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Estimating Consistent Fundamental Equilibrium Exchange Rates

William R. Cline

Abstract

This paper sets forth a new methodology for obtaining a consistent set of exchange rate realignments needed to accomplish international adjustment in current account imbalances to reach fundamental equilibrium exchange rates (FEERs). The approach is named the symmetric matrix inversion method (SMIM). It is symmetric in that it treats all countries considered equally rather than seeking exact adjustment for the United States and obtaining other adjustments residually. Country-specific impact parameters based on assumed trade elasticities are applied to a target set of changes in current accounts as percentages of GDP to obtain a corresponding set of target changes in real effective (trade-weighted) exchange rates. A matrix inversion technique is then applied to identify the corresponding set of changes in bilateral exchange rates against the dollar needed to approach as closely as possible the target set of effective exchange rate changes.

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William R. Cline is a senior fellow jointly at the Peterson Institute for International Economics and the Center for Global Development. He has been a senior fellow at the Institute since its inception in 1981. During 1996–2001, while on leave from the Institute, he was deputy managing director and chief economist at the Institute of International Finance. He was a senior fellow at the Brookings Institution (1973–81); deputy director of development and trade research, office of the assistant secretary for international affairs, US Treasury Department (1971–73); Ford Foundation visiting professor in Brazil (1970–71); and lecturer and assistant professor of economics at Princeton University (1967–70). His publications include *Global Warming and Agriculture: Impact Estimates by Country* (2007), *The United States as a Debtor Nation* (2005), *Trade Policy and Global Poverty* (2004), *Trade and Income Distribution* (1997), *International Debt Reexamined* (1995), *International Economic Policy in the 1990s* (1994), and *The Economics of Global Warming* (1992).

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Peterson Institute for International Economics
1750 Massachusetts Avenue, NW Washington, DC 20036-1903
Tel: (202) 328-9000 Fax: (202) 659-3225 www.petersoninstitute.org

John Williamson (1983) first proposed the idea of fundamental equilibrium exchange rates (FEERs) that differed from observed market rates and that reflected exchange rate levels that would be compatible with a normatively desirable pattern of current account performances in the medium term. This paper proposes a method for estimating consistent FEERs. The estimation method involves first identifying the pattern of desired current account balances. Then it is necessary to arrive at a set of parameters for the response of current account balances to real effective exchange rate changes. With the current account target and exchange rate response parameter in hand for each country (or region), it is possible to directly calculate the change in effective exchange rate needed to obtain the target change in current account. A corresponding set of bilateral exchange rate changes against the dollar will be needed to arrive at FEERs. However, only by chance will the resulting set of calculations be consistent across all countries and regions, so the estimation method needs to ensure as much consistency as possible. This study builds on the matrix inversion approach to this problem set forth in Cline (2007).

For purposes of clarifying the concepts, the first section sets forth a three-country model. A set of three equations relates current account outcomes to changes in real effective exchange rates. There are two exchange rates, because the first country's exchange rate is the numeraire against which the others are compared and does not change against itself. The three-country model helps clarify that some degree of inconsistency is inherent in such a system, because there are more equations (current account change targets) than unknowns (exchange rates) and hence more than a single unique solution. The paper next divides the world into 34 major individual economies (of which one is the euro area) and an aggregate rest-of-world grouping. The analysis considers country adjustment targets and impact parameters and arrives at a method for calculating the full set of 35-country FEERs. The empirical estimates used here are based on the current account targets set forth in Cline and Williamson (2008).

The model developed in this study is referred to as the symmetric matrix inversion method (SMIM). It is symmetric in that it gives equal weight to the current account adjustment targets of all countries considered. In contrast, the matrix inversion approach set forth in Cline (2007) set the US adjustment target as a requirement and then applied a matrix inversion method to obtain the corresponding allocation of exchange rate changes across US trading partners.

A THREE-COUNTRY MODEL

Consider a three-country world in which country 1 is in excessive current account deficit, country 2 is in excessive current account surplus, and country 3 is in current account balance. Define a parameter γ that indicates the change in a country's current account balance as a percent of GDP that takes place in response to a change in the country's real effective exchange rate by 1 percent. Such a relationship is to be expected from the influence of the relative price variable in determining demand and supply of exports and imports. This price variable can be seen as one of the arguments in the equations for imports and exports, with the other main argument being the income variable, or the rate of growth in the domestic economy (for the import equation) or the foreign economies trade-weighted (for the export equation). From the national accounts identity it will also be necessary that the trade deficit (goods and services) equals the excess of investment over domestic saving (including saving by the government). In this general equilibrium system it will be necessary by implication that changes in domestic absorption occur in parallel to the changes directly predicted from the export and import equations in response to exchange rate and activity changes.

With this framework in mind, but without specifying detail as to the component of domestic absorption that changes for compatibility with the changes in the external account, for the three countries the respective changes in current account as a percent of GDP will be:

$$c_1 = \gamma_1 \dot{r}_1 \qquad (1)$$

$$c_2 = \gamma_2 \dot{r}_2 \qquad (2)$$

$$c_3 = \gamma_3 \dot{r}_3 \qquad (3)$$

where c is the desired change in the current account as a percent of GDP to attain fundamental equilibrium, γ is the current account impact parameter just discussed, and $\dot{r}$ is the proportionate change in the real effective exchange rate. Appendix A reports estimates of γ for the 35 countries. Appendix C discusses valuation issues.

A first hurdle of consistency is that the target changes for current account should sum up to zero globally. Suppose the targets are normative rules of thumb, for example, that deficits should not exceed 3 percent of GDP, countries in balance should not necessarily be pushed either to shift into surplus or deficit, and for symmetry, surplus countries should not exceed a surplus of 3 percent of GDP. Only by chance can all three targets be met: namely, the unlikely possibility that the GDPs of each of the three countries are exactly the magnitudes needed for this outcome. Instead, it will generally be necessary to relax one of the three target changes for the global sum of changes to be zero. Considering that balance of payments and external debt crises among deficit countries in the past have been a greater problem than inflationary excess in surplus countries, a reasonable approach is to relax the target change for the surplus country, adjusting it as the residual such that the global changes sum to zero.

Next, in order to translate the changes in real effective exchange rates into the corresponding changes needed in what markets and policymakers actually observe—bilateral exchange rates against the numeraire (dollar)—the system must identify the relationships between bilateral exchange rate changes and real effective exchange rate changes. Abstracting from any induced changes in inflation, these will depend on trade patterns and the extent of appreciation of partners. If the numeraire exchange rate is that of country 1 (the deficit country), or for simplicity, the dollar, the set of effective (or multilateral) exchange rate changes will be:

$$\dot{r}_1 = -\phi_{12} z_2 - \phi_{13} z_3 \qquad (4)$$

$$\dot{r}_2 = \phi_{21} z_2 + \phi_{23}(z_2 - z_3) \qquad (5)$$

$$\dot{r}_3 = \phi_{31} z_3 + \phi_{32}(z_3 - z_2) \qquad (6)$$

where *z* is the percent rise in the bilateral exchange rate of the country against the dollar, and ϕ_{ij} is the share of country *j* in total trade turnover of country *i*. For country 1, in this case the United States, the effective exchange rate falls when the foreign exchange rates rise against the dollar; hence the negative signs on nominal exchange rates 2 and 3. There is no bilateral exchange rate change "*z*" for country 1 because the numeraire currency (the dollar) does not change against itself. The system ultimately has only two unknowns (z_2 and z_3) but three independent equations and is hence overdetermined.

The rationale for the final terms in equations 5 and 6 is that a country (for example, country 2) will have an effective exchange rate increase that is identical to the rise of its exchange rate against the dollar if its entire trade is with the United States (i.e., $\phi_{21} = 1$) but otherwise will have its effective exchange rate increase diminished to the extent that its other trading partner also increases its exchange rate against the dollar. If partner 3 has an exchange rate rise against the dollar identical to that of country 2, and country 2 has most of its trade with partner 3, then the weighted effective exchange rate change for country 2 will be close to zero, because the final term in the equation will be close to zero while the first right-hand-side term will be small because of the small trade weight.

Substituting equations 1 to 3 into equations 4 to 6 yields:

$$\dot{r}_1 = \frac{c_1}{\gamma_1} = -\phi_{12} z_2 - \phi_{13} z_3 \qquad (7)$$

$$\dot{r}_2 = \frac{c_2}{\gamma_2} = \phi_{21} z_2 + \phi_{23}(z_2 - z_3) = z_2 - \phi_{23} z_3 \qquad (8)$$

$$\dot{r}_3 = \frac{c_3}{\gamma_3} = \phi_{31} z_3 + \phi_{32}(z_3 - z_2) = z_3 - \phi_{32} z_2 \qquad (9)$$

The final right-hand side in equations 8 and 9 follows from the fact that the sum of the trade shares of a country with its two trading partners is unity.

Given the target changes in current account as a percent of GDP (c_i) and parameter values γ_i, three equations (7 to 9) are available to solve for two unknowns (z_2 and z_3). Although this system is overdetermined, it is possible to obtain three sets of solutions for the two exchange rate changes (from equation pairs 7-8, 8-9, and 7-9).

MULTICOUNTRY METHOD

To generalize the three-country model into a method capable of calculating FEERs for a considerably larger number of countries, it is helpful to formulate the solution in terms of matrix algebra. The real effective exchange rate change for any given country will be the change of the bilateral rate for the country less the trade-weighted average of the changes of partner countries' exchange rates against the dollar, the counterpart of equations 4 through 6 in the simple model above. The desired set of real effective exchange rate changes, or r_i for country *i*, can be expressed as a vector *R* in which the element in each row *i* is equal to c_i/γ_i, where now there are many countries and hence equations rather than just three as in the corresponding equations 7 through 9 in the simple model above. Similarly, the set of trade weights (i.e., the weights comparable to the ϕ weights on the right-hand side of equations 4 through 6 can be expressed as a matrix ϕ in which the element in row *i* and column *j* is calculated as: $\phi_{ij} = (x_{ij} + x_{ji})/(X_i + M_i)$, where x_{ij} is the flow of exports from country *i* to country *j* (such that the second term in the numerator is the same as imports of country *i* from country *j*, based on partner f.o.b. export data). Each element in the trade-weights matrix is thus the importance to the row country of trade turnover with the column country, as a share of total trade turnover of the row country. Table D.1 in appendix D shows these trade share coefficients for 2006 for 35 countries and economies. The set of changes in bilateral exchange rates against the dollar can be expressed as a vector *Z* in which each row *i* has the percent change of the exchange rate for the country in question against the dollar. (For the United States, this element is zero.) This vector is the multicountry counterpart of the individual bilateral exchange rate changes against the dollar for countries 2 and 3, or z_2 and z_3, in equations 4 through 9 in the simple model.

For a given country, the real effective exchange rate change will equal the change in its exchange rate against the dollar minus the corresponding changes in the exchange rates against the dollar by its trading partners weighted by their respective shares in the trade of the country in question. For country 1, for example, the real effective exchange rate will rise by $\dot{r}_1 = z_1 - z_2\phi_{1,2} - z_3\phi_{1,3} \ldots - z_{35}\phi_{1,35}$. This expression is the product of two vectors: vector *Z* of exchange rate changes against the dollar by each of the partner countries and the row for country 1 in the trade share matrix but with two alterations: each entry is negative instead of positive, and entry of 0 along the diagonal (for zero trade of the country with itself) is replaced by 1, to capture the direct effect of the country's exchange rate change against the dollar. A matrix with such rows can be constructed by subtracting the trade shares matrix from the identity matrix:

$$\underset{35x35}{B} = \underset{35x35}{I} - \underset{35x35}{\phi} \qquad (10)$$

A given vector of bilateral exchange rate changes against the dollar, *Z*, will then generate a vector of real effective exchange rate changes reflecting trade shares with competing partners, calculated as:

$$\underset{35x1}{R} = \underset{35x35}{B}\ \underset{35x1}{Z} \qquad (11)$$

In a system including (in this implementation) 35 equations (for 33 individual economies, the euro area as one country, and the rest of world as one country) but only 34 unknowns, the number of possible combinations for the solution will be n = 35 entities taken k = 34 at a time, which will be n!/[k!(n – k)!] = 35!/[34!(35 – 34)!] = 35 possible solutions. The strategy adopted here is to take an average of all of the possible solutions (except, in each case, the one solution in which the omitted current account equation is that for the country in question, as discussed below).[1]

In addition, because the dollar cannot change against itself, it is necessary to modify matrix equation 11 to remove the dollar from the vector of unknown changes in bilateral exchange rates against the dollar. The United States is country 27 (given the regional format of the trade matrix, which places the Americas toward the end). So the truncated vector of exchange rates can be designated as: Z_{-27}, where the subscript indicates that country 27 is omitted from the vector of exchange rate changes.

Having truncated the *Z* vector (from 35 to 34), it is also necessary to truncate the *B* matrix and *R* vector as well, to preserve compatible dimensionality. This is done by removing the US column and one row from the *B* matrix. The US column must be deleted because the US exchange rate change against itself has been deleted from the *Z* vector; moreover, no information is lost because

[1] In contrast, in Cline (2007), the overidentification problem was solved by two alternative methods that both placed the United States' targets as supreme and all other targets as essentially residual. One method was to minimize the square of deviations from target current account changes subject to the constraint that resulting exchange rate changes generated the desired real depreciation of the dollar. Another method was to use matrix inversion to solve for an exact set of exchange rate changes that yielded the exact current account targets for all other countries, then to confront that set of exchange rate changes against the needed real effective depreciation for the United States, and then to cut back (or expand) proportionately all of the first-round exchange rate changes such that the target US real depreciation was achieved. The method used here instead treats the United States essentially symmetrically with all other countries except for the one country chosen as the residual.

in any event keeping the US column in the B matrix and each time multiplying the relevant row entry by the zero for the change of the dollar against itself would contribute zero to the real effective exchange rate change for the country in question. Implicitly, the information for each country about the importance of trade with the United States is captured not through the direct trade share coefficient but by summing up all of the trade shares of the country with other countries, weighted by the exchange rate changes of those countries.

Finally, it is necessary to delete one row from the vector of real effective exchange rate changes and the adjusted trade matrix: namely, the row for the country selected to be treated residually in the particular run in question. Following the same notation as before, this means that the truncated vector of real effective exchange rate changes will be R_{-i}. The truncated adjusted trade share matrix will be $B_{-i,\,-27}$, where the first subscript indicates that the row for country i (the country chosen to be residual for the solution in question) has been removed and the second subscript designates removal of the column for country 27 (the United States).

The solution for the set of exchange rate changes against the dollar needed to arrive at FEERs is then obtained as follows, where the –1 superscript indicates matrix inversion:

$$\underset{34\,x\,1}{Z_{-27}} = \underset{34\,x34}{B^{-1}_{-i,-27}}\ \underset{34\,x\,1}{R_{-i}} \qquad (11)$$

Once again, the vector of real effective exchange rate changes is determined exogenously and is equal to the set of country current account change targets (c_i) divided by the country adjustment impact parameters (γ_i).

ESTIMATES

Targets. Cline and Williamson (2008) set forth target changes in current account balances to reach FEER levels. In the central set of targets set forth there, deficits are generally constrained to no more than 3 percent of GDP (with twice this level allowed for Australia and New Zealand in view of past performance). Symmetrically, surpluses are in principle limited to 3 percent of GDP (with exceptions at twice this level for high-saving Singapore and Switzerland). Oil-exporting countries are exempted from this ceiling.[2] To obtain international consistency such that target changes sum to zero globally, a proportionately distributed excess above a 3 percent of GDP surplus is also allowed for a subset of high-surplus economies (Japan, China, Hong Kong, Taiwan, Malaysia, and Sweden). The euro area and the other large industrial economies in deficit are assigned targets of zero current account balances, except for the chronic-deficit US and UK economies, which are given deficit ceilings of 3

[2] For the case for excluding oil-exporting countries from target adjustment, see Cline and Williamson (2008).

percent of GDP. As a consequence, the euro area, in particular, stands in need of effective depreciation, given its baseline current account deficit of nearly 1 percent of GDP. Table 1 reports the resulting set of target current account changes. The table is arranged by geographical regions (Pacific, Asia, Middle East/Africa, Europe, and Western Hemisphere). Within each region the major industrial countries are listed first, followed by developing economies. The regional sequence facilitates interpretation of the relationship of effective exchange rate changes to bilateral changes against the dollar, in view of the tendency toward large trade shares with regional partners.

Averaging Approach. As discussed in appendix B, in carrying out the 35 sets of estimates (one each for each country left out as the residual), it turns out that there is a fairly high degree of consistency in the resulting alternative estimates of the needed bilateral change in the exchange rate against the dollar for any given country (z_i) across the 34 runs in which the country in question is included in the trade equations (designated 34OCI for own country included). But there is a wide divergence between that average and the value obtained in the run in which the country is excluded as residual (designated OCE). Unreliability for the country is to be expected in the solution in which the country is a residual, because its target current account adjustment does not have to be met in that solution. The resolution of this source of unreliability is to use as the estimate the average of exchange rate change estimates from all solutions *except* the one for which the country in question is omitted as residually determined.[3]

Base and Alternative Impact Parameters. Appendix A discusses the estimation of the impact parameters γ. These depend on the price elasticity for exports, set in the base case at unity for a relatively closed economy, falling to 0.5 for a highly open economy with exports of goods and services of 100 percent or more of GDP (with a lower elasticity reflecting increasing supply limitations as exports rise relative to GDP). The impact parameter is the multiple of this elasticity times the share of exports in GDP.

It turns out that when the base values for the impact parameters are applied, there tends to be a greater rise in the balances of deficit countries undertaking real depreciation than there is a decline in the aggregate current account surpluses of the surplus countries undertaking appreciation, causing a global surplus discrepancy. Because the impact parameter for the United States is derived from a much more complete model, it is possible that the simpler parameters used for the other countries are not consistent with the US parameter. A reasonable alternative is to specify a higher export price elasticity, which raises the impact parameters of all other countries but leaves that of the

[3] This is just one approach to identifying a single solution from an overidentified system. Other solutions would include weighting results by some sort of penalty function, such as least-square residuals from the target vector of effective exchange rate changes.

United States unchanged. This alternative generates larger surplus reduction than in the base case for the surplus countries, and thus lesser emergence of a global surplus discrepancy, as discussed below.

Table 2 reports the impact parameters used in the base case and the high-elasticities case. Correspondingly, it reports the target changes in real effective exchange rates (R^*) under the two alternative sets of impact parameters. These changes equal the target change in current account as a percent of GDP, from table 1, divided by the impact parameter for the country in question.

Results. Table 3 reports the resulting solution estimates for consistent changes in multilateral effective exchange rates and bilateral rates against the dollar, for both the base impact parameters and the high-elasticity parameters. As discussed, these results use the 34OCI average of all runs that include the country in question. The exchange rate changes are against the average exchange rate for February 2008, the base used in the IMF (2008a) forecasts.

An important feature of the bilateral exchange rate changes is that, for countries appreciating against the dollar, their bilateral rates rise by considerably more than their real effective exchange rates. For example, in the second column of table 3, China's bilateral rate against the dollar rises by 31.5 percent, but its multilateral effective rate rises by only 18.4 percent. The contrast is even more striking for Hong Kong, with a bilateral appreciation of about 29 percent but effective appreciation of only about 8 percent, and for Australia, for which a sizable bilateral appreciation of about 13 percent is nonetheless a real effective depreciation of about 1 percent. The sometimes counterintuitive changes against the dollar are driven by the fact that when key trading partners are appreciating sharply against the dollar, the country in question will also need to appreciate somewhat against the dollar in order to avoid an undesired depreciation of its multilateral effective exchange rate.

Because the system is overdetermined, it is impossible except by chance to obtain a set of results for the real effective exchange rate changes (vector R) that exactly equals the set of targets. As a result, the consistent-solution changes in effective (multilateral) exchange rates in table 3 are not exactly the same as the targets shown in table 2. The divergences between the two are modest, however. The average of the differences between the consistent-solution change in effective exchange rate and the target is –0.8 percentage point in the base case and –0.2 percentage point in the high-elasticities case. The corresponding divergences of current account changes from targets average about 0.2 percent of GDP for the base case and 0.1 percent for the high-elasticities case. The largest divergences of consistent-solution changes in effective exchange rates from targets are approximately –1.3 percent for Australia, Argentina, and Brazil, and about –1.2 percent for the euro area and the United States (base case).

Because the matrix inversion results generate effective exchange rate changes that are not identical to the target changes, the resulting changes in current account balances will not necessarily add up to zero globally. In the base case, there is relatively systematic overshooting of adjustment by deficit countries and undershooting by surplus countries, and a global discrepancy emerges totaling +$122 billion. As expected, the discrepancy is smaller when the high-elasticity set of impact parameters is used, falling to $45 billion globally. As noted in appendix C, operationally it would be cumbersome to seek to eliminate the discrepancy by imposing yet another equation on the system, one requiring that all current account changes sum to zero. Doing so would use 36 equations to solve for 34 unknowns, generating 630 possible solutions. With overdetermination, there would still be no assurance even then that the global discrepancy would be fully eliminated.

The estimates for the United States warrant special comment, considering that the large and chronic US current account deficit has been at the heart of international policy concerns about global imbalances. Earlier analyses in Cline (2005, 2007) sought to meet a US adjustment target exactly, allowing residual departures from current account adjustment targets for other countries. It turns out that in the SMIM model, which as noted gives all economies included equal weight in the effort to reach target changes in current account balances, the United States winds up overadjusting. The effective exchange rate depreciates by 8.6 percent in the base case and 7.8 percent in the high impact parameter case (which, however, leaves the US impact parameter unchanged, as discussed above). Both outcomes involve overshooting the 7.5 percent effective depreciation set as the target (table 2). The current account deficit shrinks by 1.4 percent of GDP in the central case, slightly exceeding the target adjustment of 1.2 percent (table 1). In the high-elasticities case, however, the target is almost exactly met.

The percent changes in bilateral exchange rates are all strictly linear in percent changes in effective exchange rates, and vice versa. So a US-centric approach would generate a set of effective and bilateral exchange rate changes that were all shrunk from the base-case estimates in table 3 by the fraction k = 7.5/8.6 (for the base case).

Exchange Rate Levels. The consistent-solution bilateral exchange rate changes can be applied to actual exchange rate levels to calculate the currency rates against the dollar that would represent a general realignment to FEERs. The IMF (2008) uses average exchange rates for February 2008 as the base for its current account projections, so it is against this base that the percentage changes in the bilateral rates should be applied to arrive at exchange rate levels against the dollar after general realignment to FEERs.

Table 4 reports the base case estimates and those using high elasticities (and hence impact parameters). In the base case, the euro is placed at $1.47, the yen at 90 to the dollar, the pound sterling at $1.91, the Chinese renminbi at 5.45 to the dollar, and the Canadian dollar at 2 percent below parity with the US dollar. Markets have already moved the euro and pound sterling slightly beyond these levels (to $1.55 and $1.97, respectively), and the Canadian dollar stands almost exactly at the central case level (C$ 1.01 per US dollar). In contrast, the yen (at 108 per dollar) and the renminbi (at 6.88) have a considerable way to go before reaching their estimated equilibrium levels.[4] For the major currencies, the estimates here are broadly consistent with those identified in Cline (2007), even though the earlier study was US-centric rather than symmetric.[5]

ALTERNATIVE TARGETS

Cline and Williamson (2008) incorporate the central and high-elasticity estimates set forth here and in addition include results of the SMIM model for two other approaches to setting current account adjustment targets. First, major oil-exporting economies are subject to the same current account rules as other countries. This approach does not affect estimates for Russia or Venezuela, on grounds that their current account surpluses are within the 6 percent of GDP ceiling set for other high-surplus economies. However, Norway and Saudi Arabia are subject to large reductions in their surpluses to meet this ceiling. Second, an alternative is considered in which the objective of adjustment is to stabilize the ratio of net foreign assets to GDP at its present level.[6]

These alternatives begin with different sets of targets for changes in current accounts as a percent of GDP (country targets c_i). An initial step for applying the SMIM model is to ensure that these targets are mutually consistent at least on an ex ante basis. That is, the sum of all targets calling for positive changes equals the sum of all those calling for negative changes, applying the percent of GDP changes to ex ante dollar GDP values.[7] This compatibility is ensured by first taking the average between the aggregate of all deficit reductions and all surplus reductions, and then multiplying all deficit reduction targets by one scalar and all surplus reduction targets by another scalar, with scalars chosen to reduce (or expand) the aggregate in question to the average for the two groups.[8] With the target changes in current accounts of the two alternative rules (or any other rule) thus initially adjusted for global compatibility, the implementation of the SMIM model can then proceed in the same way as in the central and high-elasticities cases examined in this study (following equations 10

[4] These rates are as of June 19, 2008 (Federal Reserve Board).

[5] In Cline (2007), the following reference rates were identified: euro, $1.51; pound sterling, $2.21; yen, 88 per dollar; renminbi, 5.9 per dollar. The rates here are within about 2½ percent of the earlier estimates for the euro and yen. The FEER estimated for the pound sterling is about 13 percent weaker, however, reflecting the absence of any adjustment target for the United Kingdom in the earlier study. For the renminbi, the remaining appreciation needed against the dollar identified here is somewhat smaller than before (32 percent in the central case instead of 36 percent in the earlier study), but the currency has already moved by about 12 percent from the previous base (first eight months of 2006) to the new base (February 2008).

[6] This method has been suggested, among other approaches, in Lee et al. (2008).

[7] That is: $\sum_{i \in d} c_i Y_i = -\sum_{i \in s} c_i Y_i$, where *d* is the set of countries reducing deficits and *s* is the set of countries reducing surpluses.

[8] That is: $\lambda_d = A/D$ and $\lambda_s = A/S$, where *D* is the aggregate change in current account of deficit-reducing countries, *S* is the aggregate reduction in the surpluses of surplus-reducing countries, and *A* is the average of the two.

to 12 after obtaining the vector of desired changes in real effective exchange rates R by dividing each of the adjusted current account adjustment targets by the impact coefficient γ of the country in question).

CONCLUSION

This paper has set forth a new methodology for estimating consistent exchange rate realignments to obtain a multilateral outcome of FEERs, namely the symmetric matrix inversion method. A key choice in this method is to apply matrix inversion to ensure consistency between the current account equations and the relationships between changes in bilateral and multilateral exchange rates. Within this approach, the issue of overdetermination caused by more country equations than unknown currencies is addressed by taking an average of all of the possible results. The only exception is that for each currency in question, the particular result obtained by omitting the current account equation for that country is discarded, because these solutions are found systematically to generate results for the currency that differ—often by large proportions—from the average results for all runs that include the country. The numerical estimates here draw on the most recent IMF (2008a) forecasts of baseline current accounts and apply normative current account targets suggested in Cline and Williamson (2008) as the basis for calculating the needed changes in exchange rates. The latter study further discusses the grounds for identifying the target current account balances, adds two variants to the current account adjustment targets considered, and examines the policy implications of the results estimated.

Table 1 GDP and current account balances for 2009 and target changes to reach FEERs

	Country/region[a]	GDP (billions of dollars)	Current account		Target change in current account	
			Billions of dollars	Percent of GDP	Billions of dollars	Percent of GDP
1	Australia	1,103	−58.2	−5.3	0.0	0.00
2	New Zealand	152	−10.8	−7.1	1.7	1.12
3	Japan	5,027	198.5	3.9	−39.0	−0.78
4	China	4,430	442.7	10.0	−253.1	−5.71
5	Hong Kong	240	20.0	8.3	−10.5	−4.36
6	Taiwan	443	35.8	8.1	−18.4	−4.15
7	Korea	1,073	−9.2	−0.9	9.2	0.86
8	India	1,357	−46.1	−3.4	5.4	0.40
9	Indonesia	536	6.5	1.2	−6.5	−1.21
10	Philippines	187	1.8	1.0	−1.8	−0.96
11	Thailand	294	3.9	1.3	−3.9	−1.33
12	Malaysia	222	24.6	11.1	−14.7	−6.59
13	Singapore	202	38.2	18.9	−26.1	−12.90
14	Israel	184	3.1	1.7	−3.1	−1.68
15	Saudi Arabia	506	121.3	24.0	0.0	0.00
16	South Africa	314	−24.9	−7.9	15.5	4.93
17	Euro area	13,978	−120.8	−0.9	120.8	0.86
18	United Kingdom	2,990	−131.0	−4.4	41.3	1.38
19	Sweden	513	34.5	6.7	−15.6	−3.04
20	Switzerland	475	65.4	13.8	−36.9	−7.76
21	Norway	471	96.3	20.4	0.0	0.00
22	Czech Republic	227	−6.3	−2.8	0.0	0.00
23	Hungary	163	−8.3	−5.1	3.4	2.08
24	Poland	481	−27.3	−5.7	12.9	2.68
25	Turkey	758	−47.9	−6.3	25.2	3.32
26	Russia	2,017	57.7	2.9	0.0	0.00
27	United States	14,533	−605.5	−4.2	169.5	1.17
28	Canada	1,632	−19.8	−1.2	19.8	1.21
29	Mexico	988	−16.3	−1.6	0.0	0.00
30	Argentina	364	−2.0	−0.5	2.0	0.55
31	Brazil	1,730	−16.0	−0.9	0.0	0.00
32	Chile	173	−2.3	−1.3	0.0	0.00
33	Colombia	209	−9.1	−4.3	2.8	1.36
34	Venezuela	339	17.1	5.0	0.0	0.00
35	Rest of world	5,042	196.2	3.9	0.0	0.00
	World	63,354	202.1	0.3	0.0	0.00

a. 1–2: Pacific; 3–13: Asia; 14–16: Middle East/Africa; 17–26: Europe; 27–34: Western Hemisphere.

Source: GDP and current account balances are from IMF (2008a).

Table 2 Current account impact parameter (γ) and target percent change in real effective exchange rate (R^*)

	Country/ region	Exports as percent of GDP[a]	Impact parameter (γ)[b]		Target percent change in R^*[c]	
			Base	High-elasticities	Base γ	High-elasticities γ
1	Australia	18.1	–0.17	–0.26	0.0	0.0
2	New Zealand	28.0	–0.25	–0.38	–4.4	–3.0
3	Japan	11.8	–0.12	–0.18	6.6	4.4
4	China	34.4	–0.30	–0.45	19.2	12.8
5	Hong Kong	172.2	–0.50	–0.75	8.7	5.8
6	Taiwan	58.4	–0.43	–0.64	9.7	6.5
7	Korea	38.2	–0.32	–0.48	–2.7	–1.8
8	India	14.6	–0.14	–0.21	–2.8	–1.9
9	Indonesia	31.2	–0.27	–0.41	4.4	2.9
10	Philippines	49.1	–0.38	–0.58	2.5	1.7
11	Thailand	65.6	–0.45	–0.68	2.9	1.9
12	Malaysia	114.9	–0.50	–0.75	13.2	8.8
13	Singapore	158.0	–0.50	–0.75	25.8	17.2
14	Israel	38.4	–0.32	–0.49	5.2	3.5
15	Saudi Arabia	47.0	–0.37	–0.56	0.0	0.0
16	South Africa	44.0	–0.36	–0.54	–13.9	–9.2
17	Euro area	14.7	–0.14	–0.21	–6.0	–4.0
18	United Kingdom	25.1	–0.23	–0.34	–6.0	–4.0
19	Sweden	43.9	–0.36	–0.53	8.6	5.7
20	Switzerland	43.7	–0.35	–0.53	21.9	14.6
21	Norway	46.0	–0.37	–0.55	0.0	0.0
22	Czech Republic	75.8	–0.48	–0.72	0.0	0.0
23	Hungary	77.6	–0.48	–0.73	–4.3	–2.9
24	Poland	40.5	–0.34	–0.50	–8.0	–5.3
25	Turkey	30.2	–0.27	–0.40	–12.4	–8.3
26	Russia	35.0	–0.30	–0.45	0.0	0.0
27	United States[d]	n.a.	–0.16	–0.16	–7.4	–7.4
28	Canada	37.8	–0.32	–0.48	–3.8	–2.5
29	Mexico	28.4	–0.25	–0.38	0.0	0.0
30	Argentina	25.0	–0.23	–0.34	–2.4	–1.6
31	Brazil	16.9	–0.16	–0.24	0.0	0.0
32	Chile	36.4	–0.31	–0.47	0.0	0.0
33	Colombia	21.4	–0.20	–0.30	–6.8	–4.5
34	Venezuela	37.0	–0.31	–0.47	0.0	0.0
35	Rest of world	—	–0.30	–0.30	0.0	0.0

n.a. = not applicable
a. Goods and services.
b. Base: for export price elasticity $\eta = -1.0$ to -0.5; High: for $\eta = -1.5$ to -0.75.
c. Equals target change in current account as percent of GDP (table 1), divided by γ.
d. For the United States includes cumulative capital services effects (Cline 2005, 96).

Table 3 Consistent-solution changes in exchange rates and current accounts to reach FEERs

	Country/ region	A. Base case				B. High-elasticities case			
		Multilateral (percent change in R^*)[a]	Bilateral (Z)[a]	Change in current account		Multilateral (percent change in R^*)[a]	Bilateral (Z)[a]	Change in current account	
				Percent of GDP	Billions of dollars			Percent of GDP	Billions of dollars
1	Australia	–1.3	12.8	0.2	2.4	–0.3	11.3	0.1	1.0
2	New Zealand	–5.4	6.7	1.4	2.1	–3.2	7.1	1.2	1.8
3	Japan	5.7	19.0	–0.7	–33.5	4.2	15.1	–0.7	–36.7
4	China	18.4	31.5	–5.5	–242.2	12.6	23.4	–5.6	–248.6
5	Hong Kong	8.2	29.0	–4.1	–9.8	5.7	21.8	–4.2	–10.2
6	Taiwan	9.0	26.0	–3.8	–17.0	6.3	19.8	–4.0	–17.8
7	Korea	–3.5	11.2	1.1	12.0	–2.0	10.0	1.0	10.4
8	India	–3.6	7.1	0.5	7.0	–2.1	7.3	0.4	6.1
9	Indonesia	3.5	22.6	–1.0	–5.2	2.7	17.8	–1.1	–5.9
10	Philippines	1.7	18.2	–0.7	–1.2	1.5	14.6	–0.8	–1.6
11	Thailand	2.0	17.9	–0.9	–2.7	1.7	14.6	–1.2	–3.4
12	Malaysia	12.3	30.7	–6.1	–13.6	8.5	23.1	–6.4	–14.2
13	Singapore	24.7	41.2	–12.3	–25.0	16.9	30.2	–12.7	–25.6
14	Israel	4.5	9.4	–1.5	–2.7	3.3	8.3	–1.6	–2.9
15	Saudi Arabia	–0.7	10.1	0.3	1.4	–0.2	9.2	0.1	0.6
16	South Africa	–14.6	–6.7	5.2	16.3	–9.4	–1.8	5.0	15.8
17	Euro area	–7.2	–0.2	1.0	143.9	–4.3	2.7	0.9	130.3
18	United Kingdom	–6.6	–2.5	1.5	45.7	–4.2	1.0	1.4	43.1
19	Sweden	7.9	10.7	–2.8	–14.4	5.5	9.9	–2.9	–15.1
20	Switzerland	21.4	23.9	–7.6	–36.1	14.4	18.6	–7.7	–36.6
21	Norway	–0.5	2.2	0.2	0.9	–0.1	4.2	0.1	0.4
22	Czech Republic	–0.5	1.4	0.2	0.5	–0.1	3.8	0.1	0.2
23	Hungary	–4.8	–1.9	2.3	3.8	–3.0	1.7	2.2	3.6
24	Poland	–8.6	–6.1	2.9	13.8	–5.5	–1.1	2.8	13.3
25	Turkey	–13.0	–8.5	3.5	26.3	–8.4	–2.9	3.4	25.6
26	Russia	–0.6	4.2	0.2	3.7	–0.2	5.7	0.1	1.5
27	United States	–8.6	0.0	1.4	196.8	–7.8	0.0	1.2	177.0
28	Canada	–4.1	–1.5	1.3	21.3	–2.6	–0.3	1.3	20.4
29	Mexico	–0.4	2.0	0.1	0.9	–0.1	2.1	0.0	0.4
30	Argentina	–3.8	2.6	0.9	3.1	–2.0	4.5	0.7	2.5
31	Brazil	–1.4	4.8	0.2	3.8	–0.4	5.8	0.1	1.6
32	Chile	–1.1	5.9	0.3	0.6	–0.3	6.4	0.1	0.2
33	Colombia	–7.8	–3.5	1.6	3.3	–4.8	–0.4	1.4	3.0
34	Venezuela	–0.8	2.8	0.3	0.9	–0.2	3.7	0.1	0.4
35	Rest of world	–1.0	5.7	0.3	14.8	–0.3	6.5	0.1	4.1
	World				**122.1**				**44.7**

a. Percent from February 2008.

Table 4 Exchange rate levels: February 2008 and subsequent to realignment to FEER levels (currency per dollar)

	Country/region	February 2008	FEER level	
			Base case	High-elasticities γ
1	Australia[a]	0.91	1.02	1.01
2	New Zealand[a]	0.80	0.85	0.86
3	Japan	107	90.1	93.1
4	China	7.17	5.45	5.81
5	Hong Kong	7.80	6.05	6.40
6	Taiwan	31.6	25.1	26.4
7	Korea	945	850	859
8	India	39.7	37.1	37.0
9	Indonesia	9,181	7,490	7,795
10	Philippines	40.7	34.4	35.5
11	Thailand	32.7	27.7	28.5
12	Malaysia	3.22	2.47	2.62
13	Singapore	1.41	1.00	1.08
14	Israel	3.61	3.30	3.33
15	Saudi Arabia	3.75	3.41	3.43
16	South Africa	7.66	8.21	7.80
17	Euro area[a]	1.47	1.47	1.51
18	United Kingdom[a]	1.96	1.91	1.98
19	Sweden	6.35	5.74	5.78
20	Switzerland	1.09	0.88	0.92
21	Norway	5.39	5.28	5.17
22	Czech Republic	17.2	17.0	16.6
23	Hungary	178	181	175
24	Poland	2.43	2.59	2.46
25	Turkey	1.21	1.32	1.25
26	Russia	24.5	23.5	23.2
27	United States	1.00	1.00	1.00
28	Canada	1.00	1.02	1.01
29	Mexico	10.8	10.6	10.6
30	Argentina	3.14	3.06	3.01
31	Brazil	1.73	1.65	1.64
32	Chile	467	441	439
33	Colombia	1907	1977	1913
34	Venezuela	2.14	2.08	2.06

a. Dollars per currency unit.

APPENDIX A
CURRENT ACCOUNT IMPACT PARAMETER ESTIMATES

The impact parameter γ used in the approach of this paper indicates the change in current account as a percent of GDP for a one percentage point change in the real effective exchange rate (trade-weighted). Cline (2005) argues that this parameter should equal the price elasticity of exports multiplied by the share of exports of goods and services in GDP. The idea is that with a unitary import elasticity, the value of imports in local currency will remain unchanged (volume change will be offset by price change). All adjustment will take place on the export side. The export price elasticity in turn is set at unity for a relatively closed economy, falling to 0.5 for an economy in which exports of goods and services are 100 percent of GDP (to account for supply constraints). For the important case of the United States, the impact parameter also incorporates the effect of changes in valuation of international assets and liabilities from an exchange rate change, and consequential effects on subsequent capital service payments.

Table 2 reports the estimated current account impact parameters. For the most part, these are from Cline (2005, 96, 250). Several countries have been added, using 2006 data for the export shares for the new countries (IMF 2008b). In addition, the parameters have been reset to remain at the maximum (absolute) values of 0.5 for the three economies with exports of goods and services in excess of GDP (Hong Kong, Malaysia, and Singapore), in preference to allowing these parameters to fall back below this maximum following the unadjusted application of the quadratic relationship of γ to the share of exports in GDP.[9]

Table 2 also reports alternative higher values for the impact parameter, as discussed in the main paper above. These are calibrated for an export price elasticity of 1.5 for a relatively closed economy, falling to 0.75 for a highly open economy with exports at 100 percent or more of GDP.[10]

The meaning of the parameter γ for the oil-exporting economies warrants further discussion. For these countries, adjustment must take place mainly on the import side, because oil exports are price inelastic. No special reestimation has been developed here for these countries. By implication, their import price elasticities would need to be higher than unity for consistency with the current account impact parameters used. It turns out that import price elasticities of about 2.2 would suffice for this purpose.[11]

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[9] Cline (2005, 252) suggested a price elasticity of unity for exports for a country with exports at 10 percent of GDP, falling to 0.5 with exports at 100 percent of GDP. The quadratic relationship fitting these two points is: $\eta = -1.056 + 0.56x$, where η is the price elasticity of exports and x is the share of exports in GDP. The current account impact parameter is then the product of this elasticity and the export share in GDP, or $\gamma = \eta x = -1.056x + 0.56\, x^2$.

[10] In this case, $\eta = -1.583 + 0.83x$, and $\gamma = \eta x = -1.583x + 0.83\, x^2$.

[11] Both Norway and Saudi Arabia have imports of goods and services of about 30 percent of GDP. Their γ parameter is –0.37 for both (table 2). The import price elasticity would need to be: 1 + 0.37/0.3 = 2.23 for a 1 percent appreciation to increase the value of imports in local currency by 0.37 percent of GDP, as volume would rise by 2.23 percent, local currency unit price would fall by 1 percent, and the resulting 1.23 percent change applied to 30 percent of GDP would amount to 0.37 percent of GDP.

APPENDIX B
AVERAGING ALTERNATIVE SOLUTIONS TO THE OVERDETERMINED EXCHANGE RATE PROBLEM

As set forth in the main paper, the matrix inversion method of identifying a set of exchange rate realignments obtains the desired vector of bilateral changes against the dollar as the product of the inverse of a matrix of trade weights and the vector of desired changes of real effective exchange rate changes. With 35 economies and 34 exchange rates (the US dollar being the residual numeraire), and with 35 target current account changes and hence target changes in real effective exchange rates, the system is overdetermined. For any given exchange rate, there will be 35 possible solutions to the appropriate change against the dollar. Of these, 34 will be generated by a set of country equations that include the country in question. However, one solution will be generated by a set of all 34 countries excluding the own country in question. For purposes of clarity, define this one solution as the own country excluded, or OCE, solution. Correspondingly, define the solution obtained for the 34 outcomes in which the own country is included as the 34OCI solution, namely the average exchange rate change for the country in question over those 34 solutions in which it has been allowed to take part. Finally, define the simple average over all solutions as the 35AV (all countries included) solution.

An empirical pattern encountered in applying this approach to the countries and targets specified in this study is that, systematically, the desired percent change in the exchange rate for a country that emerges from the OCE solution is far below the change that is identified in the 34OCI solution. The discrepancy is often so large that it is indefensible to include the OCE estimate, even if its dilution through averaging with 34 other possible estimates results in a much more plausible simple average in the 35AV result. Table B.1 reports these three respective sets of estimated bilateral exchange rate changes that are obtained in applying this study's methodology and current account targets (using the base trade elasticities and the base, or symmetric rather than US-centric, formulation).

It is evident in table B.1 that the single run excluding the current account equation for the country in question gives nonsense results for several of the smaller countries, with indicated depreciations of more than 100 percent for more than one-fourth of the countries. It is also evident that even for the other countries, the OCE solution always gives a larger depreciation or smaller appreciation against the dollar than occurs in the average of the 34 runs that include the current account equation for the country in question. The standard deviations found for the 34OCI runs also suggest relatively well-defined estimates.

At the level of first principles, there is a case for excluding the OCE results in obtaining the realignment solution. It makes little sense to determine a country's appropriate exchange rate change without directly taking account of the target change in current account for the country itself, and instead only capturing the effect of the country's exchange rates by reflection from target changes for all other countries. The risk is that, especially for the smaller countries, the passive exchange rate determination resulting from considering all other countries will bear little relationship to the active determination from taking direct account of the current account target for the country in question.

These initial estimates and this general principle provide sufficient reason in themselves to adopt the average of only the runs that *include* the country in question in arriving at the target bilateral exchange rate changes. That is, this study uses the 34OCI estimate, rather than the simple average over all runs (35AV), as its estimate for the set of bilateral exchange rate changes against the dollar. The results of table B.1 do beg the question of why the 34OCI estimates are systematically lower algebraically than the 35AV estimates, or, correspondingly, why the OCE estimates are always lower (sometimes dramatically so) algebraically than the 34OCI estimates.

To examine this question, it is helpful to simplify by returning to the three-country case. Once again let country 1 be the United States, with its currency as the numeraire and hence by definition having zero bilateral exchange rate change against the dollar. Can it be demonstrated that in general solving for, let us say, the exchange rate change of country 3 by considering only the current account equations of countries 1 and 2 must necessarily generate an exchange rate change for country 3 that is more negative than the solution found when instead country 3 is included in the pair of equations used to solve for the two unknown exchange rate changes?

It turns out, the answer is no. This can be demonstrated by considering the general form for the two-equation, two-unknown system. In this system, with subscript indicating the number of the equation, coefficients *a* and *b* on unknowns *x* and *y,* respectively, and constant *C,* each equation is: $a_i x + b_i y + C_i = 0$. The general form for the two-equation, two-unknown solution is:

$$y = -\frac{C_1 - \lambda C_2}{b_1 - \lambda b_2} \equiv -\frac{\Omega}{\theta};$$
$$x = \frac{b_1\left(\frac{\Omega}{\theta}\right) - C_1}{a_1} \qquad \text{(B.1)}$$

where, for convenience, the terms Ω and θ are defined as, respectively, the numerator and denominator in the expression for *y*, and $\lambda \equiv a_1/a_2$. When this form is applied to equations 7 to 9 of the main paper, using *x* for bilateral appreciation z_2 and *y* for bilateral appreciation z_3, the three alternative estimates for z_3 corresponding to case A for solution from equations 7 and 8, B for solution from equations 7 and 9, and C for solution from equations 8 and 9, are:

$$z_3^A = -\frac{\dot{r}_1 - \phi_{12}\dot{r}_2}{\phi_{13} + \phi_{12}\phi_{23}};$$

$$z_3^B = \frac{-\dot{r}_1 + \dot{r}_3[\phi_{12}/\phi_{32}]}{\phi_{13} + [\phi_{12}/\phi_{32}]}; \qquad \text{(B.2)}$$

$$z_3^C = \frac{\dot{r}_2 + [\dot{r}_3/\phi_{32}]}{-\phi_{23} + [1/\phi_{32}]}$$

In this setup, the solution from combination A is the OCE solution for z_3. If mathematically the OCE solution were always algebraically lower than any of the solutions in which the own country is included, the pattern in table B.1 might be considered inherent to the solution structure. But simple examples show that this is not the case. It turns out that if all three countries are the same size, so that all trade shares ϕ_{ij} = 0.5 (that is, because for country 2, for example, trade with country 1 has a share of one half, as does trade with country 3), then a desired set of real effective exchange rate changes of –0.1 for country 1 and +0.05 for both countries 2 and 3 would generate the bilateral exchange rate change z_3 = +0.1 in all three combinations (A, B, and C) rather than a lower outcome in combination A than in B and C. The same is true for other examples with real effective exchange rate targets set to be consistent. In another example in which countries 1 and 2 are large but country 3 is small, it does turn out that the OCE solution A differs from the OCI solutions B and C (both of which generate the same solution), but z_3 turns out to be larger in A than in B and C, rather than smaller.[12] So the pattern in table B.1 of OCE estimates systematically lower than OCI estimates remains an artifact in search of an explanation, but nonetheless an important artifact that by itself is sufficient to counsel the use of the average of OCI solutions and the discarding of the OCE solution to the overdetermined exchange rate problem.

[12] Suppose country 2 is half of the world economy, country 1 is 40 percent, and country 3 is 10 percent. Then country 2 is five times as important as country 3 in the trade of country 1, so ϕ_{12} = 0.833, ϕ_{13} = 0.167. Correspondingly, country 2 is 1.25 times as important as country 1 in the trade of country 3, so ϕ_{31} =0.44 and ϕ_{32} = 0.56. For country 2, the importance of trade with country 1 is ϕ_{21} = 0.8, and with country 3, ϕ_{23} = 0.2. Suppose the desired set of real effective exchange rate changes is –0.1 for country 1, +0.1 for country 2, and –0.1 for country 3. Then it turns out that z_3 = +0.05 for combination A, –0.029 for combination B, and –0.05 for combination C.

Table B.1 Estimated percent change in exchange rate against the dollar in realignment to FEERs

	Country	35AV	OCE	34OCI Average	34OCI Standard deviation
1	Australia	10.7	–60.4	12.8	3.7
2	New Zealand	–4.4	–382.7	6.7	3.6
3	Japan	18.6	4.0	19.0	2.0
4	China	31.1	20.4	31.5	2.0
5	Hong Kong	28.2	0.4	29.0	2.2
6	Taiwan	24.9	–12.7	26.0	2.1
7	Korea	10.3	–20.0	11.2	2.0
8	India	5.0	–65.7	7.1	1.9
9	Indonesia	19.9	–70.2	22.6	2.7
10	Philippines	13.3	–155.0	18.2	2.3
11	Thailand	15.8	–55.5	17.9	2.3
12	Malaysia	28.9	–33.1	30.7	2.7
13	Singapore	40.0	2.0	41.2	3.0
14	Israel	3.7	–187.8	9.4	1.7
15	Saudi Arabia	8.1	–61.1	10.1	2.0
16	South Africa	–11.1	–158.2	–6.7	2.0
17	Euro area	–0.3	–5.8	–0.2	2.5
18	United Kingdom	–3.1	–22.1	–2.5	2.4
19	Sweden	8.8	–57.8	10.7	2.9
20	Switzerland	22.3	–35.3	23.9	2.3
21	Norway	–0.7	–98.7	2.2	2.9
22	Czech Republic	–1.5	–100.0	1.4	3.0
23	Hungary	–5.4	–126.2	–1.9	2.9
24	Poland	–8.4	–84.5	–6.1	3.1
25	Turkey	–11.0	–95.0	–8.5	2.4
26	Russia	3.0	–37.3	4.2	2.7
28	Canada	–2.2	–24.8	–1.5	0.4
29	Mexico	0.9	–35.7	2.0	0.6
30	Argentina	–4.2	–234.6	2.6	4.4
31	Brazil	2.6	–72.9	4.8	3.9
32	Chile	0.2	–191.2	5.9	3.0
33	Colombia	–14.0	–369.1	–3.5	2.7
34	Venezuela	–2.0	–166.4	2.8	2.7
35	Rest of world	5.5	–3.0	5.7	2.1

35AV: average over all 35 runs.
OCE: single run in which the country in question is excluded.
34OCI: average over the 34 runs that include the country in question.

APPENDIX C
VALUATION ISSUES

In principle, in the consistent realignment analysis of this study another equation could be included, which is the constraint that the sum of changes in current accounts should equal zero. In the approach applied, this constraint is only implied by the initial set of current account change targets, rather than explicitly included as a separate equation. If this summing-up equation were added, there would be the complication of two more equations than unknowns, increasing the problem of overdetermination. Moreover, there would be what may be seen as an index number problem in the sense that the change in the dollar current account value is not simply the percent of GDP change in the current account as applied to the base dollar GDP level, but there needs to be a correction for the fact that the dollar GDP valuation changes when the exchange rate changes. For any country other than the United States, we have the following relationships.

$$CA^0_\$ = k^0 YR^0\,; \quad CA^1_\$ = k^1 YR^1\,; \quad c \equiv k^1 - k^0 \qquad \text{(C.1)}$$

where CA is current account (billions), subscript $\$$ refers to nominal dollars, superscripts 0 and 1 refer to before and after the exchange rate realignment, k is the ratio of the current account balance to GDP, Y is GDP in local currency, and R is the exchange rate defined in the euro-pound sterling-Australian dollar fashion (US dollars per unit of currency). From the definition of the nominal proportionate exchange rate change against the dollar as z, it follows that $R^1 = R^0(1+z)$.

The change in the country's dollar current account balance will thus equal:

$$\Delta CA_\$ = k^1 YR^0 (1+z) - k^0 YR^0 = YR^0 (c + k^1 z) \qquad \text{(C.2)}$$

(Note that equation C.2 also applies to the United States but in that case z is zero so the interaction-valuation term disappears.) Here it becomes evident that even for the region in balance, with a target of no change in the current account as a percent of GDP, there will be a change in the dollar value of the current account that reflects the nominal rise in the region's currency against the dollar that occurs to keep the region from depreciating in real terms in the face of a larger appreciation of the currency of the high-surplus region. This turns out not to matter much because if the change in current account as percent of GDP is $c = 0$, then because the balanced region tends to have an initial as well as postrealignment balance close to zero, the term k^1 will be close to zero and when multiplied by a moderate appreciation (suppose, for example, that z is 0.1 or 10 percent), the final expression in parentheses will be close to zero.

The index-number adjustment for valuation effect will be larger for the high-surplus region. Suppose, by way of illustration, that the initial current account surplus is 12 percent of GDP; the target change in surplus is –5 percent of GDP; and the nominal appreciation against the dollar is 20 percent. Then the final interaction term k^1z will be 20 percent of 7 percent or 1.4 percent, and the change in the dollar value of the current account is not the full reduction of 5 percent times the original dollar GDP but instead is that amount narrowed by a valuation increase of 1.4 percent of original dollar GDP.

A final consistency constraint in the system is then that the sum of changes in dollar current account balances should be zero, or:

$$\Delta CA_{\$1} + \Delta CA_{\$2} + \Delta CA_{\$3} = 0 \qquad \text{(C.3)}$$

where the new additional subscript refers to the country.

If this consistency constraint is added, then the three-country system has only two unknown nominal exchange rates (z_2 and z_3) but four equations (three for required real effective exchange rate changes, equations 7 to 9, and one for global consistency in adding up current account changes, equation C.2). In this case the number of possible solutions rises to 6, representing the number of possible combinations of four equations taken two at a time.[13] If the model is disaggregated to 35 countries and regions as in the second part of this paper, the number of possible solutions mushrooms to 630.[14] Instead of introducing a separate equation and averaging results across this many possible solutions, the main paper adopts a more workable approach of omitting the summation constraint but keeping an eye on the size of the resulting global discrepancy to ensure it is not so large as to raise serious doubts about the estimates.

[13] That is, 4!/[2!(4 – 2)!].

[14] With 34 nondollar currencies there are 35 real effective exchange rate equations and one summation of current account changes equation, or 36 equations. With 34 unknown exchange rate changes, the number of possible solutions is 36!/[34!(36 – 34)!].

APPENDIX D

MATRIX OF TRADE SHARES

Percent share of trade with column country in trade of row country, 2006

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
		ALA	**NZ**	**JPN**	**CHN**	**HK**	**TAI**	**KOR**	**IND**	**INS**	**PHL**	**THA**	**MLS**	**SGP**	**ISR**	**SAR**	**SAF**	**EUR**
1	**ALA**	0.0	4.6	14.7	11.5	2.4	3.0	5.4	3.1	2.6	0.5	3.1	2.7	5.5	0.2	1.1	1.2	11.1
2	**NZ**	24.2	0.0	9.4	6.1	1.8	2.1	3.2	0.8	2.0	0.8	1.7	2.1	3.7	0.1	1.2	0.5	9.9
3	**JPN**	3.1	0.4	0.0	15.7	4.4	5.5	6.3	0.7	2.5	1.4	3.4	2.3	2.9	0.2	3.3	0.9	9.6
4	**CHN**	1.7	0.2	11.0	0.0	18.1	6.4	6.4	1.4	1.1	0.6	1.3	1.5	3.0	0.2	1.1	0.5	12.3
5	**HK**	0.9	0.1	7.7	45.0	0.0	4.7	3.6	1.1	0.5	0.9	1.5	1.6	5.0	0.6	0.1	0.2	7.4
6	**TAI**	1.6	0.2	13.7	22.9	6.7	0.0	4.3	0.6	1.6	1.3	1.8	2.4	5.3	0.3	2.0	0.3	8.9
7	**KOR**	2.3	0.3	12.9	18.7	4.2	3.5	0.0	1.4	2.0	0.9	1.1	1.8	3.0	0.2	3.4	0.4	9.5
8	**IND**	3.1	0.1	3.3	9.8	2.9	1.1	3.3	0.0	2.1	0.2	1.3	2.6	4.9	1.0	1.6	1.0	16.8
9	**INS**	3.3	0.5	14.8	9.2	1.6	3.7	5.9	2.7	0.0	0.6	3.3	4.3	19.4	0.0	1.8	0.3	8.1
10	**PHL**	1.2	0.4	16.1	9.9	6.1	5.9	4.8	0.5	1.2	0.0	3.8	4.6	8.2	0.2	2.6	0.1	11.4
11	**THA**	3.1	0.3	15.9	8.7	4.2	3.5	2.6	1.3	2.6	1.6	0.0	6.1	8.0	0.4	2.1	0.6	8.1
12	**MLS**	2.3	0.3	9.5	8.7	3.7	4.0	3.6	2.2	3.0	1.7	5.2	0.0	20.9	0.0	0.9	0.4	9.1
13	**SGP**	2.9	0.4	7.2	10.4	7.1	5.2	3.6	2.5	8.0	1.8	4.1	12.6	0.0	0.2	1.9	0.3	8.1
14	**ISR**	0.6	0.1	2.2	3.9	4.4	1.4	1.5	2.8	0.1	0.2	1.1	0.1	0.8	0.0	0.0	1.1	25.7
15	**SAR**	1.0	0.2	15.1	7.4	0.3	3.7	7.8	1.5	1.4	1.1	2.0	1.0	3.6	0.0	0.0	1.5	16.6
16	**SAF**	2.5	0.2	8.6	6.6	1.1	1.0	2.1	2.0	0.5	0.1	1.1	0.9	1.3	0.8	3.3	0.0	26.9
17	**EUR**	0.8	0.1	3.3	6.0	1.5	1.2	1.6	1.2	0.5	0.3	0.6	0.8	1.1	0.7	1.2	0.9	0.0
18	**UK**	1.1	0.2	2.3	3.1	1.5	0.6	0.9	1.1	0.2	0.1	0.5	0.5	1.2	0.4	0.5	0.9	50.6
19	**SWE**	0.8	0.1	1.5	2.3	0.5	0.4	0.6	0.6	0.3	0.1	0.3	0.3	0.3	0.2	0.4	0.5	44.3
20	**SWZ**	0.5	0.1	2.5	1.9	0.5	0.5	0.7	0.7	0.1	0.1	0.6	0.3	0.8	0.5	0.4	0.7	56.0
21	**NOR**	0.2	0.0	1.5	1.9	0.3	0.4	0.8	0.3	0.1	0.0	0.2	0.1	0.6	0.1	0.1	0.1	40.6
22	**CZH**	0.1	0.0	1.3	1.5	0.4	0.4	0.3	0.3	0.1	0.0	0.2	0.2	0.1	0.2	0.1	0.2	59.1
23	**HUN**	0.1	0.0	1.4	2.7	0.8	0.8	0.9	0.2	0.1	0.1	0.2	0.3	0.5	0.3	0.2	0.2	55.6
24	**POL**	0.1	0.0	0.5	2.0	0.2	0.3	1.1	0.2	0.1	0.0	0.1	0.1	0.1	0.1	0.1	0.2	55.6
25	**TUR**	0.3	0.0	1.2	3.8	0.4	0.8	1.4	0.8	0.5	0.1	0.4	0.3	0.3	1.1	1.4	0.5	38.4
26	**RUS**	0.1	0.0	2.6	6.9	0.2	0.4	1.5	0.8	0.1	0.0	0.2	0.2	0.3	0.5	0.1	0.0	41.1
27	**US**	0.9	0.2	7.3	9.1	2.3	2.2	2.5	1.1	0.6	0.6	1.0	1.5	1.8	1.0	1.3	0.4	14.3
28	**CAN**	0.4	0.1	2.5	3.1	0.7	0.7	0.9	0.4	0.2	0.1	0.2	0.2	0.2	0.1	0.3	0.1	5.2
29	**MEX**	0.2	0.1	2.4	2.3	0.4	1.3	1.4	0.4	0.2	0.0	0.2	0.2	0.3	0.1	0.1	0.0	6.5
30	**ARG**	0.3	0.0	1.4	7.1	0.6	0.5	1.0	1.5	0.6	0.4	0.8	0.9	0.2	0.3	0.4	1.3	15.6
31	**BRZ**	0.5	0.0	3.0	6.8	0.9	1.2	2.1	1.0	0.5	0.1	0.6	0.5	1.0	0.3	1.3	0.8	19.3
32	**CHL**	0.3	0.1	7.8	8.8	0.5	0.3	5.3	1.8	0.4	0.2	0.7	0.2	0.1	0.1	0.1	0.1	19.8
33	**COL**	0.1	0.0	2.7	3.5	0.3	0.7	2.0	1.1	0.2	0.0	0.3	0.1	0.3	1.1	0.0	0.1	12.7
34	**VEN**	0.0	0.1	1.4	3.9	0.2	0.7	0.9	0.1	0.1	0.0	0.1	0.1	0.3	0.0	0.0	0.1	8.7
35	**ROW**	1.0	0.2	6.1	6.5	1.5	1.4	3.6	2.3	0.7	0.2	1.6	0.7	1.8	0.3	1.7	0.9	32.4

		18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35
		UK	**SWE**	**SWZ**	**NOR**	**CZH**	**HUN**	**POL**	**TUR**	**RUS**	**US**	**CAN**	**MEX**	**ARG**	**BRZ**	**CHL**	**COL**	**VEN**	**ROW**
1	**ALA**	4.3	0.9	0.6	0.1	0.1	0.1	0.1	0.2	0.2	10.2	1.1	0.4	0.1	0.5	0.1	0.0	0.0	8.2
2	**NZ**	3.8	0.4	0.4	0.1	0.0	0.0	0.0	0.2	0.2	12.6	1.5	0.7	0.1	0.2	0.1	0.0	0.3	9.7
3	**JPN**	1.9	0.4	0.7	0.2	0.2	0.2	0.1	0.2	1.0	17.7	1.6	0.9	0.1	0.6	0.6	0.1	0.1	10.7
4	**CHN**	1.8	0.4	0.3	0.2	0.2	0.2	0.3	0.5	1.9	15.4	1.3	0.6	0.3	0.9	0.5	0.1	0.2	7.9
5	**HK**	2.2	0.2	0.2	0.1	0.1	0.2	0.1	0.1	0.1	9.7	0.7	0.3	0.1	0.3	0.1	0.0	0.0	4.6
6	**TAI**	1.3	0.3	0.4	0.1	0.2	0.2	0.1	0.4	0.4	13.3	1.1	1.3	0.1	0.6	0.1	0.1	0.2	6.3
7	**KOR**	1.4	0.3	0.4	0.3	0.1	0.2	0.5	0.5	1.2	12.5	1.1	1.1	0.1	0.8	0.8	0.2	0.2	12.8
8	**IND**	4.2	0.7	0.8	0.2	0.2	0.1	0.2	0.7	1.5	12.6	1.3	0.7	0.5	1.0	0.7	0.2	0.1	19.1
9	**INS**	1.2	0.4	0.2	0.1	0.1	0.1	0.1	0.5	0.3	8.1	0.8	0.4	0.2	0.6	0.2	0.1	0.0	7.0
10	**PHL**	0.9	0.1	0.2	0.0	0.1	0.1	0.0	0.1	0.1	15.6	0.6	0.2	0.3	0.3	0.1	0.0	0.0	4.3
11	**THA**	1.8	0.3	0.7	0.1	0.2	0.1	0.1	0.3	0.3	11.2	0.7	0.3	0.3	0.6	0.3	0.1	0.0	13.3
12	**MLS**	1.6	0.3	0.3	0.1	0.1	0.2	0.1	0.2	0.2	14.8	0.5	0.4	0.2	0.4	0.1	0.0	0.0	5.1
13	**SGP**	2.4	0.2	0.5	0.2	0.0	0.2	0.1	0.1	0.3	10.9	0.3	0.3	0.0	0.5	0.0	0.0	0.1	7.5
14	**ISR**	4.4	0.5	1.7	0.2	0.4	0.5	0.4	2.6	2.3	31.7	1.1	0.4	0.2	0.8	0.1	0.6	0.1	5.9
15	**SAR**	2.1	0.5	0.5	0.1	0.0	0.1	0.1	1.2	0.1	15.0	0.8	0.2	0.1	1.2	0.0	0.0	0.0	13.5
16	**SAF**	7.3	1.1	1.9	0.2	0.3	0.2	0.3	0.8	0.1	8.8	0.9	0.2	0.9	1.6	0.1	0.1	0.1	16.3
17	**EUR**	14.3	3.5	5.1	2.2	3.2	2.4	3.9	2.4	5.5	11.8	1.1	0.9	0.4	1.3	0.5	0.2	0.3	19.4
18	**UK**	0.0	2.0	1.5	3.8	0.7	0.5	1.1	1.2	1.5	10.8	1.7	0.2	0.1	0.5	0.1	0.1	0.2	8.5
19	**SWE**	7.1	0.0	1.0	7.9	0.9	0.5	2.4	0.8	1.7	6.6	0.7	0.3	0.1	0.5	0.3	0.1	0.2	15.5
20	**SWZ**	4.8	0.9	0.0	0.3	0.8	0.5	0.7	0.9	4.4	9.9	1.0	0.4	0.3	0.6	0.1	0.1	0.1	7.6
21	**NOR**	19.9	11.6	0.5	0.0	0.7	0.1	1.8	0.4	0.8	5.1	3.0	0.1	0.0	0.5	0.1	0.0	0.0	8.1
22	**CZH**	3.7	1.3	1.4	0.7	0.0	3.0	6.3	0.5	3.6	1.8	0.2	0.1	0.0	0.1	0.0	0.0	0.0	12.7
23	**HUN**	3.2	1.0	1.0	0.2	3.7	0.0	4.3	1.1	5.6	2.2	0.2	0.2	0.0	0.1	0.0	0.0	0.0	12.8
24	**POL**	4.2	2.7	0.9	1.3	4.8	2.7	0.0	1.0	6.8	1.7	0.3	0.1	0.2	0.2	0.1	0.0	0.0	12.0
25	**TUR**	5.4	1.0	1.3	0.4	0.4	0.8	1.1	0.0	8.3	5.1	0.4	0.1	0.1	0.4	0.2	0.1	0.1	23.4
26	**RUS**	3.1	1.0	3.0	0.3	1.4	1.8	3.6	3.9	0.0	3.0	0.2	0.1	0.2	0.9	0.0	0.0	0.1	22.3
27	**US**	3.7	0.6	1.1	0.3	0.1	0.1	0.1	0.4	0.5	0.0	19.3	12.2	0.3	1.5	0.6	0.6	1.5	8.8
28	**CAN**	2.2	0.3	0.4	0.7	0.1	0.0	0.1	0.1	0.2	75.1	0.0	1.2	0.1	0.5	0.2	0.1	0.2	3.0
29	**MEX**	0.5	0.2	0.2	0.0	0.0	0.1	0.0	0.0	0.1	75.1	2.0	0.0	0.5	1.2	0.7	0.6	0.6	2.0
30	**ARG**	1.1	0.3	1.0	0.1	0.1	0.0	0.5	0.4	1.4	11.5	0.8	3.2	0.0	25.6	6.7	0.8	1.1	12.8
31	**BRZ**	1.9	0.6	0.9	0.4	0.1	0.1	0.2	0.3	1.8	18.8	1.5	2.4	8.5	0.0	2.9	1.0	1.8	16.9
32	**CHL**	1.1	0.7	0.3	0.1	0.0	0.0	0.2	0.5	0.2	17.2	1.9	3.5	5.7	7.3	0.0	0.9	0.7	13.1
33	**COL**	1.5	0.3	0.9	0.1	0.0	0.0	0.1	0.5	0.3	31.8	2.1	5.8	1.2	4.9	1.7	0.0	8.5	14.7
34	**VEN**	1.4	0.4	0.2	0.0	0.0	0.0	0.1	0.1	0.5	41.5	1.7	2.6	0.8	3.9	0.6	4.0	0.0	25.6
35	**ROW**	4.0	2.0	1.2	0.7	1.1	0.9	1.4	2.4	4.9	12.2	1.1	0.5	0.5	1.9	0.6	0.4	1.3	0.0

Key to abbreviations: ALA: Australia, NZ: New Zealand, JPN: Japan, CHN: China, HK: Hong Kong, TAI: Taiwan, KOR: Korea, IND: India, INS: Indonesia, PHL: Philippines, THA: Thailand, MLS: Malaysia, SGP: Singapore, ISR: Israel, SAR: Saudi Arabia, SAF: South Africa, EUR: Euro area, UK: United Kingdom, SWE: Sweden, SWZ: Switzerland, NOR: Norway, CZH: Czech Republic, HUN: Hungary, POL: Poland, TUR: Turkey, RUS: Russia, US: United States, CAN: Canada, MEX: Mexico, ARG: Argentina, BRZ: Brazil, CHL: Chile, COL: Colombia, VEN: Venezuela, ROW: Rest of world.

REFERENCES

Cline, William R. 2005. *The United States as a Debtor Nation.* Washington: Institute for International Economics and Center for Global Development.

Cline, William R. 2007. Estimating Reference Exchange Rates. Paper prepared for the Workshop on Policies to Reduce the Global Imbalances, sponsored by Bruegel, the Korea Institute for International Economic Policy, and the Peterson Institute for International Economics, February 8–9, Washington. Available at www.petersoninstitute.org.

Cline, William R., and John Williamson, 2008. *New Estimates of Fundamental Equilibrium Exchange Rates.* Policy Briefs in International Economics 08-7. Washington: Peterson Institute for International Economics.

IMF (International Monetary Fund). 2007. *Direction of Trade Statistics* (November). Washington.

IMF (International Monetary Fund). 2008a. *World Economic Outlook* (April). Washington.

IMF (International Monetary Fund). 2008b. *International Financial Statistics*, CD-ROM. Washington.

Lee, Jaewoo, Gian Maria Milesi-Ferretti, Jonathan David Ostry, Alessandro Prati, and Luca Antonio Ricci. 2008. *Exchange Rate Assessments: CGER Methodologies*. IMF Occasional Paper no. 261. Washington: International Monetary Fund.

Williamson, John. 1983. *The Exchange Rate System.* POLICY ANALYSES IN INTERNATIONAL ECONOMICS 5. Washington: Institute for International Economics.