vis the domestic banking system.

[14]Guttentag and Herring also note (p. 13) that "banks headquartered in countries with very large dollar reserves can attract Eurodollar deposits on more favorable terms than banks headquartered in countries with relatively small reserves . . . ." This "tiering" phenomenon, which in the 1970s was most evident in periods of international financial stress, could provide a collateral benefit to the banks of countries holding large reserves. We have seen no recent empirical work on this hypothesis, however. Fischer (1999) argues that the IMF, with the ability to provide liquidity in many currencies, can potentially act as an international LLR. Several factors, including the IMF's lack of any direct role in financial regulation and the conditionality of its loans, make its facilities an implausible substitute for national reserve holdings. Indeed the recent global reserve buildup has in part reflected reluctance to depend on the Fund, reluctance that in November 2003 led to discontinuation of the Fund's never-used Contingent Credit Lines, introduced in 1999.

2.3 Summary

Reserve adequacy should be judged relative to M2. In a simple model we illustrate why. Our empirical analysis then shows that a demand for reserves based on the size of M2 does seem to fit the data, and has greater explanatory power than the traditional factors in the long run—and even in the recent buildup, where underprediction has been the norm until now.

One paper close in spirit to ours is Lane and Burke (2001). They estimate purely cross-sectional regressions on a 1981–95 sample. They do not find financial openness to be significant in their work, though their use of time averages limits them to using as an independent variable the fraction of time a country is open. In the cross section, financial depth (measure by M2) is found to increase reserves significantly. Lane and Burke ascribe this finding to the possibility that some liabilities in the domestic financial system are denominated in foreign currency, directly generating a potential need for more reserves.[15] Our view is broader, and holds that regardless of the currency denomination of these domestic liabilities, they can add to the pressure on the reserves of a central bank that is concerned to limit currency depreciation. The Lane-Burke paper does not consider the recent surge in reserves, as its analysis ends in 1995, but it is a precursor of our paper in its examination of both financial openness and depth. Very much in line with our analysis, Rodrik (2006) argues that since emerging market countries began to embark on financial liberalization starting in the early 1990s, their reserve accumulation has been driven empirically by the size of the domestic financial sector rather than by real magnitudes such as trade flows.[16]

Our findings have important policy implications. For example, Rodrik (2006) argues that, rather than accumulating costly reserves, countries should take direct measures that would reduce vulnerability to external drains (such as a Chilean-style *encaje*, or tax on short-term capital inflows). The task of substantially reducing the domestic banking system's vulnerability is a more demanding and time-consuming one, however. In the meantime, many countries might be ill advised indeed to forgo the insurance provided by their foreign exchange reserves.

[15] Obstfeld (2004) presents a model along these lines.

[16] See figure 3 in Rodrik (2006), which shows ratios of M2 to reserves. Dominguez (2007) suggests that countries with less developed financial markets will tend to hold higher levels of reserves. In her empirical specification, financial development is proxied by the sum of portfolio debt plus equity external liabilities, measured as a share of GDP. Dominguez finds that variable to have a significant negative effect on reserve holdings. Our M2 measure of financial development, in contrast, focuses attention directly on the domestic banking system. Consistent with our interpretation, Dominguez finds that a higher level of private debt liabilities raises a country's reserve demand. Future research should seek to isolate more precisely how different aspects of a country's financial structure affect its demand for international reserves.

3 Some theoretical motivation

Empirically and in theory, a major motivation for holding international reserves is to support the overall banking system while avoiding extreme currency depreciation. Given this motivation, and a country's vulnerability to portfolio shifts by domestic residents, its demand for international reserves may go far beyond what would be needed simply to insure against a "sudden stop" in foreign capital inflows.

This section presents a simple heterogeneous-forecast model to illustrate the positive linkage between the size of the banking sector and a country's demand for international reserves. We do not purport to explicitly model every aspect of reserves demand and test it in a structural sense. Rather this section demonstrates how the banking sector can generate demand for foreign reserves if the central bank prefers some degree of exchange rate stability (as many countries do). An appendix explains implications of our crisis scenario for the central bank's balance sheet. The theory provides the basic motivation for the empirical work that follows.

There are two periods in the model, periods 0 and 1. The exchange rate e on date 1 is given by the simple formula

$$e(\theta) = \alpha\theta,$$

where θ is an indicator of the future "state" of the home economy. The exchange rate is quoted as the foreign-currency price of domestic currency, so a fall in e is a depreciation of home currency and relatively low values of θ index relatively unfavorable states. Economic actors in the home country have divergent views of the fundamental that will materialize in period 1. For a given θ—which may or may not be an unbiased forecast of the true future fundamental—domestic agent i holds the expectation that the fundamental will be $\theta + \varepsilon_i$ on date 0, where the noise ε_i is uniformly distributed over the interval $[-\overline{\varepsilon}, \overline{\varepsilon}]$ and $\theta - \overline{\varepsilon} > 0$. Domestic agents are indexed by $i \in [0, 1]$.

We assume that, in period 0, there is already a "sudden stop" situation, in that foreigners are unwilling to purchase domestic currency in the foreign exchange market at any price. For simplicity, we assume that the foreigners no longer hold domestic currency at all. As a result, the exchange rate will be determined in a market involving domestic residents and the home central bank only. We also assume that the domestic authorities can prevent domestic interest rates from fully offsetting expected exchange-rate changes, or that interest-rate increases themselves are so damaging to financial-sector stability that domestic residents discount them. As a simplified way of capturing this situation, we simply ignore the interest that could potentially be earned on currency positions. Thus, what people fundamentally care about is the future exchange rate, $e(\theta)$, compared to today's exchange rate e. If θ is very low (the crisis is expected to continue and even intensify), the currency is expected to be very weak. But among domestic residents, there will be divergent opinions about how far the currency will fall.

Domestic residents hold money as domestic bank deposits. Each agent has one deposit whose size is proportional to the broad money supply M. Deposits are perfectly liquid, in that their owners may withdraw them without notice and sell the for foreign exchange. Bank assets are illiquid however—otherwise, as loans were called in, the debtors would cause M to shrink by repaying the banks. This means that the banks can repay depositors only if they receive liquidity assistance from the domestic central bank. (The model would have the same qualitative implications if some fraction of the assets banks held against their liabilities M were liquid.)

Given the preceding assumptions, agent i wishes to trade home money for foreign exchange provided $\mathrm{E}\left\{e(\theta) \mid \theta + \varepsilon_i\right\} = \alpha\left(\theta + \varepsilon_i\right) \leq e$. In words, domestic depositors wish to buy foreign exchange if they expect the home currency to fall below its current level. For a given e, the law of large numbers implies that, the measure of traders such that

$$\alpha\left(\theta + \varepsilon_i\right) \leq e$$

or, equivalently, that $\varepsilon_i \leq \frac{e}{\alpha} - \theta$ is

$$\frac{1}{2\overline{\varepsilon}} \int_{-\overline{\varepsilon}}^{\frac{e}{\alpha}-\theta} \mathrm{d}x = \frac{1}{2\overline{\varepsilon}}\left(\overline{\varepsilon} + \frac{e}{\alpha} - \theta\right).$$

Thus, at an exchange rate of e on date 0, the demand for foreign exchange (in terms of home currency) is

$$\frac{M}{2\overline{\varepsilon}}\left(\overline{\varepsilon} + \frac{e}{\alpha} - \theta\right).$$

As the home currency depreciates in period 0, the demand for foreign currency falls.

The central bank sells R in reserves (measured in foreign currency). Then the equilibrium in the foreign exchange market is given by the equality of domestic demand and supply:

$$\frac{M}{2\overline{\varepsilon}}\left(\overline{\varepsilon} + \frac{e}{\alpha} - \theta\right) = \frac{R}{e}.$$

The equilibrium exchange rate therefore satisfies the quadratic equation

$$e^2 - \alpha\left(\theta - \overline{\varepsilon}\right)e - \frac{2\alpha\overline{\varepsilon}R}{M} = 0,$$

with (positive) solution

$$e = \frac{\alpha\left(\theta - \overline{\varepsilon}\right) + \sqrt{\alpha^2\left(\theta - \overline{\varepsilon}\right)^2 + \frac{8\alpha\overline{\varepsilon}R}{M}}}{2}.$$

This solution shows the role of both reserves and the banking system's liabilities in driving the exchange rate. As R rises the currency strengthens (e rises), and as M rises it weakens.[17]

[17] If $R = 0$, currency would have to fall in period 0 until *everybody* expected an appreciation between dates 0 and 1, making the domestic demand for foreign exchange zero. The currency would overshoot to the level $\alpha\left(\theta - \overline{\varepsilon}\right) < \alpha\theta$.

We can summarize the model's main implications easily. Suppose there is a bad realization of θ (or simply adverse beliefs about θ) and therefore pressure on the currency as people withdraw bank deposits to speculate in foreign exchange. The central bank can moderate today's depreciation using its reserves. Given the central bank's exercise of its LLR role, however, the incipient pressure on the exchange rate will be greater if the size of the banking system, measured by M, is bigger.

Because the scope of the run out of domestic-currency deposits is proportional to the domestic banking system's liabilities under the preceding specification, it is most appropriate to take the size of the broad money supply M2 as an indicator of the potential need for reserves. As we have noted, this is the theoretical approach taken by several previous authors, and as we shall see, it receives strong empirical support from our estimates of the demand for foreign exchange reserves.

4 Empirical findings

We have argued on theoretical grounds—and based on historical policymaking best practice going back more than two centuries—that financial-sector protection has always been an important motivation for reserve accumulation when a country is trying to manage its exchange rate. Our goal now is to show empirically that the same holds true today. To foreshadow our main results: we find that financial stability variables are strongly correlated with reserve holdings and that the inclusion of financial stability variables greatly improves our ability to explain the great worldwide reserve build-up of recent years. We conclude that these financial stability factors should be at center stage in any empirical analysis of reserve behavior.

To make a case for a different empirical approach, we begin by comparing our proposed new financial-stability-based model of reserve accumulation with a benchmark model of a more traditional kind. In what follows we have two main goals: first, to do better than this traditional model; and second, to do so much better that we can claim to have a credible alternative model of international reserve demand by central banks. We do not argue that elements of the traditional model, or of other models such as the "buffer stock" or "mercantilist" models, are not also important as explanatory factors (Flood and Marion 2002; Aizenman and Lee 2007). If our empirical results prove to be robust, however, it will be important to include financial-stability considerations more explicitly into future research on the demand for international reserves.

4.1 Benchmark comparison: Financial stability versus the traditional model

To begin, we estimate and compare a *traditional* model and our new *financial stability* model. To provide a benchmark traditional model we adopt a specification proposed in a recent IMF (2003) study.[18] It was the IMF's poor results using this traditional model that led Jeanne (2007) to conclude that there is no satisfactory linear regression framework that can explain current patterns of reserve accumulation.

In all of our empirical work, the dependent variable will be the (natural) logarithm of the reserves to GDP ratio. (All data are from the World Bank's World Development Indicators unless otherwise noted.) The explanatory variables in the "traditional model" are:

- the log of population;
- the log of the ratio of imports to GDP;
- exchange rate volatility (the standard deviation of the monthly percentage change in the exchange rate against the relevant base country over the *current* year, based on authors' calculations using IFS data);
- the log of real GDP per capita (converted at PPP exchange rates, in current international dollars).

Alternatively, we consider our "financial stability model," which is based on the insights discussed above. The financial stability model includes as regressors:

- the log of the ratio of M2 to GDP;
- a measure of financial openness (based on the Edwards 2007 index, scaled from 0 to 1);
- a pegged exchange rate dummy (based on the *de facto* Shambaugh 2004 coding, with annual ±2% bands);[19]
- a soft-peg exchange rate dummy (similar, but based on ±5% bands);[20]

[18]See IMF (2003), Chapter 3, Table 2.3 for details. Due to the data constraints it puts on our sample, our specification does not currently include export volatility, which is included in the IMF regression. In the IMF regression, however, the coefficient on export volatility was almost exactly zero and statistically insignificant, so we do not think that excluding this variable does any great damage to the spirit of that framework. The same section of the IMF study also experiments with some other variables in purely bivariate regressions. The specification we highlight, however, is based on the final multivariate regression specification that the IMF reports.

[19]A country is classified as pegged if its official exchange rate stays within a ±2% band with respect to its base country—the country to which it would ostensibly peg—over the course of a year; *or* if its exchange rate has no change in 11 out of 12 months and shows at most one discrete devaluation. Furthermore, to avoid "accidental" classifications, a country must stay pegged for two years to be considered pegged. See Shambaugh (2004) for extensive discussion.

[20]The soft peg classification has been created for this project by the authors. A country is considered a soft peg if its exchange rate stays within a ±5% band with respect to its base country, or if its exchange rate changes by less than 2% in every month. There are 1,050 non pegs in the sample, 844 pegs, and 777 soft pegs (with pegs and soft pegs being mutually exclusive). All but 25 of the soft pegs stay within the ±5% bands. As with the preceding peg classification, a country classified as a soft peg must satisfy one of the criteria set out above

- an advanced country dummy;[21]
- the log of the ratio of foreign trade (imports plus exports) to GDP.

The inclusion of M2 is directly motivated by the model. In addition, we note that if financial flows cannot move across borders, the likelihood of a bank run becoming a balance of payments crisis is much reduced, and thus we include the Edwards measure of financial openness. Further, as noted above, a central bank that is not concerned by exchange rate movements may simply expand domestic credit in a banking crisis and allow the exchange rate to move if necessary. Thus we include peg and soft peg exchange rate dummies.[22] In addition, a number of features (stable banking systems and the ability to borrow in one's own currency, for example) may mean that advanced economies need fewer reserves, and this is the motivation for the inclusion of an advanced country dummy, which we would expect to have a negative sign. Finally, we have included the log of trade as a control because of its robustness as an explanatory variable in other empirical studies.

We use an up-to-date and complete data set, and we use a consistent (common) sample for a fair comparison of the two specifications. Table 1 reports the results of this comparison using a simple pooled OLS specification, in which no fixed effects are allowed for the moment. As is often done in the literature, we scale reserves to GDP to make the reserves series stationary (it cannot increase or decrease indefinitely). Though not a unit root, the series is still positively autocorrelated. We thus cluster the standard errors by country to allow for heteroskedasticity across countries and, more importantly, to allow for an unstructured serial correlation in the error term within countries.[23] Also, at this point it is worth noting that our results hold in a pure cross-section (a between-groups panel estimation), so the serial correlation is in no way driving the results or generating a spurious regression. (See section 4.2 for more details). The sample consists in each case of 2,671 country-year observations. The unbalanced panel covers 26 years from 1980 to 2004 and includes 134 countries. The countries in our sample are listed in an appendix.[24]

for two years in a row to be considered a soft peg. The soft pegs are generally crawling pegs, loose basket pegs, or tightly managed floats. Of the 777 observations, 237 are declared as basket pegs, 111 pertain to loose EMS members or rates in countries that shadowed the EMS, 107 are Latin American crawling pegs, 82 are East Asian soft de facto pegs, and 114 are East European soft pegs in the last decade. In fact, these five groups make up 83 percent of the soft peg observations. We note that the Japan-U.S. dollar and Germany-U.S. dollar rates are never classified as soft pegs, which suggests that countries that allow a fair bit of flexibility are unlikely to be accidentally classified as soft pegs or pegs under our algorithm.

[21]Countries with IMF IFS codes less than 199 are classified as advanced, with the exception of Malta and Turkey.

[22]Baek and Choi (2008) examine the link between reserves and various exchange-rate regime classifications, based on the Reinhart-Rogoff data. They conclude that countries with intermediate regimes demand more reserves than countries with polar regimes, although there is no scaling of the reserves in their paper (which makes comparisons difficult and raises some potential econometric problems).

[23]See Bertrand et al. (2004) for a discussion of how clustering can properly control for serial correlation issues.

[24]We have excluded dollarized countries and multilateral currency unions (such as the CFA,

In column 1 we report results for the traditional model. Countries that import more and are richer tend to hold more reserves. In columns 2 through 4, we add to the first specification the main financial variables—relating to the fixity of the exchange rate, the openness of the financial account, and domestic financial depth. All estimates of these variables' coefficients are positive and significant, as expected. Imports remains positive and significant, but we see that including the M2/GDP ratio reduces the coefficient of the GDP per capita variable to insignificance. GDP per capita is positively correlated with financial openness and financial depth, and may simply be acting as a proxy for them when they are omitted.

In column 5 we run a horserace between the two sets of variables, replacing the import variable by a total trade (export plus imports) variable. We see that all the financial variables remain significant with the exception of the (hard) peg variable. (In particular, the soft peg variable is still positive and significant.) The result suggests that a model based on financial motives (and including trade) should be a better predictor of reserve holdings than one ignoring these factors. In column 6 we present the financial-stability based model. Dropping the insignificant traditional variables has no impact on the other variables, and a formal test that nests the two models favors our financial model against the traditional model.[25]

To conclude, we examined a "financial only" specification that drops trade (column 7). Trade is positively correlated with all the financial variables (especially pegging, because economies that are more open to trade are more likely to manage their exchange rates more closely). We show a regression that omits trade to demonstrate that the inclusion of trade only biases the results against our hypothesis. As expected, exclusion of the trade variable leads to larger and more significant estimated coefficients on all of the financial variables. In particular, we see that the coefficients on both peg variables increase substantially.

The estimated effects of pegs deserve some discussion. A country that cares more about exchange-rate stability would plausibly be more worried about its ability to cover demands for foreign funds without allowing substantial currency depreciation. While the (hard) peg variable in not statistically significant in the full model, it is qualitatively large and we cannot reject the hypothesis that it is the same as the coefficient on the soft peg variable. Thus, we do not claim that

the Eastern Caribbean Currency Union, the period during the breakup of the ruble in Former Soviet Union countries, and the Eurozone) where the allocation of reserves or M2 across countries may be ambiguous and where the need for any one country to maintain reserves is different than for countries with their own currencies. Eurozone countries are included up until 1998, after which individual member country M2 data disappear.

[25] We perform Davidson and Mackinnon (1981) tests to address this issue. We include fitted values based on the financial stability model (as in column 6) in a regression of the traditional model (as in column 1). The coefficient on these fitted values is highly statistically significant. This suggests omitting the financial variables leaves out important information. The same holds true when examining the fitted values of a regression like column 7 that includes *only* our financial variables. Alternatively, when including the fitted values from a regression like column 1 in a regression like column 6, the coefficient on the fitted values is not significantly different from zero, even at the 10 percent level. This suggests that the traditional variables add no information once the variables in our financial stability model are included.

harder pegs need fewer reserves, though we do find that the soft peg variable has a larger coefficient in nearly all specifications. In alternative specifications (not shown), in which we merge peg and soft peg into a single indicator variable, the resulting composite indicator is statistically and quantitatively significant in nearly all cases where soft peg is significant.

It is sensible that the soft peg variable is significant, with a positive relationship to reserve demand that is at least as strong as that of the peg variable. Our previous work (Obstfeld, Shambaugh, and Taylor 2004, 2005) focused on strict peg definitions when examining monetary policy autonomy in the form of interest-rate independence, because the wider the allowed currency fluctuation bands, the more monetary autonomy a country has. On the other hand, if a country holds reserves to ward off large devaluations following financial shocks, any country with a preference for non-floating rates is equally exposed, whether its preferred band is large or small. Hence, both pegs and soft pegs may need more reserves than countries that are indifferent to the exchange rate's level.

Our findings on financial depth and openness also appear to be quantitatively important. Taking our full financial stability model (column 6) as an example, when the financial openness index rises by one standard deviation (+0.243 in this sample), the model predicts that the reserve-to-GDP ratio rises by 0.16 log points. When the financial depth measure, ln(M2/GDP), rises by one standard deviation (+0.674 in this sample), the model predicts that the reserve-to-GDP ratio rises by 0.21 log points. These are potentially large effects: for a developing country that went through a transition from one standard deviation below the mean on these two dimensions to one standard deviation above the mean, the model would predict that the reserve-to-GDP ratio would close to double, all else equal (+0.74 log points). The trilemma also appears here: the impacts of all variables on the reserve/GDP ratio are magnified in countries that peg, given the log-based specification.

The contrast between the positive coefficient on GDP per capita in the traditional model and the negative coefficient on the advanced dummy in the financial stability model is worth noting. The advanced dummy in our model is intended to proxy for creditworthiness or capability to issue debt abroad in home currency. (Below we examine the latter factor directly using a smaller data sample.) As expected, advanced-country status has a strong negative effect. The positive sign of GDP per capita in the traditional model may reflect that variable's possible role as a proxy for the two excluded financial variables. Once these are controlled for, GDP per capita drops out of the regression.

4.2 Robustness: Subsamples and short-term debt

Table 1 shows that the new model has potentially good explanatory power in an absolute sense, as judged by R-squared;[26] the model also performs well relative to the current benchmark, the IMF's "traditional" model of reserve demand.

[26]Here and elsewhere we report the standard, unadjusted R-squared statistic. Because we have a large number of observations relative to the number of regressors, the two are always identical to 2 decimal places.

And our initial results illustrate the potentially large changes in reserves that could be induced by changes in financial openness and financial depth. On the other hand, much of the interest lately has centered on the behavior of emerging markets. Hence, in Table 2 we consider the emerging market sample only. In addition, recent policy debate has put great emphasis on the importance of short-term external debt. We have a more consistent series for this variable (from the World Bank's Global Development Finance dataset) when limiting our sample to emerging market countries. Thus, we introduce this variable in our analysis of the emerging-only sample.

To break the sample up into advanced, emerging, and developing groups we use a standard classification.[27] Table 2 (columns 1 through 4) repeats the regression exercise of Table 1 with the sample restricted to just the emerging market countries. The sample size is cut by more than 75 percent, falling to just 646 country-year observations, so we can no longer expect estimates to be as precise as before. Nonetheless, the basic message from Table 1 is confirmed. The fit is better under the new model (and even better in this restricted sample), with an R^2 of 0.60 for the financial stability (column 3) model versus the traditional model's 0.53 (column 1). Again, the financial variables take expected sign and significance in column 2, that is, in the horserace between the two sets of variables.[28] The peg variables provide exceptions, however. Both are roughly zero for the emerging sample. Most of the source of identification for this variable in the full sample seems to come from differences between the emerging and developed samples, and from within the developing sample, and these effects are excluded from the emerging-only sample underlying Table 2. On the other hand, column 5 shows that the peg variables are positively associated with reserves holdings, but the cross-correlation with other variables dominates in this particular sample. Looking at our financial stability model (column 3), financial openness is statistically significant and the coefficient increases in estimated magnitude to 0.918. The M2/GDP coefficient falls slightly and the trade coefficient is essentially unchanged. Again, when looking at a financial-only model (column 4), the financial variables have larger estimated coefficients.[29]

Columns 6 through 8 of Table 2 add the log of short term external debt to GDP as an additional variable to the traditional model, the horserace, and the financial stability model. The ideas of Guidotti and Greenspan have now coa-

[27] IFS codes less than 199 are classified as advanced, with the exception of Malta and Turkey. Emerging countries are those in the Morgan Stanley emerging market index plus some eastern European countries.

[28] Again, we perform Davidson and Mackinnon (1981) tests to address this issue. A coefficient on the fitted values from a traditional regression is insignificant if these are included in the financial stability model (this is true with or without short-term external debt included in the traditional model), while fitted values from the financial stability model do take on a statistically significant coefficient when included in a traditional regression.

[29] For the emerging sample, the positive coefficient on exchange rate volatility is not robust and is driven by extreme outliers in this sample, so we disregard it. Specifically, omitting 3 out of 646 large observations on this variable (which lie more than 8 standard deviations from the mean) causes this coefficient to lose statistical significance. Omitting 7 observations (a 1 percent trim) turns the coefficient negative and insignificant.

lesced into a widely cited rule of thumb, which judges emerging-market reserve adequacy relative to the potential demand for repayment connected with a country's short-term external foreign-currency borrowing. Empirically, though,the results are quite weak. The estimated coefficients in columns 6 through 8 are negative and insignificant. Thus, it appears there is a weak tendency for emerging countries to hold *fewer* reserves when they have more short-term debt.[30] We also considered the role of the debt service burden but found no effect. The lack of evidence favoring the Guidotti-Greenspan rule is consistent with the observation of Summers (2006) that many countries now hold reserves far in excess of short-term external foreign-currency debt.[31]

4.3 Robustness: Cross-section versus time-series identification

In this section we subject our benchmark financial stability model to various perturbations, both to check robustness and to identify whether the basic findings emanate from cross-sectional or time-series patterns in the data. If we expect to explain an increase in reserves for emerging markets, we need to see our results confirmed not just in the cross-section but within countries over time as well. Results are reported in Table 3. Column 1 simply reproduces column 3 from Table 2 for comparison.

In the second column of Table 2 we introduce country fixed effects (CFE). This change sweeps out all cross-sectional means, so there is no "between" identification, only "within." All coefficients are now estimated from time-series variation within country units. The country fixed effects obviously improve the fit (R^2 rises to 0.82), and they weaken some but not all of the coefficient estimates. The financial openness coefficient decreases in size, and is now significant only at the 10 percent level. The peg and soft peg coefficients remain insignificant. The trade coefficient remains large and significant. Importantly, though, the M2 coefficient increases both in magnitude and in statistical significance.

In column 3 we omit country fixed effects but add year-only fixed effects (YFE). The year effects are statistically significant, but compared with the pooled OLS results in column 1,the coefficient estimates do not change by a large or statistically significant amount, and the fit is only modestly improved.

In column 4 we add both country and year fixed effects (CFE & YFE). In this specification the estimated coefficient of the financial openness variable is now insignificant. More of the estimated effect of financial openness in the EM sample seems to come from cross-section than from time-series variation. The M2 and trade variables, though, remain positive and significant, even after

[30] Lane and Burke (2001) also find a negative correlation between external debt and reserves.

[31] Looking at the full emerging and developing country data set, we find that only 290 of the 1,935 observations are close to following the GG rule (these are countries where the short-term external debt-to-reserves ratio is between 75 percent and 125 percent). In contrast, 1,366 observations display more reserves than short-term foreign-currency debt. This is not unexpected since, as Table 2 shows, the level of short-term debt is not a good predictor of the level of reserves.

controlling for both year and country effects.

Finally, in Column 5, we remove all time-series identification and look at between-country panel estimation (running regressions across panel averages for each country), essentially reducing our observations to the number of emerging countries (31). Our results are strikingly similar to the regressions without country fixed effects. Countries which are on average more financially open tend to hold more reserves; countries that have larger M2 to GDP ratios and larger trade to GDP ratios also tend to hold more reserves. The peg variables also do not have significant coefficients in the cross section of the emerging sample, though they do in a between regression on the full or developing samples.

4.4 Original sin

The advanced dummy could reflect the possibility that poorer countries unable to issue foreign debt denominated in their own currencies may need to hold more reserves. We now explore the influence of "original sin" directly.

Given the limited information available, however, analysis is restricted to a subset of countries and years, which leaves a sample of only 770 country-year observations, including 168 advanced, 331 emerging, and 271 developing economies with data starting in 1993. Our two debt measures are SIN1 (the fraction of internationally issued securities issued in foreign currency) and the log of the ratio to GDP of all external liabilities in foreign currency. Both variables are based on authors' calculations using data from Eichengreen, Hausmann, and Panizza (2005). Findings are reported in Table 4. These results show that the "original sin" hypothesis actually fares better than the Greenspan-Guidotti guideline. While the second foreign-currency debt measure that we use here does not allow a test of the strict version of GG, it fails to show up in an economically or statistically significant manner consistent with the policy prescription. The SIN1 variable, however, is significantly positive in the full sample (column 1), a result which carries the implication that countries issuing a higher fraction of debt in foreign currency hold higher foreign reserves. Still, our financial-stability model still performs well when augmented with the SIN1 variable and the core variables remain positive and, for the most part, significant.[32]

Once country fixed effects are added, the SIN1 variable loses significance and carries a perverse sign (columns 2, 4, and 6). The reason is that the SIN1 variable has very little time variation. For nearly all emerging-market and developing countries, the original sin measure is very nearly constant and close to 100 percent. This feature of the data also ensures that SIN1 is insignificant in samples that exclude the advanced countries, even when there are no country fixed effects (column 5). On the other hand, columns 1 and 3 demonstrate that in samples where SIN1 does vary, it seems to matter quite a bit. Further, SIN1 isn't simply a proxy for advanced country status (which may entail addi-

[32]Neither peg nor soft peg are now statistically significant. However, the sample is now much smaller. Moreover, a considerable portion of the developing-country sample is excluded by the use of SIN1 as a regressor, and, as we have seen, it is in developing countries that the exchange rate regime variables seem to matter most for reserve demand.

tional structural advantages such as better prudential oversight of the financial markets): as we can see from columns 1 and 3, both advanced and SIN1 are significant even when both appear as regressors. Thus, from the point of view of economizing on reserves, it is good to be advanced, but it is even better to be a country with less sin.[33]

To conclude, our data exhibit a correlation between reserves and sin, but our main concern here is only to show that our core results are completely unaffected by this correlation. Nonetheless the causal relationship between reserves and sin may warrant further scrutiny in future research. It may be that sin causes reserves, in that a larger stock of foreign-currency debt, all else equal, requires larger reserve cover in the event of a sudden stop. But it is equally possible that some reverse causation is at work, with larger reserves at the central bank assuring the private sector that the peg is more likely to hold, and hence encouraging greater issuance of foreign-currency debt.

4.5 Then versus now: Have we entered a new era?

We next consider the model's stability over time. Specifically, we address the suggestion that the recent wave of reserve accumulation reflects a pronounced break from the central bank behavior of the recent past. To do this we examine how the model performs in three broad eras.

We divide our sample into three periods: the 1980s, the pre–Asian crisis 1990s (1990-97), and the post–Asian crisis years (1998-2004). The first three columns of Table 5 shows our findings for the EM sample. Financial openness and trade have fairly consistent estimated effects over time, but financial depth appears not to have been a factor in the 1980s (column 1) and only recently has become quite important (column 3). Over time,the trade/GDP ratio becomes less important for the EM sample while financial depth becomes increasingly important. The pattern is similar for the full sample (columns 4 through 6), although M2/GDP is positive and significant in the early 1990s as well. Thus, the EM countries seem to be coming more into line with the overall patterns in the full sample. In fact, M2/GDP is positively correlated with reserves in the EM sample in each period, but the multivariate correlation increases and the pertinent standard error falls as time goes by. Importantly, if we were to limit our emerging sample to financially open countries (results available but not shown), the M2/GDP variable is positive and significant (coefficient of 0.33, significant at the 5 percent level) even in the 1980s.

These findings suggest that the growing importance of M2/GDP for emerging market countries occurred just as these countries were becoming progressively more fully integrated into world financial markets. They also provide further support for our argument that M2 is a key driver of recent reserve growth

[33] We have also experimented with measures of bank quality and bank regulation (due to Ross Levine and his coauthors). These measures also lack time variation and in some specifications are statistically significant with the expected sign, but they are not particulary robust and do not affect the other core variables in our financial-stability model.

and that it should not be overlooked when trying to predict reserve behavior going forward.

4.6 Does money increase reserve demand or vice versa?

While our estimates could support the idea that increased financial depth in the form of M2 generates higher reserve demand, the results might instead reflect a different pattern of causation, with base money demand as the common factor, wherein broad money supply M2 and international reserves respond to a rise in the monetary base M0. Technically, a central bank can determine the composition and size of its balance sheet independently by sterilizing any transaction in which reserve levels change. In practice, however, causality could run from M0 to reserves and M2 jointly. For example, the central bank might pursue a reserve management policy of keeping the reserves/M0 ratio fixed (constant backing of money base, including the case of a currency board); in that environment, an increase in the demand for M0 (say due to increased monetization of the economy) would then spill over into both an increase in R (an endogenous central bank response) and an increase in M2 (for a given money multiplier).

We investigate this possibility in Table 6, but the results suggest that base money is not generating our results. Our first approach is to change the scaling of reserves. Rather than look at reserves divided by GDP, we scale reserves by M0 in alternative versions of the traditional and financial stability models. Column 1 shows that reserve/M0 ratios are higher when imports/GDP are higher and lower when exchange rate volatility is higher. Column 2 demonstrates that much as in our previous results, financial openness, pegging, and financial depth (now similarly rescaled, and measured by M2/M0) are still positively correlated with reserves, while the advanced country dummy again has a negative coefficient. As before, when rescaled by M0 rather than GDP, the financial stability model still has a higher R^2 than the traditional model.

For a different approach, in column 4, we scale by GDP as before, but we also include M0/GDP in the regression as an additional control variable. When added, M0/GDP is uncorrelated with the reserves/GDP ratio, conditional on the other independent variables in the financial stability model.[34] More importantly, the M2/GDP coefficient is still the same size (slightly larger) than in our main estimates presented back in Table 1. The connection between broad money M2 and reserves apparently is not due to any spurious causality running through M0. Even controlling for base money (M0), growth in the financial sector (M2) is correlated with reserve growth.

[34]The two variables are weakly positively unconditionally correlated, but one all the financial stability variables are included, the conditional relationship is effectively zero. Removing M2/GDP as a regressor makes the coefficient on M0/GDP positive but not statistically significantly different from zero.

4.7 Summary of the financial stability model

The considerations suggested by previous thinkers such as Thornton and expressed in our theoretical model do appear to matter empirically for reserve demand. As financial depth increases, the central bank will worry more about an internal-external double drain, and will hold more reserves. This will especially be true if the country is financially open and perhaps if its currency is pegged.

In our regression results, financial depth (M2/GDP) does in fact show a positive and significant coefficient when included in a traditional empirical model, in a horserace model, or in our preferred financial stability model. Financial depth is important even in just the time series dimension (within estimates) for emerging markets, and it has become more important lately as emerging market countries have grown more open financially—suggesting that M2 is potentially the key to understanding recent reserve growth.

A financial openness indicator also has a positive and significant effect on reserve demand, although once country and year effects are included, it is no longer significant in the emerging market sample. Much of the identification for this variable seems to stem from the fact that those EM countries that are financially open now hold more reserves than those that have not opened—patterns over time within countries are less clear than the between pattern. Still, we do see other variables (such as M2/GDP) mattering more as countries open their financial markets—as the model would suggest.

Finally, while significant in the overall sample, fixed exchange rates do not appear to play an important role in the emerging sample. Unconditionally, exchange rate pegging seems positively and significantly correlated with reserve holding, but that correlation may reflect omitted variables such as trade. In the developing-country or full sample, pegged exchange rates do appear to matter, but their strong positive correlation with both trade and financial depth in the EM sample leaves pegged-regime variables insignificant in those regressions. It is possible that one reason for the weakness of this variable is that even countries that are floating at a given point in time expect to peg again soon (see Klein and Shambaugh 2008). In that case, they will not necessarily hold fewer reserves while they are not pegging.

4.8 In-sample and out-of-sample prediction: Are current reserves excessive?

We now turn from a focus on model selection and statistical significance to evaluations based on model fit and quantitative significance. As we have noted above, it is often alleged that current reserve holdings are excessive or "inexplicable" based on traditional or external-debt explanations. We now present both in-sample and out-of-sample predictions to show that our financial stability model can better explain recent behavior.

4.8.1 In-sample prediction

The two panels of figure 1 show the growth in emerging market reserves over the 25 year sample period. For this period we conduct an in-sample comparison of the financial stability model and the traditional model.[35] The heights of the columns represent actual values of reserves year by year in emerging markets. The columns' subsections illustrate how changes in the model variables explain the growth of reserves over time. The bottom subsection is the amount that a model predicts for the year 1980 (constant over time). The other subsections of each column depict in turn the predicted changes since 1980 due to each regressor. The second lowest, for example, shows the effects of changes in GDP assuming all other variables had remained constant at their 1980 values. The total predicted effect, however, is not merely the sum of all those columns: the column section labeled "interaction" captures the multiplicative (nonlinear) effect of all variables changing simultaneously, given the log functional form we have used. Finally, the dark shaded subsection represents the amount that cannot be explained by the model: it is the top section when there is an underprediction and below the horizontal zero axis if there is overprediction, so that the unexplained portion is negative. Figure 1a shows that when one uses a financial stability model, growth in GDP alone (assuming a constant reserve/GDP ratio) explains a considerable amount of reserve growth. Beyond that, however, financial openness and the size of the financial sector explain considerable additional reserve growth. The model has no trouble predicting the growth in reserves from $180 billion in 1980 to $800 billion in 2001. Since then, a gap has opened, but the model still predicts reserves at over $1.1 trillion by 2004. In contrast, the traditional model in figure 1b predicts lower levels of reserves in emerging markets broadly and in particular it leaves a considerable volume of reserves unexplained by the mid 1990s. By 2004 the traditional model predicts only about $880 billion in reserves and leaves $700 billion unexplained. Figure 2, which presents the in-sample predictions for China alone, paints a very similar picture.

Projecting forward from 1980 may be a stretch for any model, so figures 3a through 3h repeat the exercise on a shorter timescale (1996-2004), and with reserves now shown as a ratio to GDP. These figures provide some key country examples utilizing the financial-only model, with the original sin variable SIN1 included as a regressor. To generate these figures, we estimated the financial-only model only on data from 1996 to 2004.[36] Next, as in Figure 2, we calculated the predicted values for the starting year (now 1996) and take those as baseline values. We then allow each independent variable, one by one, to be set equal to its actual value while holding other variables at their 1996 values and

[35]The financial stability model that we use is the one in Table 1, column 7, which has trade excluded as a regressor. We remove trade to separate clearly the financial stability model from the traditional model: we would like to see how far financial stability factors alone can go. Further, the estimates underlying figure 1 come from a restricted, balanced sample. Otherwise changes in the country sample would in part drive our predicted reserve totals.

[36]Data constraints when using the SIN1 and foreign-currency debt variables necessitate starting at the later date

again compute the difference that makes for reserves. The figures also show the amount of unexplained reserve holdings (the difference between actual and predicted) as a ratio to GDP.

For example, Figure 3a shows that in 1996, China was holding too few reserves relative to our benchmark (unexplained reserves were negative). Over time, the M2 portion of the columns continues to grow, in the end justifying an increase in the reserve/GDP ratio of 7 percentage points. Financial opening in 2004 justifies another small increase in reserves. The United States, in contrast, has not changed its reserve/GDP ratio by much, and the model suggests that this is appropriate.

Japan, on the other hand, has greatly increased its ratio of reserves to GDP in recent years, and little explanation for this can be found in our financial stability model (nor in any other model, as far as we can tell). Emerging Asia is predicted to hold roughly 20 percent of GDP in reserves, but in recent years, reserve growth has outpaced our model's benchmark, though not substantially.

For the remaining groups shown, the model does a fair job of explaining the ratios. The model predicts both emerging and developing Latin American countries' reserve shares within a few percentage points of GDP. Recent surges in emerging EU countries' reserves are left somewhat unexplained, but this residual amounts to about 7 percent of GDP. The model is able to explain why emerging Latin American countries hold fewer reserves than emerging Asia. For 2004, both groups hold reserves that are a few percent above predicted levels, but emerging Asia's predicted reserves are on average 20 percent of GDP (even with China taken out) while emerging Latin America is predicted to hold reserves equal to only 12 percent of GDP.

4.8.2 Out-of-sample prediction

In addition to asking what is driving changes in reserves over time, one may want to ask how well the model predicts reserves out of sample. Jeanne (2007) suggests that despite providing acceptable in-sample accounting, econometric equations estimated over past subsamples are unable to predict the surge in reserves in the most recent years.

We have seen that the financial stability model likewise explains reserves well on an in-sample basis, so we now turn to its out-of-sample performance. We estimate the financial-only model on data from 1993 (the first year for which there are "original sin" data) up to 2000, and then try to predict reserves in subsequent years (2004 being the last year for which we have a full set of independent variables).[37]

Figure 4a shows actual reserves on the vertical axis and compares them to the reserve levels that the financial stability model predicts for 2004. The points cluster relatively close to the 45-degree line (where actual and predicted

[37] In contrast to figure 3 which generates a slightly larger country sample by sacrificing some early years (1993–95), in this exercise, we use the years 1993–95 and include fewer countries. This choice is driven by the need for a sufficient length of time series before the cutoff date of 2000.

reserves coincide), and many controversial cases (such as that of China) are rather close to it. (China is marked by an arrow.) In contrast, Figure 4b shows the same scatter but instead using the traditional model to make the out-of-sample reserve predictions to 2004. This scatter is much more dispersed relative to the 45-degree line and, in particular, more countries are far distant from the line. (China is now well away from the diagonal.)

One way to compare the two figures is to note that the R^2 of a regression of actual reserves/GDP on the predicted ratio using the financial stability model is 0.52, and the slope coefficient is 1.33. Thus, on average, our model underpredicts some at the high end, but the amount is not glaring. In contrast, using the traditional model, the R^2 is only 0.41 and the slope coefficient is 1.81, suggesting a more severe underprediction of the largest reserve holdings using the traditional model.[38]

Figure 5 illustrates the model's performance over time for a selection of countries and country groups. We again estimate using 1993–2000 data and graph actual reserve/GDP ratios against the out-of-sample predictions of the financial stability and traditional models.[39] The financial stability model is able to largely explain the rise of reserves in China, at least until the last year of the sample, 2004.[40] The financial stability model does quite a bit better for the United States than does a traditional model. For the three emerging market country groups, the financial stability model is always more accurate than the traditional model, though in the most recent years, the gap between predicted and actual reserves is growing in emerging Asia.[41] Finally, though, we see that neither model can explain the massive run up in Japan's reserves. One could suggest many reasons for that country's high reserves: attempts to prevent deflation by buying foreign assets, attempts to prevent appreciation, or arbitrage between low home interest rates and higher United States rates. Neither the financial stability nor the traditional model captures these effects, however.

In general, we find that the financial stability model can predict with reasonable accuracy the official reserve holdings in our sample. There are notable exceptions (Japan, Singapore, and to some degree China in the last year or so), but using the financial stability model that we have proposed the reserve accumulation puzzle appears far less dramatic than either traditional models or models based on foreign debt and sudden stops would suggest.

[38]Removing the large outlier Singapore improves the performance of the financial stability model, raising the R^2 up to 0.68 and lowering the slope coefficient to 1.23. For the traditional model, the effect is mixed. Removing Singapore lowers the R^2 to 0.32, but it also lowers the slope coefficient from 1.81 to 1.38.

[39]The number of groups is smaller than in figure 3 because of the need for balanced panels.

[40]As in figure 3, an equation based on 1993–2000 data does a better job of predicting China's holdings in the early 2000s than one based on the full time sample because the 1980s data give less weight to financial variables (as shown in Table 4).

[41]Malaysia and Thailand seem to be important drivers of this result.

5 Conclusion

The recent and rapid accumulation of reserves by emerging markets with pegged or quasi-pegged exchange rates is often considered inexplicable. The practice of emerging central banks seems far ahead of any coherent theory—and hence appears to be an economic puzzle, if not a policy problem. Puzzling it may be in terms of the prevailing models of reserve accumulation from the 1960s and 1970s, and even the more recent Guidotti-Greenspan rule of the 1990s, which emerged from the Asian Crisis of 1997.

However, in terms of operational rules devised following Britain's Panic of 1797, the current trends make more sense. In the eighteenth and nineteenth centuries the Bank of England found itself with the responsibilities of a Lender of Last Resort, under a Gold Standard system, in an economy undergoing rapid financial development. And in that era too, as noted by T. S. Ashton, practice preceded theory (Kindleberger 2000, p. 162).

A visionary thinker realized that with a fixed exchange rate and a growing base of bank deposits to worry about, a central bank needed to grow its reserves if it were to face down the threat of external and internal drains. Thus, reserve adequacy had to be gauged against the size of the banking sector. It took some time for Henry Thornton's ideas to be fully appreciated in 19th century England; they appear to have been much more readily grasped in 21st century China.

Appendix:
Twin crises and the central bank balance sheet

At the center of the financial system is the central bank. Its balance sheet identity has the form

$$H + Currency + CBC = D + \bar{E}R,$$

where H denotes banking-system deposits (high-powered money), $Currency$ denotes currency (assumed held outside the central bank), CBC is central-bank capital, D denotes domestic assets of the central bank, $\bar{E}$ is the domestic-currency price of foreign exchange, and R denotes international reserves (measured in foreign currency). We assume for simplicity that the exchange rate is fixed, although, as noted earlier, matters are not much different if the rate is flexible and the authorities simply wish to limit depreciation.

The private banking system's liabilities M constitute the money supply (not including currency), whereas its assets are high-powered central bank deposits H and illiquid loans L. If PBC denotes private bank capital, the private banking system's balance sheet identity is

$$M + PBC = H + L.$$

We wish to consider a scenario of simultaneous internal and external drain, in which residents attempt to convert bank deposits M into foreign exchange.

Our assumption is that currency holdings are not responsive to depreciation expectations—perhaps they are determined by a relatively interest inelastic cash-in-advance demand. The demand for bank deposits is, however, elastic with respect to the nominal domestic bond rate i, with a Cagan-type demand given by

$$lnM - lnP = \mu - \lambda i.$$

Now suppose that there is a sudden rise in the market's depreciation expectations, such that the bond rate i doubles. If the interest elasticity of money demand is 0.5, then the volume of deposits demanded will fall by 25 percent. If the banking system cannot liquidate loans in the short run, it must pay off these deposits using central-bank deposits—so H as well as central bank international reserves fall by $0.25M$.

If central-bank foreign reserves cannot cover the capital outflow, and measures other than intervention are unavailable to support the exchange rate, there will be a depreciation. Let us suppose for the moment that international reserves are sufficient, however. It is still possible, given the importance of currency in the overall monetary base, that banking-system liquidity cannot cover desired withdrawals: $H < 0.25M$ In this case the central bank will act as a lender of last resort, effectively purchasing debt instruments worth $0.25M - H$ from the banking system in exchange for newly issued high-powered money. At the end of the day, the central bank's balance sheet has become

$$\begin{aligned} Currency + CBC &= (D + .25M - H) + \bar{E}R - H - (.25M - H) \\ &= (D + .25M - H) + (\bar{E}R - .25M). \end{aligned}$$

The second line emphasizes that domestic assets are higher by the amount of the LLR support, whereas reserves are lower by $0.25M$. The private banking system is illiquid and its balance sheet is

$$.75M + PBC = L - (.25M - H).$$

Now let us consider, realistically, that such an operation might stretch the central bank's international reserves. What options are available to the central bank if it wishes to control the exchange rate? At this stage, much of the central bank's domestic assets may consist of banking system loans that it will be unable to market except at a steep loss. At a time of uncertainty the line between illiquidity and insolvency may be blurred, if it is visible at all. This is, after all, why the LLR is needed in the first place. But with the banks' loans (now passed on to the central bank directly or as collateral) being difficult to value, it may be uncertain ex ante whether the liquidity provision is a loan or a subsidy. If the latter, a large prospective (or actual) bailout may endanger central bank capital and, in fact, pose a possible drain on the public-sector finances more generally.

Matters are not much better if the authorities seek merely to limit, rather than stop, depreciation. The considerations making a large reserve stock essential are basically the same. The ability of domestic residents to switch into foreign-currency deposits offered by the domestic banking system also helps little, because banks will be under interest-rate pressure and will wish to buy central bank foreign reserves so as to avoid an increasing currency mismatch on their own books.

References

Aizenman, Joshua, and Jaewoo Lee. 2007. "International Reserves: Precautionary versus Mercantilist Views, Theory and Evidence." *Open Economies Review* 18(2): 191–214.

Aizenman, Joshua, and Nancy Marion. 2003. "The High Demand for International Reserves in the Far East: What's Going On?" *Journal of the Japanese and International Economies* 17 (September): 370–400.

Baek, Seung-Gwan, and Changkyu Choi. 2008. "Exchange Rate regimes and International Reserves." *Korean Economic Review* 24(1). Forthcoming.

Bagehot, Walter. 1873. *Lombard Street: A Description of the Money Market.* London: Kegan, Paul & Co.

Bahmani-Oskooee, M., and F. Brown. 2002. "Demand for International Reserves: A Review Article." *Applied Economics* 34 (July): 1209–26.

Bertrand, Marianne, Esther Duflo, and Sendhil Mullainathan, 2004. "How Much Should We Trust Differences-in-Differences Estimates?" *Quarterly Journal of Economics* 119 (February): 249–75.

Bird, Graham, and Ramkishen Rajan. 2003. "Too Much of a Good Thing? The Adequacy of International Reserves in the Aftermath of Crises." *World Economy* 86 (June): 873–91.

Blustein, Paul. 2005. *And the Money Kept Rolling In (And Out): Wall Street, the IMF, and the Bankrupting of Argentina.* New York: Public Affairs.

Calvo, Guillermo A. 1996. "Capital Flows and Macroeconomic Management: Tequila Lessons." *International Journal of Finance and Economics* 1 (July): 207–23.

Calvo, Guillermo A. 2006. "Monetary Policy Challenges in Emerging Markets: Sudden Stop, Liability Dollarization, and Lender of Last Resort." Working Paper 12788, National Bureau of Economic Research.

Calvo, Guillermo A., and Enrique G. Mendoza. 1996. "Mexico's Balance-of-Payments Crisis: A Chronicle of a Death Foretold." *Journal of International Economics* 41 (November): 235–64.

Calvo, Guillermo A., and Carmen M. Reinhart. 2000. "When Capital Flows Come to a Sudden Stop: Consequences and Policy." In *Reforming the International Monetary and Financial System*, edited by P. B. Kenen and A. K. Swoboda. Washington, D.C.: International Monetary Fund.

Chang, Roberto, and Andrés Velasco. 2001. "Financial Crises in Emerging Markets: A Canonical Model." *Quarterly Journal of Economics* 116: 489–517.

Davidson, Russell, and James G. MacKinnon. 1981. "Several Tests for Model Specification in the Presence of Alternative Hypotheses." *Econometrica* 49 (May): 781–93.

della Paolera, Gerardo, and Alan M. Taylor. 2002. "Internal Versus External Convertibility and Emerging-Market Crises: Lessons from Argentine History." *Explorations in Economic History* 39 (4): 357–89.

della Paolera, Gerardo, and Alan M. Taylor. 2003. "Gaucho Banking Redux." *Economía* 3: 1–42.

Dominguez, Kathryn M. E. 2007. "International Reserves and Underdeveloped Capital Markets." Photocopy. University of Michigan (October).

Dornbusch, Rudiger, and Jacob A. Frenkel. 1984. "The Gold Standard and the Bank of England in the Crisis of 1847." In *A Retrospective on the Classical Gold Standard, 1821–1931*, edited by M. D. Bordo and A. J. Schwartz. Chicago: University of Chicago Press.

Durdu, Ceyhun Bora, Enrique G. Mendoza, and Marco Terrones. "Precautionary Demand for Foreign Assets in Sudden Stop Economies: An Assessment of the New Mercantilism." *Journal of Development Economics.* Forthcoming.

Edwards, Sebastian. 1985. "On the interest-rate elasticity of the demand for international reserves: Some evidence from developing countries." *Journal of International Money and Finance* 4 (June): 287–295.

Edwards, Sebastian. 2007. "Capital Controls, Sudden Stops, and Current Account Reversals." In *Capital Controls and Capital Flows in Emerging Economies: Policies, Practices, and Consequences* edited by S. Edwards. Chicago: University of Chicago Press.

Eichengreen, Barry, Ricardo Hausmann, and Ugo Panizza. 2005. "The Pain of Original Sin." In *Other Peoples' Money*, edited by B. Eichengreen and R. Hausmann. Chicago: University of Chicago Press, pp. 13–47.

Feldstein, Martin S. 1999. "A Self-Help Guide for Emerging Markets." *Foreign Affairs* 78(2): 93–109.

Fischer, Stanley. 1999. "On the Need for an International Lender of Last Resort." *Journal of Economic Perspectives* 13 (Fall): 85–104.

Flood, Robert, and Nancy Marion. 2002. "Holding International Reserves in an Era of High Capital Mobility." In *Brookings Trade Forum 2001* edited by S. M. Collins and D. Rodrik. Washington, D.C.: Brookings Institution, pp. 1–68.

Frenkel, Jacob A., and Boyan Jovanovic. 1981. "Optimal International Reserves: A Stochastic Framework." *Economic Journal* 91 (June): 507–14.

Goldstein, Itay. 2005. "Strategic Complementarities and the Twin Crises." *Economic Journal* 115 (April): 368–90.

Greenspan, Alan. 1999. "Currency Reserves and Debt." Remarks before the World Bank Conference on Recent Trends in Reserves Management, Washington, D.C. (April 29). http://www.federalreserve.gov/boardDocs/speeches/1999/19990429.htm.

Guttentag, Jack, and Richard Herring. 1983. "The Lender-of-Last-Resort Function in an International Context." *Princeton Essays in International Finance* 151 (May).

Heller, H. Robert. 1966. "Optimal International Reserves." *Economic Journal* 76 (June): 296–311.

IMF. 2003. *World Economic Outlook 2003.* Washington, D.C: International Monetary Fund.

Jeanne, Olivier. 2007. "International Reserves in Emerging Market Countries: Too Much of a Good Thing?" *Brookings Papers on Economic Activity* 1: 1–79.

Jeanne, Olivier, and Romain Rancière. 2006. "The Optimal Level of International Reserves for Emerging Market Countries: Formulas and Applications." IMF Working Paper WP/06/229 (October).

Johnson, Harry G. 1958. "Towards a General Theory of the Balance of Payments." In *International Trade and Economic Growth.* London: George Allen and Unwin.

Kaminsky, Graciela L., and Carmen M. Reinhart. 1999. "The Twin Crises: The Causes of Banking and Balance of Payments Problems." *American Economic Review* 89 (June): 473–500.

Keynes, John Maynard. 1971. *A Treatise on Money. Volume 2: The Applied Theory of Money.* In *The Collected Writings of John Maynard Keynes, Volume VI.* London: Macmillan (for the Royal Economic Society).

Kindleberger, Charles P. 2000. *Manias, Panics, and Crashes: A History of Financial Crises,* 4th ed. New York: Wiley.

Klein, Michael W., and Jay C. Shambaugh. 2008. "The Dynamics of Exchange Rate Regimes: Fixes, Floats, and Flips." *Journal of International Economics* 75(1): 70–92.

Lane, Philip R., and Dominic Burke. 2001. "The Empirics of Foreign Reserves." *Open Economies Review* 12 (October): 423–34.

Levy Yeyati, Eduardo. 2006. "The Cost of Reserves." Documento de Trabajo 10/2006, Centro de Investigación en Finanzas, Universidad Torcuato Di Tella (July).

Levy Yeyati, Eduardo, Sergio L. Schmukler, and Neeltje Van Horen. 2004. "The Price of Inconvertible Deposits: The Stock Market Boom During the Argentine Crisis." *Economics Letters* 83(1): 7–13.

Miller, Victoria. 1996. "Speculative Currency Attacks with Endogenously Induced Commercial Bank Crises." *Journal of International Money and Finance* 15 (June): 383–403.

Miller, Victoria. 2000. "Central Bank Reactions to Banking Crises in Fixed Exchange Rate Regimes." *Journal of Development Economics* 63 (December): 451–72.

Obstfeld, Maurice. 2004. "Globalization. Macroeconomic Performance, and the Exchange Rates of Emerging Economies." *Monetary and Economic Studies* 22 (December): 29–55.

Obstfeld, Maurice, Jay C. Shambaugh, and Alan M. Taylor. 2004. "Monetary Sovereignty, Exchange Rates, and Capital Controls: The Trilemma in the Interwar Period." *IMF Staff Papers* 51: 75–108.

Obstfeld, Maurice, Jay C. Shambaugh, and Alan M. Taylor. 2005. "The Trilemma in History: Tradeoffs among Exchange Rates, Monetary Policies, and Capital Mobility." *Review of Economics and Statistics* 87 (August): 423–38.

Reinhart, Carmen M., and Kenneth S. Rogoff. 2004. "The Modern History of Exchange Rate Arrangements: A Reinterpretation." *Quarterly Journal of Economics* 119 (February): 1–48.

Rodrik, Dani, 2006. "The Social Cost of Foreign Exchange Reserves." *International Economic Journal* 20 (September): 253–66.

Rothenberg, Alexander D., and Francis E. Warnock. 2006. "Sudden Flight and True Sudden Stops." Working Paper 12726, National Bureau of Economic Research.

Sachs, Jeffrey D. 1998. "Creditor Panics: Causes and Remedies." Photocopy. Harvard University (October). http://www.cid.harvard.edu/archive/hiid/papers/cato.pdf.

Shambaugh, Jay C. 2004. "The Effects of Fixed Exchange Rates on Monetary Policy." *Quarterly Journal of Economics* 119 (February): 301–52.

Shin, Hyun Song. 2005. "Liquidity and Twin Crises." *Economic Notes* 34 (3): 257–77.

Summers, Lawrence H. 2006. "Reflections on Global Account Imbalances and Emerging Markets Reserve Accumulation." L. K. Jha Memorial Lecture, Reserve Bank of India (March). http://www.president.harvard.edu/speeches/ 2006/0324_rbi.html.

Thornton, Henry. 1939 [1802]. *An Enquiry into the Nature and Effects of the Paper Credit of Great Britain.* Edited with an introduction by F. A. von Hayek. London: George Allen and Unwin.

Velasco, Andrés. 1987. “Financial Crises and Balance of Payments Crises: A Simple Model of Southern Cone Experience.” *Journal of Development Economics* 27: 263–83.

Viner, Jacob. 1937. *Studies in the Theory of International Trade.* New York: Harper & Brothers.

Wijnholds, J. Onno de Beaufort, and Arend Kapteyn. 2001. “Reserve Adequacy in Emerging Market Economies.” IMF Working Paper WP/01/43 (September).

Williamson, John. 1973. “Surveys in Applied Economics: International Liquidity.” *Economic Journal* 83 (September): 685–746.

Table 1: Traditional and Financial Stability Models of Reserves Demand

	1	2	3	4	5	6	7
	Traditional model	Add financial openness	Add peg	Add M2	Horserace	Financial stability w/ trade	Financial stability w/o trade
Ln(population)	0.021	0.018	0.023	0.004	-0.012		
	0.035	0.035	0.035	0.034	0.032		
Ln(imports/GDP)	0.806	0.776	0.774	0.726			
	0.097**	0.096**	0.097**	0.096**			
Exchange rate	-0.011	-0.008	-0.006	-0.008	-0.001		
	0.009	0.01	0.01	0.01	0.008		
Ln(GDP/person)	0.158	0.104	0.148	0.077	0.063		
	0.042**	0.044*	0.040**	0.054	0.055		
Financial openness		0.451			0.599	0.671	1.035
		0.202*			0.171**	0.174**	0.212**
Peg			0.144		0.09	0.095	0.246
			0.080+		0.077	0.077	0.093**
Soft peg			0.188		0.161	0.167	0.289
			0.065**		0.059**	0.060**	0.078**
Ln(M2/GDP)				0.234	0.284	0.311	0.444
				0.092*	0.087**	0.072**	0.086**
Ln(trade/GDP)					0.544	0.583	
					0.084**	0.071**	
Advanced					-0.625	-0.554	-0.858
					0.145**	0.125**	0.161**
Constant	-6.818	-6.491	-6.754	-6.436	-6.265	-6.253	-4.538
	0.911**	0.905**	0.897**	0.891**	0.788**	0.360**	0.288**
Observations	2671	2671	2671	2671	2671	2671	2671
R-squared	0.31	0.32	0.32	0.33	0.38	0.38	0.27

Robust standard errors clustered by country in parentheses.
+ significant at 10%; * significant at 5%; ** significant at 1%.
No fixed effects.
Dependent variable: Ln(reserves/GDP).

Table 2: Emerging Markets Sample

	1	2	3	4	5	6	7	8
	Traditional model	Horserace	Financial stability w/ trade	Financial stability w/o trade	Peg only	Add debt	Add debt	Add debt
Ln(population)	0.034	-0.043				-0.018	-0.095	
	0.068	0.056				0.08	0.066	
Ln(imports/GDP)	0.79					0.69		
	0.131**					0.106**		
Exchange rate volatility	0.092	0.328				0.101	0.314	
	0.143	0.164+				0.117	0.154+	
Ln(GDP/person)	0.149	-0.017				0.16	0.075	
	0.088	0.086				0.114	0.105	
Ln(S.T.Ext.Debt/GDP)						-0.135	-0.129	-0.048
						0.085	0.076	0.068
Financial openness		0.93	0.918	1.632			0.589	0.701
		0.238**	0.186**	0.337**			0.219*	0.191**
Peg		0.036	0.023	0.022	0.584		0.098	0.07
		0.119	0.118	0.127	0.176**		0.117	0.104
Soft peg		0.006	-0.012	0.065	0.441		0.035	0.009
		0.111	0.115	0.124	0.184*		0.085	0.09
Ln(M2/GDP)		0.299	0.238	0.569			0.337	0.198
		0.123*	0.118+	0.117**			0.114**	0.113+
Ln(trade/GDP)		0.491	0.57				0.428	0.59
		0.108**	0.075**				0.088**	0.090**
Constant	-6.731	-4.935	-5.904	-5.242	-2.46	-5.89	-4.82	-5.816
	1.958**	1.644**	0.424**	0.491**	0.137**	2.236*	1.894*	0.559**
Observations	646	646	646	646	646	504	504	504
R-squared	0.53	0.61	0.6	0.49	0.1	0.45	0.54	0.51

Robust standard errors clustered by country in parentheses.
+ significant at 10%; * significant at 5%; ** significant at 1%.
No fixed effects.
Dependent variable: Ln(reserves/GDP).

Table 3: Source of Identification for Emerging Markets Sample

	1	2	3	4	5
	No FE	CFE	YFE	CFE+YFE	Between
Financial openness	0.918	0.393	0.789	0.121	1.600
	0.186**	0.213+	0.249**	0.206	0.757*
Peg	0.023	0.054	0.029	0.071	-0.240
	0.118	0.081	0.125	0.063	0.338
Soft peg	-0.012	0.046	-0.034	0.023	-0.137
	0.115	0.086	0.111	0.079	0.370
Ln(M2/GDP)	0.238	0.492	0.215	0.348	0.351
	0.118+	0.130**	0.114+	0.121**	0.180+
Ln(trade/GDP)	0.57	0.8	0.574	0.604	0.392
	0.075**	0.120**	0.080**	0.177**	0.213+
Observations	646	646	646	646	646
R-squared	0.6	0.82	0.62	0.85	0.57

Robust standard errors clustered by country in parentheses.
+ significant at 10%; * significant at 5%; ** significant at 1%.
No FE = no fixed effects; CFE = country fixed effects; YFE = year fixed effects.
In column 5, the regresssion is a between groups panel regression
there are 31 country groups.
Within R-squared is .30, between is .73, and overall is .57
Dependent variable: Ln(reserves/GDP).

Table 4: Original Sin

	1	2	3	4	5	6
	Full sample No FE	Full sample CFE	Full sample YFE	Full sample CFE+YFE	Emerging Markets No FE	Emerging Markets CFE+YFE
Financial openness	0.413	-0.046	0.409	-0.037	0.871	-0.168
	0.229+	0.217	0.228+	0.19	0.321*	0.219
Peg	0.082	0.225	0.073	0.165	-0.079	0.063
	0.091	0.078**	0.092	0.069*	0.119	0.087
Soft peg	0.078	0.063	0.068	0.057	0.021	0.006
	0.062	0.05	0.062	0.048	0.084	0.065
Ln(M2/GDP)	0.548	0.535	0.54	0.301	0.343	0.627
	0.086**	0.198**	0.088**	0.184	0.104**	0.249*
Ln(trade/GDP)	0.376	0.818	0.376	0.57	0.517	0.41
	0.098**	0.175**	0.102**	0.169**	0.082**	0.211+
Advanced	-0.712		-0.643			
	0.148**		0.166**			
SIN1	1.354	-0.621	1.438	-0.281	-0.901	-0.603
	0.402**	1.123	0.411**	1.032	2.211	1.263
Ln(ForCurDebt/GDP)	0.035	-0.007	0.015	-0.076	0.003	-0.094
	0.03	0.031	0.035	0.031*	0.044	0.044*
Constant	-7.228	-7.174	-7.342	-5.855	-5.089	-5.439
	0.627**	1.452**	0.639**	1.491**	2.275*	1.904**
Observations	770	770	770	770	331	331
R-squared	0.58	0.89	0.58	0.9	0.63	0.9

Robust standard errors clustered by country in parentheses.
+ significant at 10%; * significant at 5%; ** significant at 1%.
No FE = no fixed effects; CFE = country fixed effects; YFE = year fixed effects.
Dependent variable: Ln(reserves/GDP).

Table 5: Financial Stability Model Across Eras

	1	2	3	4	5	6
	Emerging markets 1980s	Emerging markets preAsia 90s	Emerging markets postAsia	Full sample 1980s	Full sample preAsia 90s	Full sample postAsia
Financial openness	0.923	0.829	0.648	0.782	0.43	0.024
	0.490+	0.419+	0.253*	0.299*	0.232+	0.214
Peg	0.177	0.081	-0.089	0.027	0.18	0.213
	0.195	0.201	0.116	0.133	0.109	0.108+
Soft peg	-0.087	-0.002	0.101	0.13	0.153	0.243
	0.229	0.112	0.089	0.106	0.078+	0.074**
Ln(M2/GDP)	0	0.154	0.45	0.22	0.34	0.386
	0.193	0.172	0.101**	0.142	0.083**	0.072**
Ln(trade/GDP)	0.625	0.614	0.479	0.638	0.57	0.379
	0.172**	0.147**	0.069**	0.105**	0.083**	0.097**
Advanced				-0.218	-0.662	-0.831
				0.163	0.154**	0.182**
Constant	-5.327	-5.807	-6.07	-6.298	-6.197	-5.114
	0.605**	0.516**	0.456**	0.610**	0.368**	0.458**
Observations	217	212	217	976	930	864
R-squared	0.54	0.51	0.71	0.33	0.4	0.35

Robust standard errors clustered by country in parentheses.
+ significant at 10%; * significant at 5%; ** significant at 1%.
No fixed effects.
Dependent variable: Ln(reserves/GDP).

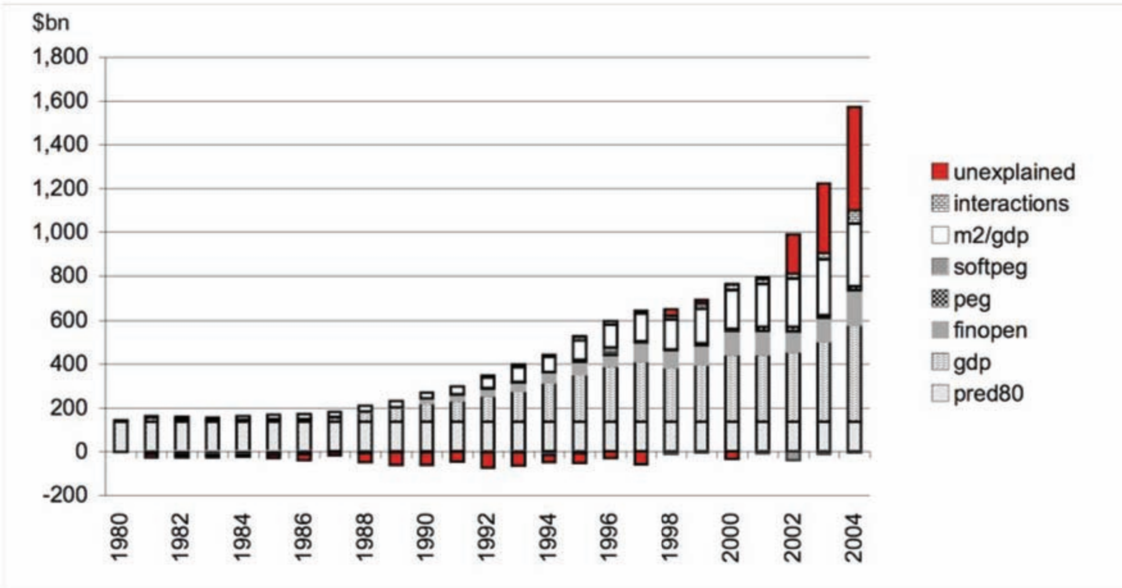
Table 6: The Monetary Base and M2

	1	2	3	4
	Traditional model	Financial stability model	Financial stability model	Financial stability model
Dependent variable	Ln(reserves/M0)	Ln(reserves/M0)	Ln(reserves/M0)	Ln(reserves/GDP)
Ln(population)	-0.065			
	0.087			
Ln(imports/GDP)	0.339			
	0.156*			
Exchange rate volatility	-0.052			
	0.322			
Ln(gdp/cap)	0.354			
	0.154*			
Ln(M2/M0)		0.726	0.81	
		0.114**	0.113**	
Financial openness		1.407	1.777	0.894
		0.235**	0.289**	0.196**
Peg		-0.222	-0.144	0.046
		0.141	0.133	0.14
Soft peg		-0.066	0.014	-0.004
		0.114	0.114	0.122
Ln(trade/GDP)		0.278		0.571
		0.072**		0.077**
Ln(M2/GDP)				0.261
				0.113*
Ln(M0/GDP)				-0.06
				0.123
Constant	-3.269	-2.928	-2.155	-5.831
	2.569	0.372**	0.287**	0.467**
Observations	646	646	646	646
R-squared	0.35	0.57	0.54	0.6

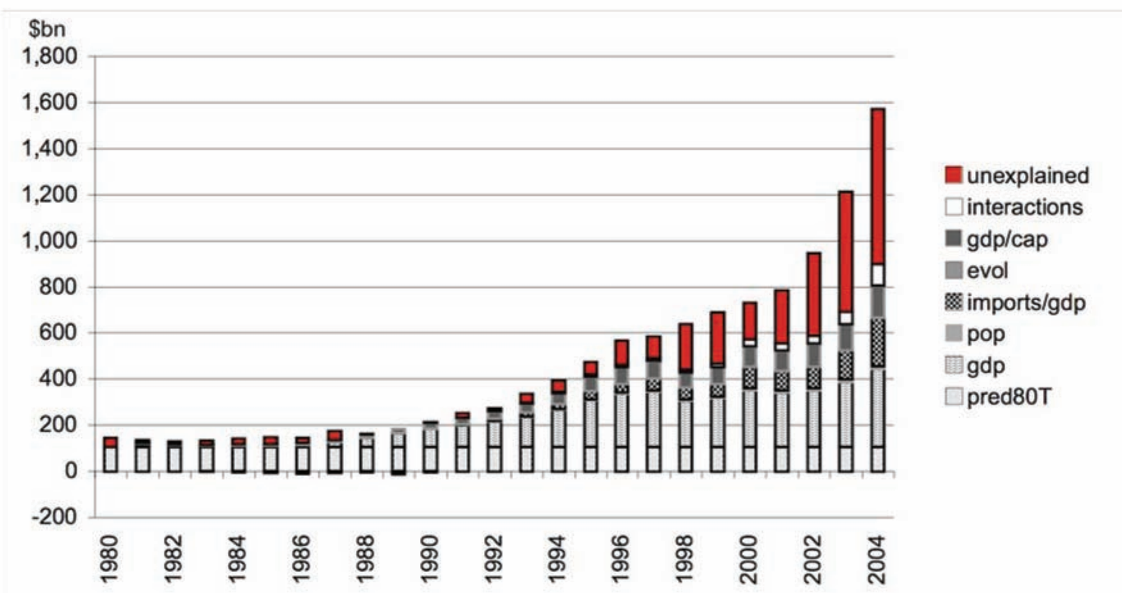
Robust standard errors clustered by country in parentheses.
+ significant at 10%; * significant at 5%; ** significant at 1%.
No fixed effects.

Figure 1: In-Sample: What Explains Post-1980 Increases in Emerging Market Reserves?

(a) Emerging Market Sample: Financial Stability Model



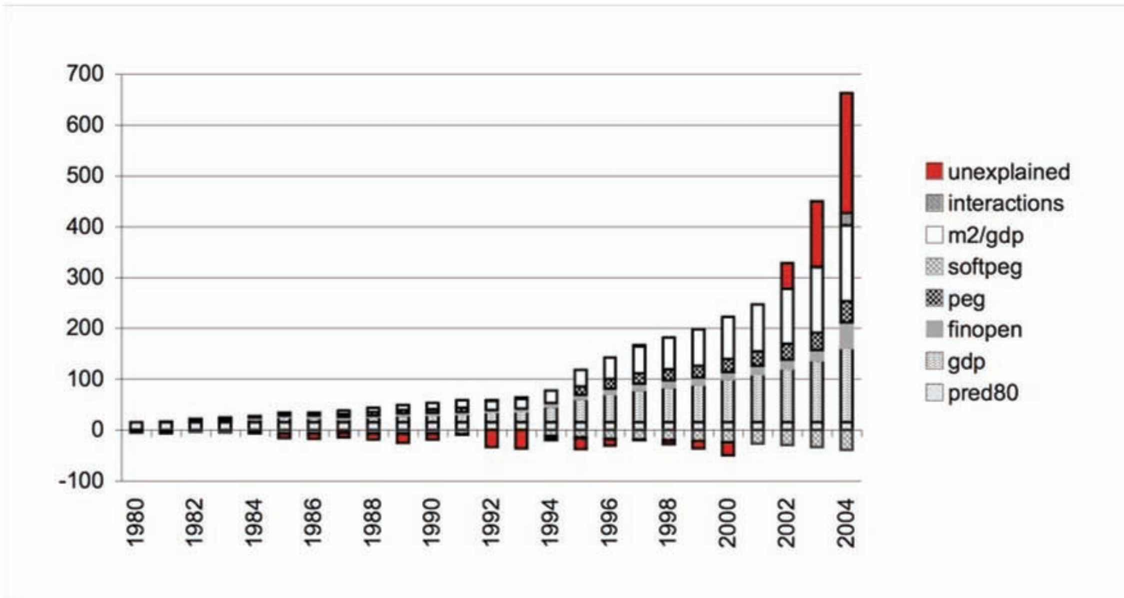
(b) Emerging Market Sample: Traditional Model



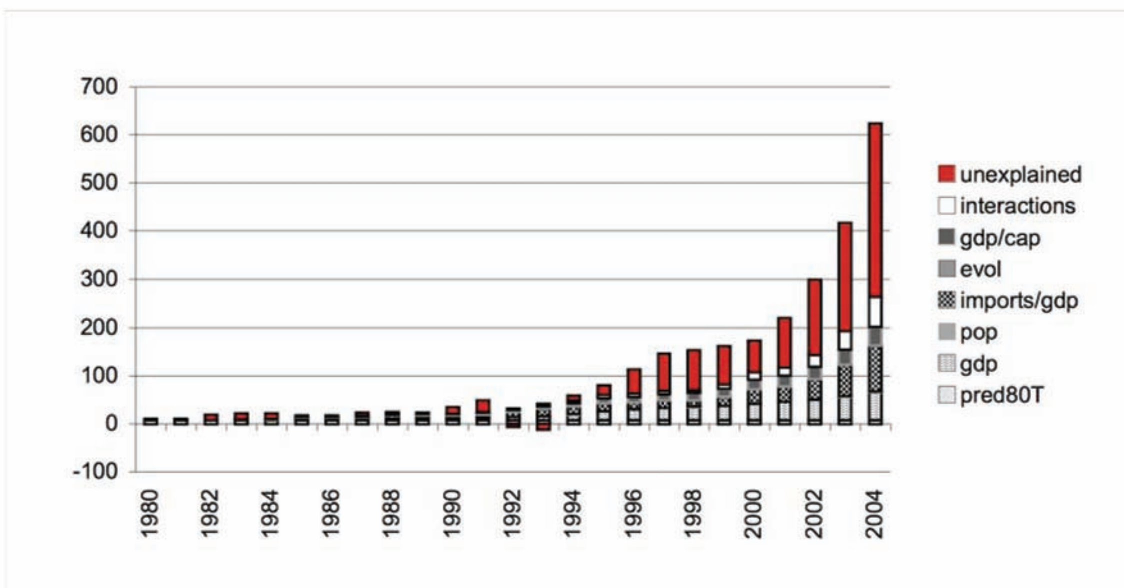
Note: these two figures show the increase in reserves over 25 years for emerging market countries in billions of current US dollars. The sub-sections of the bars represent the explanators of the growth. The bottom bar is the amount predicted in 1980 (constant over time). Other sub-sections allow for changes in 1 variable at a time. The second lowest is simply the change in GDP assuming all other variables remain constant, etc. The top section represents the amount that cannot be explained by the model.

Figure 2: In-Sample: What Explains Post-1980 Increases in China's Reserves?

(a) China: Financial Stability Model



(b) China: Traditional Model



Note: these two figures show the increase in reserves over 25 years for China in billions of current US dollars. The sub-sections of the bars represent the explanators of the growth. The bottom bar is the amount predicted in 1980 (constant over time). Other sub-sections allow for changes in 1 variable at a time. The second lowest is simply the change in GDP assuming all other variables remain constant, etc. The top section represents the amount that cannot be explained by the model.

Figure 3: In-Sample: What Explains Recent Increases in Reserves/GDP? Examples

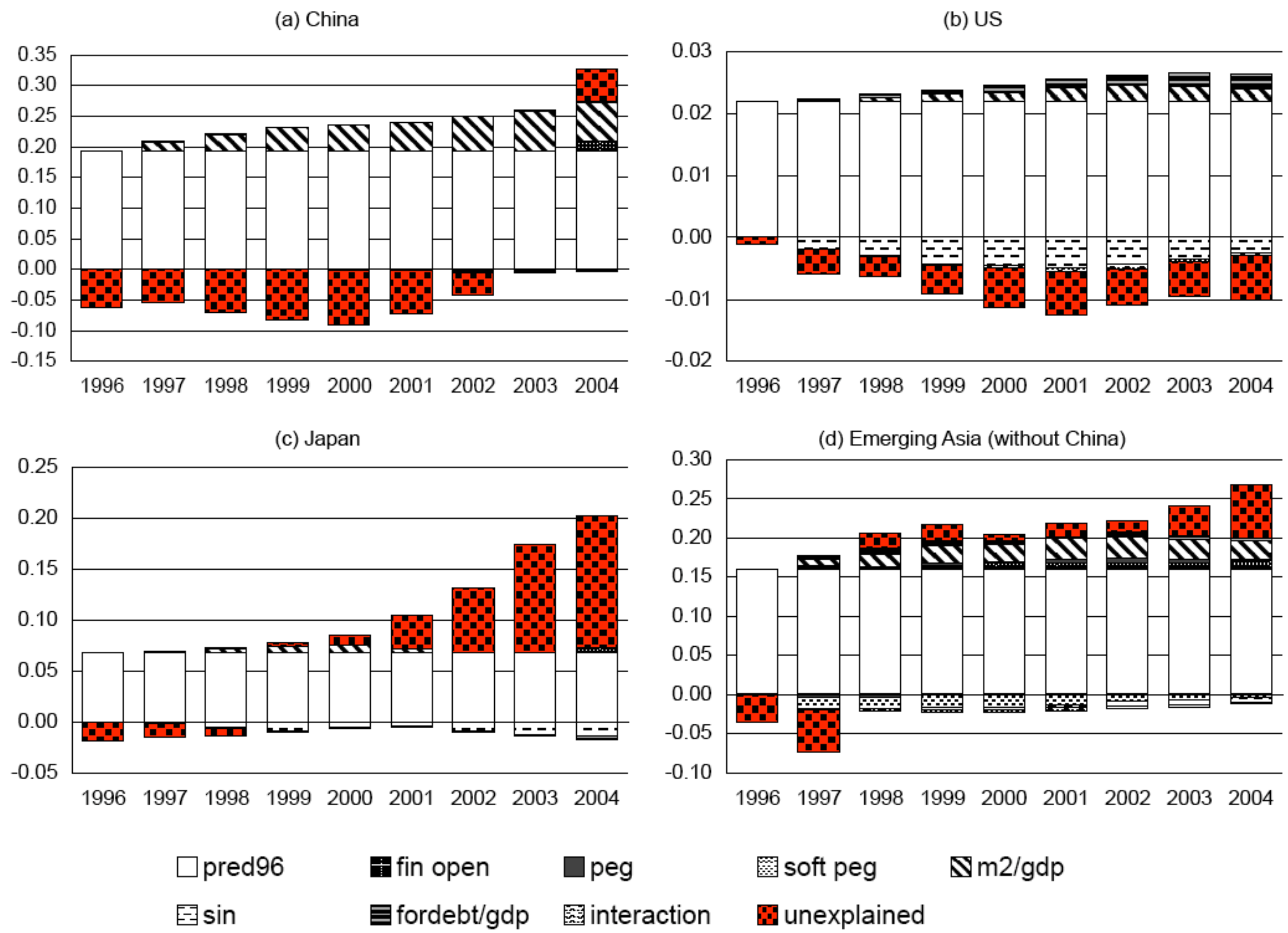
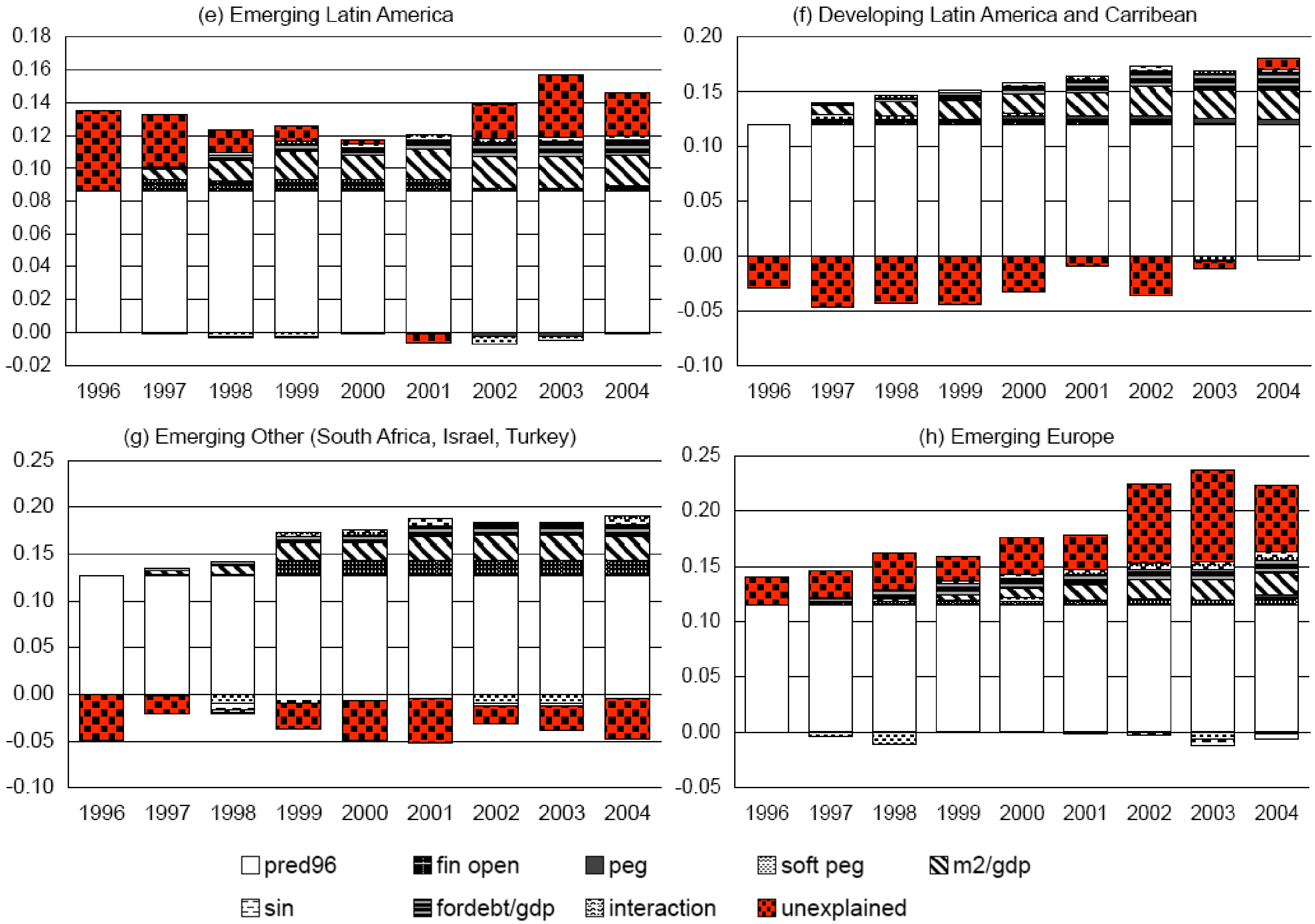


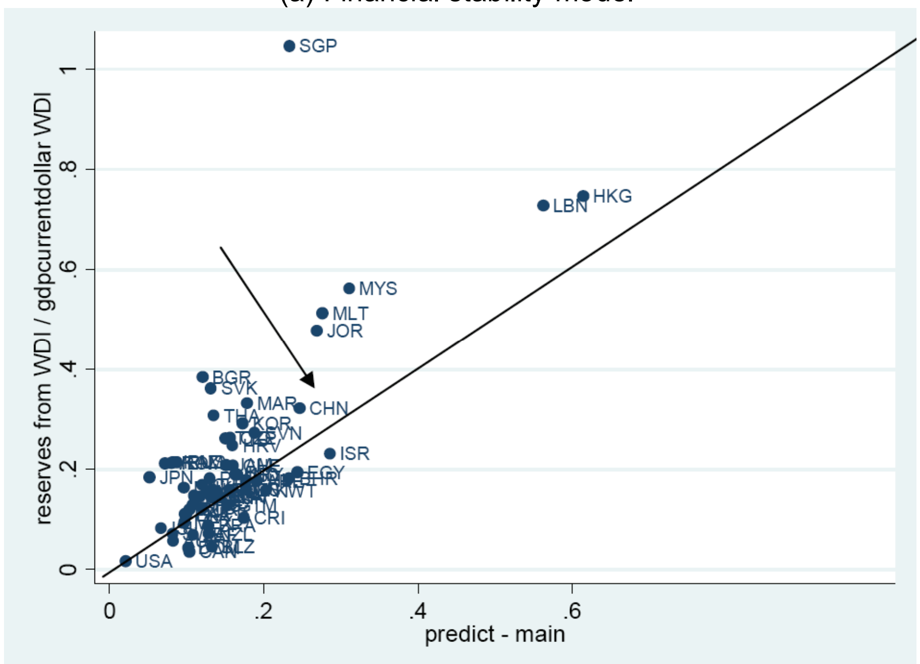
Figure 3: Continued



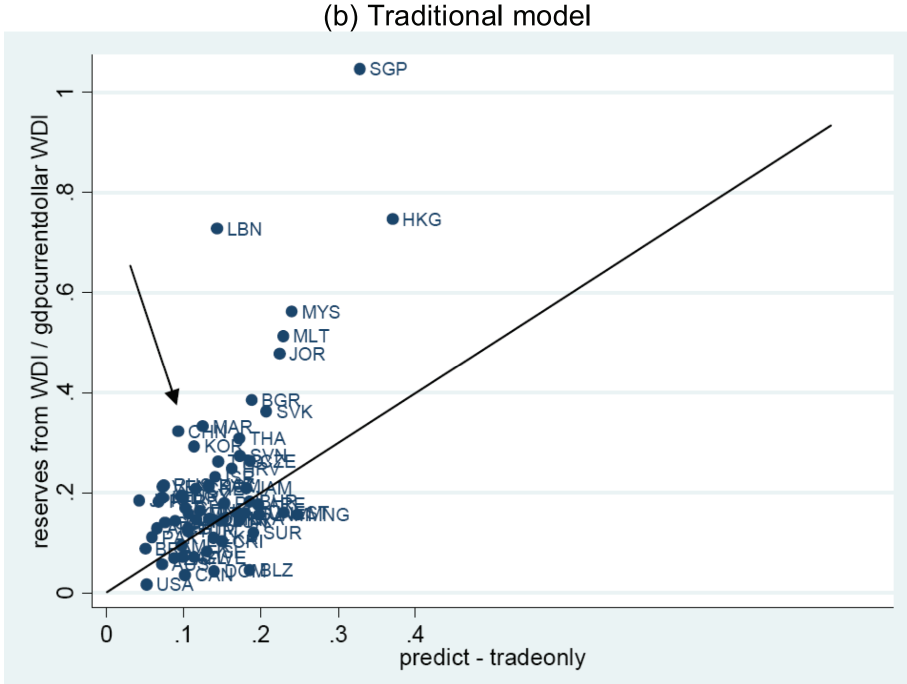
Note: these figures show the increase in reserve/GDP ratios over 9 years. The sub-sections of the bars represent the explanators of the growth. The bottom bar is the amount predicted in 1996 (constant over time). Other sub-sections allow for changes in 1 variable at a time. The second lowest is simply the change in GDP assuming all other variables remain constant, etc. The top section represents the amount that cannot be explained by the model.

Figure 4: Out-of-Sample Predictions: 2004 projected from 1993–2000

(a) Financial stability model



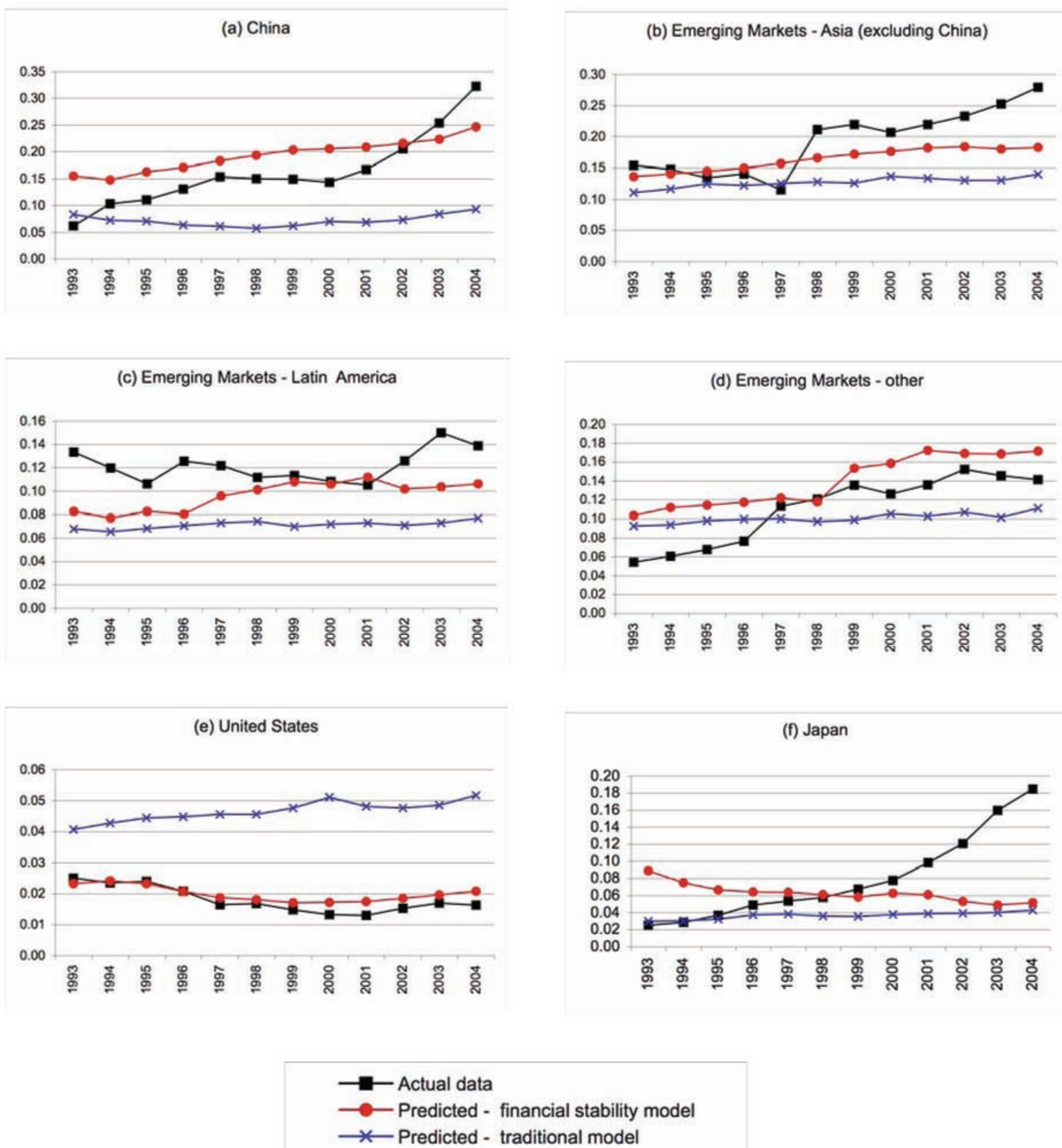
(b) Traditional model



Note: Figure (a) shows actual (y-axis) vs. predicted (x-axis) reserve/GDP ratios in 2004. Predicted values come from the financial stability model (with sin and foreign debt) estimated for 1993-2000. A regression of actual reserves on predicted yields a coefficient of 1.33 (s.e. 0.16) and R^2 of 0.52. The arrow points to China.

Figure (b) shows actual (y-axis) vs. predicted (x-axis) reserves/GDP in 2004. Predicted values come from the traditional model estimated for 1993-2000. Samples in the two figures are the same. A regression of actual reserves on predicted yields a coefficient of 1.81 (s.e. 0.28) and R^2 of 0.41. The arrow again points to China.

Figure 5: Out-of-Sample Predictions over Time



Note: These figures show the actual reserve/GDP ratios; those predicted by a financial stability model (including Sin and foreign currency debt) along the lines of Table 4, column 1 without trade included; and those predicted by a traditional one as shown in Table 1, column 1. Both models are estimated for 1993-2000. For the figures showing a combination of countries within a group, the same countries are used for all three lines and the panels are balanced (no countries enter or exit).

Data Appendix: List of Countries and Years in the Full Sample

	ifscode	country_name	type	minyear	maxyear
1	111	United States	ADV	1980	2004
2	122	Austria	ADV	1980	1997
3	124	Belgium	ADV	1980	1997
4	128	Denmark	ADV	1980	2004
5	132	France	ADV	1980	1997
6	134	Germany	ADV	1980	1998
7	136	Italy	ADV	1980	1998
8	138	Netherlands	ADV	1980	1997
9	142	Norway	ADV	1980	2003
10	144	Sweden	ADV	1980	2004
11	146	Switzerland	ADV	1980	2004
12	156	Canada	ADV	1980	2004
13	158	Japan	ADV	1980	2004
14	172	Finland	ADV	1980	1998
15	174	Greece	ADV	1980	2000
16	176	Iceland	ADV	1980	2004
17	178	Ireland	ADV	1982	1998
18	181	Malta	DEV	1980	2004
19	182	Portugal	ADV	1980	1998
20	186	Turkey	EM	1980	2004
21	193	Australia	ADV	1980	2004
22	196	New Zealand	ADV	1980	2004
23	199	South Africa	EM	1980	2004
24	213	Argentina	EM	1980	2004
25	218	Bolivia	DEV	1980	2004
26	223	Brazil	EM	1980	2004
27	228	Chile	EM	1980	2004
28	233	Colombia	EM	1980	2004
29	238	Costa Rica	DEV	1980	2004
30	243	Dominican Republic	DEV	1980	2004
31	258	Guatemala	DEV	1980	2004
32	263	Haiti	DEV	1980	2003
33	268	Honduras	DEV	1980	2004
34	273	Mexico	EM	1980	2004
35	278	Nicaragua	DEV	1980	2004
36	288	Paraguay	DEV	1980	2004
37	293	Peru	EM	1980	2004
38	298	Uruguay	DEV	1980	2004
39	299	Venezuela, RB	EM	1980	2004
40	313	Bahamas, The	DEV	1980	1987
41	316	Barbados	DEV	1980	2004
42	336	Guyana	DEV	1980	2004
43	339	Belize	DEV	1980	2004
44	343	Jamaica	DEV	1980	2004
45	366	Suriname	DEV	1980	2004
46	369	Trinidad and Tobago	DEV	1980	2004
47	419	Bahrain	DEV	1980	2004
48	423	Cyprus	DEV	1980	1999
49	429	Iran, Islamic Rep.	DEV	1980	1982
50	436	Israel	EM	1980	2004
51	439	Jordan	DEV	1980	2004
52	443	Kuwait	DEV	1980	2004
53	446	Lebanon	DEV	1989	2004
54	449	Oman	DEV	1980	2004
55	453	Qatar	DEV	1994	2004
56	456	Saudi Arabia	EM	1980	2004
57	463	Syrian Arab Republic	DEV	1980	1988
58	466	United Arab Emirates	DEV	1980	2004
59	469	Egypt, Arab Rep.	EM	1980	2004
60	474	Yemen, Rep.	DEV	1991	2004
61	513	Bangladesh	DEV	1980	2004
62	514	Bhutan	DEV	1984	2004
63	524	Sri Lanka	DEV	1980	2004
64	532	Hong Kong, China	EM	1992	2004
65	534	India	EM	1980	2004
66	536	Indonesia	EM	1980	2004
67	542	Korea, Rep.	EM	1980	2004
68	544	Lao PDR	DEV	1988	2004
69	548	Malaysia	EM	1980	2004
70	556	Maldives	DEV	1995	2004
71	558	Nepal	DEV	1980	2004
72	564	Pakistan	EM	1980	2004
73	566	Philippines	EM	1980	2004
74	576	Singapore	EM	1980	2004
75	578	Thailand	EM	1980	2004
76	582	Vietnam	DEV	1996	2004
77	611	Djibouti	DEV	1990	2004
78	612	Algeria	DEV	1980	2004
79	614	Angola	DEV	1996	2004
80	616	Botswana	DEV	1980	2004
81	618	Burundi	DEV	1980	2004
82	624	Cape Verde	DEV	1986	2003
83	632	Comoros	DEV	1983	2004
84	636	Congo, Dem. Rep.	DEV	1980	1995
85	644	Ethiopia	DEV	1981	2004
86	648	Gambia, The	DEV	1980	2004
87	652	Ghana	DEV	1980	2004
88	654	Guinea-Bissau	DEV	1987	2004
89	656	Guinea	DEV	1991	2004
90	664	Kenya	DEV	1980	2004
91	666	Lesotho	DEV	1980	2004
92	672	Libya	DEV	1980	2002
93	674	Madagascar	DEV	1980	2004
94	676	Malawi	DEV	1980	2004
95	682	Mauritania	DEV	1980	2003
96	684	Mauritius	DEV	1980	2004
97	686	Morocco	DEV	1980	2004
98	694	Nigeria	DEV	1980	2004
99	714	Rwanda	DEV	1980	2004
100	716	Sao Tome & Principe	DEV	1996	2004
101	718	Seychelles	DEV	1980	2004
102	724	Sierra Leone	DEV	1980	2004
103	728	Namibia	DEV	1992	2004
104	734	Swaziland	DEV	1980	2004
105	738	Tanzania	DEV	1990	2004
106	744	Tunisia	DEV	1980	2004
107	746	Uganda	DEV	1980	2004
108	754	Zambia	DEV	1980	2004
109	813	Solomon Islands	DEV	1980	2004
110	819	Fiji	DEV	1980	2001
111	846	Vanuatu	DEV	1981	1999
112	853	Papua New Guinea	DEV	1980	2002
113	862	Samoa	DEV	1994	2004
114	866	Tonga	DEV	1980	2004
115	911	Armenia	DEV	1996	2004
116	912	Azerbaijan	DEV	1996	2004
117	913	Belarus	DEV	1996	2004
118	914	Albania	DEV	1995	2004
119	915	Georgia	DEV	1996	2004
120	916	Kazakhstan	DEV	1996	2004
121	917	Kyrgyz Republic	DEV	1996	2004
122	918	Bulgaria	DEV	1992	2004
123	921	Moldova	DEV	1996	2004
124	922	Russian Federation	EM	1996	2004
125	923	Tajikistan	DEV	1999	2004
126	924	China	EM	1980	2004
127	926	Ukraine	DEV	1996	2004
128	935	Czech Republic	EM	1994	2004
129	936	Slovak Republic	EM	1994	2004
130	939	Estonia	EM	1996	2004
131	941	Latvia	EM	1996	2004
132	944	Hungary	EM	1983	2004
133	946	Lithuania	EM	1996	2004
134	948	Mongolia	DEV	1992	2004
135	960	Croatia	DEV	1994	2004
136	961	Slovenia	EM	1992	2004
137	962	Macedonia, FYR	DEV	1994	2004
138	963	Bosnia&Herzegovina	DEV	1998	2004
139	964	Poland	EM	1990	2004
140	968	Romania	DEV	1990	2004