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Estimating Reference Exchange Rates[1]

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Introduction

This paper applies the optimal exchange rate realignment model developed in Cline (2005) to a set of target international current account adjustments proposed by Williamson (2006) for simulation by several models to arrive at reference exchange rates. The objective set in this paper is to seek as close adherence to the Williamson adjustment targets as possible while meeting the overall trade-weighted depreciation of the dollar needed to reduce the US current account deficit to the range of 3 percent of GDP.

The discussion first reviews the US current account model developed in Cline (2005) that underlies the calculation of the target for further real depreciation of the US dollar, and includes a comparison of the forecasts of that model in mid-2005 against actual outcomes for 2005 and 2006. The analysis then identifies the target for further trade-weighted real depreciation of the dollar for consistency with reducing the US current account deficit to the desired range. The subsequent section sets forth the structure optimal realignment model (ORM). The analysis then implements the ORM for each of the three international adjustment scenarios identified by Williamson. The paper then develops an alternative formulation of the ORM that applies a matrix inversion method (ORM-MIM model) to arrive at homogeneous proportional achievement of the international adjustment profile, in view of disparate achievement across trading partners in the ORM. A syntheses of preferred results is then developed and applied to actual exchange rates to identify a set of reference exchange rates at 2006 prices. The concluding section recapitulates and suggests areas for further research.

The KGS Current Account Model

Cline (2005) develops a model for projecting the US current account balance. Labeled "KGS" for Krugman-Gagnon-Symmetrical, the model is in the family of "Massachusetts Avenue" models, an eponym for locations of research organizations in

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Cambridge Massachusetts and Washington. In this model class, exports depend on the real exchange rate and foreign growth, and imports depend on the real exchange rate and domestic growth. The exchange rate is essentially set exogenously, in principle being positively related to the differential between the domestic interest rate and the foreign interest rate.

A classic question about such models for the United States is whether they should assume the "Houthakker-Magee asymmetry" by applying a higher income elasticity on the import side than on the export side. The novelty of the KGS model is to incorporate a term for growth in foreign capacity into the import equation, and growth in domestic capacity into the export equation, as a more appealing means of addressing the secular downward drift in the US trade balance. In this formulation, income elasticities are set at identical levels on both the import and export side, intuitively more satisfactory than an arbitrary assumption that somehow foreigners must have lesser response of imports to income than do Americans. Instead, it is a secular excess of outward shifting capacity abroad over the pace domestically that has accounted for the unfavorable drift in the US trade balance at constant real exchange rates.

The KGS model specifies distributed lags for the influence of the real exchange rate on imports and exports over two years. The pass-through of exchange rate change to price change is set at 0.5 on the import side and 0.8 on the export side. Import and export price elasticities are set equal at unity. Import and export income elasticities are set equal at 1.5, with corresponding cylical elasticities set at 2 for changes from trend growth rates. The domestic and foreign capacity elasticties are also set equal, at 0.75. This means that other influences being equal, 1 percent real domestic growth boosts exports by 0.75 percent, and 1 percent real foreign growth boosts imports by 0.75 percent.

The model incorporates additional equations for capital services, transfers, autonomous inward and outward flows of direct investment and portfolio equity, residual accumulation of US debt owed to foreigners based on the financing required to cover the current account deficit, and valuation changes in foreign assets and liabilities from price and exchange rate movements. Crucially, the rate of return on US direct investment abroad is set at about 4.5 percent higher than that on foreign direct investment in the United States, a historical stylized fact that helps explain the still near-zero balance on capital services despite the slide of the United States into a position of net external liabilities amounting to more than 20 percent of GDP at end-2005.

Table 1 reports the baseline projections prepared in July 2005 and reported in Cline (2005) for 2005 and 2006 under the assumption of a constant real exchange rate at the average level of January-May 2005, as well as the actual outcomes for 2005 and estimated actual results for 2006.

Table 1

Projected and Actual US Current Account for 2005 and 2006
($ billions and percent of GDP)

	2005		2006		
	Projected	Actual	Projected	Actual	
Exports, GS	1,296.9	1,275.2	1,434.6	1,467.8	b
Imports, GS	1,973.4	1,992.0	2,087.7	2,211.1	b
Oil	232.0	251.9	243.8	301.0	
Trade balance	-676.5	-716.8	-653.1	-743.4	
Transfers	-80.4	-86.1	-84.7	-90.3	c
Capital services	12.6	11.3	-58.9	-22.0	
Income	431.0	474.7	477.2	631.3	c
Payments	418.4	463.4	536.1	653.2	c
Current account	-744.3	-791.5	-796.6	-855.7	
CA/Y %	-6.0	-6.4	-6.1	-6.5	
NIIP	-3,346.4	-2,546.2	-4,122.1	na	
Assets	10,245.0	11,079.2	10,615.4	na	
Liabilities	13,591.3	13,625.4	14,737.5	na	
NIIP %Y	-27.1	-20.4	-31.6	na	
Real ER (a)	96.5	97.9	96.5	96.7	
GDP	12,364.4	12,455.8	13,027.5	13,253.9	

a. Federal Reserve broad real index (March 1973 = 100)
b. Based on Jan-Nov for merchandise trade
c. Estimated as 2005 actual times ratio of 2006 to 2005 for first three quarters.
na: not available

The actual current account deficit in 2005 was about 0.4 percent of GDP wider than projected, and it appears that the excess above the baseline projection will have continued to be about this amount in 2006. The discrepancy has been almost entirely attributable to higher than expected oil imports. The mid-2005 projections had assumed average oil prices of $50 per barrel, whereas the actual averages turned out to be about $65. In contrast, the capital services deficit projected for 2006 appears to have overstated the actual outcome by about $37 billion, or 0.3 percent of GDP.

The trade estimates for the fourth quarter of 2006 warrant special mention. They amount to increase of 17.1 percent from 2005 for exports but only 5.8 percent for imports. For the full year, exports rose by an estimated 15.1 percent, considerably more than the model-projected 10.6 percent, and also well above the actual import increase of 11.0 percent.[2]

Whereas the trade and current account projections were close to the actual outcomes, the Net International Investment Position outcome diverged sharply from the projection even for end-2005. The model projection placed the NIIP at -27.1 percent of GDP, but the actual outcome was only -20.4 percent – ironically, a smaller net liability position relative to GDP than in 2004 (-21.7 percent). Once again in 2005 valuation

[2] Monthly data for merchandise trade through November form the basis for the estimates (BEA, 2007). The December trade data are estimated by applying the percent increase for September-November from 2005 to 2006.

effects swamped the current account. In particular, there was a remarkable gain of $1.06 trillion from "price effects," mainly reflecting the brisk rise in global stock prices (BEA, 2006). Thus, even though the 2005 current account deficit reached about $790 billion, and despite adverse currency valuation effects of -$394 billion caused by the appreciation of the dollar from end-2004 to end-2005, the overall effect was to boost net liabilities by only about $100 billion, from $2.45 trillion at the end of 2004 to $2.55 trillion. NIIP data for end-2006 will not be available until June 2007. However, once again there were major increases in global equity prices, so it is quite possible that valuation effects will have substantially moderated the boost to net liabilities that otherwise would be expected from the 2006 current account deficit of about $860 billion.

US External Adjustment and Further Exchange Rate Adjustment

The present study applies the optimal exchange rate realignment model developed in Cline (2005) to the set of external account adjustments proposed by John Williamson for examination by several models in this conference, with the purpose of identifying a range of reference exchange rates. The approach of this paper is to divide the task into two components. The first component is to identify the amount of trade-weighted real exchange rate depreciation still needed for the dollar in order to achieve a reduction of the current account balance to the range of 3 to 3.5 percent of GDP. The second component is to apply the optimal realignment model, which identifies exchange rate changes by major individual economies in a manner that approximates a desired profile of current account changes as closely as possible while accomplishing the target amount of trade-weighted depreciation of the dollar. The Williamson scenarios are applied as the profiles of desired current account changes.

Simulations using the KSG model indicated that the following scenario would reduce the US current account deficit in 2010 from a baseline value of 7.3 percent of GDP to 2.9 percent. There would be a real appreciation of foreign currencies against the dollar, weighting by US trade weights (the weights in the Federal Reserve broad real exchange rate index), amounting to 10 percent in 2006 and another 10 percent in 2007, for a total of 21 percent (equivalent to a real depreciation of the dollar by 17.4 percent). In addition, foreign economies would temporarily accelerate their growth (thereby boosting their demand for US exports) by 0.75 percentage point annually for three years.

The analysis below applies the same assumption about the needed decline in the real dollar. The base real exchange rate used in my earlier projections was set at the level for January through May of 2005, when the Federal Reserve broad real index averaged 96.5. As discussed below, the Williamson current account targets are derived from the September 2006 IMF baseline projections for 2010, which assumed unchanged exchange rates from 2006. The period of observed exchange rates available to the IMF analysts would have been January-August 2006. In this period the Fed's broad real index averaged 97.4, or about 1 percent higher than in my earlier projection baseline.

On this basis, the analysis below sets the target real foreign appreciation of foreign currencies against the dollar at 22 percent (18.0 percent dollar depreciation). The assignment, then, is to identify what set of exchange rates would be expected not only to generate a weighted real appreciation of foreign currencies against the dollar by 22 percent but also to generate the country-specific changes in current account balances identified as desirable in the Williamson scenarios.

Allocating the Global Counterpart Adjustment

An Optimal Realignment Model

The optimal realignment model (which I will call ORM) developed in Cline (2005) is as follows. First, real trade-weighted appreciation by country *i* is calculated as:

$$1)\ \hat{R}_i * = z_i - \sum_j \varphi_{ij} z_j$$

where z_i is real appreciation of the currency against the dollar, z_j is the real appreciation of each of the other countries *j* against the dollar, and φ_{ij} is a weight showing the importance of trading partner *j* to country *i*. If a country had trade with no partner other than the United States the trade-weighted real appreciation would be simply z_i. As trade with non-US partners increases in importance, the extent of real trade-weighted appreciation of country *i* will depend increasingly on whether among its important non-US partners the extent of appreciation against the dollar, z_j, is small or large. A profile of large appreciations by important trading partners combined with a relatively small appreciation against the dollar for country *i* will mean that its real trade-weighted exchange rate will depreciate despite its bilateral appreciation against the dollar ($\hat{R}_i* < 0; z_i > 0$).

The model then identifies a parameter γ_i that states the change of the country's current account balance as a percent of GDP for each percent change in the country's trade-weighted real exchange rate. The predicted change in current account as a percent of GDP will then be:

$$2)\ v_i = \hat{R}_i * \gamma_i$$

A set of current account changes is then specified. For country *i* the desired change, as a percent of GDP, is defined as c_i. The deviation of the predicted change in current account from desired change (both as a fraction of GDP) will then be:

$$3)\ d_i = v_i - c_i = \gamma_i [z_i - \sum_j \varphi_{ij} z_j] - c_i$$

The ORM then applies a penalty function for deviation from the desired current account changes, specified as the sum of squared deviations weighted by country shares in non-US GDP. The optimization problem is then to minimize this penalty function *P* subject to the constraint that the resulting array of exchange rate changes yields the target change in the US trade-weighted real exchange rate of the dollar. Thus:

$$4)\ MIN\ P = \sum_i \theta_i d_i^2$$

where θ_i is the share of country *i* in aggregate GDP of US trading partners,

subject to:

$$5)\ Z = \sum_i \alpha_i z_i = Z^*$$

where α_i is the weight of country *i* in the broad real exchange rate index of the Federal Reserve Board and *Z** is the target trade-weighted real appreciation of foreign currencies against the dollar.

The Williamson Adjustment Targets

In a background note prepared for this workshop, Williamson (2006) has specified three alternative profiles for foreign changes in current account balances as the counterpart for US external adjustment. He begins with IMF projections of 2011 current account balances to be expected with 2006 real exchange rates. He rescales these back to levels consistent with 2007 GDP. The changes are intended to be consistent with a reduction of the US current account deficit from the IMF 2011 baseline of 6.8 percent of GDP to a sustainable 3 percent of GDP. The first thing that might be said about this exercise is that the IMF baseline may be too optimistic. The KGS model projections in Cline (2005) place the 2010 current account deficit at 7.3 percent of GDP, increasing yearly at a rate of 0.3 percent of GDP, and likely understated by a sizable portion of the 0.4 percent of GDP understatement already apparent in 2006 as discussed above. So the corresponding baseline deficit by 2011 might be in the range of 8 percent rather than the IMF's 6.8 percent.

Williamson sets forth three scenarios, as shown in table 2. In the first scenario, there is a uniform 41 percent cut in the 2011 (at 2007 scale) surpluses of all surplus countries. The second scenario instead posits a ceiling of 1.1 percent of GDP for the surplus of any country. The third scenario incorporates what Williamson considers to be welfare-based differences in the profile of surpluses. China and Malaysia are set to move to zero current account balances, reflecting the inconsistency of large current account surpluses with their developing country status. The oil exporters other than Russia and Norway are posited to keep their current account unchanged at the base level, $231 billion in 2011 at 2007 economic scale. Russia and Norway then divide the residual change required.

Table 2

Targets for Current Account Adjustments
($ billions and percent)

	Base: 2011 at 2007 scale	Percent of GDP	Scenario Targets: S1	S2	S3	Change as % GDP S1	S2	S3
United States	-959	-6.8	-417	-417	-417	-3.80	-3.80	-3.80
Canada	24	1.8	10	15	7	-1.03	-0.66	-1.25
Japan	131	3.2	54	45	36	-1.67	-1.87	-2.07
Euro area	-23	-0.2	-23	-23	-23	0.0	0.0	0.0
UK	-67	-2.6	-67	-67	-67	0.0	0.0	0.0
Switzerland	44	13.3	18	4	13	-6.54	-10.06	-7.80
Sweden	27	7.1	11	4	7	-3.95	-5.68	-4.94
Norway	59	19.4	24	3	30	-9.81	-15.70	-8.13
Russia	62	4.4	26	15	31	-3.11	-4.06	-2.67
Other fuel exp.	231	53.4	96	231	231	-7.00	0.00	0.00
Korea	-5	-0.5	-5	-5	-5	0.00	0.00	0.00
China	224	6.3	93	39	0	-4.56	-6.44	-7.80
Taiwan	21	5.3	9	4	7	-3.20	-4.54	-3.74
Hong Kong	21	10.4	9	2	7	-5.96	-9.44	-6.95
Singapore	39	25.6	16	2	10	-15.92	-25.61	-20.07
Malaysia	21	12.6	9	2	0	-7.66	-12.13	-13.41
Rest of world & r	136	n.a.	137	146	133	na	na	na

S1: Equal percent cut in all surpluses
S2: Surpluses capped at 1.1% of GDP
S3: Welfare-related imbalances

It should be emphasized that the "base" current account surpluses of the oil exporting countries are already much lower than their prospective actual 2007 levels. Fuel exporters other than Russia and Norway are projected by the IMF (2006) to have current account surpluses amounting to a total of $432 billion, or $200 billion more than the 2011 base of $231 billion. The corresponding comparisons are $79 billion versus $59 billion for Norway and $124 billion versus $62 billion for Russia.

Estimated Exchange Rate Realignments: Scenario 1

Table 3 reports the results of applying the ORM to the first scenario proposed by Williamson.

Table 3

Optimal Exchange Rate Realignments from 2006 Levels:
Percent changes, Scenario 1

		Currency change:		Current account change (% GDP)		
	gamma	vs $	trade-wtd	optimal	target	ratio
Argentina	-0.23	18.0	0.00	0.00	0.00	
Australia	-0.17	24.0	0.00	0.00	0.00	
Brazil	-0.16	16.6	0.00	0.00	0.00	
Canada	-0.32	8.0	0.97	-0.31	-1.03	0.30
Chile	-0.31	18.9	0.00	0.00	0.00	
China	-0.30	36.0	13.83	-4.11	-4.56	0.90
Colombia	-0.20	11.6	0.00	0.00	0.00	
Euro Area	-0.14	20.0	0.00	0.00	0.00	
Hong Kong	-0.16	46.0	17.38	-2.74	-5.96	0.46
India	-0.14	21.3	0.00	0.00	0.00	
Indonesia	-0.27	25.2	0.00	0.00	0.00	
Israel	-0.32	15.5	0.00	0.00	0.00	
Japan	-0.12	35.4	14.33	-1.67	-1.67	1.00
Korea	-0.32	23.8	0.00	0.00	0.00	
Malaysia	-0.47	28.9	4.85	-2.30	-7.66	0.30
Mexico	-0.25	6.4	0.00	0.00	0.00	
Philippines	-0.38	24.3	0.00	0.00	0.00	
Russia	-0.30	24.1	3.10	-0.93	-3.11	0.30
Saudi Arabia	-0.37	27.0	5.64	-2.10	-7.00	0.30
Singapore	-0.27	41.8	17.65	-4.78	-15.92	0.30
Sweden	-0.36	23.1	3.33	-1.18	-3.95	0.30
Switzerland	-0.35	25.4	5.53	-1.96	-6.54	0.30
Taiwan	-0.43	27.6	2.26	-0.96	-3.20	0.30
Thailand	-0.45	24.5	0.00	0.00	0.00	
United Kingdom	-0.23	19.6	0.00	0.00	0.00	
Venezuela, Rep. Bol.	-0.31	20.0	13.21	-4.15	-7.00	0.59
Norway	-0.36	28.0	8.44	-3.05	-9.81	0.31

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The results are shown at the level of country detail included in the ORM (Cline, 2005a), as augmented to incorporate Norway explicitly. For this purpose US trade turnover with Norway is used as the weight to add that country to the trading partners included in the Federal Reserve broad real exchange rate index. The target current account changes for the additional countries not previously shown in table 2 are all zero, consistent with no change for "rest of world." The exceptions are Saudi Arabia and Venezuela in scenario 1. For both of these countries, the target change in current account is set at the -7 percent applicable to "other fuel exporters" (table 2).

Table 3 first reports the values of gamma (γ_i) for each country. It then shows the optimal real increase of each currency against the dollar from the 2006 base level. The optimization for S1 constrains the weighted average of these foreign real appreciations against the dollar, weighting by the Federal Reserve broad index weights, to have the value 22 percent. The objective function of weighted sum of squares of deviations from target changes in current account as percentages of GDP (weighting by country shares in GDP) is minimized using the "solver" function of the Microsoft Excel software.

The optimization includes as constraints the requirement that the changes in current account for China and Japan be at least 90 percent of their target changes, in light of the importance of these two countries to the overall global adjustment. All real exchange rate changes except for that of the United States are constrained to be equal to or greater than zero. As in Cline (2005a), the nominal exchange rate increase against the dollar for Hong Kong is constrained to equal the change for China plus 10 percent, in view of the likely disruption that far greater divergences between the two could cause for Hong Kong. Finally, in an effort to keep the profile of current account changes as close to S1 as possible, the solution is constrained to require the change in current account to be at least a minimum ratio *k* of the target change for each country. It turns out that the largest feasible value for this uniformity-threshold is $k = 0.3$.

The first striking pattern in the results for S1 is that there are relatively large nominal increases of exchange rates against the dollar for all countries except Mexico and Canada, even for the numerous countries in which the target trade-weighted change is zero. The euro area is perhaps the most provocative in this regard, with a further rise of 20 percent against the dollar. There is a tendency in financial circles to consider the appreciation of the euro against the dollar as complete after the sharp rise from early 2002 to end-2004 and after. However, if the trade-weighted real exchange rate of the euro is to remain at zero, as is required if the current account for the euro area is to remain unchanged (the target in all three scenarios), then when other major trading nations such as China and Japan experience large currency increases against the dollar, the euro will also have to rise somewhat against the dollar. Otherwise the euro would experience a trade-weighted real depreciation.[3]

The next major pattern is the set of large increases against the dollar in key Asian currencies. The Chinese renminbi rises 36 percent against the dollar, the Japanese yen 35 percent, and the Hong Kong dollar 46 percent. With the sharp boost in major Asian trading partner currencies, the currencies of regional economies rise substantially against the dollar even for those with zero rise in trade-weighted exchange rates. Australia, Indonesia, Korea, Philippines, Taiwan, and Thailand all have currency increases of 23-28 percent against the dollar despite their zero changes in real effective trade-weighted exchange rates.

The changes in real effective rates are much smaller than the increases against the dollar for those countries that do experience current account reductions. China's trade-weighted rate rises only 13.8 percent in S1; Hong Kong's real effective rate 17.4 percent; and that of Japan, 14.3 percent. Although there are sizable increases of real effective

[3] Even so, it should be kept in mind that the changes in exchange rates are from the January-August 2006 base. As of February 2007, the euro had already risen by 5 percent against this base.

rates for the oil exporters (about 8 percent for Norway, 13 percent for Venezuela, and 6 percent for Saudi Arabia), these changes are all considerably smaller than the bilateral exchange rate appreciations against the dollar (by 28 percent, 20 percent, and 27 percent, respectively).

An important feature of the optimal realignment is that although by constraint it accomplishes at least 90 percent of the target current account adjustments for China and Japan, it tends to fall much farther short of the full target for the other adjusting surplus countries. As a result, the aggregate of current account reductions for the twenty-seven non-US economies is significantly less than the target postulated in S1.[4] This outcome raises the question of whether there would in fact be sufficient current account adjustment abroad to mirror the required US current account adjustment.

Part of the discrepancy arises from the fact that the target 22 percent real foreign appreciation against the dollar is arrived at in a scenario in which part of the US external adjustment also occurs from a temporary acceleration in foreign growth, by 0.75 percentage point per year for three years (Cline, 2005, p. 91). From the US current account impact parameters, one percentage point of additional foreign growth maintained for one year reduces the US current account deficit by 0.41 percent of GDP by the fourth year (p. 96). This is equivalent to the impact of a foreign real appreciation of 2.9 percent.[5] The ORM does not explicitly treat foreign growth acceleration, and implicitly it would require a constraint setting the total foreign appreciation at 25.5 percent rather than 22 percent to achieve the target US adjustment solely by exchange rate change. That constraint would boost the total real exchange rate increases allowed for the US trading partners and narrow the gap between the sum of their current account reductions and the target aggregate reduction.

The other possible source of discrepancy is that the estimates used for the parameter gamma in the ORM may typically yield an understatement of the size of adjustment for a given change in the country's real trade-weighted exchange rate, thereby generating a lesser aggregate foreign adjustment than that implied by the KGS model simulation results for 22 percent foreign real appreciation.[6] Because the KGS model for the US current account is a much more fully articulated model than the corresponding single-parameter estimation in ORM for current account changes of other countries, the proper interpretation of the optimization results is that the exchange rate changes identified should be sufficient to generate the counterpart of the US target adjustment, even though the specific numeric estimates turn out to aggregate to a considerably smaller total global counterpart than the target US adjustment.

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[4] The aggregate is -\$246 billion rather than the target of -\$395 billion for these countries.

[5] With 10 percent foreign appreciation generating a correction of 1.41 percent of GDP by the fourth year, 0.41 percent of GDP corresponds to (0.41/1.41)x10 = 2.9 percent real foreign appreciation.

[6] The parameter gamma is estimated as: $\gamma = -1.056\, x + 0.56\, x^2$, where x is the ratio of exports of goods and services to GDP. This formulation is derived from the postulation (not empirically estimated) that the effective export price elasticity (incorporating both domestic supply and foreign demand considerations) is -1 for countries with exports of goods and services as low as 10 percent of GDP and falls to -0.5 for countries in which this export ratio reaches as high as 50 percent. (Cline, 2005a, pp. 209-210.)

In a model run not shown here, when the ORM omits the constraint that the ratio of current account change to target change must be at least *k*, there is an extremely skewed distribution of the adjustment. Canada and Taiwan have approximately zero adjustment, and Malaysia and Singapore accomplish only about one-sixth of their target, in contrast to the minimum 30 percent required in the model run shown in table 3.

Results for Scenarios 2 and 3

Table 4 reports the results of the ORM for scenarios 2 and 3. In scenario 2, for most countries the bilateral and trade-weighted exchange rate changes are almost identical in these scenarios to the estimates for scenario 1, because their target changes in current account have not changed. The reductions in current account surpluses for China and Japan broadly accomplish the targets, which are larger than in scenario 1. Again, however, for China this outcome reflects the constraint that its ratio of current account change to target must be at least 90 percent (although for Japan in both S1 and S2 full achievement of the target is optimal). This time, however, imposing even the modest uniformity threshold of k =0.3 causes a failure to converge. To obtain a feasible solution it is necessary to drop this constraint altogether. As a result, the departures of the solution outcome from the targets are much more extreme for a long list of countries. There is no adjustment at all in Canada, Malaysia, Russia, Singapore, Sweden, Switzerland, and Taiwan, whereas these countries all achieve at least some adjustment in scenario 1. Reflecting the greater shortfalls, the aggregate 27-country adjustment is even smaller relative to the target than for the outcome in scenario 1.[7]

The results for scenario 3 reported in table 4 are broadly similar to those in scenario 2. Once again the minimum adjustment constraint must be removed to achieve model convergence. Moreover the constraint setting Hong Kong's exchange rate change against the dollar at 10 percent above that of China must be eliminated. This time there is at least a slight adjustment in Malaysia, Russia, and Switzerland, but far below target; and once again no adjustment at all in Canada, Singapore, Sweden, and Taiwan. Norway carries out almost the same adjustment as in scenario 2 despite the more lenient target in scenario 3.

[7] At $251 billion reduction in current account surpluses compared to the new target of $488 billion.

Table 4

Optimal Exchange Rate Realignments from 2006 Levels:
Percent Changes, Scenarios 2 and 3

	Scenario 2: Change in: Currency vs $	trade-wt	dCA (% GDP) result	target	ratio	Scenario 3: Change in: Currency vs $	trade-wt	dCA (% GDP) result	target	ratio
Argentina	18.1	0.0	0.00	0.00		18.3	0.0	0.00	0.0	
Australia	24.1	0.0	0.00	0.00		24.3	0.0	0.00	0.0	
Brazil	16.6	0.0	0.00	0.00		16.7	0.0	0.00	0.0	
Canada	7.2	0.0	0.00	-0.66	0.00	7.3	0.0	0.00	-1.3	0.00
Chile	19.2	0.0	0.00	0.00		19.5	0.0	0.00	0.0	
China	41.9	19.5	-5.80	-6.44	0.90	43.9	23.6	-7.02	-7.8	0.90
Colombia	10.9	0.0	0.00	0.00		11.0	0.0	0.00	0.0	
Euro Area	19.5	0.0	0.00	0.00		19.7	0.0	0.00	0.0	
Hong Kong	51.9	21.8	-3.44	-9.44	0.36	31.0	0.0	0.00	-7.0	
India	20.8	0.0	0.00	0.00		20.3	0.0	0.00	0.0	
Indonesia	24.6	0.0	0.00	0.00		24.7	0.0	0.00	0.0	
Israel	15.2	0.0	0.00	0.00		15.0	0.0	0.00	0.0	
Japan	37.4	16.0	-1.87	-1.87	1.00	38.8	17.7	-2.07	-2.1	1.00
Korea	24.3	0.0	0.00	0.00		24.2	0.0	0.00	0.0	
Malaysia	22.7	0.0	0.00	-12.13	0.00	24.6	2.3	-1.07	-13.4	0.08
Mexico	6.4	0.0	0.00	0.00		6.5	0.0	0.00	0.0	
Philippines	24.0	0.0	0.00	0.00		23.4	0.0	0.00	0.0	
Russia	21.1	0.0	0.00	-4.06	0.00	22.5	1.1	-0.33	-2.7	0.12
Saudi Arabia	21.5	0.0	0.00	0.00		21.7	0.0	0.00	0.0	
Singapore	24.3	0.0	0.00	-25.61	0.00	23.8	0.0	0.00	-20.1	0.00
Sweden	19.6	0.0	0.00	-5.68	0.00	19.7	0.0	0.00	-4.9	0.00
Switzerland	19.5	0.0	0.00	-10.06	0.00	22.0	2.5	-0.90	-7.8	0.12
Taiwan	26.5	0.0	0.00	-4.54	0.00	25.3	0.0	0.00	-3.7	0.00
Thailand	24.2	0.0	0.00	0.00		24.1	0.0	0.00	0.0	
United Kingdom	19.2	0.0	0.00	0.00		19.2	0.0	0.00	0.0	
Venezuela, Rep. Bol.	6.8	0.0	0.00	0.00		6.9	0.0	0.00	0.0	
Norway	30.8	11.9	-4.32	-15.70	0.27	30.5	11.5	-4.15	-8.1	0.51

Feers07 s7 / orm07b orm07c

Application of the ORM to the Williamson scenarios encounters considerably more difficulties than encountered in earlier application of the model (Cline, 2005a). One reason may be that the profiles of country adjustments in the scenarios here are more concentrated across selected countries, whereas the adjustment profile in Cline (2005a) assumes broader country participation in current account reductions. Even so, this explanation may not go far, because as the scenarios here progress from the most evenly spread adjustment (S1, with all surplus countries reducing their surpluses by 41 percent) to less evenly spread adjustment (S2 and S3), it tends to be the same problem countries that occur in each scenario. Thus, Canada and Taiwan carry out no adjustment, and Malaysia and Singapore only about 15 percent of target adjustment, in scenarios S2 and S3; and as noted, in a run of S1 in which no minimum adjustment constraint is imposed (i.e. k=0), these same countries carry out the same amounts of non-adjustment as in S2 and S3.

Despite the more numerous departures from target in scenarios S2 and S3, taken together the results for the three scenarios tend to confirm several broad policy patterns. First, the degree of effective real appreciation by most countries will be far less than the degree of appreciation against the dollar, because of simultaneous appreciation of their major trading partners against the dollar in a reduction of global imbalances. Second, the remaining real appreciation of the euro area in particular can plausibly be set at close to zero, but this will not mean that the euro will not rise significantly against the dollar. Third, China and Japan should be seen as essential to the global adjustment process, and both should be expected to experience real trade-weighted appreciations in the range of at least about 14 percent (S1). If traditional concepts of the perversity of capital flows from developing to industrial countries are seen as a major guide to policy, the real appreciation would need to be even larger for China, reaching as high as 24 percent on a trade-weighted basis in S3.

It can also be said from the results here that there seems to be something special about Malaysia and Singapore. Their surpluses are enormous, but the optimization calculation tends to leave them out of the adjustment, and when an attempt is made to force their adjustment to the target, the calculation tends not converge to a feasible solution. The tendency for Canada and Taiwan, if allowed, to not participate in the adjustment also is noteworthy. Nonetheless, their surpluses are much smaller relative to economic size (at 1.8 percent and 5.3 percent of GDP, respectively) than are those of Malaysia (12.6 percent) and Singapore (25.6 percent; table 2).

An Alternative for Exact Foreign Adjustment Allocation

The inherent inexactitude of the realignment allocation problem stems from the fact that the problem is overidentified: there are more equations than there are unknowns. With the world composed of the United States and N countries, there are N unknown exchange rates against the dollar. There are N equations relating change in real exchange rate to change in current account. But there is an additional equation: the US-trade-weighted sum of the changes in real exchange rates must equal the target for foreign real appreciation against the dollar.

One alternative approach toward achieving a more exact allocation of foreign adjustment according to the desired profile would be to relax the target for weighted foreign appreciation. In the extreme, the target could simply be eliminated and then sets of exchange rate changes could be identified that would generate the desired set of foreign current account changes. If the parameters relating current account change to real exchange rate change (γ_i) were accurately calculated, in principle the result of simply solving the N current-account-change equations would generate the desired current account change for the United States, and correspondingly the desired trade-weighted foreign real appreciation against the dollar. In part because the γ_i are not well known, this approach will be less than fully satisfactory. Even so, one can approximate the desired outcome from both sides. First, the exact profile of real trade-weighted exchange rate changes necessary to obtain the profile of current account changes for foreign countries can be calculated, along with the corresponding set of nominal appreciations against the dollar. Then the corresponding implied trade-weighted real foreign appreciation against the dollar can be contrasted with the target amount. If it exceeds the target amount, a proportional reduction in all of the nominal exchange rate appreciations against the dollar in the initial solution can then be applied.

The exact calculation for the current account changes can be done as follows. Let **A** be an NxN matrix that incorporates information about the extent of nominal appreciation of each currency against the dollar and about the importance of each partner country in the trade of the other. Let **Z** be an Nx1 vector of nominal exchange rate increases against the dollar. Let **C** be an N x 1 vector of current account changes as percentages of GDP. Then an exact set of nominal appreciations against the dollar can be calculated to meet the current account adjustment allocation profile desired, as follows.[8]

6) $$\underset{NxN}{A}\,\underset{Nx1}{Z} = \underset{Nx1}{C}$$

Where:

7) $$\underset{NxN}{A} = \begin{Bmatrix} \gamma_1 & -\gamma_1\varphi_{1,2} & \cdot & \cdot & -\gamma_1\varphi_{1,N} \\ -\gamma_2\varphi_{2,1} & \gamma_2 & -\gamma_2\varphi_{2,3} & \cdot & -\gamma_2\varphi_{2,N} \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot \\ -\gamma_N\varphi_{N,1} & -\gamma_N\varphi_{N,2} & \cdot & \cdot & \gamma_N \end{Bmatrix};$$

$$\underset{Nx1}{Z} = \begin{Bmatrix} z_1 \\ z_2 \\ \cdot \\ z_N \end{Bmatrix}; \text{ and } \qquad \underset{Nx1}{C} = \begin{Bmatrix} c_1 \\ c_2 \\ \cdot \\ c_N \end{Bmatrix}$$

As before, the individual variable z_i is the proportionate appreciation of currency *i* against the dollar; c_i is the target change of current account as a percent of GDP for country *i*; and $\varphi_{i,j}$ is the weight showing the importance of trading partner *j* to partner *i*.

A unique set of exchange rate changes against the dollar satisfying the desired profile of foreign current account changes can then be obtained as:

8) $$\underset{Nx1}{Z} = \underset{NxN}{A}^{-1}\,\underset{Nx1}{C}$$

Consider, for example, the third foreign country. Its real exchange rate change $\hat{R}_3$* will be: $-\varphi_{3,1}\, z_1 - \varphi_{3,2}\, z_2 + z_3 - \varphi_{3,41}\, z_4 \ldots - \varphi_{3,N}\, z_N$. This is the result of multiplying row 3 of the ***A*** matrix by the ***Z*** vector of nominal exchange rate changes, but factoring out the term γ_3. This means that when γ_3 is factored back in, namely the result of multiplying

[8] Arvind Nair assisted in this derivation.

row 3 of ***A*** by the vector ***Z***, the result will be the product of the real exchange rate change times the current account impact parameter, which yields the change in current account as a percent of GDP, or c_3. More generally, a consistent set of nominal and real exchange rate changes meeting the vector of current account changes desired is obtained by multiplying the inverse of the matrix ***A*** by the vector of desired current account changes as percentages of GDP, or ***C***.

Now suppose that when this calculation is complete, the resulting US trade-weighted set of foreign appreciations against the dollar, using the Federal Reserve weights, amounts to *K*. Suppose that the target foreign appreciation against the dollar instead is *K**. Then defining $\lambda = K^* / K$, an adjusted set of estimates of exchange rate changes ***Z*** will simply be: $\lambda \boldsymbol{Z}$. This adjusted set of exchange rate changes will then generate the desired weighted foreign appreciation against the dollar while at the same time maintaining the same relative profile of current account adjustments across trading partners as given by vector ***C***.

This approach provides the basis for an alternative formulation of the ORM, in a variant that may be called "Matrix Inversion Method" (and the model ORM-MIM). A powerful attraction of this model variant is that it jettisons the accumulation of somewhat arbitrary constraints that seem to accumulate like barnacles as various scenarios require additional constraints to obtain feasible solutions. The disadvantage of the matrix inversion approach is precisely that it rules out the imposition of even particularly important constraints (other than the overall constraint of meeting the target US trade-weighted depreciation), such as special constraints ensuring that China and Japan meet nearly the full extent of their adjustment targets.

Table 5 reports the results of running the ORM-MIM on the three scenarios examined in this study. The raw result of equation 8) yields trade-weighted foreign appreciations against the dollar (using the Federal Reserve broad real index weights) of 37.9 percent for S1, 52.1 percent for S2, and 48.5 percent for S3. With the required foreign appreciation instead set at the 22 percent (as discussed above), the second-stage adjustment of the ORM-MIM results is to multiply all exchange rate changes against the dollar by the corresponding ratios of 22/38.9 = 0.58 for S1, 22/52.1 = 0.42 for S2, and 0.45 for S3.[9] The sets of current account adjustments in the ORM-MIM solution are then uniformly these respective ratios to the target sets of changes, as shown in table 5.

The economic information in this set of results is that there is a more favorable configuration of country-specific trade impact parameters (γ_i) combined with adjustment targets and country GDP weights in S1, a less favorable configuration in S2, and an intermediate configuration in S3, in terms of eliminating the discrepancy between the required trade-weighted change in foreign currencies against the dollar (22 percent) and the trade-matrix-weighted implicit foreign real appreciation that would be generated if

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[9] The larger ratio of K*/K for S1 mainly reflects the fact that the global aggregate current account adjustment by the 27 US partner countries in the scenario is smaller (at $395 billion) than in S2 and S2 (at $488 billion), because the set of countries specifically modeled excludes the "other fuel exporters" except for Saudi Arabia and Venezuela, and this group bears some of the adjustment in S1 but not in S2 or S3.

instead all of the foreign current account adjustments were met exogenously and the resulting overall appreciation against the dollar were allowed to vary freely.

Table 5
Optimal Realignments from 2006 Actual Levels from ORM-MIM (a):
percent changes

	Scenario 1: change in:				Scenario 2: Change in:				Scenario 3: Change in:			
	Currency		dCA (% GDP)		Currency		dCA (% GDP)		Currency		dCA (% GDP)	
	vs $	trade-wt	result	target	vs $	trade-wt	result	target	vs $	trade-wt	result	target
ARG	17.8	0.0	0.0	0.0	17.8	0.0	0.0	0.0	17.7	0.0	0.0	0.0
ALA	23.4	0.0	0.0	0.0	23.5	0.0	0.0	0.0	23.5	0.0	0.0	0.0
BRZ	16.6	0.0	0.0	0.0	16.5	0.0	0.0	0.0	16.3	0.0	0.0	0.0
CAN	8.8	1.9	-0.6	-1.0	7.8	0.9	-0.3	-0.7	8.6	1.8	-0.6	-1.3
CHL	18.2	0.0	0.0	0.0	18.1	0.0	0.0	0.0	18.1	0.0	0.0	0.0
CHN	31.3	8.9	-2.6	-4.6	31.9	9.2	-2.7	-6.4	33.9	11.9	-3.5	-7.8
COL	11.6	0.0	0.0	0.0	10.8	0.0	0.0	0.0	10.7	0.0	0.0	0.0
EUR	20.7	0.0	0.0	0.0	20.9	0.0	0.0	0.0	20.3	0.0	0.0	0.0
HK	49.1	21.9	-3.5	-6.0	52.8	25.2	-4.0	-9.4	48.1	20.0	-3.2	-7.0
IND	22.1	0.0	0.0	0.0	22.4	0.0	0.0	0.0	21.9	0.0	0.0	0.0
INS	25.1	0.0	0.0	0.0	25.3	0.0	0.0	0.0	25.1	0.0	0.0	0.0
ISR	16.0	0.0	0.0	0.0	16.2	0.0	0.0	0.0	15.8	0.0	0.0	0.0
JPN	29.6	8.3	-1.0	-1.7	28.3	6.8	-0.8	-1.9	29.4	8.0	-0.9	-2.1
KOR	23.1	0.0	0.0	0.0	23.0	0.0	0.0	0.0	23.0	0.0	0.0	0.0
MLS	34.5	9.4	-4.4	-7.7	36.6	10.8	-5.1	-12.1	37.9	12.8	-6.1	-13.4
MEX	6.3	0.0	0.0	0.0	6.2	0.0	0.0	0.0	6.3	0.0	0.0	0.0
PHL	24.4	0.0	0.0	0.0	24.7	0.0	0.0	0.0	24.4	0.0	0.0	0.0
RUS	27.1	6.0	-1.8	-3.1	27.0	5.7	-1.7	-4.1	25.0	4.0	-1.2	-2.7
SAR	31.7	10.9	-4.1	-7.0	20.9	0.0	0.0	0.0	20.8	0.0	0.0	0.0
SGP	58.2	34.1	-9.2	-15.9	64.3	40.0	-10.8	-25.6	58.1	33.6	-9.1	-20.1
SWE	27.2	6.4	-2.3	-3.9	27.7	6.7	-2.4	-5.7	26.3	6.3	-2.2	-4.9
SWZ	31.1	10.7	-3.8	-6.5	32.5	12.0	-4.2	-10.1	30.0	10.0	-3.5	-7.8
TAI	28.9	4.4	-1.9	-3.2	29.2	4.5	-1.9	-4.5	28.6	4.0	-1.7	-3.7
THL	24.3	0.0	0.0	0.0	24.4	0.0	0.0	0.0	24.3	0.0	0.0	0.0
UK	20.5	0.0	0.0	0.0	20.7	0.0	0.0	0.0	20.0	0.0	0.0	0.0
VEN	19.7	12.9	-4.1	-7.0	6.8	0.0	0.0	0.0	6.7	0.0	0.0	0.0
NOR	36.3	15.7	-5.7	-9.8	39.0	18.3	-6.6	-15.7	30.3	10.2	-3.7	-8.1

a. Optimal Realignment Model - Matrix Inversion Method

	Scenario 1	Scenario 2	Scenario 3
Uniform ratio of CA change to target change:	0.58	0.42	0.45
Feers07 s8:	orm07m1	orm07m2	orm07m3

Comparison of table 5 with tables 3 and 4 shows that for those economies in which no change in current account is the specified target, virtually all of the scenarios and both versions of the model (ORM and ORM-MIM) show the same results. In all cases the changes in the real trade-weighted exchange rates are zero. There are differences in the bilateral real exchange rate adjustments against the dollar, ranging from a low of about 6 percent for Mexico to a high of about 24-25 percent for Australia and several Asian economies, but these differences merely reflect the varying weights of trade with the United States across these economies.

The two model approaches show significant differences for identical scenarios in some of the other economies, however. To facilitate comparison, table 6 consolidates all of the countries that have non-zero trade-weighted exchange rate changes in both sets of estimates, in at least one scenario.

Table 6

Comparison of ORM and ORM-MIM Results for Countries with Differing Outcomes
(percentages)

	Scenario 1		Scenario 2		Scenario 3	
	ORM	MIM	ORM	MIM	ORM	MIM
I. Appreciation against the dollar						
Canada	8.0	8.8	7.2	7.8	7.3	8.6
China	36.0	31.3	41.9	31.9	43.9	33.9
Hong Kong	46.0	49.1	51.9	52.8	31.0	48.1
Japan	35.4	29.6	37.4	28.3	38.8	29.4
Malaysia	28.9	34.5	22.7	36.6	24.6	37.9
Russia	24.1	27.1	21.1	27.0	22.5	25.0
Saudi Arabia	27.0	31.7	21.5	20.9	21.7	20.8
Singapore	41.8	58.2	24.3	64.3	23.8	58.1
Sweden	23.1	27.2	19.6	27.7	19.7	26.3
Switzerland	25.4	31.1	19.5	32.5	22.0	30.0
Taiwan	27.6	28.9	26.5	29.2	25.3	28.6
Venezuela, Rep. Bol.	20.0	19.7	6.8	6.8	6.9	6.7
Norway	28.0	36.3	30.8	39.0	30.5	30.3
II. Appreciation of trade-weighted exchange rate						
Canada	1.0	1.9	0.0	0.9	0.0	1.8
China	13.8	8.9	19.5	9.2	23.6	11.9
Hong Kong	17.4	21.9	21.8	25.2	0.0	20.0
Japan	14.3	8.3	16.0	6.8	17.7	8.0
Malaysia	4.8	9.4	0.0	10.8	2.3	12.8
Russia	3.1	6.0	0.0	5.7	1.1	4.0
Saudi Arabia	5.6	10.9	0.0	0.0	0.0	0.0
Singapore	17.7	34.1	0.0	40.0	0.0	33.6
Sweden	3.3	6.4	0.0	6.7	0.0	6.3
Switzerland	5.5	10.7	0.0	12.0	2.5	10.0
Taiwan	2.3	4.4	0.0	4.5	0.0	4.0
Venezuela, Rep. Bol.	13.2	12.9	0.0	0.0	0.0	0.0
Norway	8.4	15.7	11.9	18.3	11.5	10.2

The following patterns are evident in the MIM results in comparison with those of the ORM. First, for China the extent of appreciation is somewhat smaller in all of the MIM variants than in their ORM counterpart scenarios. This difference reflects the fact that the ORM forces China's adjustment to a minimum 90 percent of the target, whereas the MIM treats China equally with all other countries and as a result arrives at a lower ratio to the target change (the uniform ratios shown at the bottom of table 5). Even in the MIM, however, the Chinese currency appreciates about 31 to 34 percent against the US dollar, moving from S1 to S3. China's real trade-weighted appreciation correspondingly varies from about 9 percent to about 12 percent, moving from S1 to S3.

Second, for several economies in which the optimization model cannot converge to a solution without allowing the economy to fall far below its adjustment target in the ORM, the outcome in the MIM version shows much more appreciation. For example, Malaysia experiences real trade-weighted appreciations of 9 to 13 percent in the MIM estimates, moving from S1 to S3, versus far smaller appreciations in ORM (and none at all in ORM scenario 2). The same divergence is even more extreme for Singapore, which in scenario 2 has no trade-weighted appreciation at all under ORM but a trade-weighted appreciation of 40 percent in the MIM results. The same is true (but in a far milder version) for the important case of Canada.

Third, the MIM shows somewhat smaller appreciations for the Japanese yen than does the ORM, regardless of the scenario. This outcome again is the consequence of the uniformity of target achievement under MIM in contrast to disperse achievement in the ORM.

Harmonized Results and Reference Rate Estimates

Table 7 reports what would seem to be reasonable synthesis estimates for these same countries. (For all other countries the nearly identical estimates across scenarios and the two model variants are shown in the earlier tables.) In this central, or preferred, set of estimates, the simple averages between the ORM and the MIM variant (identified as case “a”) are applied in the majority of cases, especially for S1. However, in S2 and S3 there is a frequent incidence of preferred application of the MIM results (case “b”), because of the complete lack of participation of the countries in question in adjustment in the feasible ORM outcome. The only cases in which the ORM is strictly preferred is for Hong Kong in S1 and S2, in which the constraint is observed that the exchange rate appreciation is 10 percent above that of China. Hong Kong shifts to the MIM preferred outcome in S3, where that constraint could not be met in the ORM outcome.

The central estimates of table 7 broadly repeat the key patterns identified above. The real exchange rate change for China rises from about 11 percent in S1 to 14 percent in S2 and about 18 percent in S3, reflecting the more ambitious adjustment targets for China in S2 and especially S3. Hong Kong experiences trade-weighted appreciations a few percentage points higher (but close to that of China in the welfare-based S3). The preferred estimates reveal large real trade-weighted appreciations for Singapore, reaching 40 percent in S2 which would cut its current account by a remarkable 25.6 percent of GDP. Real trade-weighted appreciations are in a range of 11 to 13 percent for Japan, 7 to 13 percent for Malaysia, 8 to 12 percent for Switzerland, and 11 to 15 percent for Norway. Other real trade-weighted appreciations are more limited, ranging from about 5 to 7 percent for Sweden, 4 to 6 percent for Russia, 3 to 4 percent for Taiwan, and only 0.9 to 1.9 percent for Canada. Although the real trade-weighted appreciations are large for Venezuela (13 percent) and Saudia Arabia (8 percent) when “other fuel exporters” are expected to adjust (S1), they are set at zero in S2 and S3 which treats baseline oil exporter surpluses by 2011 as being back to equilibrium levels.

Table 7

Central Estimates for Economies with Differing Outcomes
(percent change)

	S1	S2	S3
I. Appreciation against the dollar			
Canada	8.8 b	7.8 b	8.6 b
China	33.7 a	36.9 a	38.9 a
Hong Kong	46.0 c	41.9 c	48.1 b
Japan	32.5 a	32.8 a	34.1 a
Malaysia	31.7 a	36.6 b	37.9 b
Russia	25.6 a	27.0 b	25.0 b
Saudi Arabia	29.4 a	21.2 a	21.3 a
Singapore	50.0 a	64.3 b	58.1 b
Sweden	25.1 a	27.7 b	26.3 b
Switzerland	28.2 a	32.5 b	30.0 b
Taiwan	28.2 a	29.2 b	28.6 b
Venezuela, Rep. Bol.	19.9 a	6.8 a	6.8 a
Norway	32.1 a	34.9 a	30.4 a
II. Trade-weighted Appreciation			
Canada	1.9 b	0.9 b	1.8 b
China	11.4 a	14.3 a	17.8 a
Hong Kong	17.4 c	24.3 c	20.0 b
Japan	11.3 a	11.4 a	12.8 a
Malaysia	7.1 a	10.8 b	12.8 b
Russia	4.5 a	5.7 b	4.0 b
Saudi Arabia	8.3 a	0.0 a	0.0 a
Singapore	25.9 a	40.0 b	33.6 b
Sweden	4.9 a	6.7 b	6.3 b
Switzerland	8.1 a	12.0 b	10.0 b
Taiwan	3.3 a	4.5 b	4.0 b
Venezuela, Rep. Bol.	13.1 a	0.0 a	0.0 a
Norway	12.1 a	15.1 a	10.8 a

a. Average, ORM and MIM
b. MIM
c. ORM

Table 8 summarizes the results for reference exchange rates. The first column reports the weight of each economy in the Federal Reserve broad real index.[10] The next three columns present the central estimates for each currency's optimal appreciation against the dollar. These are the rates identified in table 7 and the simple averages of the ORM and ORM-MIM results in tables 3, 4, and 5 for the other countries.[11] The final three columns identify the corresponding level of each exchange rate in question against the dollar, based on the percent appreciations as applied to the average exchange rate against the dollar in January-August 2006.

[10] As adjusted to add Norway.
[11] Note, however, that there is a slight adjustment to keep the weighted totals to the target 22 percent.

Table 8

Reference Exchange Rates (currency per US dollar)

		Fed Weight (%)	A. Percent appreciation against US dollar S1	S2	S3	B. Reference rate at 2006 prices S1	S2	S3	
ARG	peso	0.44	17.9	17.5	17.3	2.59	2.60	2.60	
ALA	dollar	1.25	23.7	23.2	23.0	0.93	0.92	0.92	a
BRZ	real	1.78	16.6	16.2	15.8	1.87	1.88	1.89	
CAN	dollar	16.37	8.8	7.6	8.3	1.04	1.05	1.05	
CHL	peso	0.49	18.6	18.2	18.0	447	448	449	
CHN	renminbi	11.31	33.7	36.0	37.3	6.00	5.90	5.84	
COL	peso	0.41	11.6	10.6	10.4	2,130	2,150	2,152	
EUR	euro	18.73	20.4	19.7	19.2	1.49	1.48	1.48	a
HK	dollar	2.32	46.0	40.9	46.2	5.31	5.51	5.31	
IND	rupee	1.14	21.7	21.1	20.3	37.2	37.4	37.7	
INS	rupiah	0.95	25.2	24.3	23.9	7,327	7,376	7,404	
ISR	new sheq.	1.00	15.8	15.4	14.8	3.92	3.94	3.96	
JPN	yen	10.54	32.5	32.0	32.7	87.3	87.6	87.2	
KOR	won	3.85	23.4	23.1	22.6	779	781	784	
MLS	ringgit	2.23	31.7	35.8	36.4	2.80	2.72	2.70	
MEX	peso	10.00	6.3	6.1	6.1	10.2	10.3	10.3	
PHL	peso	1.06	24.4	23.8	23.0	22.1	22.2	22.3	
RUS	ruble	0.74	25.7	26.3	24.0	21.9	21.7	22.2	
SAR	riyal	0.61	29.4	20.7	20.4	2.90	3.11	3.11	
SGP	dollar	2.11	50.0	62.8	55.7	1.07	0.98	1.03	
SWE	krona	1.16	25.1	27.0	25.2	6.00	5.91	5.99	
SWZ	franc	1.43	28.3	31.7	28.8	0.98	0.96	0.98	
TAI	dollar	2.86	28.3	28.5	27.4	25.2	25.2	25.4	
THL	bhat	1.42	24.4	23.7	23.2	30.9	31.1	31.2	
UK	pound	5.15	20.1	19.5	18.8	2.17	2.16	2.15	a
VEN	bolivar	0.30	19.9	6.6	6.5	1,791	2,014	2,015	
NOR	krone	0.36	32.1	34.1	29.2	4.85	4.78	4.96	
total		100.00	22.0	22.0	22.0				

a. US dollars per currency unit

Notable results in table 8 include a reference euro at about $1.48 per euro in all three scenarios, and the yen at about 87 to the dollar in all three scenarios. The reference rate for the Chinese renminbi stands at about 6 to the dollar, with the most appreciated level reaching 5.84 per dollar in the ambitious S3.

These results reveal a somewhat surprisingly narrow range across the various scenarios. The economic (and arithmetic) consideration underlying the narrowness of the ranges is the fact that whereas the current account adjustment of the country varies in proportion to the *ratio* of the real trade-weighted appreciations across the scenarios, the level of the reference exchange rate varies with the *difference* between the trade-weighted rates across the scenarios. Thus, for China in table 7 the real trade-weighted appreciation is 17.8 percent in S3 versus 11.4 percent in S1, or 56 percent larger. The corresponding comparison in levels of the exchange rate against the dollar is only a difference of 4 percentage points between S3 and S1 (unadjusted, and an even smaller 2.7 percentage points in the final results of table 8 after shrinking the total trade-weighted outcome for the United States from the raw 22.9 percent to the target 22.0 percent).

Conclusion

This study has calculated a set of reference exchange rates designed to be consistent with reduction of the US current account deficit to the range of 3 percent, based on IMF estimates of baseline 2011 current account balances at 2006 real exchange rates. A broad pattern is that except for the countries with the highest direct trade ties with the United States – Canada and Mexico – the resulting currency appreciations against the dollar could typically be substantial. Thus, the median appreciation against the dollar for the 27 trading partners is about 23 percent in all three scenarios.

The optimal realignments identified broadly confirm the perception that the Asian economies typically have much further to go than the euro area and other major industrial countries. A group of six Asian economies (China, Hong Kong, Japan, Malaysia, Singapore, and Taiwan) have the largest prospective appreciations, with a simple average across the three scenarios of 38.9 percent against the dollar. The only European countries with relatively large prospective appreciations are Sweden and Switzerland, averaging 27.7 percent.

Developing countries in Asia with no current account adjustment expected (Korea, India, Indonesia, Philippines, and Thailand) would have average appreciations against the dollar near the overall median, at 23.2 percent. Because of their lesser trade ties to the high-appreciation Asian 6, there would be a somewhat lower average appreciation of 20.8 percent for three industrial country groups that have already appreciated substantially against the dollar and are not called upon to participate in additional reductions of current account balances: the euro area, Australia, and the United Kingdom. With greater trade ties to the United States, non-adjusting Latin American countries (Argentina, Brazil, Chile, Colombia) would have an even smaller appreciation against the dollar, at 15 percent averaging across the four countries and three scenarios. The corresponding average appreciation against the dollar for the two partners most dependent on the United States, Canada and Mexico, would be even lower, at only 7.2 percent.

The ORM used for the first set of estimates (tables 3 and 4) would benefit greatly from further research on the magnitude of the current account impact parameters, γ_i. For many trading partners this parameter may be understated, resulting in a discrepancy between the target foreign current account changes and the US current account change. Moreover, the appropriate parameter for the oil exporting countries should probably be calculated in an alternative manner, because their adjustment will need to occur primarily on the import side given the relatively exogenous determination of exports based on world oil prices. The extension of the ORM to include a matrix inversion method (MIM) helps overcome idiosyncrasies that otherwise arise in the optimization model when plausible constraints cannot be included without preventing a feasible solution.

It should be emphasized that this study has taken the Williamson adjustment targets as its script, for comparison with the results of other models used in this conference on the same scenarios. Appropriate allocation of adjustment might well include a broader list of countries expected to carry out at least some reduction in their current account positions, including a number of developing countries not expected to do so in the scenarios here (see Cline, 2005). Although broader participation would tend to moderate the extent of appreciation of each participant, going in the other direction is the fact that the IMF's baseline current account deficit of 6.8 percent of GDP for the United States in 2011 looks seriously understated.

Finally, it also warrants underscoring that the identification in this study of reference rates says nothing about what should be done with them. My broad sense is that countries whose currencies are undervalued relative to the reference rates should be expected to cease and desist from intervening in exchange markets (and piling up reserves) to keep their currencies from rising. There is, however, the question of how suddenly they should do so; the appropriate policy for a number of these countries would probably be to allow a step rise of, say, 10 percent in their currencies before resuming intervention, and to do so again the following year and so forth until their reference rates are reached. As for Japan and other countries not actively intervening, it would seem appropriate that if the exchange rate is undervalued by more than a certain degree against the reference rate, the time has arrived for coordinated intervention (like that carried out to reverse the decline of the euro in late 2000).

References

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