Part II

Determinants of the Equilibrium Real Exchange Rate
Following up on Part I’s focus on definitions and measurement of the actual real exchange rate, Part II studies the definition and estimation of the long-run equilibrium real exchange rate (LRER). This chapter focuses on conceptual issues and a review of previous empirical research on the LRER, both for industrial as well as for developing countries. The next chapter builds an analytical model of the LRER suitable for identifying its “fundamental” determinants, as well as for exploring the qualitative direction of the effects of each of those determinants on the LRER.

There is a substantial degree of agreement on an LRER definition at the broad conceptual level. As originally described by Nurkse (1945), the LRER is that value of the real exchange rate that is consistent with the dual objectives of external and internal balance, for specified values of other variables that may influence these objectives.1 The former refers to a situation in which the value of the current account deficit is one that can be financed by a “sustainable” level of capital inflows, while the latter refers to a situation in which the market for nontraded goods is in a “sustainable” equilibrium.2 While this broad conceptual definition is

1. For a recent restatement by an authority on the subject, see Edwards (1989).
2. Alternatively, in the Mundell-Fleming framework more commonly applied in the industrial-country context, the market for domestically produced goods would be required to be in a sustainable equilibrium.
helpful, giving precise operational content to the term “sustainable” as well as to the “other variables that may influence these objectives” is not a trivial matter, and different approaches to these issues have resulted in markedly different empirical methodologies for measuring the LRER.

This chapter presents an overview of these alternative empirical methodologies, as applied in both industrial and developing countries. The objectives are both to describe the methodologies, as well as to place them in a common analytical framework within which they can be compared. To achieve these objectives, the chapter starts by setting out a broad conceptual framework and then describes in succession the alternative methodologies that have been used for estimating the LRER in industrial and developing countries. These are treated in separate sections, because the analytical approaches to the LRER, as well as the methods used to estimate it, have tended to differ in these alternative contexts.

**Conceptual Issues**

The appellation “long-run” attached to the equilibrium exchange rate concept under consideration arises from the provision in the Nurkse definition that the relevant external and internal balance outcomes should be “sustainable.” The imposition of a sustainability requirement thus introduces a dynamic dimension into the definition of the equilibrium real exchange rate. Accordingly, to analyze the issues involved in defining the long-run equilibrium real exchange rate more precisely, it can help clarify matters to be as specific as possible about the dynamic structure of the economy at hand.

**Sustainability in Theory**

At any moment in time, an economy will exhibit a short-run equilibrium that can be thought of, in textbook fashion, as some combination of goods-market equilibrium and equilibrium in financial markets. This equilibrium may or may not feature full employment, a desirable rate of inflation, and a level of the current account deficit that external creditors are willing to finance indefinitely. The short-run equilibrium determines the values of the economy’s endogenous variables—including that of the actual real exchange rate (which we can denote RER)—conditioned on the current values taken on by other variables that are not themselves determined as part of the short-run equilibrium, but that may be changing over time. These include macroeconomic variables of three types: predetermined, policy, and exogenous variables. Let $X_1$ represent the set of all current values of the relevant group of predetermined variables and $X_2$, the set of all current and expected future values of the group
of relevant policy variables. Concerning the exogenous variables, I will classify them into two types: “bubble” variables, denoted $B(t)$, are extraneous factors that affect the economy only through their influence on expectations, while “fundamental” factors are those that influence the economy at any given moment independently of any effects they may exert through expectations. I will use the symbol $X_1$ to denote the set of all current and expected future values of the “fundamental” exogenous variables. With this notation, a reduced-form expression for the real exchange rate that emerges from the economy’s short-run equilibrium can be written as in equation 5.1:

$$RER(t) = f(B(t), X_1(t), X_2(t), X_3(t))$$

where the argument $t$ appearing in $X_1$ and $X_2$ indicates that expectations about the future values of the variables included in the sets are formed at time $t$. I will refer to this as the short-run equilibrium real exchange rate.

The formulation in equation 5.1 is quite broad. It is worth noting, in particular, that the inclusion of $B(t)$ makes it broad enough to encompass the role of so-called “rational bubbles,” which are speculative factors that generate price increases of a self-fulfilling nature. Equation 5.1 states that the economy’s short-run equilibrium depends on expectations about the future, consisting of expected future values of policy and exogenous variables, as well as extraneous bubble factors, if any. By creating self-fulfilling price movements, such factors are capable of creating rational price “bubbles” and thus driving the real exchange rate away from the “fundamental” value that would be observed in the absence of such extraneous influences underpinning future price expectations.

A short-run equilibrium RER given by equation 5.1, but with no “bubble” term present among the exogenous variables, is often described as “fundamentals-driven,” where the term “fundamentals” refers to the variables included in $X_1$, $X_2$, and $X_3$. For present purposes, however, I will use the more precise term “short-run fundamentals-driven” since, as will be shown presently, the definition of what constitutes “fundamentals” differs depending on the time horizon adopted. To avoid overburdening the discussion, in what follows I will abstract away from

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3. Bold lettering is used to indicate that not just current, but also expected future variables are included in $X_2$.

4. The future evolution of the predetermined variables is excluded from this list because it will itself depend on the expected future values of the exogenous and policy variables, through the influence of these on current endogenous variables, as explained below.
bubble factors altogether and restrict attention to “short-run fundamentals-driven” real exchange rate movements, given by equation 5.2:

\[ RER(t) = F(0, X_1(t), X_2(t), X_3(t)). \]

Since equation 5.2 determines the value of the real exchange rate at any moment, the dynamics of the real exchange rate arise from movements over time in \( X_1, X_2, \) and \( X_3. \) The factors that cause these variables to change over time differ across the three types of variables.

Predetermined variables are those that, while they may be fixed at any given moment, evolve endogenously over time, influenced not only by the policy and exogenous variables, but also by the current and expected future values of the endogenous variables. Because each of the latter will depend in turn on \( X_1, X_2, \) and \( X_3, \) through equations similar to 5.2, the change in the predetermined variables over time can be written as in equation 5.3:

\[ \dot{X}_i(t) = G(0, X_1(t), X_2(t), X_3(t)). \]

The economy’s stock of net international indebtedness and its capital stock are such variables, for example, and if domestic nominal wages are “sticky,” so may be the aggregate nominal wage level.5

Unlike predetermined variables, policy variables follow a dynamic path that may or may not be affected by the current state of the economy, depending on the policy regime that is in place—in other words, on whether the rules that guide policy incorporate feedback from actual economic developments. If they do, then a set of equations similar to equation 5.3 could be written for the policy variables. But even if they do not, policy variables may be evolving over time as the result of policy “gradualism”—that is, the undertaking of policy adjustments in a measured, rather than discrete, fashion. For example, the gradual liberalization of commercial policy, or the gradual removal of restrictions on

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5. It is worth noting in passing that, to capture the notion of neutrality, it is standard in textbook models to specify the variables on the right-hand side of equations 5.2 and 5.3 in real terms. This means that predetermined variables that are actually predetermined in nominal terms appear in equations 5.2 and 5.3 divided by some nominal variable. To retain their identity as predetermined variables, it is helpful to deflate these using exogenous or policy variables. For example, if it is predetermined in a particular model, the nominal wage may appear in equations 5.2 and 5.3 in the form of the real wage. To retain its predetermined character, in a fixed-exchange rate model we would want to think of it as measured in units of traded goods, rather than in units of the domestic consumption bundle or some other real unit with an endogenous price.
capital movements, would generate such policy dynamics, with or without feedback. To incorporate either possibility, the policy variables are expressed as functions of time in equations 5.2 and 5.3.

Finally, the path followed by the exogenous variables (an important component of which, for example, consists of world economic conditions) is by definition independent of the current state of the domestic economy. Because these variables will typically be changing over time, they are also expressed as functions of time in the equations above.

With this framework in place, we can now be more precise about the meaning of sustainability, and thus of “long-run equilibrium.” Suppose that we think of the policy and exogenous variables as being composed of “permanent” components that are constant over time—call these \(X_2^*\) and \(X_3^*\) respectively—and “transitory” components \(\Delta X_2(t)\) and \(\Delta X_3(t)\), where, as shown in equation 5.4:

\[
\begin{align*}
\Delta X_2(t) &= X_2(t) - X_2^* \\
\Delta X_3(t) &= X_3(t) - X_3^*.
\end{align*}
\]

The “sustainable” values of the policy and exogenous variables can be identified by their permanent components. Notice, however, that even if these two types of variables are set at their sustainable levels—that is, even if \(X_2(t) = X_2^*\) and \(X_3(t) = X_3^*\)—the predetermined variables \(X_1\) may be changing over time, according to equation 5.3. Sustainability for the predetermined variables requires that these variables have stopped evolving endogenously—that is, that they have reached their steady-state values. The steady-state value of the predetermined variables, denoted \(X_1^*\), is that which satisfies equation 5.5:

\[
0 = G(0, X_1^*, X_3^*, X_3^*).
\]

In this context, a long-run equilibrium is simply a short-run equilibrium conditioned on particular values of the three types of “forcing” variables—specifically, on the permanent values of the policy and exogenous variables, as well as on steady-state values of the predetermined variables. The LRER is thus given by equation 5.6:

\[
LRER = F(0, X_1^*, X_2^*, X_3^*, X_3^*) = H(X_2^*, X_3^*)
\]

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6. In the case of the policy variables, the permanent component may or may not correspond to “desired” values, depending on whether policies that are not necessarily desired may nevertheless tend to be sustained.
where $X_1^*(X_2^*, X_3^*)$ is the implicit function defined by equation 5.5 that expresses the predetermined variables as functions of the policy and exogenous variables. Since the second line of equation 5.6 suggests that the LRER depends only on $X_2^*$ and $X_3^*$, these are accordingly referred to as the “long-run fundamental” determinants of the LRER. This equilibrium described by equation 5.6 is “sustainable” in the sense that absent changes in the exogenous or policy variables, it can be expected to persist indefinitely.

**Misalignment**

The framework set out above can be useful in clarifying some controversial issues in the measurement of equilibrium real exchange rates. Isard and Faruquee (1998) point out that there are two schools of thought within the economics profession that question the usefulness of attempts to measure equilibrium real exchange rates. The first argues that real exchange rates can never become substantially misaligned—meaning that actual real exchange rates tend to reflect the underlying fundamentals—while the second accepts the concept of misalignment but is skeptical of the ability of any particular methodology to deliver accurate estimates of the degree of misalignment (that is, of the equilibrium real exchange rate) in practice.

The validity of the second of these views is an empirical issue. The usefulness of alternative methodologies for the measurement of equilibrium real exchange rates can be assessed in various ways—for example, by their ability to replicate historical episodes in particular countries during which informed observers agree that real exchange rate misalignment has been a serious problem, or by their ability to predict subsequent real exchange rate movements. Several of the methods described in this book have been evaluated favorably using such methods, as will be described below. At this point I focus instead on the first of these objections and consider it in the context of the conceptual framework described previously.

Isard and Faruquee (1998) characterize the first view as maintaining that real exchange rates are always “appropriate” conditional on the fundamentals and consequently that “inappropriate” exchange rates reflect unsustainable or otherwise undesirable macroeconomic policies. The implication is that under this view there is no separate welfare-enhancing role for exchange rate policy as such. The role of policy is simply to set the underlying real policy fundamentals at appropriate values. Given such policies, the observed real exchange rate will tend to be appropriate as well.

To interpret this in terms of our conceptual framework, it is useful to extend the framework slightly. Note first that the policy variables in $X_1^*$,
though sustainable, may not be desirable. Suppose we call the “optimal” levels of the policy variables $X_2^*$. In general, $X_2^*$ will depend on the values of the exogenous variables, specifically stated as: $X_2^* = J(X_1^*)$.

Substituting these values in equation 5.6, we end up with equation 5.7:

\[
(5.7) \quad DRER = H[J(X_1^*), X_2^*].
\]

As indicated in equation 5.7, the solution to equation 5.6 with this set of policy variables can be referred to as the desired equilibrium real exchange rate (DRER).

Corresponding to each definition of “equilibrium” real exchange rate offered above (that is, SRER, LRER, and DRER) is a corresponding measure of misalignment—defined as the difference between the actual RER and its equilibrium value. The broadest of these is the gap between the RER and the DRER. This gap can be decomposed into three parts as follows:

\[
RER - DRER = (RER - SRER) + (SRER - LRER) + (LRER - DRER).
\]

Thus, misalignment defined as the gap between the actual real exchange rate and the desired long-run equilibrium real exchange rate can arise because of bubble factors (accounting for the difference between RER and SRER), slow adjustment of predetermined variables (accounting for the difference between SRER and LRER), and inappropriate policies (accounting for the gap between LRER and DRER). The view that the real exchange rate is always driven by fundamentals and that the only source of misalignment with policy implications is that which arises from inappropriate policies can now be rendered in the form of two statements about this decomposition:

a. $RER - SRER = 0$, so the real exchange rate is never influenced by speculative “bubble” terms; and
b. While deviations between LRER and DRER call for corrections in the policy fundamentals, deviations between SRER and LRER are optimal and, in particular, have no implications for exchange rate policy.

The first statement is an empirical statement about the behavior of the nominal exchange rate under a free float. The second statement is implied by the view that real exchange rates are always “appropriate” conditional on the fundamentals. If deviations of SRER from LRER are the (short-run) equilibrium outcomes of the optimizing behavior of agents operating in an undistorted environment, then such deviations
are optimal and cannot be improved upon by exchange rate policy. The statement thus concerns the role of nominal rigidities in generating temporary deviations of the real exchange rate from its long-run equilibrium value and reflects the view that nominal rigidities do not help to account for such deviations.

Neither of these statements can be dismissed out of hand. The role that speculative bubbles may play in a variety of financial markets—including exchange rate markets—remains controversial and is an active topic of research in macroeconomics. For countries that maintain officially determined exchange rates, however—as is the case for the vast majority of developing countries—this issue does not directly arise, since the nominal exchange rate in such countries is not a market-determined asset price. The second statement is more fundamental. It amounts to an application to the exchange rate arena of the broader question of the role of nominal rigidities in explaining macroeconomic fluctuations. The maintained view among those who consider the estimation of equilibrium real exchange rates a worthwhile endeavor is that nominal rigidities have an important role to play in explaining such fluctuations, and consequently that temporary deviations of the RER from the LRER do indeed have implications for nominal exchange rate policies. Specifically, the presence of nominal rigidities implies that nominal exchange rate adjustments may often be useful in helping to guide the RER back to the LRER from an initial disequilibrium.

Sustainability in Practice

In principle, as defined above, “the” long-run equilibrium is that for which all of the conditioning variables—including both policy and predetermined—have reached their steady-state levels, given “permanent” values of the exogenous variables. In particular, this means that any transitory fluctuations in exogenous variables have been identified and discarded, that all policy variables have been set at their sustainable long-run values, and that all predetermined variables have been allowed to complete their endogenous adjustments and reach their steady-state levels. Unfortunately, however, a “purist” definition of this type would have little analytical or operational content. Translating this “purist” definition into a meaningful operational counterpart may be the most difficult problem that arises in the empirical measurement of the LRER. The key problem is specifying what we mean operationally by “sustainable” values of the exogenous, policy, and predetermined variables.

The issues that arise in doing so are different for each of the three types of variables. Things are perhaps most straightforward in the case of exogenous variables such as the terms of trade or world real interest rates. The issues in this regard are largely statistical, rather than concep-
tual. As assumed above, fluctuations in such variables will contain both permanent and transitory components. Thus, identifying the relevant “permanent” component $X_3^*$ empirically involves implementing statistical techniques (or using any available ex ante information) to disentangle these two components so that such “permanent” values can be isolated. Since, as already indicated, the time-series properties of these variables are independent of anything that happens in the domestic economy, all that is required for the specification of the LRER is some technique for predicting the duration of shocks to such variables. This kind of exercise is of broad applicability in macroeconomics, and relevant techniques are not specific to this particular application.7

A more complicated set of issues arises in the case of policy variables, such as the level and composition of government spending and the restrictiveness of the trade and capital-account regimes. While the values of such variables are in principle determined by the authorities, their current and long-run values could differ if future policy adjustments are envisioned. A steady-state configuration for such variables is therefore one in which they have reached their desired values, conditional on all of the exogenous variables, so that no further change is envisioned. Both desired long-run values as well as the path of adjustment will in this case depend not only on the structure of the economy, but also on the objective function that guides the behavior of the policymakers. This makes the identification of the optimal long-run configuration of the policy variables an extremely complicated task.

The requirement that all relevant policy variables be set at their optimal levels, implied by the fact that only the optimal levels of policy variables can be “desired” to be permanent, would force the analyst to solve a hopelessly complicated dynamic optimization problem before specifying the LRER. Even if it were possible to do this in a way that would satisfy many observers, it would be far too ambitious an undertaking for most practical applications.8 A far more practical alternative would be to define the LRER for given, arbitrary values of the policy variables—as long as such values are in principle sustainable—rather than for the optimal values of such variables to which welfare-maximizing policymakers would presumably eventually move them. Clearly, if

7. Because such techniques are widely discussed in other contexts, this issue is not pursued further here. By and large, with the exception of Chapter 10 by Baffes, Elbadawi and O’Connell in Part III of this volume, the chapters in this collection do not attempt to describe techniques for decomposing movements in relevant exogenous variables into permanent and transitory components.

8. Although, as we shall see below, some approaches to the estimation of the LRER take up this challenge.
we know how the LRER is related empirically to arbitrary values of the relevant set of policy variables, then we can say in particular how the long-run equilibrium value would change if those policy variables themselves change, perhaps in some direction defined as optimal. In terms of equation 5.6, this would mean knowing the function $F(\ )$, but not necessarily the values of the arguments in $X^*_2$. Thus, although the ultimate LRER to which the economy is headed may be different from that which would be predicted on the basis of, for instance, the current values of policy variables—precisely because those values are expected to change—it may be sufficient to know how any such changes would affect the equilibrium value of the real exchange rate without necessarily specifying what such changes should be.

Finally, consider the case of predetermined variables. As indicated above, such variables evolve endogenously over time toward long-run equilibrium values that themselves depend on the long-run values of the policy and exogenous variables (as summarized in the function $X_1(X^*_2, X^*_3)$). The difficulty posed by such variables for the analysis of long-run equilibrium real exchange rates is that they tend to approach their steady-state values at different rates, raising the question of how close they are individually required to be to their steady-state values in an operational definition of long-run equilibrium. Requiring that all such variables reach their steady-state variables in our definition of the LRER may be unduly restrictive, in that the LRER that satisfies this condition may take so long to reach that it may be of little interest to policymakers.

How can widely different speeds of adjustment among the predetermined variables be handled in the formal framework described above? An asymmetry between fast-adjusting and slow-adjusting predetermined variables can be incorporated into the framework by defining the relevant operational concept of long run as requiring that only some subset of the predetermined variables—the relatively faster-adjusting ones—be at their sustainable equilibrium values. Suppose the set of predetermined variables $X_1$ is separated into two subsets: that of fast-adjusting variables $X_{11}$ and slow-adjusting ones $X_{12}$. Then equation 5.2 could be written as 5.2':

\[(5.2') \quad \text{RER}(t) = F(0, X_{11}(t), X_{12}(t), X_2(t), X_3(t))\]

and equation 5.3 becomes 5.3':

\[9. \text{The first “if” in this sentence is not as innocent as it sounds, since it hides some deep Lucas-critique issues. These issues are treated here as they typically are in applied macroeconomics—acknowledged, then ignored. For further discussion, see Chapter 10 by Baffes, Elbadawi and O'Connell.}\]
Since the variables in $X_{11}$ adjust very rapidly compared to those in $X_{12}$, they will be relatively close to the equilibrium values defined implicitly by equation 5.4:

\[
(5.4') \quad 0 = G_1(0, X_{11}(t), X_{12}(t), X_2(t), X_3(t))
\]

that now replaces equation 5.4. Using this equation to solve for $X_{11}$ and substituting the result, together with the long-run equilibrium values of the policy and exogenous variables, into equation 5.2 produces the new expression for the long-run equilibrium real exchange rate, equation 5.5:

\[
(5.5') \quad \text{LRER} = F(0, X_{11}^*, X_{12}(t), X_2^*, X_3^*, X_4^*, X_5^*) = H(X_{12}(t), X_2^*, X_3^*)
\]

Notice that this means that the LRER is now conditioned on specific values of the remaining, slower-adjusting predetermined variables $X_{12}(t)$, in addition to the policy and exogenous variables $X_2^*$ and $X_3^*$. The slow-adjusting predetermined variables thus become part of the set of “long-run fundamentals.” Because these variables do change over time, the implication is that the LRER itself changes over time, but with sufficiently slow adjustment in the conditioning variables, the gradual evolution of the LRER would not be of policy significance.

**An Application**

While slow-adjusting predetermined variables thus do not pose major conceptual difficulties, in practice one such variable has proven quite problematic in constructing estimates of the LRER. Return to the Nurkse definition of the long-run equilibrium real exchange rate as the value of RER that is compatible with the simultaneous attainment of “sustainable” internal and external balance, and consider again the set of predetermined variables mentioned previously—the nominal wage, the stock of net international indebtedness, and sectoral capital stocks. At one extreme, it may be realistic to suppose that adjustments in the nominal wage are completed relatively quickly, say within a 3 to 5 year horizon. At the other extreme, however, capital stock adjustment is likely to be substantially slower, and should perhaps be measured in decades. From the perspective of exchange rate policy, the former time horizon is clearly relevant; the latter is not. As will be shown below, most observers have therefore operationally defined “sustainable” internal balance as requiring full...
employment (that is, the absence of cyclical factors), but not full capital stock adjustment. In this context, the “long run” would consist of a period of time sufficient for nominal wage adjustments to be completed, eliminating cyclical unemployment associated with Keynesian nominal wage stickiness—if any. Thus, “internal balance” has been interpreted as referring to goods-market equilibrium at full employment for a given value of the capital stock.

While full nominal wage adjustment has invariably been required in operational definitions of the LRER, and full capital stock adjustment has typically not, analysts have differed sharply on how to treat the third predetermined variable in the list: the stock of net international indebtedness. The problem is that this variable probably adjusts over time at a pace that is intermediate between that of the nominal wage and that of sectoral capital stocks.

How this variable is treated determines the interpretation that is given to the Nurksian concept of “sustainable external balance.” One option, assuming a policy-relevant speed of adjustment in the stock of net international indebtedness, is to treat the latter analogously with the nominal wage, thus requiring it to be in steady state in the operational definition of the long-run equilibrium. In this case, “external balance” requires the current account to be equal to the net capital inflow necessary to sustain the steady-state value of the economy’s net international creditor position.

This flow need not be zero, of course, if the country’s stock of net external liabilities would suffer inflationary erosion or would shrink relative to the size of the domestic economy in the absence of new borrowing or lending. At the other extreme, if the rate of adjustment of the stock of net international indebtedness is judged to be too slow for policy relevance, by analogy with the real capital stock the natural procedure is to condition the LRER on a predetermined value of the stock of net international indebtedness. In this case, once again the LRER would be moving over time as both types of state variables (the sectoral capital stocks and the stock of net international indebtedness) evolve, but again, this change may be sufficiently gradual as not to be of critical policy importance. In this case, the concept of “external balance” is much looser, since the equilibrium level of capital inflow will presumably be different for each value of the economy’s net international creditor position, and consequently will be changing over time.

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10. This approach is adopted in Montiel (1997) and in the analytical model in the next chapter.
12. We may want to preserve the term ultra—long run to encompass full adjustment of sectoral capital stocks as well.
There is a relatively clear distinction between these alternatives, and they fit quite neatly into the conceptual framework just described. However, among those who do not define the LRER as requiring that the stock of net international indebtedness reach a steady-state value, many analysts adopt a very different approach from either of these. Rather than condition the LRER on a predetermined value of the stock of net international indebtedness, they condition it instead on an exogenously determined sustainable value of net capital inflows only (a flow, rather than a stock concept). This “flow” procedure obviously requires a specification of how the sustainable flow of external capital is to be determined. It also requires some rather strong assumptions about the structure of the economy.

The first of these is the absence of feedback from the cumulated stock of net international indebtedness to the level of net capital inflows. Since an ongoing capital flow will imply an ever-changing stock of net international indebtedness, the sustainability of that flow requires in particular that the net capital inflow not be affected by the cumulated stock of net international indebtedness. If it were, of course, it could not be treated as an exogenous variable.

Moreover, the sustainable net capital inflow must also be exogenous with respect to the other “fundamentals.” Otherwise, the appropriate treatment for net capital inflows would be not as a separate “fundamental” but as yet another of the economy’s endogenous variables that is determined simultaneously with the short-run equilibrium real exchange rate.13

The first two conditions must hold for the level of net capital inflows to be treated as an exogenous variable. In order to also omit the cumulated stock of external debt as a state variable, one or both of the following conditions must hold: either the flow of new debt has imperceptible effects on the stock over the relevant horizon, so the latter can be treated as constant, or the net stock of debt must have weak effects on the economy’s short-run equilibrium real exchange rate through other macroeconomic mechanisms.14 If one of these conditions does not hold, the

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13. In this case, net capital inflows would be determined by a reduced-form equation similar to equation 5.1 and would not appear as a separate argument in equation 5.1.

14. Any predetermined macroeconomic variable that exerts at most very weak feedback effects on the economy’s short-run equilibrium effectively does not enter equation 5.2—meaning that it is not a component of $X$—and consequently would not affect the LRER. Thus, the LRER would be the same whether such a variable is in steady state or not, and there would indeed be no reason to impose a steady-state condition on such a variable in a definition of the LRER.
“long-run equilibrium” real exchange rate defined in this way could be changing continuously and appreciably.

In other words, the “flow” approach amounts to omitting the stock of net international indebtedness from the vector $X$, and treating net capital inflows as an exogenous variable. The conditions listed above may well come close to being met for small low-income countries that receive external financing almost exclusively in the form of official credits with a large grant element. For such countries the level of net capital inflows can be considered a policy variable or an exogenous variable. But these conditions are unlikely to apply for countries that borrow and lend extensively on market terms, even if some component of the capital account (for example, public sector borrowing) is policy determined.

Nonetheless, acknowledging that in other countries net capital inflows may contain a component that is exogenous—at least over the period of time that is relevant for exchange rate policy—does not mandate the use of the pure “flow” approach, since the analyst may be unwilling to assume in addition that the stock of net international indebtedness is not a component of $X$. In this case, the exogenous component of net capital inflows can be treated as a “fundamental,” and external balance can be interpreted as corresponding to equality between the current account and the exogenous component of net capital inflows, as in the “flow” approach described above. However, leaving the stock of net international indebtedness in $X$, would imply that the LRER in this case is determined for given values of the stock of net international indebtedness as well as of sectoral capital stocks. Thus, in practical terms, “long run” would mean in this context, as in the “stock” approach, that the nominal wage—but not the stock of net international indebtedness or sectoral capital stocks—has fully adjusted. Because this formulation shares with the “flow” approach the specification of an exogenous component of net capital inflows, and with the “stock” approach the treatment of the stock of net international indebtedness as a relevant predetermined variable, we can refer to it as a “hybrid” approach.

Operationally, then, the LRER can be conceptualized in alternative ways, depending on whether the “stock,” “flow,” or “hybrid” approach is adopted to treat the accumulation of net international indebtedness. In the “stock” approach, the LRER is the value of the short-run equilibrium real exchange rate that is conditioned on the steady-state values of all the predetermined variables other than sectoral capital stocks, as well as on given (not necessarily optimal) values of the policy variables, the exogenous variables, and the sectoral capital stocks. As implied by this discussion, the set of long-run fundamentals would include not just policy and exogenous values but also, for most policy applications, sectoral capital stocks. In the “flow” approach, the level of sustainable net capital inflows is added to the list of exogenous variables and the
stock of net international indebtedness is deleted from the set of predetermined variables. In this case, the set of long-run fundamentals includes the sustainable value of net capital inflows. In the “hybrid” approach, the exogenous component of net capital inflows is included among the exogenous variables, but the stock of net international indebtedness is retained in the set of predetermined variables. In this case, the long-run fundamentals include the exogenous component of net capital inflows.

The next issue is how the LRER can be estimated empirically. As indicated previously, academic research on this issue has proceeded along very different lines in industrial and developing countries. The key difference has concerned the specification of the LRER. In the industrial-country context, research has focused on fairly simple specifications, usually consisting of purchasing power parity (PPP) or a modification of PPP adjusted for differences in sectoral productivity growth (the Balassa-Samuelson effect, discussed below). Only very recently have potential demand-side fundamental determinants of the LRER begun to be accorded a role in academic research on the LRER for industrial countries. Research on developing countries, by contrast, while not typically focused specifically on the issue of identifying the determinants of the LRER, has nonetheless recognized for some time that factors such as the terms of trade, commercial policy, and capital flows could alter the value of the LRER. Because of these differences in perspective, these two strands of research are considered separately in the two sections that follow.

**Empirical Estimation: Industrial Countries**

Empirical research on the determination of the LRER in industrial countries has proceeded on two tracks. Academic researchers have focused on testing the validity of the PPP hypothesis and some simple variants using a single-equation methodology. The scope of this research has only recently expanded to encompass the potential role that changes in fundamentals may play in explaining LRER behavior that deviates from PPP. We can refer to this body of work as *reduced-form* estimation of the LRER, since tests of PPP essentially assess the validity of a particular method of estimating the LRER. Researchers at policy-oriented institutions, by contrast, have focused on structural approaches—including the use of estimated macroeconomic models—to calculate LRERs that respond to changes in a broad range of underlying fundamentals. The common analytical framework underpinning this work has been some variant of the Mundell-Fleming model. This section takes up each of these components of industrial-country research in turn.
**Single-Equation Reduced-Form Estimation of the LRER**

Reduced-form estimation of the LRER for industrial countries has typically focused on tests of PPP. The failure of PPP has motivated the search for “fundamentals” that could account for sustained deviations of the real exchange rate from the value predicted by PPP. The next two subsections describe these two strands of industrial country research.

**Tests of PPP**

It is clear that the actual RER has not been an immutable constant in any country, industrial or developing. What is at issue in measuring the LRER, therefore, is whether fluctuations in the actual RER represent transitory movements away from a well-defined LRER and if so, what determines the relevant value of the LRER. The PPP hypothesis offers one set of answers to these questions. The hypothesis can be expressed in the form of equation 5.8 for the nominal exchange rate:

\[ s = \alpha_0 + (p - p^*) + \varepsilon \]

where \( s \) is (the log of) the nominal exchange rate, measured as the domestic-currency price of foreign currency; \( p \) and \( p^* \) are (the logs of) the domestic and foreign price levels, respectively (including both traded and nontraded goods); \( \alpha_0 \) is a constant; and \( \varepsilon \) is a stationary random variable.\(^{15}\) In this formulation, the (log of the) RER is given by \( s + p^* - p \), and the (log of the) LRER is constant and equal to \( \alpha_0 \). Thus, movements in the actual real exchange rate are indeed viewed as consisting of transitory departures from a well-defined—and constant—value of the LRER.

Notice, in particular, that no “fundamentals” in the form of policy and exogenous variables appear to enter equation 5.8, as the conceptual discussion in the previous section suggests that they should. What has happened to them?

Observe first that equation 5.8 is a statement about the time-series properties of the RER. Specifically, since PPP requires that the deviations of the actual RER from a constant LRER be transitory (though possibly serially correlated), it implies that the RER must be a stationary time-series process. There are two ways to reconcile this with the conceptual framework described above. The first is that a broad set of fundamentals indeed affects the LRER, but all of these fundamentals are

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15. This is actually the weaker, relative form of the PPP hypothesis, which just requires that the unconditional mean of the real exchange rate \( sp^*/p \) be a constant. In the stronger, absolute form, the unconditional mean is required to be unity.
stationary (or mutually cointegrated) in a time-series sense during the sample period. If so, a reduced-form expression for the LRER would indeed contain these fundamentals, but that expression would not be inconsistent with equation 5.8. The means of the fundamentals can be interpreted as being subsumed into the constant term $\alpha_0$, and their random components into the error term $\epsilon$. If the exogenous and policy fundamentals are stationary in the conceptual framework described in the previous section, therefore, relative PPP should hold, and the real exchange rate should itself be a stationary variable. The other possibility is that some fundamentals are not stationary during the sample period, but the structure of the economy is such that any such nonstationary fundamentals do not affect the LRER. For example, suppose that among the set of potential fundamentals, the nonstationary ones are on the demand side of the economy, but that the structure of the economy makes the LRER supply-determined.16 In that case as well, the behavior of the RER would be consistent with equation 5.8.

Traditionally, this hypothesis was tested by running the regression stated by equation 5.9:

\begin{equation}
    s = \alpha_0 + \alpha_1 (p - p') + \epsilon
\end{equation}

and testing whether $\alpha_1 = 1$.17 The general finding tended to be that, while this hypothesis held up fairly well for high-inflation episodes, it could be rejected for more normal periods, and specifically for industrial countries during the post–Bretton Woods period.18

Recent developments in time-series econometrics, however, have made it clear that this methodology was inappropriate. Since $s, p^*$, and $p$ are all typically nonstationary, $\epsilon$ can only be stationary if $s, p^*$, and $p$ are cointegrated. If they are not, then equation 5.9 is a spurious regression, and if they are, tests of the null hypothesis $\alpha_1 = 1$ in equation 5.9 cannot be based on the standard $t$ distribution.

As a result, a new generation of empirical tests of PPP in industrial countries has emerged in recent years. One variant, which Froot and

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16. This would be true, for example, under a two-sector (traded-nontraded) setup in which the production function in each sector exhibits constant returns to scale, capital is internationally and intersectorally mobile, and labor is intersectorally but not internationally mobile. With symmetric productivity growth in both sectors both at home and abroad, an expression such as equation 5.8 would hold, even if potential demand-side fundamentals were nonstationary.

17. See, for example, Frenkel (1981) and Hakkio (1984). Note that the stronger “absolute” version of PPP implies the additional restriction that $\alpha_0 = 0$.

Rogoff (1994) label “stage two” tests to differentiate them from the simple ordinary least squares (OLS) procedure just described, focuses on detecting whether the real exchange rate \( s + p^* - p \) is stationary, as required under equation 5.8. By and large, these tests have been unable to reject the hypothesis of a unit root for relatively short sample periods (for example, the floating-rate period), but have been more successful in doing so for samples covering much longer spans of time—for example, a century of annual data; see Edison 1987, Kaminsky 1988, and Mark 1990. A second variant (denoted “stage three” tests by Froot and Rogoff (1994)), has instead focused on detecting cointegration among \( s, p^* \), and \( p \). Cointegration is necessary, but not sufficient, for equation 5.8 to hold. To see this, rewrite 5.8 to arrive at equation 5.10:

\[
(5.10) \quad s = \alpha_0 + \alpha_1 p + \alpha_2 p^* + \varepsilon .
\]

Cointegration implies simply that \( \varepsilon \) is stationary. For equation 5.10 to be equivalent to equation 5.8, we require as well the “symmetry” restriction that \( \alpha_1 = \alpha_2 \) and the “homogeneity” restriction that \( \alpha_1 = 1 \). Overall, the results of this work have been mixed. The null hypothesis of no cointegration can often be rejected when long spans of data are used, but even in such cases the estimated values of \( \alpha_1 \) and \( \alpha_2 \) are often far from the required values of 1 and –1. Breuer (1994) summarizes the results of this research as follows:

Cointegration between the exchange rate and domestic and foreign price series and stationarity of the real exchange rate are more likely to be confirmed for studies that met two of four conditions: When the span of data is long enough to capture a statistical equilibrium relationship, typically 70 or more years; when the trivariate specification that does not impose symmetry and proportionality is used; when bilateral exchange rate other than against the US dollar is used; and when the countries studied experienced rapid periods of inflation or deflation. (p. 268)

Of these conditions, the failure to reject PPP when the symmetry and homogeneity restrictions are not imposed, or when attention is restricted to high-inflation episodes, cannot be interpreted as providing strong support for the theory, since the symmetry and homogeneity restrictions are indispensable to it, and since the interpretation of PPP as a

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19. Recent surveys of this literature are provided by Breuer (1994), Froot and Rogoff (1994), and MacDonald (1995).
statement about long-run neutrality is not controversial. The most important qualification to a negative verdict on the empirical performance of PPP is the relatively greater success of the theory when long spans of data are used. This can be given two interpretations. One is that PPP holds in the ultra–long term but not over shorter horizons. Another is that the rejection of PPP in smaller samples may arise from the low power of the statistical tests employed. The second interpretation is of greater potential policy significance, of course, since in contrast to the first, it bears directly on the validity of PPP as an estimate of the LRER over policy-relevant horizons. However, even when adopting tests with greatly enhanced statistical power, only very weak additional support is provided for PPP among industrial countries in the post-Bretton Woods era (see Edison, Gagnon, and Melick 1994). Moreover, recent research suggests that the failure of cointegration tests to reject PPP over ultra-long-run horizons may itself be the result of problems with the statistical tests employed. Overall, then, the “new generation” tests of PPP have not been very favorable to the hypothesis in industrial-country applications.

**Testing the Role of “Fundamentals”**

Since the real exchange rate is an endogenous macroeconomic variable, one way to interpret the failure of the “new generation” PPP tests to find stationarity for the real exchange rate is to view it as driven by nonstationary fundamentals. Accordingly, recent extensions of PPP-oriented research on the determination of the LRER in the industrial-country context has begun to enrich the implied specification of the LRER for such countries by incorporating both supply- and demand-side fundamentals that may cause the LRER to deviate from PPP, thereby moving industrial-country research in this area in the direction of the type of analysis more often conducted in the context of developing countries.

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20. The fourth condition, that PPP tests are more successful for bilateral RERs that do not include the United States, is a puzzle that remains to be explained.
21. The latter interpretation is suggested as a possibility by Edison, Gagnon, and Melick (1994).
22. Williamson (1994) argues that even if PPP holds in the ultra–long term, that does not contradict the view that the equilibrium real exchange rate relevant for policy purposes can change over time.
23. Specifically, Engel (1996) shows that the “size” (probability of rejecting the null hypothesis when it is true) of the tests employed may have been understated substantially, implying too-frequent rejections of the null hypothesis of nonstationarity. In other words, the tests are overly favorable to ultra-long-run PPP.
The Balassa-Samuelson Effect. The methodology used in these recent extensions essentially involves single-equation estimation of equilibrium real exchange rates as a function of some set of fundamentals. This amounts to estimating a version of equation 5.8 in which the symmetry and homogeneity restrictions that the coefficient of \((p - p^*)\) is unity are imposed and that includes potential fundamentals as additional explanatory variables. Among such fundamentals, the factor that has received the most attention is the Balassa-Samuelson effect, a supply-side phenomenon that, while long known, has recently undergone a revival of interest. This hypothesis provides the leading supply-side explanation for the empirical regularity that, when measured in a common currency, the price level tends to be higher in a high-income country than in one with a lower level of income per capita. The specific mechanism that is relied upon to produce this effect is based on four assumptions:

a. Production in the traded- and nontraded-goods sectors is conducted under constant returns to scale, using capital and labor;

b. Higher per capita income reflects higher total factor productivity;

c. Productivity growth is faster in the traded-goods sector of the economy than in the nontraded-goods sector; and

d. Capital is highly mobile internationally and intersectorally. In particular, real interest parity holds.

As long as these conditions hold, the real exchange rate will be determined strictly by supply-side factors, and the key relevant variable is the rate of growth in total factor productivity. Countries with fast growth of total factor productivity in their traded-goods sector will tend to have higher nominal wages in their nontraded-goods sector, and thus their real wages will tend to rise, leading to an appreciation of their real exchange rate. In contrast, countries with slower growth of total factor productivity in their traded-goods sector will tend to have lower nominal wages in their nontraded-goods sector, and thus their real wages will tend to fall, leading to a depreciation of their real exchange rate.
productivity growth relative to their trading partners will experience a secularly appreciating LRER. Faruqee (1995a), for example, used this approach to explain the evolution of Japan’s postwar real effective exchange rate (REER) as largely the product of differentially rapid productivity growth in Japanese traded-goods production.

The Balassa-Samuelson effect has been well-documented for industrial countries. The typical pattern seen in the RER data for industrial countries experiencing rapid productivity growth is a strong appreciation in the internal RER, a substantial but more modest appreciation in the external RER, and stability or depreciation in the external RER for traded goods. Rogoff (1996) reviews the empirical evidence and concludes that “overall, there is substantial empirical support for the Balassa-Samuelson hypothesis, especially in comparisons between very poor and very rich countries, and in time-series data for a select number of countries, including especially Japan.”

He notes, however, that “whereas the relationship between incomes and prices is quite striking over the full data set, it is far less impressive when one looks either at the rich (industrialized) countries as a group, or at developing countries as a group.”

Canzoneri, Cumby, and Diba (1996) suggest a reason why the Balassa-Samuelson hypothesis may not explain very well some medium-term movements in external RERs between industrial countries. They argue that the effect depends upon two key elements—first, that the production technology implies that the relative price of nontraded goods in each country (its internal RER) should reflect the relative productivity in the traded- and nontraded-goods sectors, and second, that the law of one price holds for traded goods. Using data from a panel of OECD countries, they find that internal relative prices generally do reflect relative labor productivities. However, they find that the law of one price (as discussed in the chapter in this volume on the external RER) does not explain the variations in traded-goods prices very well, especially for the U.S. dollar, although their results are more favorable for the German mark. Hence, Canzoneri, Cumby, and Diba conclude that the problems with the Balassa-Samuelson hypothesis for external RERs lie in the failure of the law of one price for traded goods.

27. Rogoff (1996), p. 660. See Clark and others (1994) for an example for Japan. Bennett (1995) notes that because of relatively more rapid productivity growth in the traded than the nontraded sector, developing countries such as Hong Kong and Estonia experienced higher inflation than the industrial countries (the United States and Germany) to which they successfully pegged their exchange rates.


29. Gordon (1994) also makes this point.
Demand-Side Fundamentals. De Gregorio, Giovannini, and Wolf (1994) found, however, that while productivity growth in a sample of 14 OECD countries during 1970–85 was indeed faster in the traded-goods sector, and was indeed associated with an increase in the domestic relative price of nontraded goods (as predicted by the Balassa-Samuelson effect) in a sizable subset of the countries that they examined, the increase in the relative price of nontraded goods was associated with an increase in the relative size of the nontraded-goods sector. This caused them to speculate that demand-side factors may also have played a role in the determination of the RER for those countries. Baumol and Bowen (1966) had earlier hypothesized that if productivity in the goods-producing sector grows faster than in the service sector but demand for services is more income-elastic, the relative price of services would rise over time. Since services are concentrated in the nontradable sector, and the opposite is true for goods, such a “Baumol-Bowen effect” could cause a country’s internal RER to appreciate. If two countries have different preferences and weightings of services in their consumption baskets, then a Baumol-Bowen effect on demand could cause the external RER between them to change. This speculation was supported by De Gregorio, Giovannini, and Wolf, who estimated a static panel regression in which the RER was affected by, in addition to the supply-side productivity variables, the level of per capita income as well as by that of government spending. Increases in both of these variables were associated with RER appreciation. They interpreted the role of demand-side factors as reflecting the failure of real interest parity to hold among the countries they examined.

More recent research for industrial countries has tended to model the LRER as driven by both supply-side and demand-side fundamentals. For example, in subsequent work, De Gregorio and Wolf (1994) demonstrated formally that the failure of real interest parity can indeed create a role for demand-side factors. They showed, also for the same sample of 14 OECD countries, that the fundamental determinants of the LRER included sectoral productivity differentials, government spending, and the terms of trade. Inclusion of the latter rendered the level of per capita income insignificant. Similar results were derived by Feyzioglu (1997), who estimated the LRER for Finland using the terms of trade and the German long-term real interest rate as fundamentals, in addition to productivity differentials. MacDonald (1997) also combined supply- and demand-side factors to explain the real effective exchange rates of the United States, Germany, and Japan during the floating rate period. He

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30. The empirical technique used was seemingly unrelated regression (SUR) in first differences.
found that differential productivity growth, the terms of trade, fiscal policy, and the stock of net foreign assets all helped explain the LRER for these industrial countries. As we shall see below, specifications of this type represent a point of convergence with LRER estimates for developing countries.

Estimation of the LRER Based on Structural Models

The other strand of research on the LRER that has recently surfaced in the industrial-country context has been directly motivated by policy issues—in particular, policy coordination among the G-7 countries and European monetary unification. This work has taken as its point of departure the view that PPP provides a poor estimate of the “equilibrium” real exchange rate relevant for policy purposes, essentially because the equilibrium real exchange rate is perceived as influenced by a variety of fundamental real determinants, including several of those mentioned above. Estimates of the LRER in this literature have typically been derived from one of two alternative methodologies: a partial-equilibrium specification based on estimated trade equations, and a general-equilibrium one based on simulations from empirical macroeconomic models. The main methodological difference between these estimates and those reviewed above is that the empirical links between the LRER and its fundamental determinants are estimated from (partial- or general-equilibrium) structural econometric models, rather than from a single reduced-form equation for the real exchange rate. The partial-equilibrium approach and two variants of the general-equilibrium approach are reviewed below.31

The Partial-Equilibrium “Trade Equations” Approach

The partial-equilibrium approach has been the most frequently employed alternative to the use of PPP calculations in policy-oriented efforts to construct LRER estimates. This approach has the attraction that while it permits the calculation of the LRER to incorporate the potential influence of changes in fundamentals, it retains the virtues of simplicity, as well as of relying on a particular set of behavioral parameter estimates that are readily available for many countries. In the industrial-country context the partial-equilibrium approach is based on the standard Mundell-Fleming current account specification, as shown below in equation 5.11:

31. A detailed overview of the general-equilibrium approaches is available in Williamson (1994).
where $CA$ is the current account of the balance of payments, $RB$ is the resource balance function, $D$ is the country’s stock of net international indebtedness, and $r$ is the average interest rate that it pays on net external debt. The resource balance is taken to depend on the real exchange rate, on both domestic ($Y$) and foreign ($Y_F$) incomes, as well as potentially on other variables not specified above. The basic external input into the procedure is an exogenously determined target value of $CA$, determined from some estimate of “sustainable” net capital inflows. Given the target value of $CA$—which we will call $CA^*$—and an exogenous value of $r$, equation 5.11 can be used to determine a target value of $RB$ as a function of $D$, as shown by equation 5.11’:

$$\text{(5.11') } RB^* = CA^* - rD.$$

Let $Y^*$ and $Y_F^*$ denote the full-employment values of domestic and foreign incomes in the reference year for which the estimate of the LRER is being constructed. These values must be estimated independently. Then, given estimates of the elasticities of $RB$ with respect to the RER, as well as with respect to $Y$ and $Y_F$ (estimates of the function $RB( )$), the LRER can be calculated implicitly as equal to the value of RER that satisfies equation 5.12:

$$\text{(5.12) } RB^* = RB(\text{RER}, Y^*, Y_F^*).$$

This estimate of the LRER is consistent with internal balance in the form of full employment in both countries, as well as with external balance in the form of a current account balance equal to the value of “sustainable” net capital inflows. In general, the LRER estimate derived from this methodology will not be consistent with PPP. It will be changing over time and thus will be different when computed for different years. There are two reasons for this. First, different growth rates and income elasticities in the home and partner countries will cause the value of $RB$ associated with a given RER to change over time. And second, the sustained net capital inflow or outflow will cause $D$ to change, thus causing the required value of

32. If the LRER estimate is not for the current year, this estimate can be derived for any future year using estimates of how far the current values of $Y$ and $Y_F$ are from their full-employment levels, as well as of the rate of growth of potential real GDP for both countries.
RB* itself to change over time. In addition, changes in world interest rates, or in the assumed value of sustainable net capital inflows, will result in discrete changes in the estimated LRER. Notice also that the resulting estimate of the LRER may be either a positive or a normative construct. Whether it is one or the other depends on how the values of the “sustainable” net capital inflows are estimated. The estimate has a normative aspect to the extent that it emerges from some optimizing procedure determining desirable net capital inflows, but is positive if based on some exogenous projection of available net capital inflows.

Bayoumi and others (1994) used the trade equations methodology to assess the Smithsonian realignments of 1971. They estimated dynamic trade volume equations for each of the major industrial countries (the G-7), and from them they derived long-run price and income elasticities. They used independent estimates of the trend rate of growth of potential real GDP and of the real output gap existing at a given point in time, to estimate the change in domestic and trade-weighted foreign output required to achieve internal balance in the domestic economy and in its trading partners in 1971. They then calculated the “long-run” trade balance for that year from the fitted values of the trade volume equations (a procedure that eliminates any residual in that year, taken to be a temporary phenomenon), using the long-run elasticities as well as the relevant full-employment levels of output at home and abroad. The estimated LRER for 1971 was that which would have been required to eliminate the gap between the estimated “long-run” trade balance and an independent trade balance target for that year. Bayoumi and others arbitrarily set the trade balance target so as to achieve a current account surplus of 1 percent of GDP for each of the G-7 countries in 1971.

A version of the “trade elasticities” approach has also been adopted by the International Monetary Fund (IMF) in its surveillance function for industrial countries. The Fund’s methodology, which is dubbed the “macroeconomic balance” approach (see Isard and Faruqee 1998), differs from that described above with respect to the method used in the estimation of the sustainable level of net capital inflows. Rather than specify the volume of such flows in an ad hoc fashion, the Fund relies on the standard national income accounting identity, stated by equation 5.13:

\[
CA = S - I
\]

33. Notice that, since the feedback on the LRER of changes in the stock of net international indebtedness is taken into account, this is an example of the “hybrid” approach to external balance discussed earlier.
(where $S$ and $I$ denote national saving and gross domestic investment, respectively) to derive an estimate of sustainable capital inflows based on the medium-term determinants of saving and investment. The current account is taken, as in equation 5.11, to depend on the real exchange rate, as well as on domestic and foreign income levels. For full-employment values of domestic and foreign incomes, and given any other current account determinants, this function generates a locus with a positive slope in RER-CA space, as depicted in figure 5.1 below.34 The saving-investment balance is modeled as a function of the country’s level of per capita GDP, its dependency ratio, its fiscal position, the gap between actual and potential GDP, and the level of world real interest rates. The parameters of this function are estimated from an industrial-country panel data set. Normal values of the saving-investment balance are derived for each country by setting per capita GDP at the level that would prevail at full employment, setting the output gap to zero, and setting the fiscal deficit at its “structural” level. The world interest rate is determined endogenously as that level required to equate world saving to investment. Given these “normal” values of the explanatory variables, a “normal”—or medium-term—level of the saving-investment balance is calculated for each country. This balance provides in effect an estimate of sustainable capital inflows. Because the medium-term saving-investment balance is taken to be independent of the real exchange rate, the right-hand side of equation 5.13 generates a vertical locus in RER-CA space. The intersection of the two loci, at a point such as $B$ in figure 5.1, determines the LRER for each country.

An important property of the “macroeconomic balance” approach is its ability to model the effects of changes in a wide variety of fundamentals on the LRER. In particular, as distinct from the more traditional “trade equations” method with an ad hoc specification of sustainable capital inflows, this methodology can take account of changes in fundamentals—not only of the ones that drive the current account balance (such as productivity levels), but also of those that drive the sustainable level of capital inflows (in the form of the medium-term saving-investment balance). Such fundamentals include changes in the dependency ratio, structural fiscal balances, and world real interest rates. It is worth noting that the estimate of the LRER derived from the “macroeconomic balance” approach has no normative content. The LRER is driven by sustainable or “normal” values of the fundamentals, not necessarily by desirable ones.

Wren-Lewis and Driver (1998) recently applied the “trade equations” approach to generate LRER estimates for the G-7 countries for the years

34. The RER is expressed in domestic currency terms in figure 5.1 so that an upward movement in it represents a depreciation.
As in the cases of Bayoumi and others (1994) and Isard and Faruqee (1998), the procedure involved the estimation of dynamic trade balance equations and the calculation of “long-run” trade balances (fitted trade balances using long-run elasticities for the explanatory variables) at full employment for each of the two years in question, conditional on prevailing real exchange rates. An important difference from both Bayoumi and others and the IMF, however, was in the calculation of the trade balance targets to be reached by adjustments of real exchange rates to their long-run equilibrium values. The current account targets in Wren-Lewis and Driver (1998) for 1995 and 2000 were derived from an analysis of saving-investment balances by Williamson and Mahar (1998). As their point of departure for the estimation of sustainable current account balances, Williamson and Mahar use OECD projections in the case of industrial countries, and saving-investment balances for developing-country regions based on projections of changes in growth rates, dependency ratios, and public saving rates. Saving rates are based on estimated public and private saving functions that depend on these variables, and investment rate projections are derived from subjectively
adjusted incremental capital-output ratios (ICORs) applied to the projected growth rates. These estimates are compared with updated versions of subjective estimates—derived based on optimizing principles in Williamson (1994) (described further below)—of sustainable current account balances for these countries. The estimated current account balances were adopted as the appropriate projections for the Wren-Lewis and Driver LRER estimation unless they were greatly at variance with the updated Williamson projections, in which case the projections were adjusted subjectively on a country-by-country basis on the basis of past history and optimizing considerations.

As indicated above, this partial-equilibrium approach to the estimation of the LRER has a number of virtues that make it attractive to use. However, it also has a number of limitations. The most obvious ones are its reliance on an ad hoc trade balance specification and its partial-equilibrium nature, even in the context of the Mundell-Fleming model from which the specification is drawn. The simple current account specification in equation 5.11, while based on a model that has been a workhorse of open-economy macroeconomics, ignores a number of complications that have been incorporated in more recent models of current account determination based on intertemporal considerations.35 But even within the traditional Mundell-Fleming context, a number of general-equilibrium interactions that may be important in practice cannot be incorporated in a partial-equilibrium framework. Among these, as pointed out by Wren-Lewis and Driver (1998), there is no way to check the consistency between the exogenously estimated growth rates of potential output and the assumed sustainable net capital inflows; no feedback is allowed from the real exchange rate either to the levels of potential output or to the magnitude of the sustainable net capital inflows, and no allowance is made for potential effects on the LRER of alternative policies to move from actual to potential output.

Beyond these, there are empirical problems as well. Again as acknowledged by Wren-Lewis and Driver, estimated trade functions tend to involve large errors within the sample, and to be unstable out of sample. In general, trade elasticities tend to be estimated imprecisely, and real exchange rate elasticities do not tend to be large. Sampling errors in estimated trade elasticities imply large confidence intervals around LRER estimates based on such elasticities, as demonstrated by Kramer (1996). Small real exchange rate elasticities, however, make the point estimates for the LRER highly sensitive to the exogenously derived sustainable net capital inflow assumption. The upshot is that, while estimates of the

35. See, for example, Obstfeld and Rogoff (1996).
LRER derived using the “trade equations” approach may provide useful benchmarks, the range of uncertainty around them should probably be considered to be relatively large.

Approaches Based on General-Equilibrium Models

Some of the problems associated with the trade-elasticities approach can be handled by moving to an explicitly general-equilibrium framework. Both possible feedbacks from the RER to its determinants, as well as hysteresis effects operating through the stock of net international indebtedness, can be captured in this way. This section describes three applications of the general-equilibrium framework: Williamson’s fundamental equilibrium real exchange rate (FEER), the IMF’s desired equilibrium exchange rate (DEER), and the natural equilibrium real exchange rate (NATREX) of Stein and his associates.

**FEER and DEER.** Williamson’s fundamental equilibrium real exchange rate (FEER) concept (described in Williamson 1994) is representative of the general-equilibrium alternatives to the partial-equilibrium trade-elasticities approach. Williamson’s definition of the FEER involves the simultaneous attainment of external and internal balance, as in the simpler approach just described. In addition to using general-equilibrium structural models to simulate the LRER, however, he also explicitly adopts a normative perspective. Williamson gets around the general intractability of the optimization problem involved in finding the social welfare-maximizing LRER by restricting its scope, focusing only on the domestic rate of inflation and the steady-state value of the current account. In other words, for Williamson, the concept of internal balance has a normative element, in that it is interpreted as requiring not only full employment, but also noninflationary full employment. Similarly, external balance involves not just a current account deficit that is sustainable, but one that is desirable. He chooses the optimal value of the current account to GDP ratio for each country on the basis of past “normal” experience and a subjective judgment about the country’s investment needs and its optimal saving rate. The former is derived from a framework that suggests that a country’s desirable rate of investment is inversely related to the magnitude of its capital stock relative to the availability of complementary factors of production, and directly related to the rate of growth of the labor force, based on the standard intertemporal current account model. The latter is derived from demographic factors implied by the life-cycle saving hypothesis.36

36. See also the appendix by Williamson and Mahar in Wren-Lewis and Driver (1998).
Thus, the first step in the calculation of the FEER is making normative empirical judgments about the desirable rate of inflation and the desirable ratio of the current account to GDP. With these in hand, Williamson then derives the FEER by simulating a large macroeconometric model for the country concerned under the constraint that the path followed by the economy from its actual initial conditions must approach, within some specified period of time, a configuration with three characteristics. Those are (a) the level of output must be at its natural level; (b) the rate of inflation must have reached its previously identified low sustainable level; and (c) the external balance target must be reached. The endogenously determined RER generated by that simulation is the FEER.

Calculations of long-run equilibrium real exchange rates using general-equilibrium models have also been performed for industrial countries by the IMF’s Research Department. These calculations have relied on simulations of the IMF’s MULTIMOD econometric model, and the resulting estimate of the LRER for each country is referred to by the authors as that country’s desired equilibrium exchange rate (DEER), to emphasize its normative content (see Bayoumi and others (1994), as well as Clark and others (1994)). The general-equilibrium procedure employed by the Fund to calculate DEERs is quite similar to that used by Williamson to compute FEERs. The particular exercise reported in Bayoumi and others (1994) brings out some important aspects of the simulation approach.

First, the results illustrate the fact that the general-equilibrium simulation approach cannot eliminate the uncertainty concerning the LRER associated with the simpler “trade equations” approach. Not only do the simulated models often tend to make use of the same elasticity parameters employed in the resource-balance approach, but in broadening the set of endogenous variables, they are forced to model many other aspects of economic behavior as well. While this is a virtue in the sense that the scope of economic interactions taken into account in the calculation of the LRER is greatly increased, it requires the estimation of a large number of additional behavioral parameters, to which the resulting estimates of the long-run equilibrium real exchange rate will be sensitive. Sensitivity analysis conducted by Bayoumi and others indeed suggests that plausible changes in the values of the underlying parameters can have large effects on the values of the estimated DEERs.

Second, as mentioned above, industrial-country model simulations tend to rely on models that essentially reflect a Mundell-Fleming analytical framework. Thus, they are in effect also based on equation 5.11. However, they have some important analytical advantages over the partial-equilibrium approach. Specifically, the use of the simulation model endogenizes both the full-employment values of $Y$ and $Y_f$, as well as
that of D. This means that general-equilibrium feedback effects caused by RER changes to all three variables—as well as separate effects on each of those variables of the particular set of policies adopted to move to full employment within some specified period of time—are taken into account in the resulting estimate of the LRER. This raises two sets of issues.

The first concerns the uniqueness of the FEER (or DEER). Presumably, any well-behaved macroeconometric model would eventually reach a steady state featuring full employment. To do so by a stipulated earlier date and with a stipulated current account balance, however, requires policy action. This raises the possibility that if the number of macroeconomic targets is small—as it is in the case of FEER and DEER calculations—relative to the set of effective instruments available to achieve them, then alternative combinations of policies that can achieve the targets when required may exist. These alternative ways of achieving the targets may have different implications for other endogenous macroeconomic variables, including the equilibrium real exchange rate. Simulations by Bayoumi and others employing alternative methods for achieving the internal and external balance targets confirmed that these methods matter for other macroeconomic variables as well as for the estimate of the DEER—as is to be expected. This problem arises from the attempt to restrict the dimensions of the optimization exercise, in the effort to make it tractable. To the extent that the other macroeconomic variables affected have social welfare implications, ranking these welfare consequences would allow the unique welfare-maximizing DEER to be identified. But constructing such a ranking obviously involves increasing the scope of the optimization problem.

The second set of issues has to do with the empirical magnitude of these feedback effects. Because the general-equilibrium approach is obviously more costly to implement than the trade-equations approach, an important question is how much empirical difference the analytical advantages of the general-equilibrium approach make. Bayoumi and others find that, given the internal and external balance targets, the trade-equations and general-equilibrium approaches often give similar values for the DEER, suggesting that feedback effects from the RER itself, as well as from the policy instruments that can be used to attain internal and external balance, on the proximate determinants of the LRER can be rather weak—at least in the particular model used for simulation.

In short, general equilibrium feedbacks matter both for the estimated value of the DEER itself and for the macroeconomic outcomes that accompany it, but they do not always matter enough—at least in the context of the MULTIMOD model and for the countries studied by Bayoumi and others—so as to generate LRER estimates that differ greatly from
those derived using partial-equilibrium methods. The upshot is that, while adopting a structural general-equilibrium method can ensure that potentially important interactions have not been neglected in the estimation of the LRER, ex post the gain from employing full general-equilibrium simulation methods may not always turn out to be worth the cost.

Before leaving this section, it may be worth calling attention to the particular algorithm used to solve for the LRER in the normative model simulations discussed above, in light of the discussion in the chapter’s first section. Empirical macroeconometric models typically converge to steady-state values over extremely long periods of time. Yet the simulations employed in calculating the FEER and DEER are required to hit their targets within a small number of years, and sustain them thereafter. This has the potentially important implication that, if the model’s dynamics continue to play out after the particular targets spelled out in the calculation of the LRER have been reached—that is, if the model is not in a steady-state configuration when the targets are reached—sustaining the targets may require that policy variables continue to change after the target date. This means that to evaluate the desirability of the outcome, it would be necessary to look beyond the date when internal and external balances are reached. An alternative procedure would be to specify steady-state outcomes—rather than outcomes that emerge within a shorter period of time—as targets of policy and to define the FEER or DEER as the real exchange rate that emerges in the model’s steady-state solution. If the model’s dynamics are such that the steady state is reached too slowly to be of policy relevance, then the LRER can be defined as a dynamic concept—in other words, as the path followed by the RER on the way to a desirable steady state. In the terminology of the previous section, the LRER can be conditioned on non-steady state values of the slow-adjusting predetermined variables.37

The NATREX. Some of the difficulties in applying the FEER-DEER methodology are associated not with the use of structural general-equilibrium model simulations per se, but rather with the normative interpretation of the LRER and the particular solution algorithm adopted. An alternative approach adopted by Stein, Allen, and Associates (1995) defines the LRER in a positive rather than normative fashion and derives the simulation horizon endogenously. In addition, it bases estimation on a small medium-term model, rather than large, fully dynamic structural models. Stein (1994) and Allen (1995) define the “natural equilibrium real exchange rate,” or NATREX, as the exchange rate that would

37. This is essentially what is done conceptually in the NATREX approach.
simultaneously be consistent with the domestic unemployment rate being equal to its natural rate and with the balance of payments being in equilibrium (that is, involving no reserve movements), exclusive of speculative and cyclical factors. In other words, it is the real exchange rate that is consistent with internal balance and a particular concept of external balance—one that sets the current account equal to actual long-term capital flows, defined as flows not motivated by cyclical and speculative factors.

The basic equations underlying the NATREX for a small open economy with high capital mobility are the following (5.14 through 5.16):\(^{38}\)

\[
\begin{align*}
\frac{dK}{dt} &= I - nK \\
\frac{dD}{dt} &= RB + (r - n)D
\end{align*}
\]

where \(K, K_f,\) and \(D\) are respectively the stocks of domestic and foreign physical capital per effective worker and the domestic economy’s net external debt, \(RB\) is the resource balance function, \(r\) is the world real interest rate, \(n\) is the rate of growth of effective labor, and \(Z\) is a vector of exogenous shocks. Signs below the variables in the behavioral relationships in equation 5.14 denote partial derivatives. The model is specified at full employment, so the functions \(I()\) and \(S()\) determine the levels of domestic investment and national saving that are forthcoming at full employment. The excess of investment over saving determines the long-term capital inflow, which is a function of the predetermined variables \(K\) and \(D\) as well as the exogenous variables \(r\) and \(Z\). \(RB\) is the full-employment resource deficit, so the right-hand side of equation 5.14 is the full-employment current account deficit. Equation 5.14 is thus the “external balance” condition, and the value of \(RER\) that satisfies it is the medium-term NATREX. It is medium term in the sense that it is conditioned on \(K\) and \(D\), which change over time according to equations 5.15 and 5.16.\(^{39}\)

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38. Alternative versions of the model, incorporating a “large country” financial assumption as well as the assumption of imperfect capital mobility for a small country, can be found in Stein, Allen, and Associates (1995).

39. Notice that, in the terms discussed in the first section of the chapter, adjustments in nominal wages are assumed to occur sufficiently rapidly to be of policy relevance, while the stock of net international indebtedness and the capital stock are grouped together as slow-adjusting predetermined variables.
Stein and his colleagues thus distinguish between a “medium-run” NATREX—one conditioned on predetermined values of both the stock of net international indebtedness and the capital stock—and a “long-run” NATREX, which holds when the capital stock and stock of net international indebtedness have settled at steady-state values—that is, when \( \frac{dK}{dt} = \frac{dD}{dt} = 0 \). The “long-run” NATREX obtained for steady-state values of the stock of net international indebtedness and the capital stock is viewed as ultimately determined by the set of exogenous fundamentals \( Z \). The variables that make up \( Z \) may be country-specific. However, Stein and his colleagues assign pride of place among potential fundamentals in \( Z \) to domestic and foreign productivity and “social thrift” (essentially referring to the rate of time preference), which act in the model as shocks to the investment and saving functions. They note that for small countries the terms of trade and the world real interest rate would be exogenous, and thus would also be included among the fundamentals, though not for a large country like the United States.

To illustrate how the model works, consider the effects of a permanent negative shock to national thrift—that is, to the saving function. In the medium term, both \( K \) and \( D \) are given, so from the left-hand side of equation 5.14, the reduction in \( S \) is associated with a long-term capital inflow to finance an increase in consumption. The capital inflow must be associated with an increase in the current account deficit according to equation 5.14, so the RER must appreciate (fall). Thus, a permanent reduction in national thrift causes an appreciation in the medium-term NATREX. Since the investment function is not affected by this shock, the real capital stock does not change over any time horizon. The accumulation of external borrowing, however, increases \( D \) over time, and as a result of the associated reduction in national wealth \( K - D \), saving will rise. In the long run, the increase in saving must be such as to restore \( \frac{dD}{dt} = 0 \) in equation 5.16. This means that \( D \) must be permanently higher in the long run. To finance the associated larger external interest payments, the long-run resource deficit must fall (or the surplus must rise). This requires a long-run depreciation of the NATREX.

To test the model, Stein (1994) examined its ability to account for short-run movements in the real effective exchange rate of the United States. He decomposed the change in the short-run equilibrium RER over time into two parts: the adjustment in the short-run RER to the medium-term NATREX (which is not described in the medium-term model above), and the evolution of the medium-term NATREX to its long-run value. The model above suggests that, for given values of the fundamentals in \( Z \), the latter is driven by changes in the predetermined variables \( K, K_f, \) and \( D \). Stein relies on a real interest parity argument to conclude that the adjustment of the short-run RER to the medium-term NATREX can...
be proxied by the long-term real interest rate differential. Thus, he estimated a dynamic equation for the U.S. real effective exchange rate of the form shown in equation 5.17:

\[
(5.17) \quad RER = f[RER(-1), r - r_F, \Delta K, \Delta K_F, \Delta D]
\]

where \( r \) and \( r_F \) are respectively the U.S. and foreign long-term real interest rates, and the symbol \( \Delta \) denotes a change in a variable. Other variables are defined as before. The specification in equation 5.17 proved quite successful in tracking the recent evolution of the U.S. real effective exchange rate.

Equation 5.17 essentially models the implications of the NATREX model for the short-run equilibrium RER. To model empirically the medium-term NATREX itself, Stein took as his point of departure the regression shown in equation 5.18:

\[
(5.18) \quad RER = f[RER(-1), Z(-1), \Delta Z]
\]

where \( Z \) is the vector of fundamentals introduced previously. In practice, however, Stein used the long-term real interest differential as a proxy for changes in the fundamentals in the estimation of equation 5.18. The estimated equation thus took the form shown in equation 5.18':

\[
(5.18') \quad RER = f[RER(-1), Z(-1), r - r_F].
\]

Dynamic simulations based on this regression tracked the actual evolution of the RER for the United States quite well during 1976–89, in particular tracking the “long swings” in the U.S. dollar’s real value during the decade of the 1980s fairly closely.

Unfortunately, the interpretations both of equation 5.18' and of the simulations based on it are problematic. The basic issue is that it is unclear whether the use of the real interest gap \( r - r_F \) as a proxy for \( \Delta Z \) in

40. The logic of the model implies that the relevant maturity should correspond to the time required for cyclical deviations from full employment to dissipate.

41. Since what is observed is the actual RER, while what is modeled in equation 5.15 is the evolution of the short-run equilibrium RER, the residuals of this regression presumably include the deviations of the actual RER from its short-run equilibrium value discussed in the first section of this chapter.

42. Notice that whether equation 5.15 accurately captures the dynamics of the short-run equilibrium RER depends on the validity of long-run real interest parity. If it does not hold, then the real interest gap will be a poor proxy for the gap between the short-run RER and the medium-term NATREX.
effect introduces short-run (for example, cyclical) factors as explanatory variables. Indeed, the rationale for the inclusion of the real interest differential in equation 5.17 was precisely to capture the dynamics of adjustment of the RER to the medium-term NATREX. The inclusion of cyclical factors in equation 5.18' would mean that simulations based on its fitted values would simply be tracking the short-run equilibrium real exchange rate, as in equation 5.17, rather than generating estimates of either the medium-term or long-run NATREX.43

Nonetheless, the key point is that there is very little difference between equation 5.18, derived from a structural general-equilibrium model, and the reduced-form estimation with fundamentals to which the research on PPP has led. Equation 5.18 amounts to an error-correction representation for the real exchange rate, linking it to its long-run fundamentals. This representation thus dovetails quite nicely with the single-equation cointegration estimates described at the end of the previous section (as represented, for example, by MacDonald 1997). If estimated directly, the “long-run” NATREX could be derived from fitted values of equation 5.18 by setting $RER = RER(-1)$, $DZ = 0$, and $Z(-1)$ equal to the “permanent” values of the long-run fundamentals. The difference in empirical implementation between the NATREX and the reduced-form approaches is precisely whether equation 5.18 is estimated directly. The reduced-form cointegration approach does so (for example, in the form of an error-correction equation), while Stein used equation 5.18′ instead, replacing changes in the fundamentals with real interest differentials. The difference, therefore, amounts to different choices made with respect to the empirical modeling of short- and medium-run dynamics and does not concern the conceptual basis for the LRER and its determinants. Thus, following rather different routes, the two strands of industrial-country research have reached rather similar views about the role of the LRER in real exchange rate dynamics, as well as about the influence of real fundamentals on the LRER.

Empirical Estimation: Developing Countries

The active management of nominal exchange rates in the vast majority of developing countries and the consequent need to estimate the magnitude of possible misalignment—together with the frequent and occasionally large exogenous and policy shocks to which these economies

43. Black (1994) has made the same point about the use by Stein, Allen, and Associates (1995) of the “social consumption ratio” as a proxy for the rate of time preference, finding the former to be a cyclical variable.
have been subjected—have given the issue of estimating equilibrium real exchange rates a relatively greater urgency in the developing-country context than in the industrial-country context. While the PPP approach has often been used to estimate the equilibrium real exchange rate in practical policy applications, research on the determination of the LRER for developing countries has long acknowledged the potential role of real fundamentals. This research has often featured single-equation estimates such as those described in the previous section for industrial countries. A key difference, however, is that the developing-country variants have incorporated a richer menu of potential fundamentals for some time, reflecting the longer tradition, which was just mentioned, of recognizing the role of real variables in causing deviations from PPP.44 I will discuss two variants of this single-equation approach: a traditional reduced-form version and a more recent version based on the estimation of a cointegrating equation linking the real exchange rate to its fundamental determinants. I will not consider practical applications, because the two techniques in most frequent use—PPP and the “trade equations” approach—have already been described in the industrial-country context and are discussed at length in the developing-country context in the chapter in Part III on operational approaches for estimating the LRER empirically.45 Instead, I will focus on academic research on the LRER for developing countries.

Traditional Reduced-Form Studies

Both the traditional and cointegration approaches involve the estimation of a single reduced-form equation linking the real exchange rate to a set of fundamentals. The key difference between the two approaches concerns econometric methodology. Two applications of the traditional approach are described in this section, before turning to the cointegration approach in the section that follows.

Edwards (1989 and 1994). Perhaps the best known of the traditional single-equation reduced-form studies are those of Edwards (1989 and 1994). Edwards (1994) used panel data for 12 developing countries over the period 1962–84 to estimate a regression in which the actual real exchange rate was the dependent variable and the set of independent variables included both potential fundamentals—such as the rate of growth

44. A classic early reference is Diaz-Alejandro (1980).
45. A variant of the “trade equations” approach developed specifically for developing-country application by Devarajan, Lewis, and Robinson (1993) merits separate mention, but I do not take it up here because it is also covered in detail in Part III.
of total factor productivity, the terms of trade, the share of government consumption in GDP, a measure of the openness of the trade regime, and a measure of the severity of capital controls—and other variables interpreted as not affecting the LRER, but potentially causing the RER to deviate from the LRER. These primarily included proxies for temporary aggregate demand shocks and the change in the nominal exchange rate. Finally, the equation also included a lagged dependent variable to capture the dynamics of adjustment of the RER to the LRER. With the exception of the productivity variable, the estimation generally confirmed analytical results concerning the direction in which the included fundamentals affect the LRER. Transitory aggregate demand shocks in an expansionary direction tended to appreciate the LRER, while nominal depreciation proved capable of influencing the RER in the short run. Finally, the speed of adjustment of the LRER was found to be rather slow.

Edwards (1994) used his estimated regression to calculate estimates of the LRER. By setting the values of the transitory aggregate demand variables and of nominal exchange rate changes equal to zero, and setting the current and lagged RERs equal to each other, he solved for the coefficients of the fundamentals (essentially estimating the parameters of the function \(H(\) in equation 5.6). He then used five-year moving averages to estimate the permanent values of the fundamentals \(X_2^*\) and \(X_3^*\) in equation 5.6) and, calculating the fitted values with coefficients and explanatory variables derived in this manner, produced estimated time series for the LRER for several of the countries in his sample. The central characteristic of these estimates is that, unlike PPP-based estimates or estimates that expand on PPP by including only smoothly trending fundamentals such as total factor productivity, these time series exhibited substantial variation over time, reflecting the effects of changes in real fundamentals on the LRER. It is precisely such temporal variation in the underlying value of the LRER that makes estimation of the LRER imperative to detect potential real exchange rate misalignment.46

Razin and Collins (1997). Similar in spirit to the work of Edwards, more recently Razin and Collins (1997) estimated reduced-form real exchange rate functions for a large country panel, including explanatory variables meant to capture both “fundamentals” that would affect the LRER (defined in their case as the flexprice solution of a Mundell-Fleming model with binding capital controls) and variables interpreted as driving the short-run equilibrium RER away from the LRER. The fundamental determinants of the LRER included familiar variables such as the terms of trade and the value of net long-term capital inflows as well as less familiar ones such as a proxy for the exogenous component of the trade

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46. For a recent application of Edwards’ model, see Mongardini (1998).
balance and the excess of money growth over GDP growth. As in Edwards, favorable terms of trade movements and increases in net long-term capital inflows were associated with an appreciation of the LRER. Transitory factors driving the RER away from the LRER were modeled as deviations of output and domestic absorption from estimated ARMA (1,1) processes. The LRER was estimated for each country as the fitted value of the panel regression with the transitory variables set equal to zero. Razin and Collins then went on to show that misalignment—measured as the difference between the RER and the estimated LRER—has a nonlinear relationship with long-run growth in a cross-country regression that controls for other growth determinants. Large average overvaluation of the domestic currency during the sample period is negatively associated with growth over the period, while undervaluation that is not excessively high has a positive relationship with growth.

Estimates Based on Cointegrating Equations

In recent years, researchers working in the context of developing countries have also begun to apply unit-root econometrics to the problem of estimating equilibrium real exchange rate for such countries, akin to the “stage three” research on PPP identified by Froot and Rogoff (1994) in industrial-country applications. In keeping with the flavor of developing-country research in this area, however, economists conducting “stage three” research for developing countries have not limited their attention to detecting the presence of cointegration among nominal exchange rates and national price levels—in other words, to testing PPP. Instead, they have sought to explain the failure of PPP to explain the behavior of long-run exchange rates in these countries by attempting to detect cointegration among real exchange rates and a variety of underlying “fundamentals” drawn from determinants of the LRER identified in earlier literature. To illustrate this approach, I will briefly describe a series of papers by Elbadawi (1994) and Elbadawi and Soto (1994 and 1995), as well as recent applications by Cardenas (1997) and by Loayza and Lopez (1997).

Elbadawi (1994) developed a model of the long-run equilibrium real exchange rate in which the “fundamentals” included the terms of trade, a measure of openness (as a proxy for commercial policy), the level of net capital inflows relative to GDP, the share of government spending in GDP, and the rate of growth of exports. His empirical estimation was based on annual data spanning the period 1967–90 for Chile and Ghana, and 1967–88 for India. He found that, in all three countries, the real exchange rate and all of the fundamentals identified in the model were nonstationary and cointegrated. The qualitative signs of the coefficients in the cointegrating regressions were in accord with those predicted by
the theoretical model. Elbadawi used time-series techniques to estimate the permanent components of the fundamentals in each of the countries, and substituted these permanent values into the cointegrating equations to derive estimates of the long-run equilibrium real exchange rate over the sample in each of the countries. The differences between these estimated long-run equilibrium rates and the actual real exchange rates then were taken to represent estimates of misalignment. He found that such estimates fit the episodic descriptions of macroeconomic developments in these countries over the sample periods extremely well.

In the previous application, the actual level of net capital inflows was taken as a “fundamental.” Two extensions of Elbadawi’s original specification by Elbadawi and Soto (1994 and 1995) modified this assumption by distinguishing between long-term and short-term inflows. Elbadawi and Soto (1994) explored the Chilean case further, using annual data from 1960–90 and focusing specifically on the role of capital inflows. Separating the ratio of net inflows to GDP into long-term (portfolio and foreign direct investment (FDI)) and short-term flows, they found that the latter was stationary and consequently omitted it from the cointegrating equation, implicitly adopting an “external balance” criterion that interprets sustainable net capital inflows as long-term portfolio flows plus FDI. Using a specification otherwise similar to that of Elbadawi (1994), they found that an increase in long-term inflows tended to appreciate the LRER, and that the magnitude of the effect was large compared to that of government spending, implying that sustaining a depreciated equilibrium real exchange rate in the face of a large increase in long-term capital inflows through fiscal measures would have required very large reductions in government spending in Chile. Elbadawi and Soto also estimated a dynamic error-correction equation for the adjustment of the RER to the LRER, and found that episodes of short-term capital inflows tended to be associated with an appreciation of the RER relative to the LRER. Elbadawi and Soto (1995) extended this work to a larger sample of countries including—in addition to Chile—Côte d’Ivoire, Ghana, India, Kenya, Mali, and Mexico. In this exercise, the distinction between long-term (FDI and long-term net lending) and short-term capital inflows was retained, and the external nominal interest rate (corrected for a measure of country risk) was introduced as an additional fundamental. As in the previous work on Chile, long-term inflows played an important role in the cointegrating regression, with effects operating in the predicted direction.47 The external interest rate also figured promi-

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47. Interestingly, short-term inflows proved to be nonstationary in Mexico, where their large magnitude has been accorded an important role in the 1994 peso crisis.
nently and consistently in the cointegrating equations; an increase in the foreign interest rate was associated with a depreciation of the LRER. The effect of commercial openness was also consistent across countries; increased openness resulted in LRER depreciation in every case. Among the other fundamentals, the effects of the terms of trade, as well as of the size and composition of government expenditures, tended to vary across countries. However, the results previously obtained for Chile were duplicated in the broader sample: the magnitude of the coefficients on fiscal variables in the cointegrating equation suggested that offsetting the effects on the LRER of changes in sustained capital inflows through fiscal means would require very large changes in the fiscal variables. As in Elbadawi’s earlier work, as well as in the previous study on Chile, estimates of misalignment derived from the cointegrating equation using “permanent” values of the fundamentals again accorded well with episodic experience in the countries concerned. In particular, an overvaluation of 18 percent was estimated for Mexico in 1994.

Other authors have applied this methodology using a more restricted set of fundamentals. Cardenas (1997), for example, estimated Colombia’s LRER using quarterly data from the first quarter of 1980 to the third quarter of 1993. He considered fundamentals consisting of average labor as well as total factor productivity in the traded- and nontraded-goods sectors (to capture Balassa-Samuelson effects), the terms of trade, and government spending as a share of GDP disaggregated into various components. The Balassa-Samuelson hypothesis met with mixed success. An increase in total factor productivity (TFP) in the nontraded-goods sector was associated with real depreciation, as expected, but so was an increase in TFP in the traded-goods sector. Improvements in the terms of trade, as well as all components of government spending, resulted in appreciation of the LRER. Somewhat surprisingly, Cardenas found that the coefficients of the cointegrating equation—specifically those of the government expenditure variables—were altered by a change in the nominal exchange regime in Colombia in 1990, from a crawling peg to an exchange rate band. He acknowledges, though, that the instability may be reflecting omitted variables, perhaps associated with changes in the external financial environment that resulted in large capital inflows into Colombia beginning at the same time.

More recently, and somewhat closer in spirit to the industrial-country research in this area, Loayza and Lopez (1997) sought to measure the long-run equilibrium real exchange rate for seven Latin American countries by estimating cointegrating equations among the real exchange rate, the stock of net international indebtedness, and a Balassa-Samuelson relative sectoral productivity variable, using a sample of annual data from 1960 to 1995. For six of their seven countries, they found evidence
that all three variables were nonstationary, and that a single cointegrating vector existed among them, contrary to PPP. Improvements in both the country’s net international creditor position and in the relative productivity of its traded-goods sector relative to that of the nontraded-goods sector tended to appreciate the equilibrium real exchange rate. With a specification of “fundamentals” quite different from that of Elbadawi and Soto (1995), Loayza and Lopez estimated that the Mexican peso had become overvalued by 27 percent by 1994.

These cointegration-based estimates of the LRER for developing countries appear promising in at least two respects. First, despite the short samples (adversely affecting the power of the statistical tests involved), questionable data, and likely structural instabilities in these applications, cointegrating relationships are often found between RERs and a broad class of fundamentals suggested by theory. Moreover, estimates of the impacts of fundamentals on the LRER generally prove to be consistent with theoretical priors. Second, estimated LRERs are often capable of reproducing historical episodes of overvaluation as judged by other means. This type of confirmation supports the reliability of approaches to the estimation of the LRER based on unit-root econometrics. However, the application of this methodology is in its infancy, and it is not difficult to identify prospective problems in its implementation, despite the persuasive results of the studies listed above. Among potential pitfalls in their widespread application are the short span of data typically available for developing countries (especially for small low-income countries), the poor quality of some of the proxies that have to be employed for the relevant fundamentals, and the imperfect techniques currently available for estimating the “permanent” values of such fundamentals—which is a key step in the calculation of the LRER.

Summary

The intriguing observation that emerges from this overview is that, starting from very different positions, research on the empirical measurement of equilibrium real exchange rates in industrial and developing countries has tended to converge in methodology during recent years. Industrial-country research has tended to bifurcate into an academic branch primarily preoccupied with testing PPP, and a policy-oriented branch primarily focused on the evaluation of exchange-rate movements among G-7 countries as well as on the adequacy of exchange rate arrangements within the European Union. The failure of the PPP-implied restrictions to hold has led academic researchers to gradually expand the set of real “fundamentals” that may explain sustained deviations from PPP. The research has moved beyond Balassa-Samuelson produc-
tivity effects operating on the supply side of the economy, to encompass variables such as the terms of trade and government consumption, which may affect the LRER through both the demand and supply side or even strictly through the demand side of the economy. Policy-oriented researchers explicitly adopted Nurkse’s definition of the LRER and have tended to implement it in two forms: through the traditional “trade equations” methodology and through the use of model simulations. One set of analysts working in this tradition (Williamson and the IMF’s Research Department) has given the LRER an explicitly normative definition and has opted to simulate large existing models to measure the LRER, while others (Stein, Allen, and Associates) have specified the LRER in positive form and based estimation on a generic class of custom-built small models of much more limited scope. The implied reduced-form solutions for the LRER in these models essentially amount to cointegrating relationships linking the real exchange rate to a small set of real fundamentals, in effect quite similar to those that the PPP-based industrial-country research has begin to consider. The set of fundamentals emphasized in the reduced-form solutions of NATREX models for small countries—productivity, thrift, the terms of trade, and the external real interest rate—also have much in common with those that have long been considered in the developing-country literature, the key omissions from the list being commercial policy, fiscal variables, and capital flows. The work of De Gregorio and Wolf (1994) for OECD countries, for example, obviously has much in common with that of Cardenas (1997) for Colombia.

With the development of unit-root econometrics, a second type of convergence has begun to emerge, in the form of increased consistency between the statistical methodology applied in industrial- and developing-country research on determinants of long-run equilibrium real exchange rates. Estimation of the LRER has clearly been advanced by the development of unit-root econometrics. This has, on the one hand, facilitated meaningful tests of PPP (the “stage two” tests of Froot and Rogoff 1994). On the other hand, it has freed the estimation of the long-run relationship between the RER and its fundamental determinants from dependence on appropriate specification and estimation of short-run macroeconomic dynamics. Estimation of the LRER on the basis of cointegrating equations appears to be a promising avenue for research at present. Particularly in the developing country context, such estimates have yielded measured effects of fundamentals consistent with theoretical predictions, and the fitted values of the LRER derived from such equations have produced estimates of misalignment that have tended to correspond well with commonly accepted features of the recent macroeconomic histories of the countries involved. Moreover, the statistical significance of lagged error-correction terms in dynamic real exchange
rate equations implies that estimated LRERs are significant predictors of future movements in actual RERs—a key test of whether the methodology has succeeded in capturing an important aspect of real exchange rate dynamics.

Where does all of this leave us? Conceptually, monetary neutrality implies that relative PPP should hold in the face of nominal shocks, but theory does not require that PPP hold in response to real shocks. The issue depends on the persistence of those shocks. Empirically, the evidence suggests that PPP may or may not hold as an extremely long-run proposition (that is, over spans of time in excess of half a century) in industrial countries. Over shorter periods of time—including over the complete span of data that tend to be available for developing countries—the real exchange rate tends to be nonstationary, and PPP provides a poor approximation of the equilibrium real exchange rate. Since the real exchange rate is an endogenous macroeconomic variable, the nonstationarity of the real exchange rate suggests nonstationarity in some subset of its underlying real fundamental determinants. There is a substantial amount of agreement on the eligible set of such fundamentals. They consist of sectoral total factor productivity levels, the economy’s terms of trade, commercial policy, the level and composition of government spending, and some indicator of the external financial environment.

The last of these fundamentals raises an important unresolved issue on the conceptual side of LRER measurement. Specifically, just how long is the relevant long run? The literature has taken different positions on this question. While all observers take the long run as being long enough to eliminate speculative and cyclical phenomena, the majority of the papers reviewed here do not go to the extent of defining the long run as sufficiently long as to eliminate capital-stock dynamics. The issue is whether the relevant time frame should allow for full adjustment of the country’s stock of net international assets. Most writers have not been explicit on this, and their implicit assumptions have to be inferred from the way they treat external financial variables in the estimation of the LRER. At one extreme, allowing for full adjustment in the economy’s net creditor position involves conditioning the LRER on the external interest rate, and not on net capital inflows or the stock of net international debt. At the other extreme, conditioning the LRER on the stock of net international debt implies adopting a relatively shorter-run horizon. The common procedure of conditioning the LRER on a “sustainable” level of net capital inflows can be understood as a special case of the latter in which the adjustment in the economy’s net creditor position implied by the ongoing net capital inflow is small (in other words, the rate of adjustment of the net creditor position is slow). The empirical challenge in this case is how to measure this exogenous component of
net capital inflows. No single method that commands wide agreement has emerged.

On the empirical side, the reliability of approaches to the estimation of the LRER based on unit-root econometrics remains to be established. Among potential pitfalls in their application are the short span of data typically available for developing countries (which adversely affects the power of the statistical tests involved), the poor quality of some of the proxies that have to be employed for the relevant fundamentals, and the imperfect techniques currently available for estimating the “permanent” values of such fundamentals, a key input into the calculation of the LRER. Overall, these methods offer the promise of improving on PPP when the nonstationarity of the RER suggests that the latter is a poor empirical hypothesis. However, they have not yet been shown to deliver the robustness and precision that would be required for a nonstructural approach such as this to dominate more traditional structural approaches to the estimation of the LRER in policy applications.

In short, the single-equation approach appears to be the most promising avenue for further research; but data problems can limit its usefulness in specific policy applications, particularly in low-income and transition economies. Simulations from large macroeconomic models have not proved very tractable or reliable in either industrial or developing countries. Hence, the trade-equations approach, which is less appealing theoretically, but more feasible to implement empirically, is likely to continue for some time as the policy workhorse. Even the trade-equations approach, however, is too time consuming to implement in multicountry studies, and for these the PPP-based approach to estimating misalignment remains the only feasible one, despite its limitations.