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Global Current Account Imbalances and Exchange Rate Adjustments

THIS IS THE third in a series of papers we have written over the past five years about the growing U.S. current account deficit and the potentially sharp exchange rate movements any future adjustment toward current account balance might imply.[1] The problem has hardly gone away in those five years. Indeed, the U.S. current account deficit today is running at around 6 percent of GDP, an all-time record. Incredibly, the U.S. deficit now soaks up about 75 percent of the combined current account surpluses of Germany, Japan, China, and all the world's other surplus countries.[2] To balance its current account simply through higher exports, the United States would have to increase export revenue by a staggering 58 percent over 2004 levels. And, as we argue in this paper, the speed at which the U.S. current account ultimately returns toward balance, the triggers that drive that adjustment, and the way in which the burden of adjustment is allocated across Europe

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1. See Obstfeld and Rogoff (2000a, 2004). From an accounting perspective, a country's current account balance essentially adds net interest and dividend payments to its trade balance. As we discuss below, the United States presently receives about the same amount of income on its foreign assets as it pays out to foreign creditors. Hence, for the United States (and indeed many countries), the current account balance and the trade balance are quantitatively very similar. As we later emphasize, however, the current account does not include capital gains and losses on existing wealth. Thus the overall change in a country's net foreign asset position can, in principle, be less than or greater than its current account deficit or surplus.

2. Calculated from the World Economic Outlook database of the International Monetary Fund, using current account data from 2004.

and Asia all have enormous implications for global exchange rates. Each scenario for returning to balance poses, in turn, its own risks to financial markets and to general economic stability.

Our assessment is that the risks of collateral damage—beyond the risks to exchange rate stability—have grown substantially over the five years since our first research paper on the topic, partly because the U.S. current account deficit itself has grown, but mainly because of a mix of other factors. These include, not least, the stunningly low U.S. personal saving rate (which, driven by unsustainable rates of housing appreciation and record low interest rates, fell to 1 percent of disposable personal income in 2004). But additional major risks are posed by the sharp deterioration in the U.S. federal government's fiscal trajectory since 2000, rising energy prices, and the fact that the United States has become increasingly dependent on Asian central banks and politically unstable oil producers to finance its deficits. To these vulnerabilities must be added Europe's conspicuously inflexible economy, Japan's continuing dependence on export-driven growth, the susceptibility of emerging markets to any kind of global financial volatility, and the fact that, increasingly, the counterparties in international asset transactions are insurance companies, hedge funds, and other relatively unregulated nonbank financial entities. Perhaps above all, geopolitical risks and the threat of international terror have risen markedly since September 2001, confronting the United States with open-ended long-term costs for financing wars and homeland security.

True, if some shock (such as a rise in foreign demand for U.S. exports) were to close up these global imbalances quickly without exposing any concomitant weaknesses, the damage might well be contained to exchange rates and to the collapse of a few large banks and financial firms—along with, perhaps, mild recession in Europe and Japan. But, given the broader risks, it seems prudent to try to find policies that will gradually reduce global imbalances now rather than later. Such policies would include finding ways to reverse the decline in U.S. saving, particularly by developing a more credible strategy to eliminate the structural federal budget deficit and to tackle the country's actuarially insolvent old-age pension and medical benefit programs. More rapid productivity growth in the rest of the world would be particularly helpful in achieving a benign adjustment, but only, as the model we develop in this paper illustrates, if that growth is concentrated in nontraded (domestically produced and consumed) goods rather than the export sector, where such productivity growth could actually widen the U.S. trade deficit.

It is also essential that Asia, which now accounts for more than one-third of global output on a purchasing power parity basis, take responsibility for bearing its share of the burden of adjustment. Otherwise, if demand shifts caused the U.S. current account deficit to close even by half (from 6 percent to 3 percent of GDP), while Asian currencies remain fixed against the dollar, we find that European currencies would have to depreciate by roughly 29 percent. Not only would Europe potentially suffer a severe decline in export demand in that scenario; it would also incur huge losses on its net foreign asset position: Europe would lose about $1 trillion if the U.S. current account deficit were halved, and twice that sum if it went to zero.

We do not regard our perspective as particularly alarmist. Nouriel Roubini and Brad Setser make the case that the situation is far grimmer than we suggest, with global interest rates set to skyrocket as the dollar loses its status as the premier reserve currency.[3] Olivier Blanchard, Francesco Giavazzi, and Filipa Sa present an elegant and thoughtful analysis suggesting that prospective dollar exchange rate changes are even larger than those implied by our model.[4] William Cline argues that an unsustainable U.S. fiscal policy has substantially elevated the risk of an adverse scenario.[5] In our view, any sober policymaker or financial market analyst ought to regard the U.S. current account deficit as a sword of Damocles hanging over the global economy.

Others, however, hold more Panglossian views. One leading benevolent interpretation, variously called the "Bretton Woods II" model or the "Deutsche Bank" view, focuses on China; that view is forcefully exposited in this volume by Michael Dooley and Peter Garber. This theory explains the large U.S. current account deficit as a consequence of the central problem now facing the Chinese authorities: how to maintain rapid economic growth so as to soak up surplus labor from the countryside. For China, a dollar peg (or near peg) helps preserve the international competitiveness

3. Roubini and Setser (2004).
4. Blanchard, Giavazzi, and Sa (this volume).
5. Cline (forthcoming). Mann (2005), although not alarmist, also points to risks in the adjustment process. Of course, similar discussions accompanied earlier U.S. adjustment episodes, but the present situation is quite different in both scale and setting. Krugman (1985, 1991) takes as dim a view as anyone on the sustainability of long-term twin (fiscal and current account) deficits. His views on the 1980s experience would seem to apply with even greater force to the current scene.

of exports while attracting foreign direct investment and avoiding stress on the country's fragile banking system. Is this argument plausible? Set aside the fact that China maintained its peg even through the Asian financial crisis of 1997–98 and as the dollar soared at the end of the 1990s (presumably making Chinese exports much less competitive), or that China risks a classic exchange rate crisis if its fortunes ever turn, say, because of political upheaval in the transition to a more democratic system. The real weakness in the Bretton Woods II theory is that the Chinese economy is still less than half the size of Japan's, and less than three-quarters the size of Germany's, at market exchange rates. So, while running surpluses of similar size to China's relative to their GDP, Germany and Japan actually account for a much larger share of global surpluses in absolute terms. (After all, Germany, not China, is the world's leading exporter.) And surplus labor is hardly the problem in these aging countries.

U.S. Federal Reserve Chairman Alan Greenspan, in a 2003 speech at the Cato Institute and in many subsequent speeches, offers an intriguing argument.[6] He agrees that the United States is unlikely to be able to continue borrowing such massive amounts relative to its income indefinitely, and he recognizes that the U.S. current account deficit will therefore narrow substantially someday. Greenspan argues, however, that increasing global financial integration is both what allows the United States to run such large deficits and the saving factor that will greatly cushion the process of unwinding those deficits.

We completely agree that increasing global financial integration can explain larger current account deficits, particularly to the extent that greater trade integration helps underpin financial integration, as in our original analysis.[7] Indeed, this was a major point of our first approaches to this problem. A narrowing of the U.S. current account deficit must ultimately be the result, however, of more balanced trade, because the trade account is overwhelmingly the main component of the current account. And, as seemingly open as the U.S. economy is to financial flows, international product markets remain quite imperfectly integrated.

Thus any correction to the trade balance is likely to entail a very large change in the real effective dollar exchange rate: our baseline figure, which assumes a moderate speed of adjustment and that the world's major

6. Greenspan (2004).
7. Obstfeld and Rogoff (2000a, 2000b).

regions all return to current account balance, is 33 percent. A much smaller dollar devaluation is possible only if the adjustment is stretched over a very long period (say, a decade), in which case labor and capital mobility across sectors and economies can significantly reduce the need for relative price changes. On the other hand, should adjustment take place very abruptly (say, because of a sudden collapse in U.S. housing prices leading to an increase in saving, or a dramatic reallocation of global central bank reserves toward the euro), the potential fall in the dollar is much larger than our baseline estimate of 33 percent, primarily because sticky nominal prices and incomplete exchange rate pass-through hamper adjustment.

True, in a recent Federal Reserve study, Hilary Croke, Steven Kamin, and Sylvain Leduc argue that sustained current account imbalances in industrial countries have typically terminated in a relatively benign fashion.[8] But their threshold for a current account "reversal"—the country must have run a deficit of at least 2 percent of GDP for three years, and must have improved its current account balance by at least 2 percent of GDP and a third of the total deficit—is a very low bar compared with where the United States stands today. (Croke, Kamin, and Leduc are forced to choose a low threshold, of course, because current account deficits of the size, relative to GDP, of the recent U.S. deficits, although far from unprecedented, are not the norm.) Most important, the United States accounts for over 75 percent of global deficits today, as we have noted, and so any comparison based on the experience of small countries, even small industrial countries, is of limited value.

In addition to Chairman Greenspan, a number of academic researchers have emphasized how some important changes in the global financial system, particularly over the past ten years, have changed the nature of international financial adjustment. Philip Lane and Gian Maria Milesi-Ferretti, in a series of papers, have documented the explosion of gross asset flows.[9]

8. Croke, Kamin, and Leduc (2005). Freund and Warnock (2005) survey current account adjustment in industrial countries and find that deficits tend to be associated with real depreciations, which are larger for consumption-driven deficits.

9. See especially Lane and Milesi-Ferretti (2005a, 2005b). In line with this development, Cooper (2001) identifies ongoing international portfolio diversification as a driving force behind the U.S. deficit. Diversification does not, however, require any *net* capital flows: even with a balanced current account, foreigners and U.S. residents can still swap assets. According to preliminary estimates by the Bureau of Economic Analysis, for example, private foreign investors added $1.1 trillion in U.S. assets to their portfolios in 2004, far more than that year's U.S. current account deficit of $666 billion.

They and Cédric Tille, as well as Pierre-Olivier Gourinchas and Hélène Rey, have shown that asset revaluation effects from dollar depreciation can have a significant impact on U.S. net financial obligations to foreigners.[10] Gourinchas and Rey point out, in fact, that the historical extent of such revaluations suggests that the United States might need to adjust its trade balance by only two-thirds of the amount that would be needed to fully repay its net external debt; even this, however, would still imply very large dollar movements. We agree that the size and composition of gross asset positions are increasingly important, and our model simulations in this paper explicitly take account of the revaluation channel. We find, however, that valuation effects mute the requisite exchange rate changes only modestly.

The growing financial globalization that these authors and Chairman Greenspan emphasize is, moreover, a two-edged sword. Enhanced global financial integration may well facilitate gradual current account and exchange rate adjustment, but it might also promote the development of large, unbalanced financial positions that leave the world economy vulnerable to financial meltdown in the face of sharp exchange rate swings. The net foreign asset revaluation channel might help modestly, but a rise in U.S. interest rates could well wipe out the benefits. Because the United States borrows heavily in the form of low-risk bonds, while lending heavily in the form of equities and high-risk bonds, it is especially sensitive to even a modest rise in the interest rates it pays on its foreign debt. Indeed, we show that, in terms of exchange rate adjustments, the adverse effect of a 1.25-percentage-point rise in the interest rate that the United States pays on its short-term foreign debt is similar in magnitude to the benefits gained via the valuation channel, even with a 20 percent dollar depreciation. More generally, although increased global financial integration and leverage can indeed help countries diversify risk, they also expose the system to other vulnerabilities—such as counterparty risk—on a much larger scale than ever before. All in all, although we believe that growing financial globalization is largely a positive development, it does not justify excessive confidence in a benign adjustment process.

This paper begins by trying to put the recent U.S. experience with current account imbalances in historical perspective. We hope this first section will provide a useful reference, although some readers will already be famil-

10. Tille (2004); Gourinchas and Rey (2005a, 2005b).

iar with the essential elements. One historical observation that is important for our later analysis is that the United States (so far) has had the remarkable ability to consistently pay a lower rate of interest on its liabilities than it earns on its assets. Some component of this differential in returns has been due to luck, another to huge central bank holdings of U.S. Treasury bills, another perhaps to the unique and central role of the dollar in international finance. Still another, which we have already emphasized, is the fact that Americans hold a much larger share of their foreign assets in equities and high-risk (equity-like) bonds than foreigners hold of U.S. assets (and thus benefit more from the equity premium). An open question is whether this advantage can continue in the face of large and persistent U.S. deficits.

We then provide a nontechnical summary of our core three-region (Asia, Europe, and the United States) model. Readers interested in the technical details of our model can read the theoretical section that follows, and the most adventurous can venture into appendix A, where we fully lay out the structure. Our model simulations calibrate the requisite dollar decline against European and Asian currencies under various scenarios. Most of our analysis focuses on real exchange rates, but, by assuming that the regions' central banks target GDP or consumption deflators (or sometimes, in the case of Asia, exchange rates against the dollar), we are able to extract nominal exchange rate predictions (relative to the initial position) as well.

As noted earlier, our baseline simulation, in which Asia's, Europe's, and the United States' current accounts all go to zero, implies that the dollar needs to depreciate in real effective terms by 33 percent (and in nominal terms by a similar amount). Because the trade balance responds to an exchange rate change only with a lag, this exercise slightly overstates the necessary depreciation relative to today's exchange rates. However, our calibration assumes flexible prices and does not allow for possible exchange rate overshooting, which could significantly amplify the effect. A halving of the U.S. deficit, with counterpart surplus reductions shared by Asia and Europe in the same proportions as in the first simulation (arguably a more likely scenario over the short term) of complete current account adjustment, would lead to a depreciation of the real effective dollar of 17 percent. In our base case the real value of Asian currencies would need to rise by 35 percent and that of European currencies by 29 percent against the dollar.

If, however, Asia sticks to its dollar exchange rate peg as the U.S. current account deficit narrows, the real effective value of the European currencies would have to rise by almost 60 percent. Indeed, to maintain its dollar peg in the face of global demand shifts that fully restore U.S. current account balance, Asia would actually have to better than double its already massive current account surplus. Even halving these numbers (corresponding, for example, to the case in which the U.S. current account deficit falls only by half), one can still appreciate the enormous protectionist pressures that are likely to emerge if Asia tries to stick to its dollar peg in the face of a significant pullback in the United States' voracious borrowing.

It is perhaps surprising that, despite Asia's current account surplus being several times that of Europe (which we define broadly here to include the euro zone and the other largest non-Asian, non-U.S. economies), the required rise in the Asian currencies relative to the European currencies is not even larger in the global rebalancing scenario. As we shall see, a couple of factors drive this result: one is that Asia's economies are relatively more open than Europe's to the rest of the world, so that a given exchange rate change has a bigger impact on trade; the other is that a large, unanticipated dollar depreciation inflicts brutal damage on Asia's net foreign asset position, a factor we explicitly incorporate in our calibrations.

The analysis highlights two important but widely misunderstood points about the mechanism of U.S. current account deficit reduction. First, real dollar depreciation is not a substitute for policies that raise U.S. saving, such as reductions in the federal fiscal deficit. Instead, depreciation and saving increases are complements: exchange rate changes are needed to balance goods markets after a change in global consumption patterns, whereas dollar depreciation that is not accompanied by U.S. expenditure reduction will lead to inflationary pressures that, over time, will offset the initial gains in U.S. competitiveness. The second, and related, point is that it makes little sense to ask how much dollar depreciation is needed to reduce the current account deficit by 1 percent of GDP. Exchange rates and current account balances are jointly determined endogenous variables. As the simulations in this paper illustrate, there are numerous different scenarios in which the U.S. external deficit might be erased, all with different implications for the dollar's foreign exchange value.

Although our model is considerably richer than those previously advanced in the literature (including our own earlier studies), it remains subject to a wide range of qualifications and interpretations; we try to emphasize the most important ones. Nevertheless, we view the simulations as quite useful. The paper's final section highlights the main conclusions that we draw from the technical analysis.

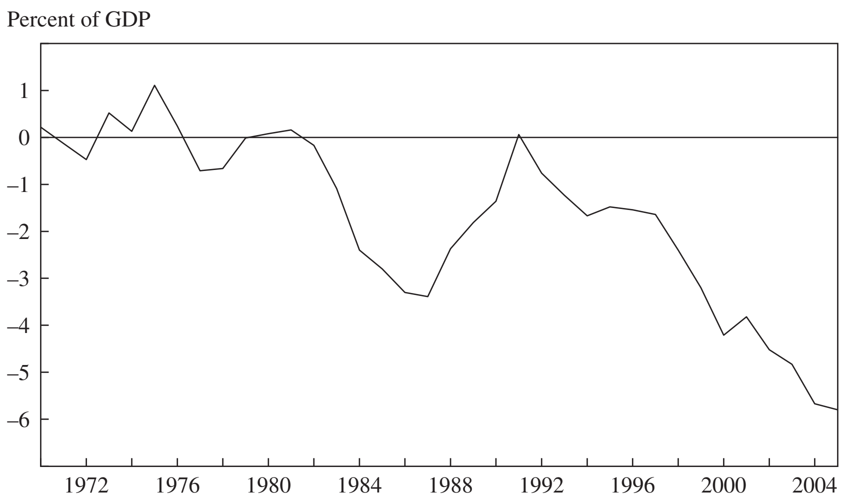
The U.S. Current Account and Foreign Wealth Position, 1970–2005 and Beyond

The main analytical contribution of the paper is its modeling and numerical calibration of exchange rate and net foreign asset valuation adjustments under alternative scenarios for reducing the U.S. current account deficit. Our framework is intended as a tool for assessing risks and evaluating policy options. At some level, however, the exercise must entail an assessment of how unstable the current trajectory of external payments imbalances really is, along with the likelihood of adjustment taking place in the next few years. In order to think about this overarching issue, it is helpful to understand the history of the problem.

Perspectives on the U.S. Deficit

Figure 1 traces the U.S. current account balance as a percent of GDP from 1970 to the present. After fluctuating between +1 and −1 percent of GDP during the 1970s, the current account began to go into deep deficit during the mid-1980s, reaching 3.4 percent of GDP in 1987. After recovering temporarily at the end of the 1980s and actually attaining a slight surplus

Figure 1. Current Account, 1970–2005[a]



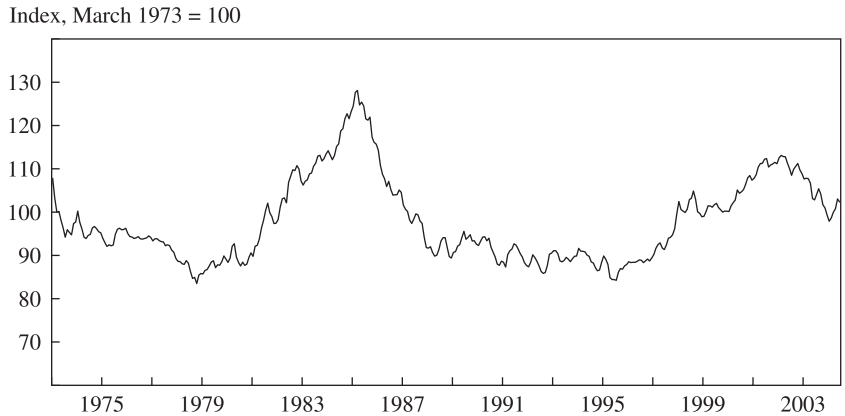
Source: Bureau of Economic Analysis, National Income and Product Accounts, International Transactions Accounts.
a. Data for 2005 are projections.

in 1991 (propped up by a large, one-time transfer from foreign governments to help pay for the Gulf War), the U.S. current account balance began a slow, steady deterioration throughout the 1990s, which continues today. As already noted, U.S. international borrowing in 2004 accounted for about 75 percent of the excess of national saving over investment of all the world's current account surplus countries.

What are the proximate causes of this profound deterioration in the U.S. external balance? That, of course, is the $666 billion (and rising) question. Since, in principle, the current account balances of all countries should add up to zero, the U.S. current account deficit—equal to the excess of U.S. investment over national saving—has to be viewed as the net result of the collective investment and saving decisions of the entire world. German demographics, OPEC oil revenue investment decisions, depressed investment in Asia—all these factors and many others impinge on global interest rates and exchange rates and, in turn, on U.S. investment and saving. We do not believe there is any simple answer.

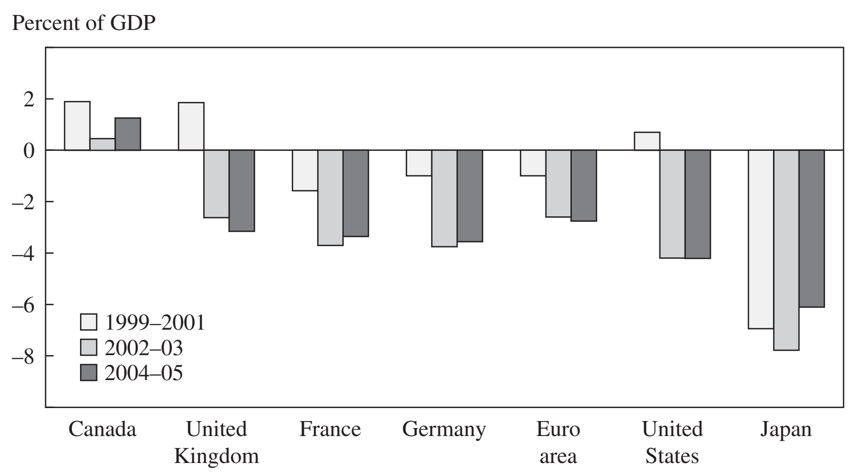
Nevertheless, U.S. fiscal policy clearly has played a dominant role in some episodes. The current account balance equals, by definition, the sum of government saving less investment plus private saving less investment. Because the Ricardian equivalence of public debt and taxes does not seem to hold in practice, the big Reagan tax cuts of the 1980s almost certainly played a role in the U.S. current account deficits of that era. Similarly, the Bush II tax cuts of the 2000s have likely played a role over the past few years, preventing the current account deficit from shrinking despite the post-2000 collapse in U.S. investment. Currency over- and undervaluations also loomed large in both episodes, usually operating with a lag of one to two years. For example, the peak of the U.S. current account deficit in 1987 lagged by two years the peak of the real trade-weighted dollar exchange rate (figure 2). The weak dollar of the mid-1990s was matched by a pause in the U.S. current account's decline, and the dollar peak in early 2002 was followed again, with some lag, by a sharp worsening in the external balance. Admittedly, both correlations with the current account deficit—of fiscal deficits and dollar appreciation—are fairly loose. As figure 3 illustrates, U.S. fiscal deficits have expanded massively in recent years compared with those of the rest of the world. But, as the figure also illustrates, Japan has run even larger fiscal deficits relative to its GDP than the United States, yet at the same time it has consistently run the world's largest current account surplus in absolute terms.

Figure 2. Real Effective Exchange Rate of the Dollar, 1973–2004[a]



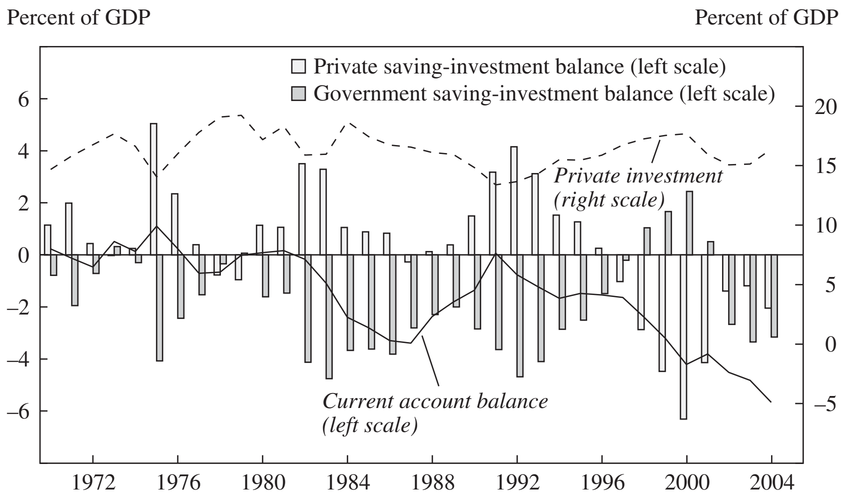
Source: Federal Reserve data.
a. Broad currency index.

Figure 3. Fiscal Balances in Selected Major Economies[a]



Source: *2005 OECD Factbook, OECD Economic Outlook* No. 77.
a. The data are on a national accounts basis, averaged across years indicated.

Figure 4. U.S. Current Account, Saving, and Investment, 1970–2004



Source: Bureau of Economic Analysis data.

Indeed, during the 1990s the major proximate drivers of the U.S. current account balance were a declining rate of private saving and rising rate of investment. The U.S. personal saving rate, which had been stable at around 10 percent of disposable personal income until 1985, has steadily declined since, reaching a mere 1 percent in 2004. The declining private saving rate has apparently been driven first by the stock price boom of the 1990s and then by the still-ongoing housing price boom.[11] Were the U.S. personal saving rate simply to rise to 5 percent of disposable personal income, or halfway toward its level of two decades ago, more than half of today's current account deficit could be eliminated.

During the late 1990s U.S. investment was robust, as shown in figure 4, so that the United States' high external borrowing really was, in principle, financing future growth. Today, however, the picture has changed. As figure 4 also shows, the main proximate driver of recent U.S. current account deficits has been low private and government saving rather than high

11. Obviously, if one measures saving taking into account capital gains and losses on wealth, the trend decline in saving is much less, although housing wealth is largely not internationally tradable and both housing and securities wealth can evaporate quickly.

investment. So much for the prominent view of former Treasury secretary Paul O'Neill, who argued that the U.S. external deficit was driven mainly by foreigners' desire to invest in productive U.S. assets. The more sophisticated analysis of Jaume Ventura is also inconsistent with declining U.S. investment.[12]

Another important factor contributing to the U.S. current account deficit since the late 1990s has been the persistently low level of investment in Asia since the region's 1997–98 financial crisis. Indeed, today, sluggish investment demand outside the United States, particularly in Europe and Japan but also in many emerging markets, is a major factor holding global interest rates down. Low global interest rates, in turn, are a major driver in home price appreciation, which, particularly in the United States with its deep, liquid home-equity loan markets, contributes to high consumption.

International Assets, Liabilities, and Returns

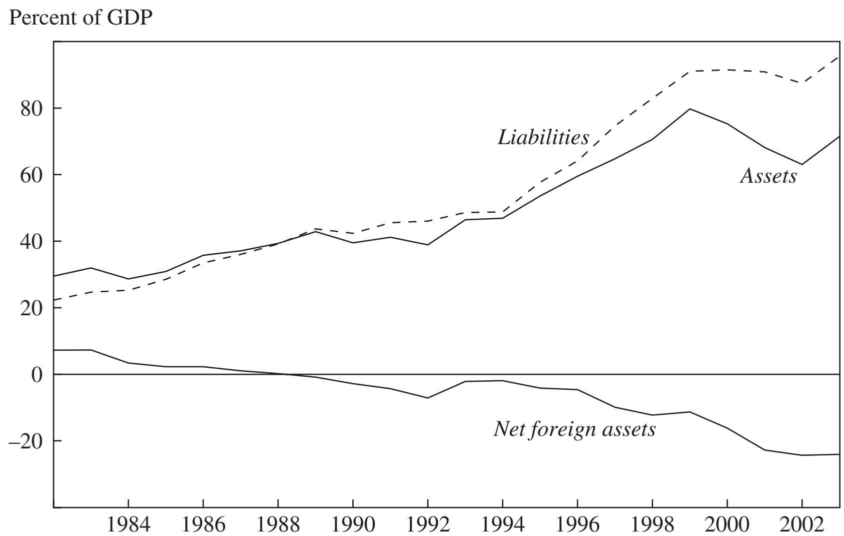
Naturally, this sustained string of current account deficits has led to a deterioration in the United States' net foreign asset position, as illustrated in figure 5. In 1982 the United States held net foreign assets equal to just over 7 percent of GDP, whereas now the country has a net foreign debt amounting to about 25 percent of GDP. Accompanying this growth in net debt has been a stunning increase in *gross* international asset and liability positions, as figure 5 also shows. From 29.5 percent and 22.3 percent of GDP in 1982, U.S. gross foreign assets and liabilities, respectively, had risen to 71.5 percent and 95.6 percent of GDP by the end of 2003. This process of increasing international leverage—borrowing abroad in order to invest abroad—characterizes other industrial country portfolios and is in fact much further advanced for some smaller countries such as the Netherlands and primary financial hubs such as the United Kingdom; see table 1 for some illustrative comparative data.[13]

The implications of the reduction in U.S. net foreign wealth would be darker but for the fact that the United States has long enjoyed much better

12. Ventura (2001).

13. See also Lane and Milesi-Ferretti (2005a, 2005b) and Obstfeld (2004). The BEA applies market valuation to foreign direct investment holdings starting only in 1982. Gourinchas and Rey (2005b) construct U.S. international position data going back to 1952. In 1976, with foreign direct investment valued at current cost rather than at market value, U.S. gross foreign assets amounted to 25 percent of GDP, and gross foreign liabilities were 12.6 percent of GDP.

Figure 5. U.S. Foreign Assets and Liabilities, 1982–2003



Source: Bureau of Economic Analysis data.

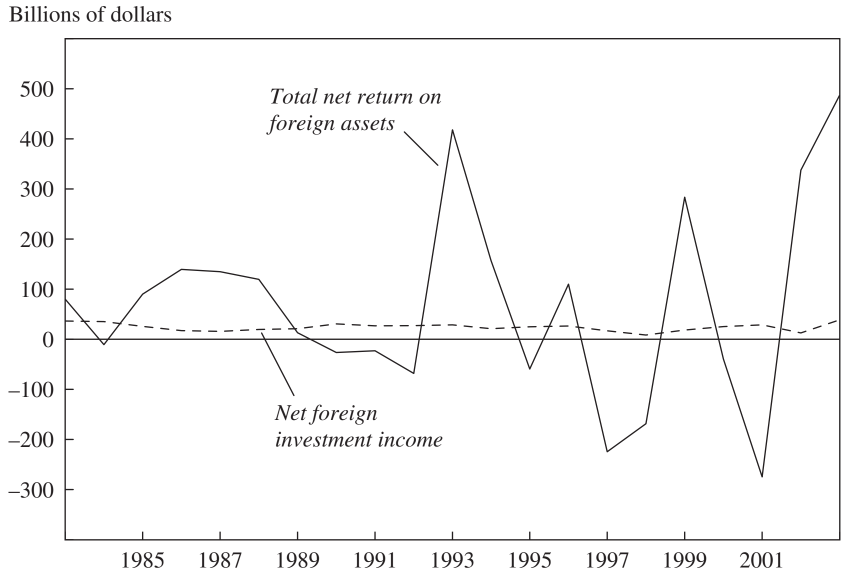
investment performance on its foreign assets than have foreign residents on their U.S. assets. This rate-of-return advantage, coupled with the expansion in foreign leverage documented in figure 5, has so far allowed the United States to maintain a generally positive balance of net international investment income even as its net international investment position has become increasingly negative. Figure 6 shows two measures of U.S.

Table 1. International Investment Positions of Selected Industrial Countries, 2003
Percent of GDP[a]

Country	*Gross assets*	*Gross liabilities*	*Net position*
Canada	75	93	−18
Euro area	107	118	−10
France	179	172	7
Germany	148	141	6
Italy	95	100	−5
Japan	87	48	39
Switzerland	503	367	135
United Kingdom	326	329	−2

Source: International Monetary Fund, International Financial Statistics.
a. Gross assets may differ from the sum of gross liabilities and the net position because of rounding.

Figure 6. U.S. Net Foreign Investment Income and Total Net Return on Foreign Assets, 1983–2003



Source: Bureau of Economic Analysis, National Income and Product Accounts, International Transactions Accounts.

net international investment income.[14] The first, net foreign investment income (income receipts on U.S. assets owned abroad less income payments on foreign-owned assets in the United States), is taken from the U.S. balance of payments accounts and comprises transactions data only, that is, actual income earned on assets. Interestingly, this balance has not yet entered negative territory, although it could do so soon. Over 1983–2003 the income return on U.S.-owned assets exceeded that on U.S. liabilities by 1.2 percentage points a year on average.

A more comprehensive investment income measure adds the capital gains on foreign assets and liabilities, reflecting price changes that could be due to either asset price movements (such as stock price changes) or exchange rate changes. The Bureau of Economic Analysis (BEA) incorporates estimates

14. Gourinchas and Rey (2005b) present a similar graph covering a much longer period. The estimates in the text are consistent with those found by Obstfeld and Taylor (forthcoming) using a different methodology. For a complementary discussion of returns on foreign assets and liabilities, see Lane and Milesi-Ferretti (2005b).

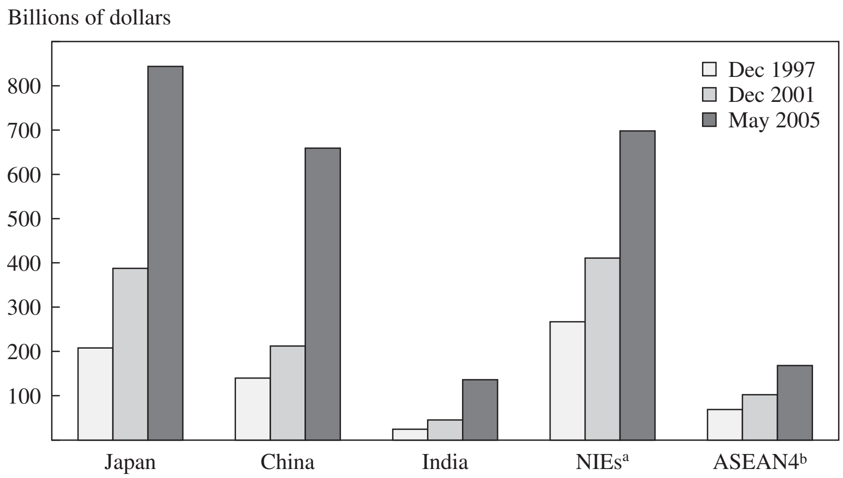
of these gains into its updates of the U.S. international investment position, although they do not appear in the international transactions or national income accounts. As one would expect, figure 6 shows this net income measure to be much more volatile than that based on investment income alone. Although it is negative in some years, cumulatively this balance is even more favorable for the United States than the smoother transactions measure. On average over 1983–2003, the total return on the United States' foreign investment, inclusive of capital gains, exceeded that on U.S. liabilities to foreigners by a remarkable 3.1 percentage points a year.[15]

To understand better the implications of the U.S. rate-of-return advantage, let r^W be the rate of return on foreign assets, r^U the rate of return on liabilities, F the stock of net foreign assets, and L gross liabilities. Then the net total return on the international portfolio is $r^W F + (r^W - r^U)L$. This expression shows that, even when $F < 0$ as it is for the United States, total investment inflows can still easily be positive when $r^W > r^U$ and the stock of gross liabilities is sufficiently large. The expression also reveals, however, that the leveraging mechanism generating the U.S. surplus on investment returns also heightens the risk associated with a possible reversal. An unresolved but critical question is whether the United States' favorable position in international markets will be sustained in the face of a large and growing external debt. Should the United States at some point be forced to pay a higher rate on its liabilities, the negative income effect will be proportional to the extent of leverage, L.

Part of the historical U.S. international investment advantage is a matter of chance and circumstance. Japanese investors famously bought trophy properties like Pebble Beach golf club, Rockefeller Center, and Columbia Pictures at premium prices, only to see those investments sour. Europeans poured money into the U.S. stock market only at the end of the 1990s, just as the technology bubble was about to burst. However, a deeper reason why the United States' net debt position has accumulated only relatively slowly is that Americans hold a considerably larger fraction of their foreign assets

15. The broad rate-of-return measures for gross assets and liabilities are constructed by adding to the investment income flow the total capital gain on the previous end-of-period assets (or liabilities) and then dividing this total return by the previous value of assets (or liabilities). Thus, in 2003, a year in which the dollar depreciated, the rate of return on U.S. foreign assets was 19 percent, and that on liabilities 8.4 percent. Total capital gains are calculated by subtracting the change in U.S.-owned assets abroad (change in foreign-owned assets in the United States), as reported in the financial account, from the change in U.S. foreign assets (liabilities) at market value, as reported in the BEA international position data.

Figure 7. Foreign Exchange Reserves, Selected Countries, Various Years



Sources: *The Economist,* Ministry of Finance of Japan.
a. Newly industrializing economies (Brazil, Hong Kong, Korea, Singapore, Taiwan).
b. Four members of the Association of Southeast Asian Nations (Indonesia, Malaysia, Philippines, Thailand).

in equities (both portfolio equity and foreign direct investment) than do foreigners of their U.S. assets. At the end of 2003, Americans held almost $7.9 trillion in foreign assets, of which 60 percent was in equities, either foreign stocks or foreign direct investment (here measured at market value). Foreigners, by contrast, held only 38 percent of their $10.5 trillion in U.S. assets in the form of equity. Given that equity has, over long periods, consistently paid a significant premium over bonds, it is not surprising that U.S. residents have remained net recipients of investment returns even though the United States apparently crossed the line to being a net debtor in the late 1980s.

A major reason why foreigners hold relatively more U.S. bonds than Americans hold foreign bonds is that the dollar remains the world's main reserve and vehicle currency. Indeed, of the $3.8 trillion in international reserves held by central banks worldwide, a very large share is in dollars, and much of it is in short-term instruments.[16] Figure 7 illustrates the burgeoning reserves of Asia, now in excess of $2 trillion. According to the

16. See the survey in *Central Banking,* "The Rise of Reserve Management," March 2005, p. 14.

BEA, over 45 percent of the $700 billion stock of dollar currency is held abroad, and this is probably an underestimate.[17] (Note that, when one speaks of the United States enjoying rents or seigniorage from issuing a reserve currency, the main effects may come from foreigners' relative willingness to hold cash or liquid short-term Treasury debt, rather than from any substantial inherent U.S. interest rate advantage.) In any event, our empirical analysis will take account of the systematically lower return on U.S. liabilities than on assets elsewhere, and will ask what might happen should that advantage suddenly disappear in the process of current account reversal.[18]

At present, as we have noted, the net U.S. foreign debt equals about 25 percent of GDP. This ratio already roughly equals the previous peak of 26 percent, reached in 1894. A simple calculation shows that if U.S. nominal GDP grows at 6 percent a year and the current account deficit remains at 6 percent of nominal GDP, the ratio of U.S. net foreign debt to GDP will asymptotically approach 100 percent. Few countries have ever reached anywhere near that level of indebtedness without having a crisis of some sort.[19]

If large, sudden exchange rate movements are possible, the greater depth of today's international financial markets becomes a potential source of systemic stress. As we have documented, the volume of international asset trading is now vast. Although many participants believe themselves to be hedged against exchange rate and interest rate risks, the wide range of lightly regulated or unregulated nonbank counterparties now operating in the markets raises a real risk of cascading financial collapse. In a world where a country's current account may adjust abruptly, bringing with it large changes in international relative prices, a persistently large U.S. deficit constitutes an overhanging systemic threat.

A sober assessment of present global imbalances suggests the need for a quantitative analysis of how a U.S. current account adjustment would affect exchange rates. We take this up next.

17. See Porter and Judson (1996).

18. Of course, multinationals' practice of income shifting in response to differing national tax rates on profits distorts reported investment income flows, making an accurate picture of the true flows difficult to obtain. See, for example, Grubert, Goodspeed, and Swenson (1993) and Harris and others (1993). The expansion of gross international positions over the past decade may have worsened this problem.

19. Obstfeld and Rogoff (2000a).

Summary of the Analytical Framework

Here we summarize the main features and mechanisms in our analysis. After reading this section, readers who are primarily interested in our exchange rate predictions can skip the following section, which presents the details of the model, and proceed directly to the discussion of our numerical findings.

We work within a three-region model of a world economy consisting of the United States, Europe, and Asia. These regions are linked by trade and by a matrix of international asset and liability positions. Each region produces a distinctive export good, which its residents consume along with imports from the other two regions. In addition, each region produces non-traded goods, which its residents alone consume.

A key but realistic assumption is that each country's residents have a substantial relative preference for the traded good that is produced at home and exported; that is, consumption of traded goods is intensive in the home export, creating a home bias in traded goods consumption. This feature builds in a "transfer effect" on the terms of trade, which provides one of the key mechanisms through which changes in the international pattern of current account balances change real and nominal exchange rates. A reduction in the U.S. current account deficit, if driven by a fall in U.S. spending and a matching rise in U.S. saving, represents a shift in world demand toward foreign traded goods, which depresses the price of U.S. exports relative to that of imports from both Asia and Europe. (The international terms of trade of the United States deteriorate.) Because the U.S.-produced export good has a larger weight in the U.S. consumer price index (CPI) than that of foreign imports, whereas foreign export goods similarly have larger weights in their home countries' CPIs, the result is both a real and a nominal depreciation of the dollar.

This terms-of-trade effect of current account adjustment has been prominent in the literature, but it is potentially less important quantitatively than is a *second* real exchange rate effect captured in our model. That effect is the impact of current account adjustment on the prices of *nontraded* goods. The CPI can be viewed as made up of individual sub-CPIs for traded and nontraded goods, with the latter empirically having about three times the weight of the former in the overall CPI, given the importance of nontraded service inputs into the delivery even of traded products to consumers. The real exchange rate between two currencies is the ratio of the issuing countries' overall CPIs, both expressed in a common currency. Thus a fall in a country's prices for nontraded goods, relative to the same-currency price of nontraded goods abroad, will depress its relative price level just as a terms-of-trade setback does, causing both a real and a nominal depreciation of its currency. Because nontraded goods are so important a component of the CPI, ignoring effects involving their prices would omit much of the effect of current account adjustment on exchange rates. Hence this additional mechanism, absent from much of the policy discussion, is critical to include.

When the U.S. external deficit falls as a result of a cut in domestic consumption, part of the reduction in demand falls on traded goods (exports as well as imports), but much of it falls on U.S. nontraded goods. The consequent fall in the nontraded goods' prices reinforces the effect of weaker terms of trade in causing the dollar to depreciate against the currencies of Europe and Asia. As noted, in our calibration this second effect receives more than twice the weight that terms-of-trade effects receive in explaining exchange rate movements.

We consider several scenarios for U.S. current account adjustment, involving different degrees of burden sharing by Europe and Asia and the resulting effect on those regions' bilateral and effective exchange rates. For example, if Europe's deficit rises to offset a fall in America's deficit, while Asia's surplus remains constant, the dollar will depreciate more against Europe's currencies, and less against Asia's, than if Asia and Europe shared in the burden of accommodating the U.S. return to external balance. In terms of its trade-weighted effective exchange rate, the dollar depreciates more under the second of these two scenarios. Because Asia trades more with the United States than Europe does, bilateral depreciation against Asia's currencies plays the more important role in determining the effective depreciation.

We also consider the effect of dollar exchange rate changes in revaluing gross foreign asset positions, thus redistributing the burden of international indebtedness, as well as the possibility that the adjustment process, especially if disorderly, could entail higher interest payments abroad on U.S. short-term foreign obligations. Finally, key parameters in our model govern the substitutability in consumption among various traded goods and between traded and nontraded goods. In general, the lower these substitution elasticities, the greater the relative price changes caused by current account adjustment and the greater, therefore, the resulting terms-of-trade and exchange rate responses. Because the values of these elasticities are quite uncertain and can differ between the short and the long run, we quantitatively examine their role in generating our numerical estimates.

The Model

The three-country endowment model we develop here extends our earlier small-country and two-country frameworks.[20] We label the three countries (or regions), whose sizes can be flexibly calibrated, *U* (for the United States), *E* (for Europe), and *A* (for Asia). The model distinguishes both between home- and foreign-produced traded goods and between traded and nontraded goods (with the latter margin, largely ignored in many discussions of the U.S. current account deficit, turning out to be the more important of the two quantitatively in our simulations). Our focus here will be on articulating the new insights that can be gained by going from two countries to three, particularly in understanding different scenarios of real exchange rate adjustment across regions as the current account deficit of the United States falls to a sustainable level.

Four features of our model are of particular interest. First, by assuming that endowments are given exogenously for the various types of outputs, we implicitly assume that capital and labor are not mobile between sectors in the short run. To the extent that global imbalances close only slowly over long periods (which experience suggests is not the most likely case), factor mobility across sectors will mute any real exchange rate effects.[21] Second, we do not allow for changes in the mix of traded goods produced or for the endogenous determination of the range of nontraded goods, two factors that would operate over the longer run and could also mute the effects on real exchange rates of current account movements. Third, our main analysis assumes that nominal prices are completely flexible. That assumption—in contrast to our assumption on factor mobility—almost surely leads us to understate the likely real exchange rate effects of a current account reversal. As we discuss later, with nominal rigidities and imperfect pass-through from exchange rates to prices, the exchange rate will need to move more, and perhaps much more, than in our base

20. See Obstfeld and Rogoff (2000a and 2004, respectively).
21. Obstfeld and Rogoff (1996).

case in order to maintain employment stability. Fourth, we do not explicitly model the intertemporal allocation of consumption, but rather focus on the intratemporal price consequences of alternative patterns of production-consumption imbalances.

The Core Model

Although notationally intricate, our core three-region model is conceptually quite simple. We assume that consumers in each of the three regions allocate their spending between traded and nontraded goods. Within the category of traded goods, they choose among goods produced in each of the three regions. The equilibrium terms of trade and the relative price of traded and nontraded goods (and thus both bilateral and effective real exchange rates) are determined endogenously. Given assumptions about central bank policy (depending, for example, on whether the central bank aims to stabilize the CPI deflator, the GDP deflator, or a bilateral exchange rate), the model can also generate nominal exchange rates.

We begin by defining $C^i_j \equiv$ country i consumption of good (or good category) j. The comprehensive country i consumption index depends on U.S., European, and Asian traded goods consumption (T), as well as consumption of domestic nontraded goods (N). It is written in the following nested form:

(1) $$C^i = \left[\gamma^{\frac{1}{\theta}}\left(C^i_T\right)^{\frac{\theta-1}{\theta}} + (1-\gamma)^{\frac{1}{\theta}}\left(C^i_N\right)^{\frac{\theta-1}{\theta}}\right]^{\frac{\theta}{\theta-1}}, \quad i = U, E, A,$$

with

(2) $$C^U_T = \left[\alpha^{\frac{1}{\eta}}\left(C^U_U\right)^{\frac{\eta-1}{\eta}} + (\beta-\alpha)^{\frac{1}{\eta}}\left(C^U_E\right)^{\frac{\eta-1}{\eta}} + (1-\beta)^{\frac{1}{\eta}}\left(C^U_A\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

$$C^E_T = \left[\alpha^{\frac{1}{\eta}}\left(C^E_E\right)^{\frac{\eta-1}{\eta}} + (\beta-\alpha)^{\frac{1}{\eta}}\left(C^E_U\right)^{\frac{\eta-1}{\eta}} + (1-\beta)^{\frac{1}{\eta}}\left(C^E_A\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}$$

$$C^A_T = \left[\delta^{\frac{1}{\eta}}\left(C^A_A\right)^{\frac{\eta-1}{\eta}} + \left(\frac{1-\delta}{2}\right)^{\frac{1}{\eta}}\left(C^A_E\right)^{\frac{\eta-1}{\eta}} + \left(\frac{1-\delta}{2}\right)^{\frac{1}{\eta}}\left(C^A_U\right)^{\frac{\eta-1}{\eta}}\right]^{\frac{\eta}{\eta-1}}.$$

We do not assume identical preferences in the three countries. On the contrary, we wish to allow, both in defining real exchange rates and in assessing the effects of shocks, for a realistic home bias in traded goods consumption, such that each country has a substantial relative preference for the traded good that it produces and exports abroad.[22] Home consumption bias gives rise to a "transfer effect," whereby an increase in relative national expenditure improves a country's terms of trade, that is, raises the price of its exports relative to that of its imports.

In the equations above, the United States and Europe are "mirror symmetric" in their preferences for each other's goods, but each attaches the same weight to Asian goods. Asia weights U.S. and European imports equally but may differ in openness from the United States and Europe. Specifically, we assume that $1 > \beta > \alpha > ½$. We also assume that $\delta > ½$. For example, if $\beta = 0.8$ and $\alpha = 0.7$, then the U.S. traded goods consumption basket has a weight of 0.7 on U.S. exports, 0.1 on European exports, and 0.2 on Asian exports. (A very similar—and for many exercises isomorphic—model arises if one assumes that all countries have identical preferences, but that international trading costs are higher than domestic trading costs.)[23]

The values of the two parameters θ and η are critical in our analysis. Parameter θ is the (constant) elasticity of substitution between traded and nontraded goods. Parameter η is the (constant) elasticity of substitution between domestically produced traded goods and imports from either foreign region. The two parameters are important because they underlie the magnitudes of price responses to quantity adjustments. Lower substitution elasticities imply that sharper price changes are needed to accommodate a given change in quantities consumed.

Price Indexes and Real Exchange Rates

Using standard methods, we derive exact consumption-based price indexes.[24] Define $P_j^i \equiv$ the country i exact price index for consumption category j. The corresponding overall CPIs, in dollars, are

$$P_C^i = \left[\gamma\left(P_T^i\right)^{1-\theta} + (1-\gamma)\left(P_N^i\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}, \; i = U, E, A, \tag{3}$$

22. Warnock (2003) also takes this approach.
23. Obstfeld and Rogoff (2000b).
24. See, for example, Obstfeld and Rogoff (1996).

where subscript C denotes the comprehensive consumption basket. (Our main analysis is in terms of real prices and exchange rates, so all prices can be expressed in terms of the common numeraire.) In equation 3,

$$(4)\qquad \begin{aligned} P_T^U &= \left[\alpha P_U^{1-\eta} + (\beta - \alpha) P_E^{1-\eta} + (1-\beta) P_A^{1-\eta}\right]^{\frac{1}{1-\eta}} \\ P_T^E &= \left[\alpha P_E^{1-\eta} + (\beta - \alpha) P_U^{1-\eta} + (1-\beta) P_A^{1-\eta}\right]^{\frac{1}{1-\eta}} \\ P_T^A &= \left[\delta P_A^{1-\eta} + \left(\frac{1-\delta}{2}\right) P_U^{1-\eta} + \left(\frac{1-\delta}{2}\right) P_E^{1-\eta}\right]^{\frac{1}{1-\eta}}. \end{aligned}$$

Here P_i, $i = U, E, A,$ is just the price of the differentiated traded good produced by country i.

We assume the law of one price for traded goods, so that the price of any given country's traded good is the same in all regions. (In practice, of course, the law of one price holds mainly in the breach, partly because of the difficulties in separating out the truly tradable component of "traded" goods.) Because of the home export consumption bias we have assumed, the price indexes for traded goods P_T^i can differ across countries even when the law of one price holds, reflecting the asymmetric consumption weightings. As a result, changes in the terms of trade, through their differential effects on countries' price levels for traded goods, affect real exchange rates.

There are three bilateral terms of trade, three bilateral real exchange rates, and three real effective exchange rates. The terms of trade are

$$(5)\qquad \tau_{U,E} = \frac{P_E}{P_U},\ \tau_{U,A} = \frac{P_A}{P_U},\ \tau_{E,A} = \frac{P_A}{P_E} = \frac{\tau_{U,A}}{\tau_{U,E}}.$$

Here, for example, a rise in $\tau_{U,E}$ is a rise in the price of European traded goods in terms of U.S. traded goods, that is, a deterioration in the U.S. terms of trade. Bilateral real exchange rates are

$$(6)\qquad q_{U,E} = \frac{P_C^E}{P_C^U},\ q_{U,A} = \frac{P_C^A}{P_C^U},\ q_{E,A} = \frac{P_C^A}{P_C^E} = \frac{q_{U,A}}{q_{U,E}}.$$

A rise in $q_{U,E}$, for example, is a rise in the price of the European consumption basket in terms of the U.S. consumption basket, that is, a real depreciation of the dollar.

As we have noted, asymmetric preferences over traded goods allow the terms of trade to affect traded goods price indexes. The United States' price index places a comparatively high weight on U.S. exports, whereas

Europe's does the same for its own exports. Thus the U.S. traded goods price index falls relative to Europe's when Europe's bilateral terms of trade against the United States improve. Denoting a percent change with a caret, we can logarithmically approximate the evolution of the relative European-to-American traded goods price ratio as

$$\hat{P}_T^E - \hat{P}_T^U = (2\alpha - \beta)\hat{\tau}_{U,E}. \tag{7}$$

(Exact formulas for relative price indexes, which we use to generate the numerical results reported below, are given in appendix A.) This expression equates the difference between European and U.S. price inflation in traded goods to the European consumption weight on its own exports, α, less the U.S. consumption weight on imports from Europe, $\beta - \alpha$, all multiplied by the percentage increase in Europe's terms of trade against the United States. Observe that the terms of trade against Asia do not enter this expression. Given the bilateral Europe-U.S. terms of trade, changes in the terms of trade against Asia enter the European and U.S. traded goods price indexes symmetrically (that is, with identical consumption weights of $1 - \beta$) and therefore drop out in computing their log-difference change.

Similarly, the evolution of the Asian price level for traded goods relative to that of the United States also reflects terms-of-trade movements. But because, under our assumptions, Asia trades more extensively with Europe than the United States does, the prices of European exports have a relatively bigger impact on Asia's average import prices. This is shown by the following logarithmic approximation:

$$\hat{P}_T^A - \hat{P}_T^U = [\delta - (1 - \beta)]\hat{\tau}_{U,A} + \left[\left(\frac{1 - \delta}{2}\right) - (\beta - \alpha)\right]\hat{\tau}_{U,E}. \tag{8}$$

The weights on the terms-of-trade changes here simply reflect relative consumption weights, as before. Now, however, given the bilateral Asia-U.S. terms of trade, an improvement in Europe's terms of trade vis-à-vis the United States raises Asia's price index for traded goods relative to that in the United States when, as we assume in our simulations, the Asian consumption weight on European imports, $(1 - \delta)/2$, exceeds the weight attached by U.S. consumers, $\beta - \alpha$. Such third-country asymmetries cannot be captured, of course, in a two-country framework.

Bilateral real exchange rate movements follow immediately from the expressions above. For Europe and the United States, for example, the log change in the bilateral real exchange rate is simply the consumption weight on traded goods times the log change in relative traded goods price indexes, plus the consumption weight on nontraded goods times the log change in relative nontraded goods price indexes:

$$\hat{q}_{U,E} = \gamma(2\alpha - \beta)\hat{\tau}_{U,E} + (1-\gamma)\left(\hat{P}_N^E - \hat{P}_N^U\right). \tag{9}$$

Analogously, between the United States and Asia we have

$$\hat{q}_{U,A} = \gamma[\delta - (1-\beta)]\hat{\tau}_{U,A} + \gamma\left[\left(\frac{1-\delta}{2}\right) - (\beta - \alpha)\right]\hat{\tau}_{U,E} + (1-\gamma)\left(\hat{P}_N^A - \hat{P}_N^U\right). \tag{10}$$

We emphasize one key aspect of these expressions. The weight on nontraded goods is likely to be quite large because of the large component of nontradable services included in the consumer prices of goods generally classified as entirely tradable. In our simulations we therefore take the weight on nontraded goods above, $1 - \gamma$, to be 0.75. An implication is that, although the terms of trade certainly are an empirically important factor in real exchange rate determination given home consumption bias, relative prices for nontraded goods potentially play an even larger quantitative role.

Solution Methodology

The methodology we use to calculate the effects of current account shifts on relative prices is essentially the same as that in our earlier papers, extended to a three-region setting.[25] Given fixed output endowments, an assumed initial pattern of current account imbalances, an assumed initial pattern of international indebtedness, and a global interest rate, relative prices are determined by the equality of supply and demand in all goods markets. Changes in the international pattern of external imbalances, whether due to consumption shifts or other changes (including changes in productivity), shift the supply and demand curves in the various markets, resulting in a new set of equilibrium prices. These are the price changes we report below, under a variety of current account adjustment scenarios. (The global sums of external imbalances and of net international asset positions are both constrained to be zero.)

25. The methodology is specified in appendix A and further online at www.economics.harvard.edu/faculty/rogoff/papers/BPEA2005.pdf.

There are six market-clearing conditions, covering the three regional nontraded goods markets and the three global markets for traded goods (although one of these is redundant by Walras' Law). The five independent equilibrium conditions allow solutions for

—the U.S. terms of trade against Europe, $\tau_{U,E}$

—the U.S. terms of trade against Asia, $\tau_{U,A}$

—the price of nontraded goods in terms of traded goods in the United States, P_N^U/P_T^U

—the price of nontraded goods in terms of traded goods in Europe, P_N^E/P_T^E

—the price of nontraded goods in terms of traded goods in Asia, P_N^A/P_T^A.

One can then calculate the three bilateral real exchange rates, for which these five relative prices are the critical inputs. Because of the asymmetric preferences over traded goods, there is, as we have noted, a transfer effect in the model (wealth transfers feed into the terms of trade and through that channel into real exchange rates), although it is more complex than would be the case with only two countries in the world. Finally, we will also want to define and analyze real *effective* (loosely speaking, trade-weighted) exchange rates:

$$(11) \qquad q^U = \frac{\left(P_C^E\right)^{\frac{\beta-\alpha}{1-\alpha}}\left(P_C^A\right)^{\frac{1-\beta}{1-\alpha}}}{P_C^U}$$

$$q^E = \frac{\left(P_C^U\right)^{\frac{\beta-\alpha}{1-\alpha}}\left(P_C^A\right)^{\frac{1-\beta}{1-\alpha}}}{P_C^E}$$

$$q^A = \frac{\left(P_C^U\right)^{\frac{1}{2}}\left(P_C^E\right)^{\frac{1}{2}}}{P_C^A}.$$

Three extensions to the analysis add to its relevance and realism.[26] First, we ask how real exchange rate changes translate into nominal exchange rate changes; this depends on central bank policy. In general, this turns out not to be a critical issue empirically; the other two extensions are potentially far more important. One of these is to take into account how exchange rate changes affect the net foreign asset positions of the different regions, because of currency mismatches between gross

26. Details can be found in appendix A and online at www.economics.harvard.edu/faculty/rogoff/papers/BPEA2005.pdf.

assets and liabilities.[27] This valuation effect is significant, but its impact on aggregate demand is of secondary importance compared with the primary demand shifts emphasized in our preceding analysis. Finally, our third extension takes into account the effect of a rise in relative U.S. interest rates (due, say, to concern about government deficits or erosion of the dollar's reserve currency status). This effect, which works to worsen rather than ease the adjustment problem, is also significant, although again it is less important (at least over the range of interest rates we consider) than the primary effects of a rebalancing of global demand.

Model Predictions

With these critical behavioral parameters in hand, we are now ready to explore the model's quantitative predictions for global exchange rates and the terms of trade under various scenarios for rebalancing the U.S. current account. We first need to think about parametrizing the model.

Choosing Parameters

As we have already observed, the critical parameters in the model are θ, the elasticity of substitution in consumption between traded and nontraded goods, and η, the elasticity of substitution in consumption among the traded goods produced by the three regions. The lower are these elasticities, the greater the exchange rate and price adjustments needed to accommodate any interregional shifts in aggregate demand. Most of our simulations will be based on a value of $\theta = 1$, which is high relative to some estimates suggested in the literature.[28] We will also report results, however, for an even higher elasticity of $\theta = 2$.

Our baseline choice of $\eta = 2$ as a representative aggregate trade elasticity is a compromise between two sets of evidence. Estimates based on trade flows within disaggregated product categories cover a wide range

27. As noted above, this effect has recently been emphasized by Tille (2004), Lane and Milesi-Ferretti (2005a, 2005b), and Gourinchas and Rey (2005a, 2005b).

28. Mendoza's (1991) point estimate is 0.74, Ostry and Reinhart (1992) report estimates in the range 0.66 to 1.28 for a sample of developing countries, and Stockman and Tesar (1995) use an estimate of 0.44. Using a different approach, Lane and Milesi-Ferretti (2004) derive estimates as low as 0.5. Indeed, for larger and relatively closed economies (such as the United States, Europe, and Japan), they suggest that the value should be even lower.

but typically include many values much higher than $\eta = 2$.[29] On the other hand, conventionally estimated aggregate trade equations, as well as calibrations of dynamic general equilibrium models, tend to indicate much smaller values for η, typically 1 or even lower.

A number of mechanisms have been suggested to explain this discrepancy, some echoing Guy Orcutt's classic skepticism about the low elasticities seemingly implied by macro-level estimators.[30] Aggregation bias lowers estimated macroelasticities because the price movements of low-elasticity goods tend to dominate overall movements in import and export price indexes.[31] Another issue is that macroeconomic estimates of business-cycle frequency correlations tend to confound permanent and temporary price movements, in contrast to micro-level cross-sectional or panel studies centered on trade liberalization episodes.[32] In taking $\eta = 2$, we try, in a crude way, to address these biases while also recognizing the empirically inspired rules of thumb that inform policymakers' forecasts. We also include an illustrative simulation of the case $\eta = 100$ (in which all traded goods are essentially perfect substitutes). That simulation shuts down the terms-of-trade effects and thereby shows how large a role is being played by substitution between traded and nontraded goods, the channel we have emphasized elsewhere.[33]

We set both α and δ equal to 0.7; these are the consumption weights that Americans and Europeans, on the one hand, and Asians, on the other, attach to their own domestic products within their traded goods consumption baskets. That choice is plausible based on our discussion in an earlier

29. Examples are the estimates of Feenstra (1994) and the more recent figures of Broda and Weinstein (2004).

30. Orcutt (1950).

31. For an excellent example of this bias in action, see Hooper, Johnson, and Marquez (2000), who report that, because oil and tourism demand are relatively price-inelastic, trade equations based on aggregates that include oil and services imply apparently much lower price elasticities than equations for nonoil manufactures only. For the Group of Seven countries, Hooper, Johnson, and Marquez report short-run price elasticities for imports and exports (including oil and services) that in most cases do not satisfy the Marshall-Lerner condition. We view the elasticities implied even by aggregated estimates that exclude oil and services as unreasonably low; but, if they are accurate, they imply larger terms-of-trade and real exchange rate effects of international spending shifts.

32. See Ruhl (2003). Our model omits not only dynamics of the type suggested by Ruhl, but also those resulting from the introduction of new product varieties, which would act over the longer run to dampen the extent to which a rise in a country's relative productivity lowers its terms of trade. See, for example, Krugman (1989) and Gagnon (2003).

33. Obstfeld and Rogoff (2000a).

paper.[34] We set $\beta = 0.8$, implying that Europe and the United States alike place weights of $\beta - \alpha = 0.1$ on each other's traded goods, and twice that weight (0.2) on Asian goods. Asia, by assumption, distributes its demand evenly across the other two regions (placing a weight of 0.15 on the exports of each). So, in our model, Europe and the United States both trade more with Asia than with each other. We assume that all three regions produce the same number of units of tradable goods output.

Appendix A discusses in detail our assumptions regarding gross liabilities and assets for each region, as well as the currencies of denomination of these stocks. The point we stress here is that, to a first approximation, the United States is a net debtor (to the tune of 25 percent of its GDP, or 100 percent of its exportable GDP), and greater Europe has approximately a zero net international position. Our model's third region, Asia, therefore is left as a net international creditor in an amount equal to 100 percent of U.S. tradable GDP. U.S. gross foreign liabilities are almost all in dollars, but U.S. gross foreign assets are only about 40 percent in dollars. We assume that greater Asia's gross liabilities are equally divided among U.S., European, and Asian currencies (because Japan borrows in yen), whereas Asian gross foreign assets are 80 percent in dollars and 20 percent in European currencies. For Europe we assume that gross foreign assets are 32 percent in dollars, 11 percent in Asian currencies, and 57 percent in European currencies. In our model, 80 percent of European gross liabilities are denominated in European currencies, and the balance in dollars. These numbers are very rough approximations, based in some cases on fragmentary or impressionistic data, but portfolio shares can shift sharply over time, and so there is little point in trying too hard to refine the estimates. As we shall see, these shares do imply large potential international redistributions of wealth due to exchange rate changes, but those redistributions themselves have only a secondary impact on the exchange rate implications of current account adjustment.

For nominal interest rates we take a baseline value of 3.75 percent a year for U.S. liabilities but 5 percent a year for all other countries' liabilities. This assumption captures the "exorbitant privilege" the United States has long enjoyed of borrowing from the world more cheaply than it lends.[35]

34. Obstfeld and Rogoff (2000b).

35. The phrase "exorbitant privilege" is commonly but wrongly attributed to French president Charles de Gaulle. For its true origin, see the interesting historical note provided by Gourinchas and Rey (2005b).

Turning to current accounts, we place the U.S. external deficit at 20 percent of U.S. tradable GDP.[36] This is consistent with a U.S. current account deficit of 5 percent of total GDP, a reasonable baseline if part of the 2004 deficit is due to temporarily high oil prices. Because we find our simulation results to be approximately linear within the parameter space we are considering, it is easy to adjust the prediction to the case in which the 2004 deficit of 6 percent of GDP persists. In any event, what matters most for our calibration is how much the current account balance adjusts (for example, from 6 to 3 percent of GDP). We assume an initial position with Europe's current account surplus at 5 percent of U.S. tradable GDP and Asia's at 15 percent.[37]

A final benchmark to establish is our initial reference value for measuring subsequent exchange rate adjustments. This issue was less critical in our earlier two papers, because trade-weighted effective exchange rates move more slowly than the bilateral exchange rates that we consider below. In our basic model prices are flexible and economic responses to them are immediate. In practice, however, there are considerable lags: Michael Mussa, for example, posits the rule of thumb that the U.S. trade balance responds with a two-year lag to dollar exchange rate changes.[38] In that case, if today's current account balances reflect averages of exchange rates over the past two years, it would be more accurate to think of our simulations as giving exchange rate changes relative to two-year average reference rates rather than current rates. Table 2 presents some resulting reference exchange rates. (The Chinese and Malaysian currencies have been pegged over the past two years, and so their current and average rates are the same.)

Simulations

With the model and our parameter assumptions in hand, we are ready to consider alternative simulations. Underlying much of our analysis is the assumption that demand shocks (such as a rise in U.S. saving) are driving the redistribution of global imbalances. This seems by far the most realistic assumption, given the magnitude of the external financing gaps.

36. As noted earlier, we estimate tradable GDP to be at most 25 percent of total GDP.

37. It would be interesting and useful to extend the model to include emerging markets and OPEC as a composite fourth region, as suggested by our discussant T. N. Srinivasan.

38. Mussa (2005).

Table 2. Recent and Two-Year-Average Exchange Rates of Selected Currencies
Currency units per dollar except where noted otherwise

	Exchange rate	
Currency	*As of June 1, 2005*	*Two-year average*
U.K. pound sterling[a]	1.81	1.79
Canadian dollar	1.25	1.23
Euro[a]	1.22	1.23
Korean won	1,010	1,129
New Taiwan dollar	31.30	33.21
Singapore dollar	1.67	1.69
Japanese yen	108.4	109.3

Source: Federal Reserve data.
a. In dollars per indicated currency unit.

Tables 3 through 6 lay out the results of three scenarios under which the U.S. current account balance might improve by 20 percent of tradable GDP or, equivalently, 5 percent of total GDP. (All simulations include the effect of exchange rate changes in revaluing the regions' foreign assets and liabilities.) In the "global rebalancing" scenario (the first column in each table), all regions' current account balances go to zero (with trade balances adjusting as needed to service interest flows on the endogenously determined stocks of net foreign assets). Looking first at bilateral real exchange rates, in table 3, we see that Asia's exchange rate with the United States rises by 35.2 percent, and Europe's rises by 28.6 percent (we define the real exchange rate such that these changes indicate real depreciations of the dollar). Europe sees an improvement in its terms of trade against the United States (a rise in the price of Europe's exports relative to its U.S. imports) of 14.0 percent, and Asia sees an improvement of 14.5 percent.

What are the implications for *nominal* exchange rates? To answer this question we must specify monetary policies. We consider two possibilities: that central banks stabilize the domestic CPI, and that they stabilize the domestic GDP deflator. Table 4 reports the results. Under CPI targeting, the monetary authorities hold overall price levels constant, so that the only source of real exchange rate change is nominal exchange rate change. As a result, nominal and real exchange rate changes are equal, as can be seen by comparing table 4 with table 3.[39] Because none of the three regions is extremely open to trade, movements in CPIs and in GDP deflators are

39. We provide a detailed account of nominal exchange rate determination under GDP deflator targeting at www.economics.harvard.edu/faculty/rogoff/papers/BPEA2005.pdf.

Table 3. Changes in Real Exchange Rates and Terms of Trade Following U.S. Current Account Adjustment under Baseline Assumptions[a]

Log change × 100

	Adjustment scenario		
Real exchange rate or terms of trade	*Global rebalancing*[b]	*Bretton Woods II*[c]	*Europe and United States trade places*[d]
Real exchange rate			
United States/Europe	28.6	58.5	44.6
United States/Asia	35.2	–0.5	19.4
Europe/Asia	6.7	–59.0	–25.2
Terms of trade			
United States/Europe	14.0	29.4	22.0
United States/Asia	14.5	7.2	11.1
Europe/Asia	0.5	–22.2	–10.8

Source: Authors' calculations using model described in the text.

a. Exchange rates are defined such that an increase represents a real depreciation of the first region's currency against the second's; terms of trade are defined such that an increase represents a deterioration for the first region (that is, a fall in the price of the first region's export good against the second). Assumed parameter values are as follows: substitution elasticity between traded and nontraded goods $\theta = 1$; substitution elasticity between traded goods of different regions $\eta = 2$; share of traded goods in total consumption $\gamma = 0.25$.

b. Current account balances of all three regions go to zero.

c. Asia's current account surplus rises to keep its exchange rate with the dollar fixed. Europe's current account absorbs all changes in the U.S. and Asian current accounts.

d. Europe absorbs the entire improvement in the U.S. current account balance while Asia's current account balance remains unchanged.

Table 4. Changes in Nominal Exchange Rates Following U.S. Current Account Adjustment under Alternative Inflation Targets[a]

Log change × 100

	Adjustment scenario		
Nominal exchange rate	*Global rebalancing*	*Bretton Woods II*	*Europe and United States trade places*
Target is consumer price index[b]			
United States/Europe	28.6	58.5	44.6
United States/Asia	35.2	–0.5	19.4
Europe/Asia	6.7	–59.0	–25.2
Target is GDP deflator			
United States/Europe	30.0	61.4	46.8
United States/Asia	36.9	0.0	20.6
Europe/Asia	6.9	–61.4	–26.3

Source: Authors' calculations using model described in the text.

a. See table 3 for definitions of exchange rates, scenarios, and parameter assumptions.

b. With flexible prices and CPI targeting by central banks, nominal exchange rate changes are equal to the real exchange rate changes reported in table 3.

Table 5. Changes in Real and Nominal Effective (Trade-Weighted) Exchange Rates Following U.S. Current Account Adjustment under Baseline Assumptions[a]

Log change × 100

	Adjustment scenario		
Effective exchange rate[b]	*Global rebalancing*	*Bretton Woods II*	*Europe and United States trade places*
U.S. real	−33.0	−19.1	−27.8
U.S. nominal	−34.6	−20.5	−29.3
Europe real	5.1	58.9	31.7
Europe nominal	5.4	61.4	33.1
Asia real	20.9	−29.8	−2.9
Asia nominal	21.9	−30.7	−2.9

Source: Authors' calculations using model described in the text.

a. See table 3 for definitions of scenarios and parameter assumptions. An increase is an appreciation of the indicated currency against foreign currencies.

b. Nominal exchange rate changes are calculated under the assumption of GDP deflator targeting; see appendix A for details.

fairly close, and, as a result, nominal exchange rate changes when the GDP deflator is stabilized differ very little from those under CPI stabilization.

The appreciation of Europe's currencies against the dollar is smaller than that of Asia's under the first scenario, because Asia starts out in our simulation with a much larger external surplus than Europe does, and so it has more adjusting to do. But the Asian currencies' appreciation against the dollar is mitigated somewhat by the fact that Asia trades more with the United States than Europe does.[40] We see in table 5 that Europe's real *effective* currency appreciation—represented, as is traditional for such multilateral indexes, by a positive number—is much smaller than Asia's: only 5.1 percent versus 20.9 percent. Again, this reflects the greater weight of the dollar in Asia's trade-weighted real exchange rate than in Europe's. Notice that, as in table 4, nominal (under GDP deflator targeting) and real effective exchange rate changes are again quite close numerically.

Another factor underlying the equilibrium exchange rate responses is that dollar depreciation implies a much bigger reduction in Asia's net foreign asset position than in Europe's. (Table 6 shows the impacts under GDP

40. Indeed, if one recalibrates the model so that $\beta = 0.85$ (in which case all countries' preferences are completely symmetric, so that Europeans and Americans no longer prefer Asian goods to each other's), then, in the global rebalancing scenario, Asia's currency appreciates in real terms against the dollar by 37.8 percent and against European currencies by 12.2 percent. These numbers exceed the 35.2 percent and 6.7 percent reported in table 3.

Table 6. Net Foreign Assets by Region Following U.S. Current Account Adjustment[a]
Ratio to value of U.S. traded goods output

		Adjustment scenario[b]		
Region	*Baseline net foreign asset position*	*Global rebalancing*	*Bretton Woods II*	*Europe and United States trade places*
United States	–1.0	–0.3	–0.1	–0.2
Europe	0.0	–0.1	–0.7	–0.4
Asia	1.0	0.4	0.8	0.6

Source: Authors' calculations using model described in the text.
a. See table 3 for definitions of exchange rates, scenarios, and parameter assumptions.
b. Net asset positions taking into account valuation effects of changes in nominal exchange rates under GDP deflator targeting.

deflator targeting.) Asia has 80 percent of its assets, but only 34 percent of its liabilities, in dollars. Thus, under the global rebalancing scenario, dollar depreciation raises Asia's gross liabilities relative to its gross assets, pushing its net foreign assets down (as a fraction of U.S. tradable GDP) by 60 percent. Europe, by contrast, has only 32 percent of its assets and 20 percent of its liabilities in dollars. The fact that Asia loses so much on the asset side implies that its trade surplus shrinks by less than its current account surplus does. Because trade surpluses are what drive the constellation of real exchange rates, the real appreciation of the Asian currencies is mitigated. In sum, thanks to Asia's greater openness and to the fact that Asia suffers particularly large capital losses on foreign assets when the dollar falls, Asian exchange rates do not need to change quite as much as a model-free, back-of-the-envelope calculation might suggest.

The tables cover two other possible scenarios. The second column in tables 3 through 6 analyzes a "Bretton Woods II" scenario, in which Asia clings to its dollar peg.[41] We calibrate this case by setting the U.S. current account balance to zero and endogenously varying Asia's and Europe's current account balances in a way that both maintains Asia's bilateral nominal exchange rate with the United States (assuming GDP deflator targeting) and absorbs the fall in U.S. borrowing. (Of course, nonmonetary policy instruments such as fiscal policy would have to be used to attain just the right constellation of current account balances.) In this case the bilateral real exchange rates of the European currencies against the dollar

41. Dooley, Folkerts-Landau, and Garber (2004a, 2000b).

must rise spectacularly, by 58.5 percent, and they would rise against the Asian currencies by 59 percent. This result also is approximately linear in the change in the U.S. current account balance. Thus, under the Bretton Woods II scenario, eliminating only half the U.S. current account deficit would raise the real value of the European currencies against the dollar by as much as would occur in a global rebalancing scenario that eliminates the U.S. current account deficit entirely.

For Asia to maintain its nominal exchange rate peg in the face of a balanced U.S. current account, it must drive its own current account balance significantly further into surplus, from 15 percent to 31 percent of U.S. tradable GDP. And Europe would have to move from a surplus equal to 5 percent of U.S. tradable GDP to a 31 percent deficit! (See the footnotes to table 3.) When Asia pegs its currencies to a falling dollar, its own traded goods become more competitive and its imports more expensive relative to domestic nontraded goods. Both factors shift world demand away from Europe, which, by assumption, is passively absorbing the blow, and toward Asia. These calibrations make patently clear why sustaining Asia's dollar peg is likely to be politically unpalatable for many of its trading partners if the U.S. current account deficit ever shrinks. Asia would be extremely vulnerable to a protectionist backlash.

As table 6 shows, the sharp appreciation of Europe's currencies in the Bretton Woods II scenario also decimates its external asset position, which declines from balance to −70 percent of the value of U.S. tradable production. Asia suffers somewhat, and the U.S. net asset position is the major beneficiary, because U.S.-owned foreign assets are concentrated in European currencies. Europe is thus hammered both by a sharp decline in its competitiveness and by a loss on its net foreign assets of about $2 trillion.

The third scenario reported in tables 3 through 6 is a muted version of the Bretton Woods II scenario. Here, instead of maintaining its dollar currency peg, Asia maintains its current account surplus unchanged in the face of U.S. adjustment to a balanced position. That is, rather than increasing its current account surplus, it allows enough exchange rate adjustment to keep the surplus constant. In this case, as table 5 shows, Europe's real effective exchange rate rises by much less than in the Bretton Woods II scenario (31.7 percent versus 58.9 percent), and the Asian currencies experience a real effective depreciation of only 2.9 percent, versus 29.8 percent in Bretton Woods II. Still, because the U.S. current account balance improves dramatically while Asia's holds steady, the Asian currencies rise in real terms by 19.4 percent against the dollar (table 3). This exercise reveals a fallacy in the argument that Asia cannot allow its dollar peg to move without losing the ability to absorb its surplus labor. To the extent that European demand increases, Asia can retain its external surplus while releasing its dollar peg.

In table 7 we revisit the global rebalancing scenario but vary the critical substitution elasticities in the model. (Only real exchange rate changes, which equal nominal changes under CPI inflation targeting, are listed.) In the first column we assume an elasticity of substitution between traded and nontraded goods, θ, of 2 instead of 1. As we have already argued, the limited evidence in the empirical macroeconomics literature suggests that this estimate is well on the high side, but it allows us to incorporate a more conservative range of potential exchange rate adjustments alongside our baseline estimates. Under this assumption the real dollar exchange rate with the European currencies rises by only 19.3 percent, instead of 28.6 percent as in the first column of table 3, and the Asian currencies rise against the dollar by 22.5 percent instead of 35.2 percent. The dollar falls in real effective terms (results not shown) by 21.5 percent rather than 33 percent. These calculations show that, even with a relatively high value for θ, the required adjustment of exchange rates is quite significant even if, as here, prices are flexible.

Table 7. Changes in Real Exchange Rates and Terms of Trade in the Global Rebalancing Scenario under Alternative Calibrations[a]

Log change × 100

Real exchange rate or terms of trade	*Higher elasticity of substitution between traded and nontraded goods ($\theta = 2$, $\eta = 2$)*	*Very high elasticity of substitution between regions' traded goods ($\theta = 1$, $\eta = 100$)*
Real exchange rate		
United States/Europe	19.3	16.5
United States/Asia	22.5	23.5
Europe/Asia	3.3	7.0
Terms of trade		
United States/Europe	14.6	0.0
United States/Asia	15.1	0.0
Europe/Asia	0.5	0.0

Source: Authors' calculations using model described in the text.

a. In the global rebalancing scenario all regions' current account balances go to zero. See table 3 for definitions of exchange rates and other parameter assumptions.

The second column in table 7 examines the case in which $\theta = 1$ but $\eta = 100$, so that the various countries' tradable outputs are almost perfect substitutes. This exercise, which essentially eliminates terms-of-trade adjustments as a factor in moving real exchange rates, allows us to see how much of the change in exchange rates is due to within-country substitution between traded and nontraded goods. This variation mutes the exchange rate changes by an amount roughly similar to those found in the previous exercise. The real effective dollar exchange rate (again not shown) falls by 21 percent. According to this calibration, roughly two-thirds of the needed dollar adjustment is driven by substitution between traded and nontraded goods, and only one-third is driven by the terms-of-trade channel typically emphasized in the literature. This should not be surprising, given that (according to our previously cited calibration) roughly 75 percent of GDP is nontraded. With more conservative assumptions about international trade, however (either greater home bias in consumption or lower substitutability of countries' traded outputs, such that $\eta = 1$), the terms-of-trade channel would become more important.

At present the United States is absorbing traded goods (domestic and foreign) equivalent to roughly 30 percent of its GDP. This demand needs to adjust downward while avoiding a reduction in nontraded goods absorption if full employment is to be maintained; such a shift will therefore require a significant change in the relative price of nontraded goods. Still, terms-of-trade changes do account for about one-third of the overall adjustment, a proportion slightly larger than that found in our two-country model, where we did not allow for trade or terms-of-trade adjustments between non-U.S. economies.

Given the United States' leveraged international portfolio, with gross debts mostly in dollars and assets significantly in foreign currencies, an unexpected dollar depreciation reduces the U.S. net foreign debt. The first two columns of table 8 report the results of simulations, within the global rebalancing scenario, that illustrate the quantitative importance of such asset valuation effects. Gourinchas and Rey have recently estimated that nearly one-third of the settlement of the U.S. net foreign debt has historically been effected by valuation changes, with the remaining two-thirds covered by higher net exports.[42] The first column in table 8 shows results

42. Gourinchas and Rey (2005a).

Table 8. Changes in Real Exchange Rates and Terms of Trade in the Global Rebalancing Scenario with and without Valuation and Interest Rate Effects[a]

Log change × 100

Real exchange rate or terms of trade	*With valuation effects and without interest rate effects*[b]	*Without valuation effects or interest rate effects*	*With valuation effects and interest rate effects*[c]
Real exchange rate			
United States/Europe	28.6	33.7	30.1
United States/Asia	35.2	40.7	37.2
Europe/Asia	6.7	7.0	6.3
Terms of trade			
United States/Europe	14.0	16.5	15.1
United States/Asia	14.5	16.5	15.3
Europe/Asia	0.5	0.0	0.2

Source: Authors' calculations using the model described in the text.

a. In the global rebalancing scenario all regions' current account balances go to zero. See table 3 for definitions of exchange rates and other parameter assumptions.

b. Same as the baseline scenario reported in first column of table 3.

c. Interest rates on U.S. short-term liabilities held by foreigners are assumed to rise 1.25 percentage points, to the same level as the return earned by U.S. residents abroad.

for the global rebalancing scenario with valuation effects taken into account (identical to the first column in table 3). The second column shows the changes in bilateral exchange rates that would be required if there were no valuation effects (or, equivalently, if exchange rate changes were accurately anticipated and nominal returns adjusted fully to compensate). All relative price changes against the United States are larger in this case, because the United States does not get the benefit of a sharp reduction in its net dollar liabilities. Correspondingly, the U.S. trade balance needs to adjust more for any given adjustment in the current account deficit. The real exchange rate between the dollar and the European currencies needs to move by 33.7 percent, rather than 28.6 percent when valuation effects are taken into account, and the real value of the Asian currencies needs to rise by 40.7 percent against the dollar instead of 35.2 percent. The real effective dollar exchange rate falls by 37.8 percent instead of 33.0 percent (results not shown). According to these numbers, asset revaluation effects will mute the required movement in exchange rates as the U.S. current account closes up, but the trade balance has to do the heavy lifting, since 87 percent (33.0 ÷ 37.8) of the necessary real exchange rate adjustment remains. That valuation effects have only a secondary effect on equilibrium relative price changes is not surprising: big valuation effects can only come from big exchange rate movements.

Our calculations so far do not take into account the likelihood of an accompanying rise in global interest rates, which would hurt the United States (a net debtor) and help Asia (a net creditor). A broad range of scenarios are possible here; we examine only a single very simple one. (Appendix A gives details of the calculation.) In the third column of table 8, we assume that annual interest rates on short-term U.S. debt rise from 3.75 percent to 5 percent, the same level assumed for all other liabilities. In other words, perhaps because of heightened risk perceptions, the United States simply loses its historical low borrowing rate and is put on a par with other debtors. This change wipes out a good deal of the effect of the valuation changes (and would wipe out even more if it applied to all U.S. external liabilities, not just the roughly 30 percent consisting of short-maturity debt). As our introductory discussion suggested, the United States, as an important issuer of bonds relative to equity, is extremely vulnerable to increases in interest rates, even when all global bond rates rise together.

Until now we have been concentrating on demand shocks. Productivity shocks may make the adjustment process more or less difficult, depending on their source. Higher productivity in foreign traded goods production can actually result in an even greater real depreciation of the dollar as equilibrium is reestablished in world markets. If, on the other hand, it is nontraded goods productivity in Asia and Europe that rises, the exchange rate effects of global rebalancing will be muted. As table 9 illustrates, a

Table 9. Changes in Real Exchange Rates and Terms of Trade in Global Rebalancing Scenario with Higher Productivity in Non-U.S. Nontraded Goods[a]

Log change × 100

Real exchange rate or terms of trade	*Without increase in productivity*[b]	*With 20 percent increase in productivity in European and Asian nontraded goods*
Real exchange rate		
United States/Europe	28.6	17.0
United States/Asia	35.2	23.6
Europe/Asia	6.7	6.6
Terms of trade		
United States/Europe	14.0	15.0
United States/Asia	14.5	15.3
Europe/Asia	0.5	0.2

Source: Authors' calculations using model described in the text.

a. In the global rebalancing scenario all regions' current account balances go to zero. See table 3 for definitions of exchange rates and other parameter assumptions.

b. Same as the baseline scenario reported in the first column of table 3.

20 percent rise in nontraded goods productivity outside the United States implies notably smaller real exchange rate changes, although the terms-of-trade shifts are similar. A large rise in U.S. traded goods productivity would also facilitate a softer landing. In this case, however, although the extent of real dollar depreciation is somewhat reduced, the U.S. terms of trade fall much more sharply (results not reported).

Some Further Considerations

We believe our model offers many useful insights, but of course there are many caveats to its interpretation. Some of these suggest that our results understate the dollar's potential decline, and some that they overstate it.

Intersectoral Factor Mobility

A critical implicit assumption of our model is that capital and labor cannot quickly migrate across sectors, so that prices rather than quantities must bear the burden of adjustment in response to any sudden change in relative demands for different goods. This assumption seems entirely reasonable if global current account adjustment (full or partial) takes place moderately quickly, say, over one to two years. In the short run, workers cannot change location easily, worker retraining is expensive, and a great deal of capital is sector-specific. Over much longer periods, however (say, ten to twelve years), factor mobility is considerable. If, for example, prices rise dramatically in the U.S. traded goods sector, new investment will be skewed toward that sector, as will new employment. Thus, in principle, a gradual closing of the U.S. current account deficit would facilitate much smoother adjustment with less exchange rate volatility. Unfortunately, our model is not explicitly dynamic.[43] One can, however, artificially approximate gradual current account adjustment by allowing for progressively higher elasticities of substitution. We do this in table 10, where we reconsider our central scenario (which assumed $\theta = 1$ and $\eta = 2$) by comparing it with two cases in which substitution elasticities are much higher. As the table shows, in the case with "gradual" unwinding (proxied

43. For an example of a dynamic approach see the small-country *q*-model analysis in Obstfeld and Rogoff (1996, chapter 4).

Table 10. Changes in Real Exchange Rates under Alternative Assumed Speeds of Global Rebalancing[a]

Log change × 100

	Speed[b]		
Real exchange rate	*Moderate (1–2 years)*[c]	*Gradual (5–7 years)*	*Very gradual (10–12 years)*
United States/Europe	28.6	13.4	6.5
United States/Asia	35.2	17.3	8.5
Europe/Asia	6.7	3.9	2.0

Source: Authors' calculations using model described in the text.

a. In the global rebalancing scenario all regions' current account balances go to zero. See table 3 for definitions of exchange rates and other parameter assumptions.

b. Proxied by varying elasticities of substitution: moderate, $\theta = 1$, $\eta = 2$; gradual, $\theta = 2$, $\eta = 4$; very gradual, $\theta = 4$, $\eta = 8$.

c. Same as the baseline scenario reported in the first column of table 3.

by $\theta = 2$ and $\eta = 4$), which we loosely take to capture a five- to seven-year adjustment horizon, the bilateral exchange rate changes involving the dollar are only about half as big as in our central global rebalancing scenario. For a "very gradual" unwinding (which we take to occur over ten to twelve years, with $\theta = 4$ and $\eta = 8$), the same real exchange rate changes are less than a quarter as large as in the central scenario.

Sticky Prices

Factor mobility kicks in to smooth current account adjustment if the adjustment is slow and relatively well anticipated. If, on the other hand, current account imbalances have to close up very quickly (say, because of a collapse in U.S. housing prices), the bias in our estimates would point in the other direction. Nominal rigidities in prices would then play a large role, and actual exchange rate movements would likely be two or more times as large as in our central scenario, for several reasons.[44]

For one thing, our model assumes that the law of one price holds for traded goods, whereas in fact at most half of an exchange rate adjustment typically passes through to traded goods prices even after one year.[45] Thus, in order to balance supply and demand for the different categories of goods

44. See the discussion in Obstfeld and Rogoff (2000a).

45. P. Goldberg and Knetter (1997); Campa and L. Goldberg (2002). For recent evidence suggesting a substantial decline in pass-through to U.S. import prices, see Marazzi and others (2005).

while maintaining full employment, central banks would have to allow much larger exchange rate movements—possibly double those suggested by the model. These larger movements would be "overshoots" in the sense that they would unwind over time as domestic prices adjust.

The nominal prices of nontraded goods are typically even stickier than those of traded goods; this further amplifies the overshooting effect. In general, both sticky prices and slow factor mobility point toward the likelihood that a slow unwinding of the U.S. current account deficit will lead to smaller changes in real exchange rates than would a relatively abrupt correction.

Rising U.S. Interest Rates and the Dollar

Another qualification to our results is that our model does not account for financial factors, and in particular for the possibility of temporarily high real interest rates in the United States muting the dollar's decline. Using the Federal Reserve's macroeconomic model, David Reifschneider, Robert Tetlow, and John Williams estimate that a 1-percentage-point rise in the federal funds rate (presumably unmatched by the rest of the world) leads to a 2.2 percent appreciation of the dollar after one year, and a 4.9 percent appreciation after two years.[46] Therefore the fact that, over the past year, U.S. short-term interest rates have been rising relative to Europe's is a countervailing consideration to those discussed above (although our calculations suggest that it is likely to be far less important quantitatively). In addition, Europe and Asia can always choose to lower their interest rates to further mute the dollar's decline. Of course, interest rate policy can only affect the dollar's real value temporarily, and so long-term global rebalancing will still require a combination of real exchange rate adjustment and factor reallocation across sectors.

The Fundamental Unpredictability of Exchange Rates

Our model suggests that the gaping U.S. current account deficit is a very large negative factor in assessing the future prospects of the dollar. It

46. Reifschneider, Tetlow, and Williams (1999). A back-of-the-envelope calculation based on the Dornbusch overshooting model (Dornbusch, 1976) yields a similar result.

is well known, however, that it is extremely difficult to explain exchange rate swings between major currencies, much less forecast them, at least at horizons up to eighteen months.[47] Although a number of small qualifications must be made to this result,[48] it remains broadly true. How, then, can one be concerned about a medium-term dollar decline if a rise is equally likely? There are two broad answers to this question. First, even the most cheery U.S. current account optimist would have to concede that an abrupt reversal is a potential risk, particularly while federal government deficits remain less than fully tamed. Reversal need not result from what Guillermo Calvo, in the context of emerging markets, has called a "sudden stop" of capital inflows;[49] as we have noted, it could follow, for example, from a rise in U.S. saving due to a purely domestic asset price collapse. Our calibrations are useful in laying out the exchange rate consequences and in illuminating how the burden of adjustment might be shared among the major economies.

Second, and more fundamentally, there is some evidence that nonlinearities are also important, so that, when exchange rates are particularly far out of line with one or more fundamentals, some predictability emerges. Obstfeld and Alan Taylor, for example, argue that convergence to purchasing power parity is much more important quantitatively when a currency is relatively heavily over- or undervalued compared with its long-term real exchange rate.[50] Gourinchas and Rey argue that, contrary to the canonical Meese-Rogoff result, there is a forecastable component to trade-weighted dollar exchange rate movements when net foreign assets or debts are large relative to the United States' net export base.[51] Their work supports much earlier work by Peter Hooper and John Morton suggesting that net foreign assets may be important in explaining dollar movements.[52] As we argued in the introduction, the U.S. current account deficit today is so large and unprecedented that it is difficult to project its future path and the consequences thereof simply by extrapolating from past data.

47. Meese and Rogoff (1983).
48. See the survey in Frankel and Rose (1995), for example.
49. Calvo (1998).
50. Obstfeld and Taylor (1997).
51. Gourinchas and Rey (2005a).
52. Hooper and Morton (1982).

Conclusions

We have developed a simple stylized model that can be used to calibrate exchange rate changes in response to various scenarios under which the U.S. current account deficit might be reduced from its unprecedented current level. Aside from its quantitative predictions, the model yields a number of important qualitative insights.

First, Asia's greater openness to trade implies that the requisite exchange rate adjustments for that region are not all that much greater than Europe's. This appears true despite the fact that Asia starts from a much larger current account surplus than Europe.

Second, we find that, if Asia tries to stick to its dollar peg in the face of, say, a rise in the U.S. saving rate that closes up the U.S. current account gap even partly, Asia will actually have to run significantly *larger* surpluses than it does now. Europe would bear the brunt of this policy, ending up with a current account deficit even larger than that of the United States today, while at the same time suffering a huge loss on its net foreign assets.

Third, although dollar depreciation does tend to improve the U.S. net foreign asset position (because virtually all of its gross foreign liabilities, but less than half of its gross foreign assets, are denominated in dollars), this effect only slightly mitigates the requisite exchange rate change. Valuation effects will not rescue the United States from a huge trade balance adjustment. Indeed, if relative interest rates on U.S. short-term debt rise even moderately during the adjustment process, this adverse effect could easily cancel out any gain due to valuation effects.

Fourth, our model suggests that the need for deficit countries to shift demand toward nontraded goods (and for surplus countries to shift demand away from them) is roughly twice as important quantitatively as the much more commonly stressed terms-of-trade channel (which involves substitution between the traded goods produced by different countries). The importance of the terms of trade would be greater with lower international trade elasticities than we have assumed, or with a greater degree of home bias in consumption.

We have only scratched the surface of the possible questions that can be asked within our framework. To that end, we have tried to make our approach as transparent as possible so that other researchers can easily investigate alternative scenarios using the model. Clearly, it would be interesting to extend the model in many dimensions, in particular to allow for sticky prices and for dynamic adjustments, such as factor movement across sectors. It would also be interesting to extend the framework to allow for more regions of the world economy, for example, oil producers, non-Asian emerging markets, and Asian subregions. Nonetheless, in a literature that is often long on polemics and short on analysis, we hope it is useful to have a concrete model on which to base policy evaluation.

APPENDIX A

Equilibrium Prices, Revaluation Effects, and Interest Rate Effects

Equilibrium Prices

Here we show how real exchange rates depend on equilibrium relative prices, and we spell out the relevant equilibrium conditions for our three-region world economy. By definition, real exchange rates depend on relative international prices for both traded and nontraded goods. We take up relative traded goods prices first.

As the text noted, notwithstanding the law of one price, the assumed internationally asymmetric preferences over tradables permit relative regional price indexes for tradable consumption to vary over time. Instead of being fixed at unity, these ratios are given in our model by

(A1)

$$\frac{P_T^E}{P_T^U} = \frac{\left[\alpha\tau_{U,E}^{1-\eta} + (\beta - \alpha) + (1-\beta)\tau_{U,A}^{1-\eta}\right]^{\frac{1}{1-\eta}}}{\left[\alpha + (\beta-\alpha)\tau_{U,E}^{1-\eta} + (1-\beta)\tau_{U,A}^{1-\eta}\right]^{\frac{1}{1-\eta}}}$$

$$\frac{P_T^A}{P_T^U} = \frac{\left[\delta\tau_{U,A}^{1-\eta} + \left(\frac{1-\delta}{2}\right) + \left(\frac{1-\delta}{2}\right)\tau_{U,E}^{1-\eta}\right]^{\frac{1}{1-\eta}}}{\left[\alpha + (\beta-\alpha)\tau_{U,E}^{1-\eta} + (1-\beta)\tau_{U,A}^{1-\eta}\right]^{\frac{1}{1-\eta}}}$$

$$\frac{P_T^A}{P_T^E} = \frac{\left[\delta\tau_{U,A}^{1-\eta} + \left(\frac{1-\delta}{2}\right) + \left(\frac{1-\delta}{2}\right)\tau_{U,E}^{1-\eta}\right]^{\frac{1}{1-\eta}}}{\left[\alpha\tau_{U,E}^{1-\eta} + (\beta-\alpha) + (1-\beta)\tau_{U,A}^{1-\eta}\right]^{\frac{1}{1-\eta}}}.$$

Thus shifts in interregional real exchange rates q reflect both shifts in the relative prices of traded and nontraded goods and shifts in the relative prices of exports and imports:

(A2)
$$q_{U,E} = \frac{P_T^E}{P_T^U} \times \frac{\left[\gamma + (1-\gamma)\left(P_N^E / P_T^E\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}}{\left[\gamma + (1-\gamma)\left(P_N^U / P_T^U\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}}$$
$$= \frac{\left[\alpha\tau_{U,E}^{1-\eta} + (\beta-\alpha) + (1-\beta)\tau_{U,A}^{1-\eta}\right]^{\frac{1}{1-\eta}}}{\left[\alpha + (\beta-\alpha)\tau_{U,E}^{1-\eta} + (1-\beta)\tau_{U,A}^{1-\eta}\right]^{\frac{1}{1-\eta}}} \times \frac{\left[\gamma + (1-\gamma)\left(P_N^E / P_T^E\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}}{\left[\gamma + (1-\gamma)\left(P_N^U / P_T^U\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}}$$

$$q_{U,A} = \frac{P_T^A}{P_T^U} \times \frac{\left[\gamma + (1-\gamma)\left(P_N^A / P_T^A\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}}{\left[\gamma + (1-\gamma)\left(P_N^U / P_T^U\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}}$$
$$= \frac{\left[\delta\tau_{U,A}^{1-\eta} + \left(\frac{1-\delta}{2}\right) + \left(\frac{1-\delta}{2}\right)\tau_{U,E}^{1-\eta}\right]^{\frac{1}{1-\eta}}}{\left[\alpha + (\beta-\alpha)\tau_{U,E}^{1-\eta} + (1-\beta)\tau_{U,A}^{1-\eta}\right]^{\frac{1}{1-\eta}}} \times \frac{\left[\gamma + (1-\gamma)\left(P_N^A / P_T^A\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}}{\left[\gamma + (1-\gamma)\left(P_N^U / P_T^U\right)^{1-\theta}\right]^{\frac{1}{1-\theta}}}.$$

Having defined relative price indexes, one can easily derive global market-clearing conditions for each region's tradable output, again using very standard techniques for constant elasticity of substitution models such as the one we have here.[53] For real U.S. tradable goods output, the market-clearing condition is given by

(A3)
$$Y_T^U = \gamma\alpha\left(\frac{P_U}{P_T^U}\right)^{-\eta}\left(\frac{P_T^U}{P_C^U}\right)^{-\theta} C^U + \gamma(\beta-\alpha)\left(\frac{P_U}{P_T^E}\right)^{-\eta}\left(\frac{P_T^E}{P_C^E}\right)^{-\theta} C^E + \gamma\left(\frac{1-\delta}{2}\right)\left(\frac{P_U}{P_T^A}\right)^{-\eta}\left(\frac{P_T^A}{P_C^A}\right)^{-\theta} C^A,$$

53. As illustrated, for example, in Obstfeld and Rogoff (1996).

and that for real European traded goods output is given by

$$\text{(A4)}\quad Y_T^E = \gamma\alpha\left(\frac{P_E}{P_T^E}\right)^{-\eta}\left(\frac{P_T^E}{P_C^E}\right)^{-\theta} C^E + \gamma(\beta-\alpha)\left(\frac{P_E}{P_T^U}\right)^{-\eta}\left(\frac{P_T^U}{P_C^U}\right)^{-\theta} C^U + \gamma\left(\frac{1-\delta}{2}\right)\left(\frac{P_E}{P_T^A}\right)^{-\eta}\left(\frac{P_T^A}{P_C^A}\right)^{-\theta} C^A.$$

Walras' Law implies that the condition for Asian traded goods equilibrium is superfluous, given the two others. One can similarly derive the market-clearing condition for U.S. nontraded goods as

$$\text{(A5)}\quad Y_N^U = (1-\gamma)\left(\frac{P_N^U}{P_C^U}\right)^{-\theta} C^U$$

(which depends, of course, only on U.S. demand), as well as the two corresponding conditions for European and Asian nontraded goods.

We take output endowments as given, and we then use the market-equilibrium conditions just stated to solve for relative prices as functions of current account balances and initial net foreign asset positions. (In our simulations we allow for currency revaluation effects on foreign assets and liabilities, and for the feedback to trade balances needed to sustain any given constellation of current accounts.)

To proceed, we first rewrite the equilibrium condition for the U.S. export good's market as

$$\text{(A6)}\quad Y_T^U = \alpha\left(\frac{P_U}{P_T^U}\right)^{-\eta} C_T^U + (\beta-\alpha)\left(\frac{P_U}{P_T^E}\right)^{-\eta} C_T^E + \left(\frac{1-\delta}{2}\right)\left(\frac{P_U}{P_T^A}\right)^{-\eta} C_T^A,$$

or, in nominal terms, as

$$\text{(A7)}\quad P_U Y_T^U = \alpha\left(\frac{P_U}{P_T^U}\right)^{1-\eta} P_T^U C_T^U + (\beta-\alpha)\left(\frac{P_U}{P_T^E}\right)^{1-\eta} P_T^E C_T^E + \left(\frac{1-\delta}{2}\right)\left(\frac{P_U}{P_T^A}\right)^{1-\eta} P_T^A C_T^A.$$

If trade were balanced and international debts zero, then, of course, the value of U.S. traded goods consumption would have to equal that of U.S.

traded goods production. Here we want to allow for international debt as well as for trade and current account imbalances (which are the same in the model except for net factor payments). The U.S. current account surplus in dollars is given by

$$CA^U = P_U Y_T^U + rF^U - P_T^U C_T^U, \tag{A8}$$

where F^U is the stock of U.S. net foreign assets (in dollars) and r is the nominal (dollar) rate of interest. Similarly, for Europe (and again measuring in dollars),

$$CA^E = P_E Y_T^E + rF^E - P_T^E C_T^E. \tag{A9}$$

In the aggregate, of course (in theory if not in the actual data),

$$CA^U + CA^E + CA^A = 0. \tag{A10}$$

Similarly,

$$F^U + F^E + F^A = 0. \tag{A11}$$

Thus,

$$CA^A = -\left(CA^U + CA^E\right) = P_A Y_T^A - r\left(F^U + F^E\right) - P_T^A C_T^A. \tag{A12}$$

In this framework one can consider the effects of a variety of shocks that change the current nexus of global current account imbalances into one where, say, $CA^U = 0$. (Other external balance benchmarks can be analyzed just as easily.)

To do so, we use the above current account equations (and the implied trade balances) to substitute for dollar values of consumption of traded goods in the goods-market equilibrium conditions. The results are

$$\begin{aligned} P_U Y_T^U = {} & \alpha\left(\frac{P_U}{P_T^U}\right)^{1-\eta}\left(P_U Y_T^U + rF^U - CA^U\right) \\ & + (\beta - \alpha)\left(\frac{P_U}{P_T^E}\right)^{1-\eta}\left(P_E Y_T^E + rF^E - CA^E\right) \\ & + \left(\frac{1-\delta}{2}\right)\left(\frac{P_U}{P_T^A}\right)^{1-\eta}\left[P_A Y_T^A - r\left(F^U + F^E\right) + CA^U + CA^E\right] \end{aligned} \tag{A13}$$

$$P_E Y_T^E = \alpha \left(\frac{P_E}{P_T^E} \right)^{1-\eta} \left(P_E Y_T^E + rF^E - CA^E \right)$$
$$+ (\beta - \alpha) \left(\frac{P_E}{P_T^U} \right)^{1-\eta} \left(P_U Y_T^U + rF^U - CA^U \right)$$
$$+ \left(\frac{1-\delta}{2} \right) \left(\frac{P_E}{P_T^A} \right)^{1-\eta} \left[P_A Y_T^A - r\left(F^U + F^E\right) + CA^U + CA^E \right].$$

Critically, current account imbalances also spill over into relative prices for nontraded goods, to a degree that depends on the elasticity of substitution between traded and nontraded goods. For the three nontraded goods markets, one can show that

$$\text{(A14)} \quad P_N^U Y_N^U = \frac{1-\gamma}{\gamma} \left(\frac{P_N^U}{P_T^U} \right)^{1-\theta} P_T^U C_T^U$$
$$= \frac{1-\gamma}{\gamma} \left(\frac{P_N^U}{P_T^U} \right)^{1-\theta} \left(P_U Y_T^U + rF^U - CA^U \right)$$
$$P_N^E Y_N^E = \frac{1-\gamma}{\gamma} \left(\frac{P_N^E}{P_T^E} \right)^{1-\theta} \left(P_E Y_T^E + rF^E - CA^E \right)$$
$$P_N^A Y_N^A = \frac{1-\gamma}{\gamma} \left(\frac{P_N^A}{P_T^A} \right)^{1-\theta} \left[P_A Y_T^A - r\left(F^U + F^E\right) + CA^U + CA^E \right].$$

Revaluation of Gross Asset Stocks through Exchange Rate Changes

A key variable in the simulation analysis is f^i, which is the ratio of net foreign assets (in dollars), F^i, divided by the dollar traded goods income of the United States, $P_U Y_T^U$. In reality, a country's gross assets and liabilities are often denominated in different currencies, so that focusing only on the net position misses important revaluation effects that can occur as the exchange rate changes. Here we show how we have modified our simulation analysis to take into account both the normalization of dollar net foreign assets and the revaluation effects of exchange rate changes.[54]

54. Details can be found online at www.economics.harvard.edu/faculty/rogoff/papers/BPEA2005.pdf.

Let H^i equal the gross assets of country i and L^i its gross liabilities, measured in dollars. Then

$$F^i = H^i - L^i \tag{A15}$$

and

$$f^i = \frac{H^i - L^i}{P_U Y_T^U}. \tag{A16}$$

One can show that, under a monetary policy that targets the GDP deflator,

$$P_U = \left(\frac{P_N^U}{P_T^U}\right)^{\gamma-1} \left[\alpha + (\beta - \alpha)\tau_{U,E}^{1-\eta} + (1-\beta)\tau_{U,A}^{1-\eta}\right]^{\frac{\gamma-1}{1-\eta}}. \tag{A17}$$

The first step is to substitute this formula for P_U into the denominators of f^U, f^E, and f^A. The second step is to consider how exchange rate changes affect the numerators.

Let ω_j^i be the share of region i gross foreign assets denominated in the currency of region j, $j = U, E, A$, where the European and (especially) the Asian regional currencies are composites. Similarly, define the portfolio currency shares λ_j^i on the liability side. We will assume that central banks target GDP deflators and that $E_{U,j}$ denotes the (nominal) dollar price of currency j ($j = E, A$) under the monetary rule. Then, after a change in exchange rates, the new dollar values of net foreign assets (with values after the change denoted by primes) are

$$\begin{aligned}
F^{U\prime} &= F^U + \left(\frac{E'_{U,E} - E_{U,E}}{E_{U,E}}\right)(\omega_E^U H^U - \lambda_E^U L^U) \\
&\quad + \left(\frac{E'_{U,A} - E_{U,A}}{E_{U,A}}\right)(\omega_A^U H^U - \lambda_A^U L^U) \\
F^{E\prime} &= F^E + \left(\frac{E'_{U,E} - E_{U,E}}{E_{U,E}}\right)(\omega_E^E H^E - \lambda_E^E L^E) \\
&\quad + \left(\frac{E'_{U,A} - E_{U,A}}{E_{U,A}}\right)(\omega_A^E H^E - \lambda_A^E L^E) \\
F^{A\prime} &= F^A + \left(\frac{E'_{U,E} - E_{U,E}}{E_{U,E}}\right)(\omega_E^A H^A - \lambda_E^A L^A) \\
&\quad + \left(\frac{E'_{U,A} - E_{U,A}}{E_{U,A}}\right)(\omega_A^A H^A - \lambda_A^A L^A).
\end{aligned} \tag{A18}$$

Note that the following two constraints must hold in a closed system:

$$\text{(A19)} \qquad \omega_E^U H^U + \omega_E^E H^E + \omega_E^A H^A = \lambda_E^U L^U + \lambda_E^E L^E + \lambda_E^A L^A$$

$$\omega_A^U H^U + \omega_A^E H^E + \omega_A^A H^A = \lambda_A^U L^U + \lambda_A^E L^E + \lambda_A^A L^A.$$

So we can eliminate the European asset shares by writing the preceding as post-change net asset values:

$$\text{(A20)} \qquad F^{U\prime} = F^U + \left(\frac{E'_{U,E} - E_{U,E}}{E_{U,E}}\right)\left(\omega_E^U H^U - \lambda_E^U L^U\right)$$

$$+\left(\frac{E'_{U,A} - E_{U,A}}{E_{U,A}}\right)\left(\omega_A^U H^U - \lambda_A^U L^U\right)$$

$$F^{E\prime} = F^E + \left(\frac{E'_{U,E} - E_{U,E}}{E_{U,E}}\right)\left(\lambda_E^U L^U + \lambda_E^A L^A - \omega_E^U H^U - \omega_E^A H^A\right)$$

$$+\left(\frac{E'_{U,A} - E_{U,A}}{E_{U,A}}\right)\left(\lambda_A^U L^U + \lambda_A^A L^A - \omega_A^U H^U - \omega_A^A H^A\right)$$

$$F^{A\prime} = F^A + \left(\frac{E'_{U,E} - E_{U,E}}{E_{U,E}}\right)\left(\omega_E^A H^A - \lambda_E^A L^A\right)$$

$$+\left(\frac{E'_{U,A} - E_{U,A}}{E_{U,A}}\right)\left(\omega_A^A H^A - \lambda_A^A L^A\right).$$

We also know that

$$\text{(A21)} \qquad H^U + H^E + H^A = L^U + L^E + L^A.$$

For our numerical findings we must posit estimated values for nominal assets and liabilities. Given the well-known measurement problems, any numbers are bound to be loose approximations at best. For the United States, the numbers we use are for end-2003 (from the 2005 *Economic Report of the President*) and show foreign-owned assets in the United States to be \$10.5 trillion and U.S.-owned assets abroad to be \$7.9 trillion. We take the current values to be \$11 trillion and \$8.25 trillion, respectively, for purposes of our simulations. To a first approximation, essentially all U.S. foreign liabilities are denominated in dollars, but only about 40 percent of U.S. foreign assets are. (In principle, foreign assets such as stocks and land are real, but in practice the dollar returns on these assets are highly correlated with dollar exchange rate movements.) Of the remaining 60 percent, we take 41 percent to be in European currencies and 19 percent in Asian currencies. Following Tille (2004), and including Canada, the United Kingdom, and Switzerland in region *E,* the United States does have a very small share of its liabilities in foreign currencies. The exact portfolio weights that we assume for the United States are

(A22)
$$\omega_E^U = 0.405,\ \omega_A^U = 0.193,$$
$$\lambda_E^U = 0.03,\ \lambda_A^U = 0.006.$$

Drawing on the work of Lane and Milesi-Ferretti (but taking into account the adding-up constraints that need to hold in our theoretical model), we take Asia's assets to be $11 trillion and its liabilities to be $8.25 trillion.[55] As for portfolio shares, on the asset side, data from the International Monetary Fund's 2001 Coordinated Portfolio Investment Survey suggest that most Asian countries hold predominantly U.S. dollars (and some yen), but that Japan's foreign assets are more evenly balanced between dollar and euro holdings. If we assume that Japan owns about 40 percent of the region's gross foreign assets, we have the following approximation:

(A23)
$$\omega_E^A = 0.2,\ \omega_A^A = 0.$$

On the liabilities side, Japan borrows in yen, but the other Asian economies have equity liabilities (including foreign direct investment) in local currencies, and extraregional debt liabilities predominantly in dollars and euros (or sterling). We assume that

(A24)
$$\lambda_E^A = 0.33,\ \lambda_A^A = 0.33.$$

We again base our portfolio estimates for the *E* zone in our model on the latest data from Lane and Milesi-Ferretti, which indicate that assets and liabilities at the end of 2003 were both approximately $11 trillion. Thus we take $H^E = L^E =$ \$11 trillion. Most of greater Europe's liabilities are in domestic currencies; here we assume the share is 80 percent. We take the remaining 20 percent to be entirely in U.S. dollars. On the asset side, however, we derive from equation A19 that 32 percent of Europe's holdings are in dollar assets, and 11 percent in assets denominated in

55. Lane and Milesi-Ferretti (forthcoming).

Asian currencies, with the remaining 57 percent in assets denominated in European currencies.[56]

In our simulations we take $P_U Y_T^U = \$(11/4)$ trillion, based on Obstfeld and Rogoff (2000b), who argue that roughly one-quarter of U.S. GDP may be regarded as traded.

Given our assumptions on each region's gross assets and liabilities and their currencies of denomination, our analysis will also tell us how net foreign assets change across various scenarios for the current account and the exchange rate, as well as allow for the feedback effect on interest payments. We will see that, given the large size of gross stocks, large changes in exchange rates can translate into large changes in net foreign asset positions. Indeed, for many short-run and medium-run issues, knowing the gross asset and liability positions is at least as important as understanding the net positions. This conclusion is very much in line with the empirical findings of Gourinchas and Rey (2005a) for the United States.

Effects of Changing Interest Rates

It seems plausible that, in the process of U.S. current account adjustment, global interest rates will shift. Such changes could come about simply as a result of the reequilibration of the global capital market, or they could also reflect a shift in the portfolio preferences of foreign investors such that, given the exchange rate of the dollar, higher dollar interest rates are necessary to persuade them to maintain their existing dollar-denominated portfolio shares. We adopt the latter perspective, allowing the interest rate on U.S. short-term debt liabilities to rise as the dollar adjusts, without a corresponding increase in the earnings on U.S. foreign assets. Capital market shifts of this nature are likely to be quantitatively more important for the dollar than more generalized, synchronized increases in world interest rates (although the United States, as a debtor, would naturally lose while its creditors would gain).

To illustrate this channel, we first, for simplicity, abstract from the effects of nominal exchange rate changes on asset stocks (for the purpose of our

56. The European position assumptions are not needed to implement equation A20, but they are necessary for assessing the effects of interest rate changes below.

simulations, this case is only a computation check). We focus on the scenario under which, as the United States adjusts, it faces a sharp increase in its borrowing rates. Thus there are two interest rates in the world economy: the rate r^U that the United States pays on its liabilities, and the rate $r^W > r^U$ that all other countries pay on their liabilities and that all countries, including the United States, earn on assets outside the United States. We focus on the implications of r^U rising when the United States adjusts; the increase in r^U may itself have an effect on U.S. adjustment, although that possibility does not affect our calculation.

There is also a long-run versus short-run distinction: in the short run only U.S. short-term liabilities will pay higher interest (as these are rolled over). According to U.S. Treasury data for September 2004 (from www.treas.gov/tic/debta904.html), U.S. short-term liabilities were about 30 percent of total liabilities (and thus about 30 percent of U.S. GDP). If the United States were required to pay, for example, 200 basis points more on this liability base, the result would be an additional drain of about $0.02 \times 0.3 =$ 0.6 percent of total GDP.

Let $\tilde{\omega}^i_j$ represent the share of country i gross foreign assets invested in country j.

To make the previous modeling consistent, we replace rF^i everywhere (for the United States, Europe, and Asia, respectively) by

$$r^W H^U - r^U L^U \tag{A25}$$
$$\left[\tilde{\omega}^E_U r^U + \left(1 - \tilde{\omega}^E_U\right) r^W\right] H^E - r^W L^E$$
$$\left[\tilde{\omega}^A_U r^U + \left(1 - \tilde{\omega}^A_U\right) r^W\right] H^A - r^W L^A.$$

From estimates described in the last subsection, we have the dollar values of H^i and L^i. Asian currency shares probably exceed the Asian country shares, because of Asian claims on offshore Eurodollars; we might assume that $\tilde{\omega}^A_U = 0.6$. Since total U.S. liabilities equal the claims on the United States of Europe and Asia,

$$\tilde{\omega}^E_U H^E + \tilde{\omega}^A_U H^A = L^U, \tag{A26}$$

and so, with H^E, H^A, and L^U each equal to \$11 trillion, we must have $\tilde{\omega}^E_U = 0.4$.

We now turn to the calibration of interest rates (or, rather, nominal rates of return on asset and liability portfolios). We know that, for the United States currently, $r^W H^U - r^U L^U \approx 0$. Since, also, $H^U/L^U \approx 0.75$, $r^U/r^W \approx 0.75$.

So we take $r^U = 3.75$ percent initially,[57] but we maintain the earlier baseline assumption that $r^W = 5$ percent. We ultimately wish to consider alternative increases in r^U, for example, of 125 basis points or more. These possibilities range from a scenario in which the United States simply loses its privilege of borrowing at a favorable rate, to some in which there is an element of loss of confidence in U.S. solvency absent ongoing dollar depreciation. We will also assume that only the interest rate on short-term liabilities rises in the short run. Suppose the share σ of short-term liabilities in total U.S. foreign liabilities is 30 percent, or σ = 0.3. Then the investment income account of the United States and the other two regions would change as follows:

$$\text{(A27)} \quad r^W H^U - r^U L^U \rightarrow r^W H^U - (r^U + \sigma \Delta r^U) L^U$$

$$\left[\tilde{\omega}_U^E r^U + (1 - \tilde{\omega}_U^E) r^W\right] H^E - r^W L^E \rightarrow$$

$$\left[\tilde{\omega}_U^E (r^U + \sigma \Delta r^U) + (1 - \tilde{\omega}_U^E) r^W\right] H^E - r^W L^E$$

$$\left[\tilde{\omega}_U^A r^U + (1 - \tilde{\omega}_U^A) r^W\right] H^A - r^W L^A \rightarrow$$

$$\left[\tilde{\omega}_U^A (r^U + \sigma \Delta r^U) + (1 - \tilde{\omega}_U^A) r^W\right] H^A - r^W L^A.$$

The last two changes assume that, empirically, $\tilde{\omega}_U^E + \tilde{\omega}_U^A \approx 1$ and that Europe and Asia hold equal proportions of short-term U.S. liabilities.

One might also consider a formulation where $\Delta r^U = f(\Delta CA^U)$, $f' > 0$. In this case adjustment could be quite painful if the f function is too rapidly increasing, L^U is too big, or σ is too big (or any combination of these three). We leave this possibility for future research.

Synthesis of Interest Rate Changes and Asset Revaluations

We are now ready to illustrate the techniques used to calculate the results in the third column in table 8, in which asset revaluations and interest rate changes occur simultaneously and interactively. We proceed as in the last section but add the following equations:

57. This number is in line with the estimate given above of the excess return of U.S. foreign assets over U.S. liabilities to foreigners.

(A28)
$$H^{U\prime} = H^{U} + \left(\frac{E'_{U,E} - E_{U,E}}{E_{U,E}}\right)\omega_{E}^{U} H^{U} + \left(\frac{E'_{U,A} - E_{U,A}}{E_{U,A}}\right)\omega_{A}^{U} H^{U}$$
$$H^{E\prime} = H^{E} + \left(\frac{E'_{U,E} - E_{U,E}}{E_{U,E}}\right)\omega_{E}^{E} H^{E} + \left(\frac{E'_{U,A} - E_{U,A}}{E_{U,A}}\right)\omega_{A}^{E} H^{E}$$
$$H^{A\prime} = H^{A} + \left(\frac{E'_{U,E} - E_{U,E}}{E_{U,E}}\right)\omega_{E}^{A} H^{A} + \left(\frac{E'_{U,A} - E_{U,A}}{E_{U,A}}\right)\omega_{A}^{A} H^{A}$$

and

(A29)
$$L^{U\prime} = L^{U} + \left(\frac{E'_{U,E} - E_{U,E}}{E_{U,E}}\right)\lambda_{E}^{U} L^{U} + \left(\frac{E'_{U,A} - E_{U,A}}{E_{U,A}}\right)\lambda_{A}^{U} L^{U}$$
$$L^{E\prime} = L^{E} + \left(\frac{E'_{U,E} - E_{U,E}}{E_{U,E}}\right)\lambda_{E}^{E} L^{E} + \left(\frac{E'_{U,A} - E_{U,A}}{E_{U,A}}\right)\lambda_{A}^{E} L^{E}$$
$$L^{A\prime} = L^{A} + \left(\frac{E'_{U,E} - E_{U,E}}{E_{U,E}}\right)\lambda_{E}^{A} L^{A} + \left(\frac{E'_{U,A} - E_{U,A}}{E_{U,A}}\right)\lambda_{A}^{A} L^{A}.$$

These equations, rather than the equations for net positions used in the simpler revaluation exercise in which interest rates do not change, become necessary because assets and liabilities can now pay different rates of interest and therefore must be tracked separately.