In addition to the damage they cause the economy, misaligned real exchange rates (RERs) can be a serious problem for economists. When the RER in a country is overvalued, everyone turns to economists for a quantitative estimate of the degree of misalignment. The usual response of suggesting a multiyear research project to answer the question often will not do, as urgent policy decisions—such as the magnitude of currency devaluation—hinge on this estimate. Instead, the economist has to make use of available data and other information, often without the aid of a model or other consistency check, to develop quick estimates of the degree of RER misalignment.

The situation in the CFA franc zone prior to the January 12, 1994, devaluation illustrates this problem. Most observers agreed that the RER was overvalued, but they disagreed on the extent of the overvaluation. Since data were scarce, robust estimates, let alone formal models, were hard to come by. But the particular nature of the franc zone made the problem even more complicated. Since the CFA franc was convertible, there was no parallel market in foreign exchange, which is often used as

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*I am grateful to Larry Hinkle for suggesting this chapter and to him, Peter Montiel, and three anonymous readers for helpful comments at various stages. Valuable assistance was provided by Fabien Nsengiyumva and Ingrid Ivins.

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The fact that 13 countries shared the same currency (across two monetary unions) meant that the degree of misalignment could be (and was) different across the countries of the zone. Finally, the CFA franc had never been devalued before, so the implication of an estimate of extreme misalignment could be quite profound. It could signal the need for a nominal devaluation that would, in turn, call the credibility of the zone’s fixed exchange rate regime into question.

Theoretically, it would be desirable to estimate the equilibrium exchange rate using a full macroeconomic model that simultaneously takes into account all of the important interactions of the key variables affecting the exchange rate. However, as discussed in the following chapter by Haque and Montiel, constructing and estimating such models is so data- and time-intensive that it is not feasible in many cases in which estimates of the equilibrium exchange rate are needed for policy purposes. Fortunately, there are other approaches to estimating RER misalignment that do not require a full econometric model. This chapter illustrates one such approach.

There is a long tradition of using multisector computable general equilibrium (CGE) models to calculate equilibrium real exchange rates (See Dervis, de Melo, and Robinson (1982), Lewis and Urata (1984)). The model developed in this chapter is a miniature version of these large-scale models. As shown in Devarajan, Lewis, and Robinson (1993), these tiny models can approximate the larger models quite closely for real exchange rate calculations. Consequently, recent efforts have concentrated on these smaller models—see, for example, Abdelkhalek and Dufour (1997), Sekkat and Varoudakis (1998), and Tokarick (1995).

The purpose of this chapter is to show how RER misalignment such as that observed in the CFA zone can be estimated using one such simple general-equilibrium model of an open economy. The model by Devarajan, Lewis, and Robinson (1993) presented here permits a quick calculation of RER misalignment using minimal data. Hence, it is feasible to estimate the extent of RER misalignment for a number of countries in a limited amount of time. The model is used here to gauge the extent of misalignment in 12 of the CFA zone countries prior to the January 1994 devaluation. The model captures some of the salient features of such economies, particularly the effects of volatile terms of trade. At the same time, as we will show, the model incorporates the purchasing power parity (PPP) estimate of RER misalignment as a special case.

1. For a cautionary note on this procedure, see Chapter 12 by Ghe and Kamin on the use of the parallel exchange rate as a guide for setting the official rate.
The following section of this chapter describes the basic model and its relationship to the other methods of calculating RER misalignment. The next section applies the model to 12 of the (then) 13 CFA zone countries to calculate the degree of RER overvaluation just before the devaluation. For each country, it also shows how RER misalignment evolved over time. Then comes a section that discusses the sensitivity of the calculation to the choice of base-year and model parameters and presents extensions of the model to allow for changes in commercial policy and sustainable capital flows. The final section contains some concluding remarks.

The DLR Model

The DLR method extends the Salter-Swan model by dividing the economy into three goods: exports, imports, and “domestic goods.” The latter are goods produced and consumed in the country. Exports are substitutes for domestic goods in production but are assumed not to be consumed domestically. The relationship between exports \( E \) and domestic goods \( D \) can be expressed as a transformation function, with a constant elasticity of transformation, \( W \). Profit maximization implies that the ratio of \( E \) to \( D \) is given by equation 8.1:

\[
E / D = k(P_E / P_D)^\omega
\]

where \( P_E \) and \( P_D \) are the prices of exports and domestic goods, respectively, and \( k \) is a constant. Assuming the country’s exports are small in relation to world markets and are subject to the law of one price, the domestic price of exports is equal to the border price, \( P_E^* \) multiplied by the nominal exchange rate in domestic-currency terms, \( s \).

Imports \( M \) are (imperfect) substitutes for domestic goods in consumption. This relationship is expressed as a constant elasticity of substitution (CES) utility function with elasticity of substitution, \( \sigma \), giving rise to a first-order condition expressed in equation 8.2:

\[
M / D = k'(P_D / P_M)^\sigma
\]

where \( P_M \) is the price of imports. On the assumption again that the law of one price holds, \( P_M \) is equal to \( sP_M^* \), with \( P_M^* \) being the border price of

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2. This subsection gives a summary description of the DLR model. The model’s equations are given in the appendix. Readers interested in applying the DLR model should see Devarajan, Lewis, and Robinson (1993) for a fuller presentation of it.
imports. There are two real exchange rates in the model: the ratio of the price of domestic goods \((P_D)\) to either the price of imports \((P_M)\) or to the price of exports \((P_E)\), expressed in domestic-currency terms. Note that the DLR model retains the Salter-Swan notion of the real exchange rate’s being a ratio of the internal prices of tradables to nontradables—although here “nontradables” are all domestic goods, which are imperfectly substitutable with traded goods, and traded goods are divided into imports and exports. The advantages of this approach are that \(P_D, P_M, \) and \(P_E\) are readily obtained from national accounts data and that the effects of changes in the terms of trade can be analyzed.

The equilibrium real exchange rate in the DLR approach is that rate which is consistent with a specified current account target, given changes in import and export prices—that is, the terms of trade. Equations 8.1 and 8.2 provide two equations for the three unknowns \(E/D, M/D,\) and \(P_D\). The current account target provides the third equation, a relationship between \(E/D\) and \(M/D\). If, relative to a year in which the current account was in balance, import prices have risen and export prices fallen, for a given nominal exchange rate, \(P_D\) would most likely have to fall to restore the balance. If the nominal exchange rate were flexible, the required adjustment could also occur through numerous combinations of changes in this rate and in domestic prices.

The amount by which \(P_D\) would have to fall depends not just on the changes in import and export prices but also on the elasticities of transformation and substitution. For small changes, the relationship between the required adjustment in \(P_D\) and the size of the terms-of-trade shocks and elasticities can be derived by log-differentiating equations 8.1 and 8.2. Denoting the log-derivative by a hat (“\(^\hat{\cdot}\)”), we obtain equation 8.3 (equation 16 in DLR):

\[
\hat{p}_D = [(\sigma - 1)\hat{p}_M + (\Omega + 1)\hat{p}_E]/(\sigma + \Omega).
\]

To understand the economic intuition behind equation 8.3, it is useful to rewrite it as equation 8.4:

\[
\hat{p}_D = (\sigma \hat{p}_M + \Omega \hat{p}_E)/(\sigma + \Omega) + (\hat{p}_E - \hat{p}_M)/(\sigma + \Omega).
\]

The first term on the right-hand side of equation 8.4 is a weighted average of changes in world prices facing the country, in which the weights are elasticities. This term is similar to the adjustment implied by the

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3. See below and Chapter 4 on the three-good internal RER, which explains the calculations of these different RER measures.
A SIMPLE GENERAL EQUILIBRIUM MODEL

Purchasing power parity approach: domestic prices should proportionately rise with world prices, in order to keep the real effective exchange rate at its equilibrium level. The second term on the right-hand side of equation 8.4 is the terms-of-trade change divided by a factor representing the "multiplier effect" of world prices on domestic prices. Equation 8.4 says, therefore, that domestic prices have to adjust not just to changes in the overall level of world prices but also to changes in the relative price of exports to imports (the terms of trade). Put another way, the purchasing power parity base-year approach is consistent with the DLR approach when there are no terms-of-trade shocks.

There is also some similarity between the DLR method and the trade-elasticities approach, since both use constant elasticity assumptions and aim at a specified current account target. However, note that the elasticities in equations 8.1 and 8.2 are constant elasticities of transformation and substitution, whereas the trade-elasticities approach in Chapter 7 uses constant elasticities of export supply and import demand. In the DLR model the equilibrium price in the specification of the domestic-goods market, $P_D$, and hence the real exchange rate, is that price which clears the nontraded (domestic) goods market.

Finally, the basic DLR model can be viewed as a special case of the reduced-form single-equation approach, inasmuch as both calculate the response of the equilibrium real exchange rate to terms-of-trade shocks. The reduced-form approach, though, postulates that the equilibrium RER is also a function of other variables, such as real income, openness, fiscal policy, and a time trend. Furthermore, while the DLR approach estimates only the equilibrium real exchange rate, the reduced-form approach also models the adjustment of the actual exchange rate to its equilibrium value.

The bare-bones version of the DLR model described above can, however, be extended to take into account several additional fundamental variables. Two such variables—which are particularly relevant for RER misalignment in the CFA countries—are changes in (a) sustainable capital flows and (b) trade policy. The remainder of this section describes how the basic DLR model can be extended to incorporate these. The section on sensitivity analyses and extensions subsequently provides illustrative calculations of the impact of these two effects on the estimates of RER misalignment for one country, Côte d’Ivoire.

The calculation of the equilibrium real exchange rate in equations 8.3 and 8.4 assumed that there were no changes in the levels of sustainable capital flows; the only changes were the shifts in world import and export prices. Yet in many cases, the source of the RER misalignment is not just a terms-of-trade shock but also a change in the sustainable capital inflow. For example, in the early 1980s many developing countries—
including those that faced no major terms-of-trade shocks—found themselves with reduced access to financing in world capital markets following the “debt crisis.” To incorporate the impact of a change in the sustainable capital flow on the equilibrium real exchange rate, we add a variable, $\lambda$, which represents the ratio of total imports to total exports. When capital inflows are positive, zero, or negative, $\lambda$ is greater than, equal to, or less than 1, respectively. The effect of a change in $\lambda$ on the equilibrium real exchange rate is given by the following extension of equation 8.4, equation 8.4’:

\[
\hat{P}_D = \left(\sigma \hat{P}_M + \Omega \hat{P}_E\right)/(\sigma + \Omega) + \left(\hat{P}_e - \hat{P}_m\right)/(\sigma + \Omega) + \lambda/(\sigma + \Omega).
\]

Thus, a drop in the level of sustainable capital inflows ($\lambda$ declining) will lead to a depreciation of the equilibrium real exchange rate. The magnitude of this depreciation is a function of the two elasticities, $\sigma$ and $\Omega$.

To estimate the response of the equilibrium domestic price to a change in the tariff rate, we incorporate the tariff into the definition of the domestic price of the import, so that $P_M = sP_M^* (1 + t)$, where $t$ is the tariff rate on imports. We make the additional simplifying assumption that tariff revenues are rebated to the consumer in a lump-sum fashion. With this assumption, the change in the equilibrium domestic price for a given change in the tariff rate is expressed by equation 8.5:

\[
\hat{P}_D = \sigma \hat{t}/(\sigma + \Omega)
\]

where, as shown in equation 8.6:

\[
\hat{t} = \hat{t}/(1 + t).
\]

Note that, as $\sigma$ approaches infinity, the change in the domestic price level approaches the change in the tariff rate. (This result makes sense since in this case imports and domestic goods are almost perfect substitutes.) However, for relatively small values of $\sigma$, the response of the domestic price level to tariff changes is also small.

The relationship between trade policy and the equilibrium real exchange rate is a complex one, and occasionally a source of confusion in the literature. By raising the domestic price of importables (part of the tradable sector), an import tariff also causes the internal real exchange rate for imports to depreciate. However, the internal RER for exports may remain constant or appreciate as a result of an induced increase in the price of domestic goods. The explicit distinction among imports, exports, and domestic goods made in the DLR model clarifies the confusion. The effect of an import tariff is to raise the price of imports and
also to raise the price of domestic goods, but not to the same extent as the price of imports (because imports and domestic goods are imperfect substitutes). Thus, the relative price of imports to domestic goods rises, so that the real exchange rate for imports depreciates. In contrast, the relative price of exports to domestic goods falls, so that the real exchange rate for exports appreciates, moving resources away from the export sector. The sign of the net effect of the depreciation of the internal RER for imports and of the appreciation of the internal RER for exports on the weighted average internal RER for all tradable goods and on the external RER is theoretically ambiguous. Empirically, however, the weighted average internal RER for traded goods will usually depreciate like the internal RER for imports because (a) the RER for imports will normally depreciate by much more than the RER for exports will appreciate and (b) if the country is a net capital importer like most developing countries, imports are usually larger than exports (see Chapter 4 on the three-good internal RER).

As with sustainable capital flows, we provide illustrations of the role of the tariff policy in real exchange rate misalignment for the case of Côte d’Ivoire.

### Applying the DLR Model to the Pre-1994 CFA Zone

We now estimate the extent of RER misalignment in the CFA zone just before the January 1994 devaluation. The model’s underlying equations 8.1 and 8.2 are applied to 12 of the 13 member countries of the zone in 1994 for which adequate data were available. Since many of the terms-of-trade shocks these countries faced were large, the linear approximation given by equations 8.3 and 8.4 cannot be used (although these equations will help in interpreting the results). Instead, we solve the full-blown nonlinear model, which consists of equations 8.1 and 8.2 and the set of accounting identities set out in appendix A.

The calculation of RER misalignment proceeds in several steps. First, we decide on a base year in which the actual RER was equal to the equilibrium RER so that we can estimate the amount by which domestic prices should have changed in order to preserve equilibrium. Column 2 of table 8.1 lists the base year chosen. In most cases, this choice was based on the last year in which the current account in those countries was thought to be in equilibrium in the sense that it could be financed by sustainable capital flows. For most countries, the base year is in the mid-1980s, the period after which terms of trade began moving sharply against the CFA countries. Since the choice of base year is somewhat arbitrary, we subsequently perform sensitivity tests around the selected year as discussed in the next section on sensitivity analyses and extensions.
Second, we decide on the values of the export transformation and import substitution elasticities to be used (columns 3 and 4, table 8.1). These parameter values are based on informed estimates or, in some cases such as Cameroon, may come from larger models of the country (Devarajan, Lewis, and Robinson (1993)). Again, the following section tests the sensitivity of the results to the assumptions about the parameters. Recent econometric evidence (Devarajan, Go, and Li, (1998)) suggests that these elasticities are less than 1 for most developing countries and are considerably lower for low-income primary-exporting economies. The base case export transformation elasticities were, therefore, assumed to be slightly higher (0.5) for the more diversified middle- and former middle-income economies, such as Côte d’Ivoire, Cameroon, and Senegal, than for the low-income countries (0.3). The elasticity of import substitution, in contrast, was assumed to be the same (0.4) in all the countries.

We turn now to the data. Table 8.2 presents first the changes in import and export prices between the base year and 1993. With a fixed nominal exchange rate in the CFA countries, if there had been no change in domestic prices, the real exchange rate would almost surely have been out of equilibrium in the wake of these terms-of-trade shocks. But, of course, domestic prices did change (column 3 of table 8.2), so the empirical question we attempt to answer is whether they changed enough—and in the right direction—to restore equilibrium.

### Table 8.1 Assumptions

<table>
<thead>
<tr>
<th>Country</th>
<th>Base Year</th>
<th>Sigma</th>
<th>Omega</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benin</td>
<td>1986</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>1985</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Cameroon</td>
<td>1984</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Central African Republic</td>
<td>1981</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Chad</td>
<td>1984</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Congo</td>
<td>1984</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
<td>1985</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Gabon</td>
<td>1984</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Mali</td>
<td>1984</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Niger</td>
<td>1984</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>Senegal</td>
<td>1977</td>
<td>0.4</td>
<td>0.5</td>
</tr>
<tr>
<td>Togo</td>
<td>1984</td>
<td>0.4</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*Source: Author’s judgment.*
Table 8.2  Changes in Prices between Base Year and 1993 (in percent)

<table>
<thead>
<tr>
<th>Country</th>
<th>Base Year</th>
<th>Import Prices</th>
<th>Export Prices</th>
<th>Terms of Trade</th>
<th>Domestic prices (GDP Deflator)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benin</td>
<td>1986</td>
<td>25</td>
<td>18</td>
<td>−7</td>
<td>12</td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>1985</td>
<td>−14</td>
<td>−13</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Cameroon</td>
<td>1984</td>
<td>−32</td>
<td>−60</td>
<td>−28</td>
<td>15</td>
</tr>
<tr>
<td>Central African  Republic</td>
<td>1981</td>
<td>97</td>
<td>67</td>
<td>−30</td>
<td>66</td>
</tr>
<tr>
<td>Chad</td>
<td>1984</td>
<td>−28</td>
<td>−16</td>
<td>12</td>
<td>−16</td>
</tr>
<tr>
<td>Congo</td>
<td>1984</td>
<td>10</td>
<td>−60</td>
<td>−70</td>
<td>−27</td>
</tr>
<tr>
<td>Côte d’Ivoire</td>
<td>1985</td>
<td>−3</td>
<td>−32</td>
<td>−29</td>
<td>−11</td>
</tr>
<tr>
<td>Gabon</td>
<td>1984</td>
<td>15</td>
<td>−43</td>
<td>−58</td>
<td>−7</td>
</tr>
<tr>
<td>Mali</td>
<td>1984</td>
<td>−9</td>
<td>−31</td>
<td>−22</td>
<td>17</td>
</tr>
<tr>
<td>Niger</td>
<td>1984</td>
<td>10</td>
<td>−15</td>
<td>−25</td>
<td>−11</td>
</tr>
<tr>
<td>Senegal</td>
<td>1977</td>
<td>−3</td>
<td>15</td>
<td>18</td>
<td>56</td>
</tr>
<tr>
<td>Togo</td>
<td>1984</td>
<td>−15</td>
<td>−36</td>
<td>−21</td>
<td>20</td>
</tr>
</tbody>
</table>

Source: World Bank data.

Table 8.2 shows that 3 of the 12 CFA countries did not suffer a negative terms-of-trade shock between their base year and 1993. Of these, Senegal experienced the largest improvement in its terms of trade. However, as we will show later, this does not necessarily mean that the real exchange rate was undervalued even in that country. The reason is that the observed 56 percent increase in domestic prices in the same period could have been excessive, given the terms-of-trade changes that occurred. Similarly, five countries experienced a decline in domestic prices during the period in question. Yet, some of these (such as Gabon) will turn out to be among the most overvalued in 1993 because the decline in their export prices was much sharper. The variations in the terms-of-trade change can be largely attributed to the differences in the composition of the countries’ exports.4

Having spelled out the assumptions and presented the basic data, we are now in a position to calculate the degree of RER misalignment in each of the 12 countries. We solve the DLR model using the elasticities in

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4. At first glance, it may seem surprising that the import price deflator varied so much across these countries, even though they import roughly the same basket of goods. There are two reasons for this variation. First, the base from which the price change was calculated varied substantially across countries. Second, some countries import petroleum products whereas others export them.
table 8.1 and import- and export-price changes in table 8.2. The model calculates the domestic price level that, for a fixed nominal exchange rate, is consistent with those price changes, given the elasticities and structure of the economy. The economic structure, in turn, is determined by the levels of real GDP, imports, and exports only—hence the claim that the model is economical in its demands on data. We then compare this model-calculated price level with the actual price level in 1993 to determine the extent of RER misalignment in that year.

Before discussing the results, two presentational issues must be addressed. First, the essence of the DLR model is the notion that the price of domestic goods adjusts to restore equilibrium in the economy. The calculations assume that the nominal exchange rate is fixed—as it is in the CFA economies. While the adjusting domestic price is precisely defined, and can be easily calculated using national accounts data, it is not always reported in standard price statistics. Instead, these statistics usually report the consumer price index (CPI) and the GDP deflator. Since there is a straightforward relationship between the price of domestic goods and the GDP deflator (the latter is a weighted average of the former and the export price deflator) in the national accounts and the DLR model, we will report the results in terms of the GDP deflator in order to make them more readily comparable to available price statistics. That is, we use the model first to calculate the equilibrium domestic price and subsequently compute the equilibrium GDP deflator. We then compare the latter to the actual level of the GDP deflator to determine the degree of price level overvaluation.

It may seem curious that, while we have stressed the advantage of the DLR model as capturing the two real exchange rates, we use neither in our estimation of price misalignment. We have adopted this procedure in order to simplify the presentation and focus it on the model’s endogenous price variable—the domestic price level. Recall that the RERs for imports (RERM) and for exports (RERE) are defined as shown in equations 8.7 and 8.8:

\[
RERM = \frac{P_M}{P_D} = \frac{sP_M^*}{P_D} = \frac{P_M^*}{\left(\frac{1}{s}\right) P_D}
\]

\[
RERE = \frac{P_E}{P_D} = \frac{sP_E^*}{P_D} = \frac{P_E^*}{\left(\frac{1}{s}\right) P_D}
\]

---

5. See the appendix to Chapter 3 on the two-good internal RER.
In the DLR model, $P_M^*$ and $P_E^*$ are specified exogenously; and $(1/s)P_d^*$, the price of domestic goods in foreign currency terms, is the model’s endogenous price variable. If $s$ is also fixed as in the CFA countries, $P_d^*$ becomes the model’s single endogenous price variable and the endogenous determinant of the RERs for both exports and imports. The equilibrium RERs for imports and exports can, however, be readily computed with equations 8.7 and 8.8 using the equilibrium domestic price level and the exogenously determined border prices of imports and exports.

A second presentational issue, which all studies of real exchange rates have to confront, is the question of whether the measure should be expressed in domestic- or foreign-currency terms. In the figures in this chapter, the results are presented in foreign-currency terms, so that an upward movement of the RER or domestic price level is an appreciation and a downward one is a depreciation. Since we are comparing price levels, our measure of overvaluation is the degree to which domestic prices will have to fall in order to restore equilibrium.

With these clarifications in mind, figure 8.1 presents the degree of overvaluation of the GDP deflator in the CFA countries in 1993. For example, the domestic price level in Cameroon, the most overvalued country, needed to fall by 78 percent because the equilibrium price level was only 22 percent of the actual price.

Several points about these results are worth noting. First, the degree of real overvaluation in 1993 was substantial—an unweighted average of 31 percent for the CFA countries as a group. Second, the variation in RER misalignment across countries was also substantial: the middle- and former middle-income countries, and within that group the oil producers (Cameroon, Gabon, Congo), were the most overvalued, while some of the low-income countries were only slightly overvalued or, in one case (Chad), undervalued.6 Third, the comparable calculation using the PPP base-year method yields much lower degrees of real overvaluation. The reason, as mentioned earlier, is that the PPP base-year approach leaves out the effects of changes in the terms of trade on the country’s equilibrium real exchange rate. To the extent that CFA countries suffered adverse terms-of-trade shocks during this period, such an omission will lead to an underestimation of the degree of overvaluation (see equation 8.4).7

6. The large variation in RER misalignment does not necessarily imply that a uniform nominal devaluation was unwarranted, since a nonuniform devaluation would have necessitated introducing multiple currencies and, therefore, undermined the zone’s two monetary unions.

7. In addition, the PPP base-year approach usually uses the country’s overall price level (CPI). Since this index reflects tradable as well as nontradable prices (import prices in the CPI), it is not directly comparable to the price of domestic goods.
Figure 8.1 summarizes the extent of price overvaluation on the eve of the devaluation. Was this overvaluation persistent, or had it arisen in the last few years? To answer this question, we examine the evolution of misalignment over time for each of the 12 countries. We do so first by using the DLR model to compute the level of the GDP price deflator required to restore equilibrium for every year after the base year and then by comparing the equilibrium level to the actual levels of those years. Such an exercise helps answer another question: How much of the overvaluation was due to changes in the equilibrium price level, and how much to changes in the actual domestic price level?

The results of this exercise for three representative countries are presented in figure 8.2. The picture painted in the previous discussion now comes into sharper view. Cameroon, a major oil producer, suffered a major terms-of-trade shock in 1986 (when the price of oil plummeted) and remained severely overvalued subsequently. Even though the price level in the country rose only slightly, it was still far above the equilibrium level, which declined sharply. Similarly, in another highly overvalued country, Côte d’Ivoire, the gap between the equilibrium and actual price levels started growing in the mid-1980s and continued to grow until the end of 1993. By contrast, in one of the low-income countries, Niger, the GDP deflator was either in equilibrium or even undervalued for most of the 1980s. Niger’s GDP deflator became overvalued only...
Figure 8.2 Equilibrium vs. Actual GDP Deflators

Note: An upward movement is an appreciation.
Source: Computed from World Bank data using the DLR model.
after 1990, when uranium prices fell. Nevertheless, by the early 1990s, a significant gap between the equilibrium and actual GDP deflator rate had appeared in 10 of the 12 CFA countries, with the gaps becoming ominously large (more than 30 percent) in six countries. Most of the countries were subject to adverse terms-of-trade shocks for their primary export commodities; and the appreciation of the French franc (to which the CFA franc was pegged) relative to the U.S. dollar following the 1985 Plaza Accords exacerbated the decline in their export earning in CFA terms.

**Sensitivity Analyses and Extensions**

This section discusses the sensitivity of the estimates of misalignment to the model's assumptions. The two most crucial are the choice of base year and the assumed elasticities of transformation and substitution. The section goes on to give an example of an extension of the basic analysis to incorporate changes in sustainable capital flows and commercial policy.

**Sensitivity to Choice of Base Year**

As mentioned earlier, the choice of base year for the calculation of RER misalignment is somewhat arbitrary. The analyst has to decide in which year the actual RER equaled the equilibrium RER and the resource balance of the economy reflected a sustainable level of capital flows. Significantly, that level of capital flows need not be zero: a country may have a current account deficit, or a negative resource balance, and still be in a sustainable equilibrium. Indeed, the resource deficit could be larger in the base year than in a current (disequilibrium) year if the external capital inflows have fallen. In this case the smaller current resource deficit would not be sustainable, although the larger one in the equilibrium base year was sustainable. In short, the choice of a base year does not lend itself to some simple, mechanical formula, such as “the year in which the resource balance was x percent of GDP.” Hence, we based our choice of base years on the knowledge of economists familiar with the particular situation of the individual countries. Given that this is a subjective method for determining a potentially crucial component of the analysis, we examined the sensitivity of the price misalignment estimates to the choice of base year.

Figure 8.3 reports on simulations with the DLR model using different candidates for the base year from 1980 to 1990 for three representative countries. For each different base year, both the terms-of-trade shock (with respect to 1993) and the structure of the economy (in the base year) are different. The resulting patterns are quite revealing. For one of the
Figure 8.3 Sensitivity of the 1993 Equilibrium GDP Deflator to Choice of Base Year

Cameroon

Côte d’Ivoire

Benin

Source: Computed from World Bank data using the DLR model.
most overvalued former middle-income countries, Cameroon, the degree of price misalignment is quite robust to the choice of base year up to 1986–87. This pattern is not surprising. Cameroon faced the largest terms-of-trade shocks in the mid-1980s. Yet, after 1986–87 export and import prices were not that different from the level in 1993. Hence, if one of the years after 1986–87 is chosen as the base year, the degree of misalignment is much lower. Yet no economist familiar with Cameroon would suggest that 1988, for example, was a reasonable base year for it. The country was then in the middle of a major adjustment period because of the oil-price shock. In contrast, for a less overvalued low-income country such as Benin, the magnitude, and possibly even the sign, of the price misalignment depends on the choice of base year. Benin could be considered undervalued or overvalued depending on which year in the 1980s was picked as its base year. To be sure for the years after 1982, the degree of misalignment would range only from +10 percent to −5 percent so that Benin would still be close to equilibrium in any case. Finally, note that for Côte d’Ivoire—which is often thought to be the leader in the CFA zone—the degree of price overvaluation is quite sensitive to the choice of base year even if the choice is restricted to the first half of the 1980s because of sharp swings in its terms of trade. For instance, if 1982 were to be chosen, the country was hardly out of equilibrium in 1993. But if 1985 were the base year, Côte d’Ivoire was above the CFA average in overvaluation. These results provide a partial explanation of why observers of Côte d’Ivoire may have disagreed on whether the country’s RER was misaligned: they may have been thinking in terms of different base years.

**Sensitivity to Elasticities**

As the DLR model relies on assumed values of two key parameters, it is also important to investigate how robust the results are with respect to assumptions about these parameters. The results of sensitivity tests using values of these elasticities below and above the base case values are reported below.

As figure 8.4 indicates, for the most overvalued country, Cameroon, the degree of price overvaluation is not very sensitive to either elasticity. The range of price overvaluation between the high elasticity case (both elasticities equal to 2, four to five times the base case levels) and the low elasticity case (0.2 and 0.25, one half the base case levels) is only between 66 percent and 81 percent. This result is not surprising since, as we saw earlier, Cameroon suffered a sharp terms-of-trade decline, which (with a fixed nominal exchange rate and downward price rigidity) would lead to a substantial overvaluation for any reasonable substitution and
transformation elasticities. This result is repeated for all the highly overvalued oil-producing countries. However, as with the choice of base year, assumptions about the elasticities can affect the sign of the misalignment for less overvalued low-income countries such as Benin. Again, though, the range between the high and low cases is not very large—around 20 percentage points. In Côte d’Ivoire’s case, the degree of misalignment, while somewhat sensitive to the choice of base year, is less sensitive to the elasticities: the range between the high and low cases is around 20 percentage points, with very little variation in the intermediate values. Again, this outcome is driven by the fact that Côte d’Ivoire’s overvaluation was the result of the large terms-of-trade shocks it suffered in the mid-1980s. These shocks were sufficiently large that they dominated the effect of reasonable variations in the assumed elasticities.
Extensions

Finally, as anticipated in the section that introduced the DLR model, we now present some illustrative calculations for Côte d’Ivoire of the RERs for exports and imports, and the two extensions to the DLR model discussed in this chapter—namely, changes in sustainable capital flows and in tariffs. Figure 8.5 shows the evolution of the actual and equilibrium RERs for exports and imports expressed relative to the GDP deflator in Côte d’Ivoire. Note that the two RERs behaved somewhat differently. The actual RER for exports appreciated by about 35 percent, while the equilibrium export rate depreciated by almost 20 percent. For imports, in contrast, the actual RER changed little, whereas the equilibrium rate depreciated by nearly 40 percent.

As for the first of the two extensions, estimating sustainable capital flows and determining target current account deficits is a significant analytical problem in its own right, which is discussed further in the preceding chapter on traditional methodologies and operational techniques by Ahlers and Hinkle. Recall that the assumption in figure 8.1 that there was no change in the level of sustainable flows yielded a degree of overvaluation for Côte d’Ivoire of 36 percent. How does this estimate vary with changes in the level of sustainable capital flows? We can use equation 8.4’ to obtain an approximation of the additional overvaluation for a given reduction in the level of sustainable capital flow. Note that since λ allows us to adjust for changes in capital flows, the critical factor in choosing a base year is that, taking into account all of the fundamentals, the actual RER be as close as possible to the equilibrium RER.

The calculation proceeds in the following steps. First, we translate a 1 percent of GDP reduction in the level of capital inflow (or increase in the level of outflow) into a change in the ratio of total imports to total exports. Given the levels of GDP, imports, exports, and the resource balance in Côte d’Ivoire in the base year (1984), this 1 percent of GDP reduction is equivalent to a 3 percent decrease in λ. Second, from (8.4’), we determine that a 3 percent reduction in λ would require an additional decline in the domestic price of 3.3 percent to restore equilibrium (given elasticities of 0.4 and 0.5). Third, this 3.3 percent decline in the domestic price would lower the overall price level by an additional 2 percentage points (exports are about 40 percent of GDP). The next result is that if Côte d’Ivoire was overvalued by 36 percent when capital flows return to the base-year level, it is overvalued by 39 percent when they are 1 percent of GDP lower than in the base year. In sum, for every 1 percent of GDP decline in the level of sustainable capital inflow from the 1984 level, Côte d’Ivoire’s degree of price overvaluation goes up by 3 percentage points.
**Figure 8.5.a Côte d’Ivoire: RER for Exports**

Export RER ($P_x/P_e$)

![Graph showing export RER for Côte d’Ivoire from 1985 to 1993.](image)

**Figure 8.5.b Côte d’Ivoire: RER for Imports**

Import RER ($P_x/P_m$)

![Graph showing import RER for Côte d’Ivoire from 1985 to 1993.](image)

*Note:* An upward movement is an appreciation.

*Source:* Computed from World Bank data using the DLR model.
The calculation for a change in tariffs proceeds along similar lines. For example, if the initial effective tariff rate (tariff revenues collected as a share of imports) in Côte d’Ivoire was 20 percent, then a 30 percent reduction in the effective tariff rate (that is, the effective tariff rate being reduced to 14 percent) would have implied a reduction in the equilibrium domestic price of 2.2 percent (using equation 8.5). However, the domestic price of imports including tariffs would also have fallen by 5 percent, while the domestic price of exports would have remained constant. If we go back to the definitions of two real exchange rates—the relative prices of imports to domestic goods and of exports to domestic goods—the former would have appreciated by 2.8 percent, while the latter would have depreciated by 2.2 percent. If one were using a weighted average of the two real exchange rates for the internal RER, the net effect would probably be an appreciation, given the greater change in the import RER and the fact that for most capital importing countries (like Côte d’Ivoire) imports exceed exports. Hence, a reduction in protection is likely to lead to an appreciation of the equilibrium RER but to have asymmetric effects on the RERs for imports and exports, appreciating the former but depreciating the latter.

Conclusion

This chapter has demonstrated the use of a simple general-equilibrium model that captures some salient features of RER misalignment in developing countries (specifically, the change in the equilibrium RER in response to changes in the terms of trade and capital flows) but requires only minimal data for the calculations. The analysis has shown that neglecting changes in the equilibrium RER can be seriously misleading in determining the extent of RER overvaluation. Several CFA countries experienced a decline in their domestic price levels over the late 1980s and early 1990s; yet some of these same countries were still the most overvalued as the equilibrium RER declined even further because of adverse terms-of-trade shocks. Two extensions of the basic model—one that allowed for changes in the level of sustainable capital inflows, the other for changes in the tariff regime—were also presented and used to calculate the impact of each of these changes on the degree of RER overvaluation in Côte d’Ivoire.

The simplicity of the DLR model permits a range of sensitivity analyses of the estimates of misalignment. While the choice of base year is often controversial, we find that our estimates of misalignment do not change significantly for a wide range of base years. Specifically, for the most overvalued countries, any base year in the early- to mid-1980s before the adverse terms-of-trade shock would give more or less the same
estimate of overvaluation, since the terms of trade of these countries fell sharply in the mid-1980s and have not recovered since.

The estimate of domestic price overvaluation for the countries experiencing large terms-of-trade shocks is similarly robust to assumptions about the model’s elasticities. The terms-of-trade shocks were so severe that for a wide range of elasticities the gap between the equilibrium and actual real exchange rate in 1993 was substantial. In contrast, for the countries where the terms-of-trade shocks were smaller, the estimates are quite sensitive to the elasticities. However, insofar as the economies of these countries are relatively simple, we can attach more confidence to our “base case” levels of the elasticities (which were quite low) and therefore to our initial estimates of RER overvaluation in those countries.

Two limitations of the approach in this chapter should be highlighted here. First, being an equilibrium model but not a dynamic one, the model only calculates the gap between the actual and equilibrium real exchange rates. It is silent about the path that the economy should take to achieve equilibrium, or even how long it should take. Second, as a model of relative prices, it is better suited for analyzing countries with fixed exchange rates, as the domestic price level can be uniquely determined only if the nominal exchange rate is predetermined or exogenously specified. In addition, in countries with fully flexible exchange rates, changes in the nominal exchange rate can affect real variables through the monetary sector. These effects are left out of the present model. That said, if the situation calls for the rapid calculation of the equilibrium real exchange rate in a country subject to terms-of-trade shocks, the general-equilibrium model presented in this chapter can help put the estimate of RER misalignment on a firmer analytical footing.
Appendix

The DLR Model

Equations

(8.A.1) \[ X = G(E, D; \Omega) \]
(8.A.2) \[ Q = F(M, D; \sigma) \]
(8.A.3) \[ E/D = g(P_M, P_E; \Omega) \]
(8.A.4) \[ M/D = f(P_M, P_M'; \sigma) \]
(8.A.5) \[ P_M = sP_M^* \]
(8.A.6) \[ P_E = sP_E^* \]
(8.A.7) \[ P_M^*M = P_E^*E \]
(8.A.8) \[ s = 1. \]

Endogenous variables

E  Exports
M  Imports
D  Domestic goods
Q  Composite goods
P  Price of domestic goods
P_M  Domestic price of imports
P_E  Domestic price of exports
s  Nominal exchange rate

Exogenous variables

X  Aggregate output
P_M^*  World price of imports
P_E^*  World price of exports
\lambda  Ratio of value of imports to value of exports
\Omega  Elasticity of transformation of supply
\sigma  Elasticity of substitution in demand