Chapter VII

The Real Exchange Rate

VII.1 Introduction and Overview

The present chapter will focus on the ***real exchange rate***, which is the relative price of a foreign goods bundle in terms of a domestic goods bundle. While previous chapters predominantly analyzed the current account and international capital flows, exchange rates were only mentioned in passing, if at all. This omission was due to two important assumptions: first, most of the models we considered were based on the notion that the ***law of one price (LOP)*** held for all components of the relevant goods basket.[1] Second, we assumed that this basket had the same structure in all countries – with the simplest version of this idea claiming that there was actually just *one* good. If both these conditions are satisfied, neither technology or preference shocks nor changes in government policy have an impact on the value of the domestic goods bundle relative to the foreign goods bundle, and we can safely set the real exchange rate equal to one. Conversely, if any of these conditions fails to hold, the real exchange rate potentially varies over time.

The purpose of this chapter is to describe the determinants and consequences of real exchange rate fluctuations. As we will show, the real exchange rate is a macroeconomic variable of considerable importance – first, because it reflects changes in the structural characteristics of an economy and possibly signals undesirable developments. Second, because it has an important influence on an economy's exports, imports and financial markets. Understanding the determinants and consequences of real exchange rate fluctuations is thus a crucial condition for correctly interpreting the behavior of an open economy and for taking appropriate policy decisions.

The rest of this chapter is structured as follows: in Section VII.2, we will start by presenting some important definitions, which are necessary to empirically operationalize the concept of the real exchange rate. Section VII.3 will introduce the concept of ***purchasing power parity (PPP)***, which offers a simple

[1] Of course, in Section IV.4 we deviated from this principle. In that section, we presented a model that allowed for the presence of non-tradable goods whose prices potentially differed across countries.

theory of the real exchange rate. In Section VII.4, we will show how the prices of non-tradable goods and the terms of trade affect the real exchange rate, and discuss the various economic forces that may affect country-specific price structures. Section VII.5 will consider the influence of the real exchange rate on a country's net exports and discuss its role as a measure of "***price competitiveness***". Finally, Section VII.6 will present alternative concepts to identify the ***equilibrium real exchange rate*** and show how this equilibrium value is related to the determinants of the current account that we have identified in previous chapters.

VII.2 Definitions

VII.2.1 The Bilateral Real Exchange Rate

On our way towards an analysis of the *real* exchange rate, we start by introducing the (***bilateral***) ***nominal exchange rate***, which is the relative price of one currency in terms of another currency. There are two alternative ways to present this variable: the ***quantity notation*** shows the amount of foreign currency units that one receives for one unit of the domestic currency. This convention has the appealing feature that an increase in the nominal exchange rate reflects an ***appreciation*** of the domestic currency: agents receive more foreign-currency units for one unit of the domestic currency. The presentation of exchange rates in quantity notation dominates in policy discussions and in the business press.[2] By contrast, most of the academic literature uses the ***price notation***, which documents how many units of the domestic currency have to be paid for one unit of a foreign currency. This convention implies that an increase of the nominal exchange rate signals a ***depreciation*** of the domestic currency: in this case, one has to pay more domestic-currency units for one unit of the foreign currency. Counterintuitive as it seems at first glance, this convention makes a lot of sense: it reflects the notion that the "dollar exchange rate" is the *price* of a foreign currency in domestic-currency units. For this reason – and also to be compatible with the standard applied in most scientific publications – we will stick to the price notation, defining the nominal exchange rate E_t between the domestic currency (say, the Euro) and a foreign currency (say, the US dollar) as the amount of Euros that has to be paid for one US dollar at time t.[3] When publishing exchange rate quotes using three-letter currency codes, commercial sources

[2] For example, the "Euro foreign exchange reference rates" published by the European Central Bank give the price of the Euro in terms of foreign-currency units.

[3] Note that there are lots of "E's" in this book. In order to avoid confusing the nominal exchange rate E_t with the expectations operator introduced in Chapter IV, we use *italics* for the former, while the expectations operator is represented by a „straight" E_t.

often do not refer to "domestic" and "foreign" currencies. Instead, they mention the "base currency" first and the "counter currency" second. Following this convention, a USD/EUR quote indicates how many Euros have to be paid for one US dollar, and a EUR/USD quote indicates how many US dollars have to be paid for one Euro.

While a (bilateral) *nominal* exchange rate reflects the price of a foreign currency in terms of the domestic currency, a (***bilateral***) ***real exchange rate*** is a relative price that indicates how many units of a "domestic good" or "domestic goods bundle" have to be spent on acquiring one unit of a "foreign good" or "foreign goods bundle". We can compute the real exchange rate Q_t at time *t* by multiplying the nominal exchange rate E_t in price notation – i.e. domestic currency units that have to be paid for one foreign currency unit – with the foreign price level P_t^F, and by dividing this product by the domestic price level P_t^H, i.e.

$$(7.1) \qquad Q_t = \frac{E_t\, P_t^F}{P_t^H}$$

A decline (increase) of the real exchange rate – i.e. a ***real appreciation*** (***depreciation***) – implies that a lower (higher) amount of domestic goods units has to be paid for a given amount of foreign goods units.[4]

It is important that you intuitively understand the information given by the real exchange rate, so consider the following simple example: suppose, for the time being, that P_t^F and P_t^H literally refer to the same good – say, a *latte macchiato* in a fancy coffee shop – and that, as a resident of Germany (the home country), you are planning a trip to the United States (the foreign country). Thinking about your travel budget, you know that you have to sacrifice some consumption at home in order to be able to afford a latte macchiato in the US. To find out how much, you start by transforming the foreign price (P_t^F) into domestic currency units, using the nominal exchange rate (E_t). By dividing the product $E_t\, P_t^F$ by the domestic price (P_t^H) – and by thus computing a "latte-based" real exchange rate – you find out that you have to give up $E_t\, P_t^F / P_t^H$ *latte macchiati* in Germany in order to afford one in the US.

Of course, there are many types of price variables that can be substituted into the expression in (7.1). Which one of them is the appropriate one predominantly

[4] Note that our exposition implicitly identifies the area in which the domestic price level prevails with the area in which the domestic currency is the official means of payment. If we abstract from regional price differences, this is accurate in most cases – US residents use the US dollar, British residents use the British pound – but there are also important exceptions. The most prominent one is the Euro area where countries share a common currency, but may have different price levels. The ***Harmonized Consumer Price Index (HCPI)*** aggregates these national price levels into one price variable that applies to all countries using the Euro.

depends on the type of question you want to answer using the real exchange rate. In practice, national ***consumer price indices (CPI)*** are often used to represent the foreign and national price level. The CPI gives the price of the goods and services bundle that is consumed by a representative inhabitant of a country. Computing a "CPI-based" real exchange rate is easy since CPI data are regularly published by statistical authorities. However, as we will argue later in this chapter, some applications may suggest the use of alternative price variables, e.g. the prices of an internationally standardized goods basket or a variable that represents production costs.

Figure 7.1 shows the evolution of the nominal and the CPI-based real exchange rates of the Euro against the US dollar between January 1999 and July 2015. The Euro's initial nominal depreciation against the dollar is clearly discernible, followed by a trend appreciation that lasted until mid-2008. Since then, the Euro has depreciated against the dollar. Figure 7.1 also reveals that the nominal and real exchange rate time series are almost identical. In what follows, the high correlation between nominal and real exchange rates will be an important subject of our analysis.

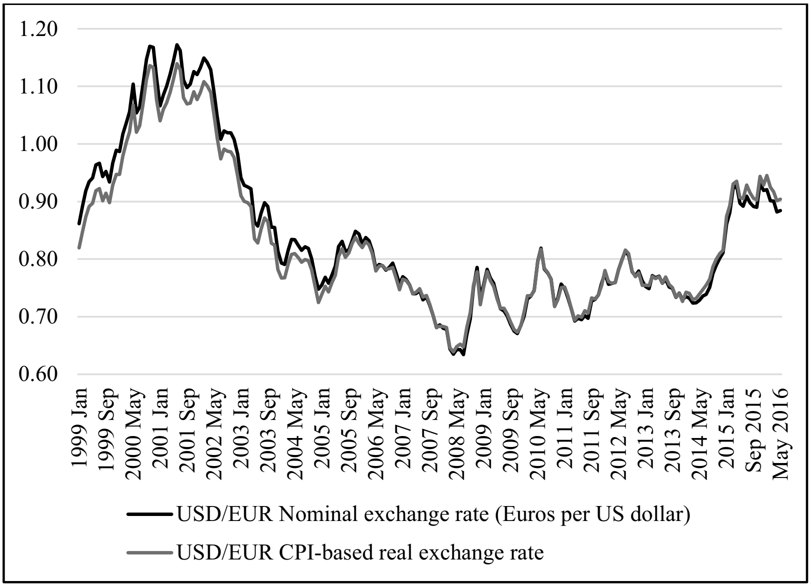

Figure 7.1: Nominal and real USD/EUR exchange rates (Euros per US dollar). The real exchange rate has been computed using the US consumer price index (CPI) for the US and the harmonized CPI for the Euro area (base year 2010). Source: IMF (International Financial Statistics).

VII.2.2 The Real Effective Exchange Rate

A *bilateral* exchange rate describes the relative price of *two countries*' currencies or goods bundles. In order to arrive at a more comprehensive picture of a currency's external value in real terms, we can compute a ***real effective exchange rate*** Q_t^{eff}, which is a weighted geometric average of bilateral real exchange rates Q_t^j. More specifically, the real effective exchange rate against J foreign currencies is given by the following expression:[5]

$$Q_t^{eff} = \prod_{j=1}^{J} \left(Q_t^j \right)^{\omega_j} \tag{7.2}$$

Note that, in order to combine individual bilateral real exchange rates in equation (7.2), we have to transform each of them into an index that equals 100 in the same base year. Hence, an effective exchange rate also is an index whose value can only be interpreted in the time series dimension, but has no cross-sectional interpretation.

How the effective exchange rate is influenced by fluctuations of individual bilateral exchange rates crucially depends on the weights ω_j of the respective currencies. These weights reflect the intensity of bilateral trade relationships – i.e. the share of exports to and imports from country (or currency area) j. In addition, so-called ***third-market effects*** are usually considered. These effects account for the fact that domestic firms compete with firms from country j not only on the respective national markets, but also in other economies. The higher country j's market share in a country that absorbs a lot of domestic exports, the higher the weight of currency j in the effective exchange rate. Box 7.1 describes the weights used by the European Central Bank (ECB) to compute an effective exchange rate.

Figure 7.2 shows how the (bilateral) real exchange rate of the Euro against the US dollar has evolved since January 1999 and compares this evolution with the Euro's *real effective* exchange rate. Given the principle according to which effective exchange rates are computed, it is not surprising that the effective exchange rate time series is much less volatile than the bilateral exchange rate. This is due to the imperfect correlation of bilateral exchange rates. Whenever the Euro appreciated or depreciated against the US dollar in real terms, it did not necessarily appreciate or depreciate to the same extent – if at all – against

[5] A *nominal* effective exchange rate is computed in the same way, replacing bilateral real exchange rates by bilateral *nominal* exchange rates. Note also that the term "real effective exchange rate" is a bit misleading and that "effective real exchange rate" would be more appropriate.

the other currencies included in the *effective* exchange rate. This explains the apparent stability of the latter time series.

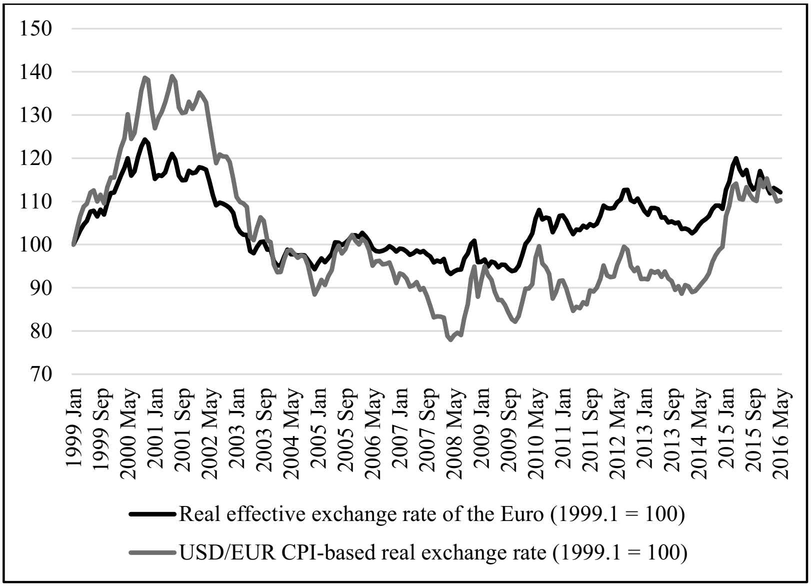

Figure 7.2: Evolution of the USD/EUR CPI-based real exchange rate and the Euro's real effective exchange rate (EER-38). Source: ECB and IMF (International Financial Statistics). The original EER-38 has been inverted to make it compatible with the price notation used in this book. The USD/EUR dollar real exchange rate has been transformed into an index using January 1999 as a base period. Recall that the USD/EUR *nominal* exchange rate reflects the amount of Euros that have to be paid for one US dollar.

Box 7.1: Weights in the Euro's Effective Exchange Rate

The ECB publishes two effective exchange rate indices for the Euro area: the EER-19 is based on the bilateral exchange rates vis-à-vis members of the European Union which are not part of the Euro area plus Australia, Canada, China, Hong Kong, Japan, Norway, Singapore, South Korea, Switzerland and the United States. The EER-38 additionally considers the currencies of Algeria, Argentina, Brazil, Chile, Iceland, India, Indonesia, Israel, Malaysia, Mexico, Morocco, New Zealand, the Philippines, Russia, South Africa, Taiwan, Thailand, Turkey and Venezuela. Figure B7.1 shows a subset of the weights that were computed for the years 1995-1997 and 2010-2012. The weights are updated every three years, and their variation reflects the changing trade pattern of Euro area member countries.[6] While the US dollar and the British pound still have a joint weight of more than 20 percent in the EER-38, Figure B7.1 shows that the importance of the Chinese yuan has massively increased since the mid-1990s.

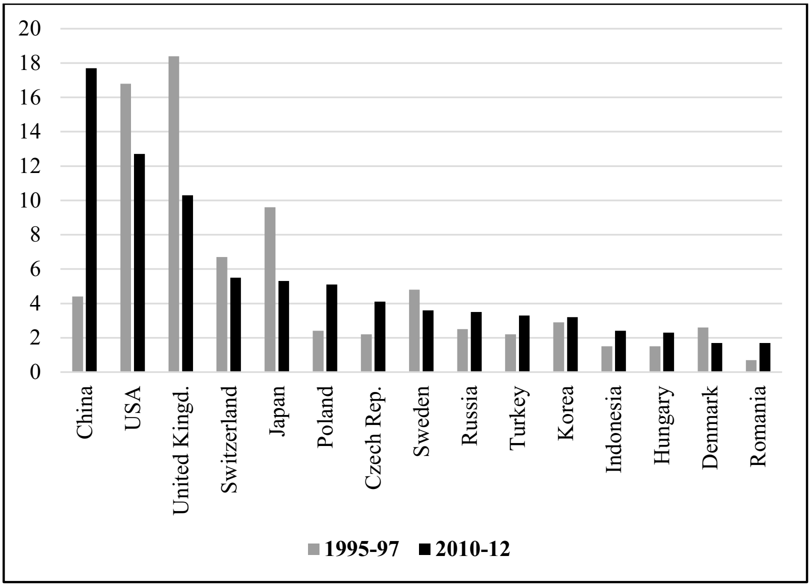

Figure B7.1: Weights of selected currencies in the EER-38, 1995-97 and 2010-12. Source: European Central Bank (2015).

VII.3 Purchasing Power Parity

VII.3.1 The Law of One Price and Absolute Purchasing Power Parity

The ***law of one price (LOP)*** postulates that, in the absence of trade costs and other frictions, the price of good i is independent of the currency in which it is originally denominated, i.e.

$$P_{i,t}^{H} = E_t \cdot P_{i,t}^{F}, \tag{7.3}$$

[6] To ensure comparability across time periods, the ECB applies the method of ***chain-weighting***. Roughly speaking, this amounts to computing the index based on the old and on the new weights for adjacent years and then taking a geometric average of the two resulting values.

with $P_{i,t}^{H}$ denoting the domestic-currency price of good i at time t, and $P_{i,t}^{F}$ the foreign-currency price of the identical good at the same time. Using the bilateral nominal exchange rate E_t, the foreign-currency price is transformed into the domestic currency.

The theoretical justification of the law of one price runs as follows: if equation (7.3) did not hold – e.g. if we observed $P_{i,t}^{H} < E_t \cdot P_{i,t}^{F}$ – there would be an opportunity to earn a lot of money through ***international goods arbitrage***. In this specific case, people would have an incentive to buy good i where it is cheaper (country *H*) and to sell it in the country where the price – transformed into domestic-currency units – is higher (country *F*).[7] The resulting shifts in supply and demand would make the arbitrage opportunity disappear: at a given exchange rate, the higher demand for good i in the home country and the higher supply of this good in the foreign country would raise the price $P_{i,t}^{H}$ and lower the price $P_{i,t}^{F}$. If the above inequality applied to a large number of goods, there might even be a reaction of the foreign exchange market: the resulting arbitrage activities would raise both the demand for the domestic currency and the supply of the foreign currency. Both tendencies would generate an appreciation of the domestic currency, i.e. a decreasing value of E_t.

Moving from individual goods prices to the price of entire goods *bundles*, we assume that the domestic and the foreign goods bundle's prices are computed as weighted geometric averages of individual goods prices, i.e.

$$(7.4) \qquad P_t^H = \prod_{i=1}^{N^H} \left(P_{i,t}^H\right)^{\gamma_i^H} \quad \text{and} \quad P_t^F = \prod_{i=1}^{N^F} \left(P_{i,t}^F\right)^{\gamma_i^F}$$

with the weight of good *i* (γ_i^H, γ_i^F) reflecting the importance of that good in the respective country's goods bundle.

If both countries' goods bundles have exactly the same structure – i.e. if $N^H = N^F = N$ and $\gamma_i^H = \gamma_i^F = \gamma_i$ for all *i* – and if the law of one price holds for all goods, we arrive at the following result:

$$(7.5) \qquad P_t^H = \prod_{i=1}^{N} \left(P_{i,t}^H\right)^{\gamma_i} = \prod_{i=1}^{N} \left(E_t \cdot P_{i,t}^F\right)^{\gamma_i} = E_t \cdot P_t^F ,$$

which implies for the real exchange rate that $Q_t = E_t \cdot P_t^F / P_t^H = 1$. This is the key hypothesis established by the theory of ***absolute purchasing power parity***

[7] Our presentation of the LOP implicitly assumes that goods whose prices are denominated in different currencies, are offered in different countries. Asplund and Friberg (2001) show that this need not be the case. They analyze prices on Scandinavian ferry boats and show that, in the same shop, prices in different currencies coexist.

(PPP): the nominal exchange rate and/or national price levels adjust to keep the real exchange rate at a constant value of one at every point in time. As a consequence, both currencies have the same "purchasing power", and transforming domestic currency into foreign currency using the nominal exchange rate neither increases nor reduces the volume of goods that can be bought.[8]

For given prices of national goods bundles, we can compute the level of the nominal exchange rate that is compatible with the theory of absolute purchasing power parity:

$$E_t^{PPP} = \frac{P_t^H}{P_t^F} \tag{7.6}$$

where we are using the superscript „PPP" to indicate that this level of the nominal exchange rate – often called "*the* purchasing power parity" – is a hypothetical one that is consistent with the *theory* of absolute purchasing power parity. If one trusts this theory, purchasing power parities can be compared to observed exchange rates in order to identify the over- or undervaluation of a currency. However, when applying this concept, we have to make sure that the price variables in the numerator and denominator of (7.6) actually refer to identically structured goods bundles, i.e. that the assumptions underlying the theory of absolute PPP are satisfied. This condition is usually not met by national consumer price indices (CPIs) whose composition depends on country-specific demand patterns. Moreover, by definition a CPI is an *index* whose value is set equal to 100 in a base year. Since such an index does not reveal whether, in the base year, goods were particularly cheap or expensive in the country under consideration it is pointless to use CPIs for a computation of purchasing power parities.

It is for these reasons that an institution like the OECD defines a standardized, supra-national goods basket and uses the price of this basket in different countries to compute purchasing power parities. However, gathering price data for all components of this goods basket is time-consuming – especially since the structure of the basket has to be adjusted from time to time. This is why the British newspaper *The Economist* uses readily available information on prices of a well-known goods bundle to compute E_t^{PPP} for a wide range of countries. This approach and the resulting assessments are described in Box 7.2.

[8] As reported by Rogoff (1996) the idea of purchasing power parity has been around for quite a long time. However, it is primarily associated with the Swedish economist Gustav Cassel (1866 – 1944) who suggested to use it as a conceptual tool to determine appropriate nominal exchange rates after World War I.

Box 7.2: BigMacs and Exchange Rates – A Beefy Approach

Twice a year, the British newspaper *The Economist* publishes a list that shows the price of a McDonald's BigMac in different countries. Table B7.2 shows part of the data that were presented in January 2016. Based on these data, the Economist assesses whether a currency is over- or undervalued against the US dollar. This is done by comparing the observed nominal exchange rate E_t in the fourth column with the hypothetical value E_t^{PPP}, which should prevail according to the theory of absolute PPP.

	BigMac Price in local currency	***E***	$\boldsymbol{E^{PPP}}$	**Overvaluation (+) or undervaluation (-) against the USD**
United States	USD 4.93	1.00	1.00	0.00
Brazil	BRL 13.5	4.02	2.74	-31.96
Canada	CAD 5.84	1.41	1.18	-15.94
Denmark	DKK 30	6.94	6.09	-12.32
Euro area	EUR 3.72	0.93	0.75	-18.88
India	INR 127	66.80	25.76	-61.44
Mexico	MXN 49	17.44	9.94	-43.00
Norway	NOK 46.8	8.97	9.49	5.77
Poland	**PLN 9.60**	**4.05**	**1.95**	**-51.89**
Sweden	SEK 45	8.60	9.13	6.11
Switzerland	CHF 6.5	1.01	1.32	30.70
Thailand	THB 112	36.22	22.72	-37.28

Table B7.2: Local-currency prices of a McDonald's BigMac in different countries, purchasing power parities against the US-dollar (E^{PPP}), market exchange rates (E) as well as undervaluations (negative) and overvaluations (positive) against the US-dollar, relative to the theory of absolute purchasing power parity. Over- and undervaluations in percent are computed using the formula $\left(E_t^{PPP} / E_t - 1\right) \cdot 100$ (Allow for small rounding errors). All data refer to January 2016. Source: *The Economist*. Currency names follow the three-letter ISO-code.

These purchasing power parities are presented in the third column of Table B7.2, and are computed by dividing the local-currency price of a Big Mac by the US dollar price observed in the United States. For Poland, the table shows $E_t^{PPP} = 9.60 / 4.93 = 1.95$, a value that is much smaller than the nominal exchange rate observed in January 2016 ($E_t = 4.05$). Hence, at that point in time, market participants had to pay more Zlotys for one US dollar than what would have been suggested by absolute PPP. This results in an assessment that the Zloty was undervalued by almost 52 percent.

The Economist keeps emphasizing that these assessments represent a thought experiment and that the "Big Mac index" is a "…lighthearted guide to whether currencies are at their 'correct' level". Nevertheless, the advantages of this exercise should not be underrated. In a study published in 2007, David Parsley and Shang-Jin Wei emphasize the advantages of the BigMac as a standardized, readily available consumption basket whose structure is transparent and does not differ across countries. This, in turn, facilitates understanding the mechanisms that generate deviations from the theory of absolute purchasing power parity.

VII.3.2 The Law of One Price: Empirical Evidence

Of course, all obstacles that hamper international goods arbitrage have the potential to generate cross-country price differences. This holds a fortiori for goods and services that are not tradable *at all*. As we have outlined in Section IV.4, these goods are not exposed to international competition, and their prices are exclusively determined by demand and supply conditions on domestic goods and factor markets.

The role of non-tradability for deviations from the law of one price becomes even more prominent once we take into account that most goods are, in fact, bundles of tradable and non-tradable components.[9] For example, the ***retail price*** of a banana in a Berlin supermarket mirrors the import price of that banana at the German border plus the price of the "retail services" that deliver it to the customer. The price of these retail services is not determined by the world market, but by domestic cost components like wages and rents for land, office space etc., as well as by the degree of competition in the retail industry.

[9] Following up on Chapter IV, we briefly remind the reader that there is a subtle, but important difference between "tradability" and "tradedness". Acknowledging that, for most goods, the question whether they are traded or not hinges as much on firms' decisions as on their physical characteristics, we nevertheless stick to the traditional distinction between tradables and non-tradables. This is mainly because many of the arguments presented in this chapter hinge on an (exogenous) distinction between goods types that – unlike (endogenous) "tradedness" – is not affected by price fluctuations.

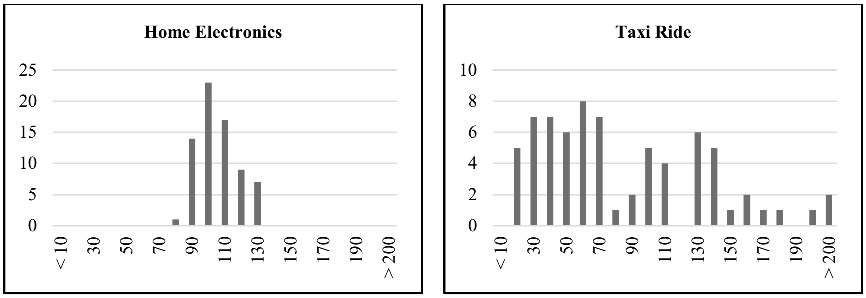

Figure 7.3: Frequency distributions of prices for a bundle of home electronics (left panel) and a five kilometer taxi ride (right panel) in the spring of 2015. All prices are expressed in percentage terms relative to New York City. Source: UBS (2015).

Our conjecture that international price differences are more pronounced for goods and services that have a high non-tradable component is supported by Figure 7.3. Referring to the year 2015, the two histograms show the relative frequency of prices that had to be paid in major cities around the globe for two items: a clearly defined basket of home electronics – consisting of an iPhone, a color TV, a digital camera, a desktop PC, and a notebook – and a five kilometer taxi ride within city limits. All prices are shown in percentage terms relative to the price prevailing in New York City.[10] It is quite obvious that the international dispersion of prices is much bigger for a taxi ride. While this difference may also be driven by the fact that international price differences for home electronics cancel out when an entire bundle of such goods is considered, and that there are substantial quality differences with respect to taxi rides, we conjecture that the main reason is the fact that the set of home electronics exhibits a much higher tradable component. Box 7.3 reports the results of a study that demonstrates that – even within the European Union, where trade barriers have been dismantled and where many countries share a common currency – substantial international price differences can be observed for homogenous tradable goods.

Box 7.3: Intra-European Price Differences – A Clean Example

When the Euro was introduced as a common currency for several European countries in 1999, it was argued that this would result in a rapid convergence of prices among member states. The logic seemed compelling, since

[10] These data are based on a survey that was conducted by the Swiss Bank UBS and whose results are documented in the publication "Prices and earnings 2015" (UBS 2015).

neither administrative barriers nor exchange rate fluctuations would prevent Euro area residents from performing the goods arbitrage that would eventually iron out international price differences.

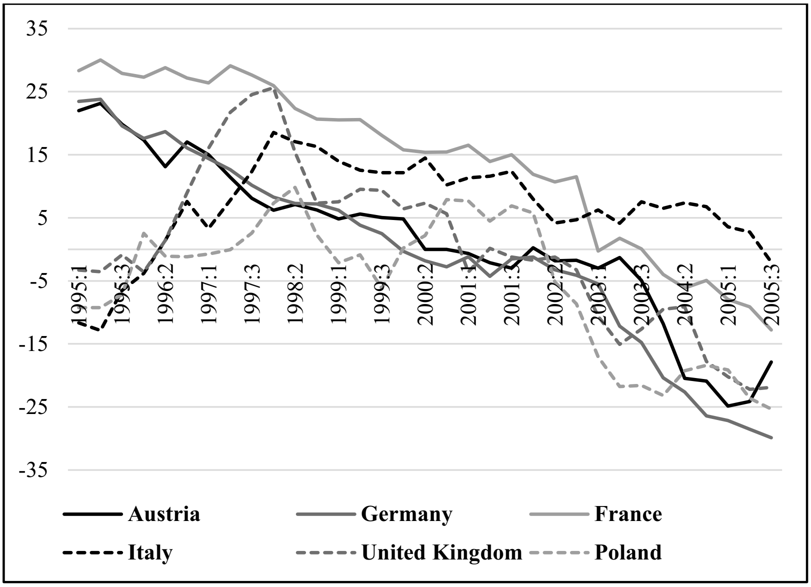

Figure B7.3: Percentage deviations of prices for a set of internationally tradable washing machines from the cross-country/cross-period mean. Source: Fischer (2012).

Was this expectation confirmed by the facts? Answering such a question is far from trivial: to identify the effect of the common currency, one has to consider the prices of goods which are actually identical across countries, and for which intra-European transactions are neither hampered by exorbitant trade costs nor by producers' elaborate market segmentation strategies. Moreover, the purchase must be substantial enough to provide an incentive for goods arbitrage, observed prices must not be distorted by hidden discounts and, of course, different national tax rates have to be accounted for.

In a recent study, Christoph Fischer (2012) meets this challenge by using scanner price data on 33 types of washing machines that are sold in a wide range of European countries, both inside and outside the Euro area. Figure B7.3 depicts the evolution of national prices for these machines between 1995 and 2005. More specifically, each time series shows the percentage deviation between the price prevailing in a given country and the cross-country and cross-period mean, averaged over all washing machine types.

The time series indicate that, in most countries, washing machines became cheaper over time. More importantly, however, there does not seem to be a tendency for the national price deviations to become smaller. Finally, the small price convergence that could be observed across countries did not necessarily take place between countries that shared the Euro, but between some Euro area economies and countries like Poland or the UK. Hence, it does not seem that the common currency – at least in the first years of its existence – spurred international price convergence.

VII.3.3 Deviations from the Law of One Price: Determinants and Interpretations

Physical and administrative trade barriers, transport costs, information deficits etc. constrain the arbitrage processes that we used as a justification for the law of one price. Once the close tie between the world market and domestic prices is severed, we are likely to observe international price differences for individual goods and services. This leaves us with the question about the factors that determine the size of these differences. Here are some important candidates:

- Of course, the fundamental determinants of supply and demand at the national level play a role once prices are not determined by the world market. Hence, differences in countries' *factor endowments*, *productivity and income levels*, consumers' *preferences* as well as differences in the composition and volume of *government spending* influence the extent of international price differences.
- What also matters are national *tax systems*. For example, retail prices are higher in countries in which goods and services are subject to higher value-added taxes.
- Another important determinant of national price levels is *market structure*: if market entry is limited for potential competitors, and if international goods arbitrage fails due to administrative barriers or trade costs, prices are likely to be higher in countries where incumbent suppliers enjoy more market power.

The arguments brought forward in the preceding paragraphs stressed the importance of *real* economic factors – factor endowments, productivities, preferences, tax and market structures – for an explanation of international price differences. This list has to be augmented by another explanation, which focuses on the delayed adjustment of nominal prices:

– Firms may be reluctant to adjust their prices despite nominal exchange rate fluctuations – e.g. because such an adjustment is associated with costs. If prices are fixed in the currency of the market where the respective goods are sold, deviations from the law of one price may be driven by variations of the nominal exchange rate.[11]

There is a fundamental difference between this last interpretation of international price differences and the preceding ones: if deviations from the LOP reflect a combination of nominal exchange rate fluctuations and the delayed adjustment of prices, these deviations should be of a temporary nature, and they should disappear once firms start adjusting their prices. By contrast, the first three explanations of international price differences imply that the size of deviations from the law of one price depends on the evolution of the underlying fundamental determinants (preferences, market structure etc.). If differences in these fundamentals persist, and if barriers to goods arbitrage do not disappear, international price differences are unlikely to vanish even in the medium and long run.

VII.3.4. Relative Purchasing Power Parity

As we have seen in Subsection VII.3.2, the empirical evidence is not kind to the theory of absolute purchasing power parity: even for tradable goods, we observe international price differences, and these differences are higher for goods and services with a large non-tradable component. Confronted with this evidence, it is hard to support absolute purchasing power parity as a reasonable theory of the real exchange rate. Moreover, as we have emphasized above, the practical application of absolute PPP hinges on the availability of internationally comparable and sufficiently comprehensive price data. These data are hard to collect. Conversely, national consumer price indices (CPIs), which are routinely published by statistical authorities, are of no use when it comes to applying absolute PPP.

Given these problems, we turn to a less restrictive variant of purchasing power parity, which allows for both international price differences and for different compositions of national goods baskets – as long as these differences are constant, and as long as *relative prices within countries* do not vary over time.

[11] These fluctuations emerge if domestic producers set a "domestic price" in domestic currency and an "export price" in foreign currency – a strategy that is called ***pricing-to-market*** or ***local currency pricing***, and that, of course, requires that the above-mentioned factors prevent international goods arbitrage. In Chapter IX, we will return to firms' pricing strategies and discuss both their implications for the effectiveness of monetary and fiscal policy, and the evidence on their empirical relevance.

The theory of ***relative purchasing power parity*** postulates that the real exchange rate adopts a *constant value* Q, which, however, does not have to equal one, i.e.

$$(7.7) \qquad \frac{E_t \cdot P_t^F}{P_t^H} = Q ,$$

By taking (natural) logarithms on both sides of equation (7.7) and using lowercase letters to denote natural logs, we arrive at the following representation:

$$(7.8) \qquad e_t + p_t^F - p_t^H = q$$

Transforming this expression into first differences, and taking into account that, according to the theory of relative purchasing power parity, q does not change over time, we get:

$$(7.9) \qquad e_t - e_{t-1} = p_t^H - p_{t-1}^H - \left(p_t^F - p_{t-1}^F\right)$$

This equation has an intuitive interpretation: if the theory of relative purchasing power parity holds, the domestic currency depreciates (appreciates) vis-à-vis the foreign currency if the domestic inflation rate exceeds (falls short of) the foreign inflation rate.

VII.3.5 Relative Purchasing Power Parity: Empirical Evidence

The theory of relative purchasing power parity postulates that the real exchange rate is constant, albeit not necessarily equal to one. A glance at Figure 7.1 shows that it is hard to sustain this claim for the real exchange rate of Euro against the US dollar. The same holds for the real exchange rate of the (British) Pound sterling against the US dollar, which is shown in Figure 7.4. Apparently, the price adjustment mechanisms sketched above do not operate in the short run, such that the real exchange rate time series almost completely coincides with the nominal exchange rate.

At the same time, however, it is striking that, as documented by Figure 7.4, extreme real depreciations or appreciations of the Pound sterling against the US dollar were usually followed by significant corrections. It thus seems like the real exchange rate fluctuates around some long-run mean.

Or is this an illusion? While few economists doubt the short-run failure of purchasing power parity, there is still an intense debate about the question whether real exchange rate time series are ***stationary*** – i.e. whether deviations from a constant mean vanish in the long run – or whether they are non-stationary and don't exhibit any ***mean reversion***.

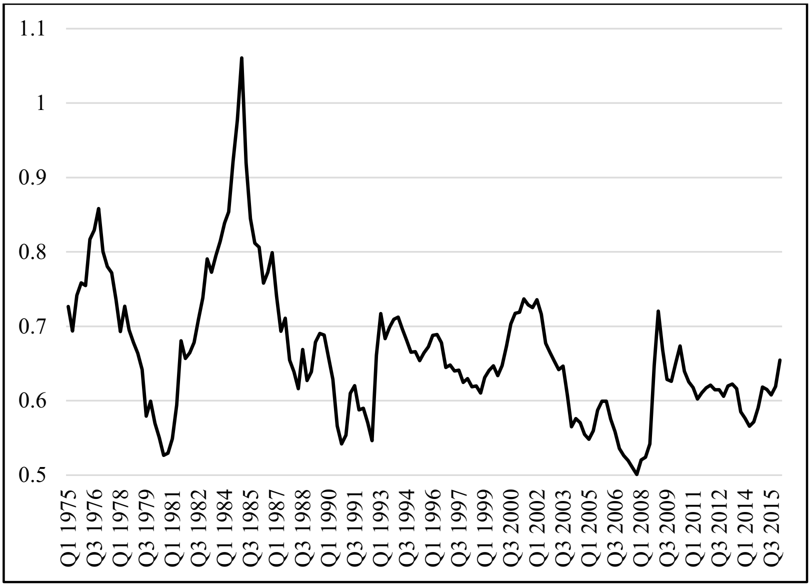

Figure 7.4: The USD/GBP CPI-based real exchange rate (with the nominal exchange rate expressed as Pound sterling per US dollar). Source: IMF (International Financial Statistics)

One approach to clarify this issue is to estimate the parameters of a process that describes the evolution of the real exchange rate. The simplest specification of such a process is a ***first-order autoregressive process*** – an ***AR(1) process*** – as in the following equation:

(7.10) $$q_t = c + \rho\, q_{t-1} + \varepsilon_t$$

In equation (7.10), q_t is the (natural) logarithm of the real exchange rate at time t, c is a constant, and ε_t is a random variable with an expected value of zero. The analysis focuses on the parameter ρ which determines at what speed – if at all – the real exchange rate returns to its long-run mean of $c/(1-\rho)$ after a one-time shock, i.e. after a positive or negative realization of ε_t.[12] If ρ is smaller than one in absolute value, the variable q_t converges to the steady state

[12] It is easy to determine the long-run ("steady state") value $q^{SS} = c/(1-\rho)$ by ignoring the time indices on both sides of the equation and by setting the disturbance term ε_t equal to zero. Obviously, such a value only exists if $\rho \neq 1$.

over time. Conversely, if ρ is equal to one or larger (in absolute value), such a convergence does not take place.

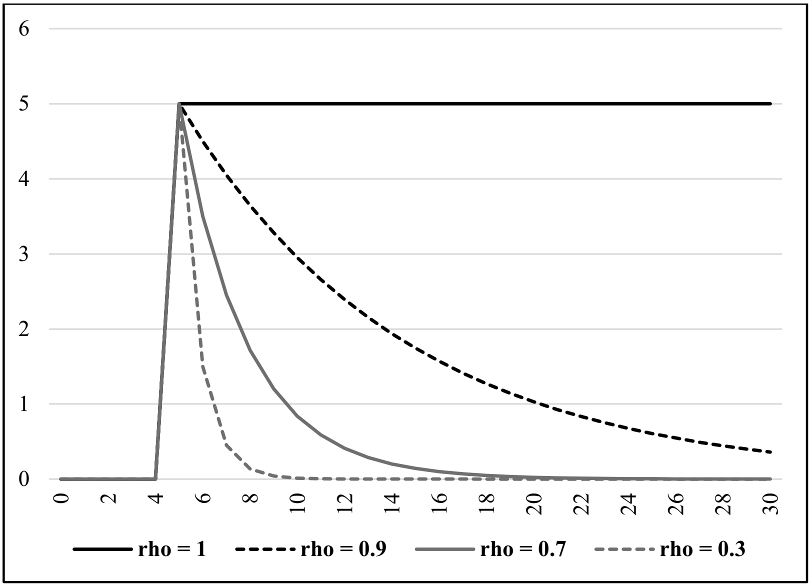

Figure 7.5 : Impulse response functions for a first-order autoregressive process $q_t = \rho\, q_{t-1} + \varepsilon_t$ and different values of ρ (rho).

The ***impulse response functions*** in Figure 7.5 depict this adjustment for different values of ρ and $c = 0$. If ρ is small, q_t quickly returns to its initial value after a shock. With a higher value, this process takes longer. Finally, if $\rho = 1$, the variable q_t remains at the new level. In this case, the real exchange rate time series is a ***random walk*** whose evolution reflects the sum of all past shocks and that does not have a tendency to return to a long-run mean.[13]

The time series properties of real exchange rates are still a subject of an intense debate. What additionally complicates the matter is the fact that, with finite samples, it is not easy to empirically distinguish a random walk from a process that is stationary, but persistent – i.e. for which the true value of ρ is close to one.[14] Nevertheless, a consensus has emerged in the profession that,

[13] It is often said that a random walk is characterized by a ***unit root***. This is due to the fact that the stationarity property of higher-order autoregressive processes hinge on the question whether the characteristic roots of the so-called "lag polynomial" are greater than one.

[14] Some recent studies whose results are summarized in a survey article by Taylor und Taylor (2004) try to solve this problem by using historical time series or by combining time series for several currency pairs.

while deviations of the real exchange rate disappear very slowly, the random walk hypothesis can be confidently rejected for many currency combinations. Box 7.4 supports this result by documenting the high correlation between inflation differentials and growth rates of bilateral nominal exchange rates that can be observed if one considers a rather long time span.

This still leaves us with the question of how to explain the high persistence of deviations from purchasing power parity. In an influential survey article, Rogoff (1996) concludes that the half life of a shock – i.e. the time span until 50 percent of the shock have disappeared – is three to five years! This is a long time, and the ***purchasing power parity puzzle*** highlighted by Rogoff is based on the observation that such a slow convergence can hardly be reconciled with conventional ideas of firms' delayed price adjustment.

Box 7.4: Purchasing Power Parity in the Long Run

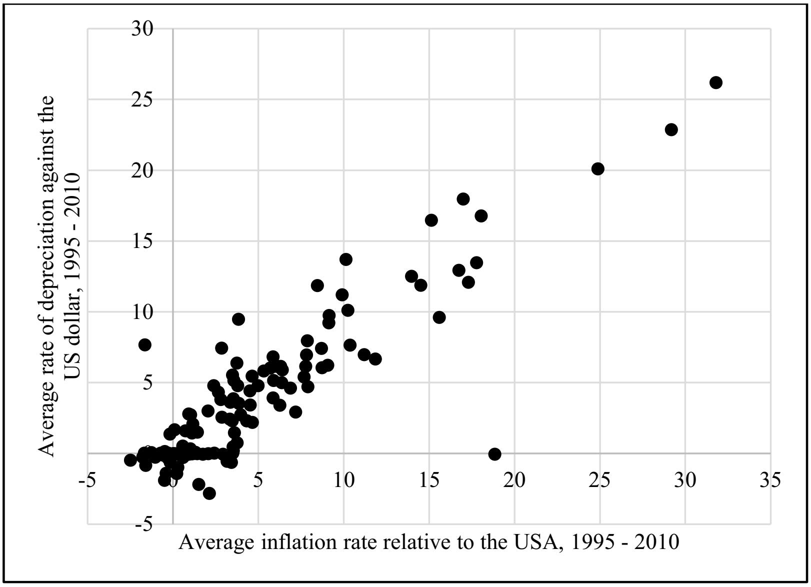

Figure B7.4: Average inflation rates relative to the USA and average rates of depreciation against the US dollar between 1995 and 2010. Source: IMF (International Financial Statistics).

Figure B7.4 suggests that the theory of relative purchasing power parity performs much better empirically if we adopt a long-run perspective. The scatterplot is based on the evolution of exchange rates and prices for a large number of countries. The horizontal axis depicts countries' inflation rate minus the US American inflation rate – i.e. the right-hand side of equation (7.9) – averaged over the years 1995 to 2010. According to the theory of relative purchasing power parity the currencies of countries that exhibited a higher inflation rate than the US should have depreciated against the US dollar.

By and large, the positive correlation depicted by the scatterplot supports this hypothesis. While there are substantial deviations for some countries, many data points are located close to the 45°- line. This lends further support to the quantitative relationship between currency depreciation and relative inflation rates postulated by equation (7.9). The two outliers, which represent the highly regulated economies of Libya (lower inflation than US, strong depreciation) and Myanmar (higher inflation than US, almost constant exchange rate) support this insight rather than jeopardizing it.

To address the purchasing power parity puzzle, various studies show that the high persistence estimated for real exchange rate time series may result from the fact that a linear specification like the one imposed by equation (7.10) may be too restrictive: for example, it is quite plausible that *large* variations of the real exchange rate result in a rather fast adjustment of prices whereas *small* variations do not induce any price changes at all and thus bring about fluctuations of the real exchange rate. Taylor et al. (2001) demonstrate that the estimated persistence of shocks is much smaller if the empirical specification accounts for this potential non-linearity.

VII.4 Non-Tradable Goods, the Terms of Trade, and the Real Exchange Rate

VII.4.1 Dissecting the Real Exchange Rate

As we have argued above, most of the price variables that are used to compute the real exchange rate – most prominently, the consumer price index – have both tradable and non-tradable components. In this subsection, we will show that accounting for non-tradable goods importantly shapes our interpretation and understanding of real exchange rate fluctuations. To achieve this goal, we adopt the setup introduced in Section IV.4 and assume that the weight of tradable goods (indexed by T) in the consumption bundle (γ) is the same across countries, implying that the weight of non-tradable goods (indexed by N) is $(1-\gamma)$. Given these assumptions, the natural logarithm of the CPI-based real exchange rate is given by the following expression:

$$(7.11) \qquad q_t^{CPI} = e_t + \left[\gamma\, p_t^{T,F} + (1-\gamma)\, p_t^{N,F}\right] - \left[\gamma\, p_t^{T,H} + (1-\gamma)\, p_t^{N,H}\right]$$

After rearranging the terms in (7.11) we can rewrite this expression as follows:

$$(7.12) \qquad \begin{aligned} q_t^{CPI} = \;& e_t + p_t^{T,F} - p_t^{T,H} \\ & + (1-\gamma)\left[\left(p_t^{N,F} - p_t^{T,F}\right) - \left(p_t^{N,H} - p_t^{T,H}\right)\right] \end{aligned}$$

This expression presents the log of the CPI-based real exchange rate as the sum of three components: the first component is the price of tradable goods in the foreign economy relative to the price of tradable goods in the domestic economy. The second component is the price of non-tradable goods relative to the price of tradable goods in the foreign economy, and the third component is the same log-difference for the domestic economy. If the tradable goods bundles have the same composition in both countries, and if the law of one price applies to all tradable goods – an assumption that is more plausible for this part of the goods spectrum than for non-tradable goods – the first part of equation (7.12) equals zero. In this case, fluctuations of the CPI-based real exchange rate are completely determined by variations of the relative prices of non-tradable goods.

This observation has important implications for our interpretation of the real exchange rate and represents a starting point for an analysis of the fundamental forces that drive real appreciations and depreciations. In the following subsections, we will present two different – albeit not mutually exclusive – approaches to explain variations in the relative price of non-tradable goods.[15] Both interpret real exchange variations as an equilibrium phenomenon, driven by shifts in demand and supply conditions. However, they substantially differ in their normative assessment of these variations.[16]

[15] Our analysis will be based on the assumption that $\left(p_t^{N,F} - p_t^{T,F}\right)$ is constant. Hence, we will entirely focus on the relative price of non-tradable goods in the domestic economy.

[16] The question of how much fluctuations of the relative price of non-tradable goods actually contribute to the observed volatility of the real exchange rate is the topic of an ongoing debate. While Engel (1999) claims that the largest part of real-exchange variations is driven by relative tradable-goods prices, Burstein and Gopinath (2014) argue that the importance of non-tradable goods prices increases once the role of (non-tradable) retail services is taken into account.

VII.4.2 The Balassa-Samuelson Model

When considering Table B7.2, readers may have noticed that BigMacs were conspicuously expensive in rich countries like Switzerland or Norway, and cheap in emerging markets like Thailand or Indonesia.

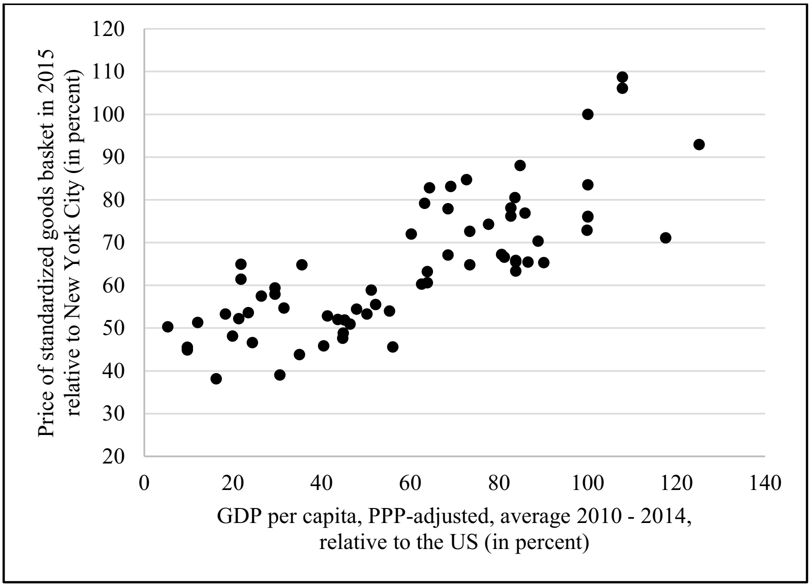

Figure 7.6 : Countries' GDP per capita, PPP-adjusted[17] (averaged from 2010 through 2014, relative to the United States, in percent) and country-specific prices of a standardized goods basket in 2015 (relative to New York City, in percent). The goods basket contains 122 goods and services, weighted according to the monthly spending habits of a three-person European family. Sources: World Bank (World Development Indicators) and UBS (2015).

The conjecture that there might be a correlation between countries' per-capita income and the price level prevailing in these countries is confirmed by the scatterplot in Figure 7.6, which relates the price of a well-defined goods basket, consisting of tradable and non-tradable components, in the year 2015 to the respective countries' average per-capita income from 2010 through 2014. While per-capita GDP levels are presented in percentage terms relative to the USA, goods prices are given relative to the level observed in New York City. Note that this allows the resulting ratios to be interpreted as (inverse) real exchange

[17] Box 7.5 provides a motivation and explanation of different types of purchasing power parity (PPP) adjustments.

rates relative to the US dollar. From a PPP-perspective we would interpret Figure 7.6 as indicating that, in 2015, the currencies of poor countries happened to be undervalued, while the currencies of rich countries happened to be overvalued. However, the strength of the correlation between income levels and real exchange rates suggests that it is more likely to be a systematic equilibrium phenomenon than a temporary deviation from PPP.

A mechanism that may generate the relationship depicted in Figure 7.6 is described by the ***Balassa-Samuelson-model***, which goes back to the influential contributions of Bela Balassa (1964) and Paul A. Samuelson (1964). Starting with the decomposition of the CPI-based real exchange rate presented in equation (7.12), the model provides an explanation of why the non-tradable/tradable goods price ratio is higher in rich countries than in poor countries. It considers a small open economy that produces a tradable and a non-tradable good. Firms employ physical capital and labor in order to produce these goods, and technologies are characterized by constant returns to scale. In our exposition of the Balassa-Samuelson model, which follows the presentation by Asea and Corden (1994), we assume that firms use the following Cobb-Douglas technologies:

(7.13) $$Y_t^T = A_t^T \left(K_t^T\right)^{\alpha_T} \left(L_t^T\right)^{1-\alpha_T}$$

(7.14) $$Y_t^N = A_t^N \left(K_t^N\right)^{\alpha_N} \left(L_t^T\right)^{1-\alpha_N}$$

In these expressions, we use the standard notation, with T and N referring to tradable and non-tradable goods, respectively. Note that $\alpha_T > \alpha_N$ implies that the tradable-good technology is capital intensive – i.e., for a given ratio of factor prices, firms in that industry use a higher capital-labor ratio.

We assume that the law of one price applies to the tradable good and set its price equal to one. Moreover, we assume that relative prices in the rest of the world remain constant. As a consequence, fluctuations of the CPI-based real exchange rate – as shown in equation (7.12) – are solely driven by variations of P_t^N, the domestic price of the tradable good relative to the price of the non-tradable good.

We further assume that goods and factor markets are characterized by perfect competition. In both sectors, the marginal value products of capital and labor thus have to coincide with the respective factor prices, with all magnitudes being expressed in units of the tradable good. Since there is perfect international capital mobility, and since we assume that capital does not depreciate, this implies for the return to capital and the wage:

(7.15) $$r = \alpha_T \; A_t^T \left(k_t^T\right)^{\alpha_T - 1}$$

$$(7.16) \qquad w_t^T = \left(1-\alpha_T\right) A_t^T \left(k_t^T\right)^{\alpha_T}$$

$$(7.17) \qquad r = P_t^N \, \alpha_N \, A_t^N \left(k_t^N\right)^{\alpha_N - 1}$$

$$(7.18) \qquad w_t^N = P_t^N \left(1-\alpha_N\right) A_t^N \left(k_t^N\right)^{\alpha_N},$$

with r representing the (constant) real interest rate prevailing on the international capital market, $k_t^i = K_t^i / L_t^i$ denoting the capital-labor ratio in industry i (with $i = T, N$), and w_t^i the wage rate (expressed in units of the tradable good) in industry i.

The key assumption of the model is that labor is perfectly mobile between industries. This implies that workers offer their labor services to firms in the industry that pays the higher wage. To sustain labor market equilibrium, both industries thus have to pay the same wage: $w_t^N = w_t^T = w_t$. Substituting this into (7.16) and (7.18), we can solve the system of equations (7.15) – (7.18) for k_t^T, k_t^N, w_t and P_t^N. The reduced form solution for P_t^N reads as follows:

$$(7.19) \qquad P_t^N = \frac{\left(A_t^T\right)^{\frac{1-\alpha_N}{1-\alpha_T}}}{A_t^N} \left(\frac{1-\alpha_T}{1-\alpha_N}\right)^{1-\alpha_N} \left(\alpha_T\right)^{\frac{\alpha_T(1-\alpha_N)}{1-\alpha_T}} \left(\alpha_N\right)^{-\alpha_N} r^{\frac{\alpha_N - \alpha_T}{1-\alpha_T}}$$

Taking (natural) logarithms on both sides of this equation and representing logarithms by lower-case letters, this is equivalent to

$$(7.20) \qquad p_t^N = \frac{1-\alpha_N}{1-\alpha_T} a_t^T - a_t^N + \phi,$$

with ϕ as a positive constant, which depends on the (constant) world interest rate and on the parameters of the production function.

Equation (7.20) shows that the relative price of the non-tradable good unambiguously increases if there is an increase in total factor productivity that is restricted to the tradable-good industry, i.e. if $\Delta a_t^T \equiv a_t^T - a_{t-1}^T > 0$, while $\Delta a_t^N \equiv a_t^N - a_{t-1}^N = 0$. The economic explanation of this result reads as follows: for a given price, a productivity increase in the tradable good industry raises the demand for labor and results in a higher wage w_t^T. Due to perfect intersectoral labor mobility, this wage also has to be offered by firms that produce the non-tradable good. Otherwise, these firms would not find any workers. The higher wage, in turn, drives up marginal costs for non-tradable good firms. Since prices equal marginal costs under perfect competition, P_t^N has to increase. This, in turn, results in a real appreciation (see equation (7.12)).

Equation (7.20) indicates that a real appreciation may occur even if total factor productivity increases at the same rate in both industries, i.e. if $\Delta a_t^T = \Delta a_t^N > 0$. A necessary condition for P_t^N to increase in this case is that the production of the tradable good is labor-intensive relative to the production of the non-tradable good, i.e. that $\alpha_T > \alpha_N$. If this condition is satisfied, the impact of the higher wage weighs more strongly than the higher productivity in the non-tradable good industry, and the resulting cost increase brings about a higher price and thus a real appreciation.

The Balassa-Samuelson model suggests the following explanation of the relationship between per-capita income levels and real exchange rates: the prosperity of rich countries is mainly based on their high productivity in manufacturing industries – with those goods representing tradable goods in the sense of the Balassa-Samuelson model. The high wage level in tradable goods industries pushes up the wage level in non-tradable goods industries, which predominantly consist of services. Note that, as outlined above, non-tradable goods enter the CPI directly, but also through the "distribution services" that influence the prices of most tradable goods at the retail level. As a consequence, even tradable goods are more expensive in rich countries than in poor countries. If we use absolute PPP as a benchmark, these countries' currencies seem overvalued. The Balassa-Samuelson model, by contrast, interprets deviations from PPP as a result of different productivity levels and thus as equilibrium phenomena, which do not require any government intervention, and which are unlikely to disappear as long as the underlying productivity differences prevail. As documented in Box 7.5, this insight has important implications for the choice of the exchange rate that should be used for international income comparisons.

Box 7.5: International Income Comparisons

If we are ready to accept a country's real GDP per capita as a measure of economic well-being, an international comparison of prosperity levels seems like a straightforward task: divide official GDP (in local currency units) by population size, use the market exchange rate to transform the resulting numbers into a common currency – say, the US dollar – and rank countries according to the outcome of these operations. However, such a simple approach may result in misleading conclusions. The reason is that the use of market exchange rates to make GDP figures internationally comparable is based on the assumption that the theory of absolute purchasing power parity is satisfied – i.e., that a resident of Poland who turns a certain amount of Zlotys into US dollars can use the resulting sum to buy the same amount of goods and services in New York City as in Warsaw. As we have seen, this is not the case, and there are systematic deviations from PPP.

More specifically, the logic of the Balassa-Samuelson model suggests that the purchasing power of a Zloty in Warsaw is much larger than in New York City. Since Polish residents are more likely to spend their income in their own country than abroad, the systematic deviation of the market exchange rate from PPP has to be taken into account when performing international income comparisons.

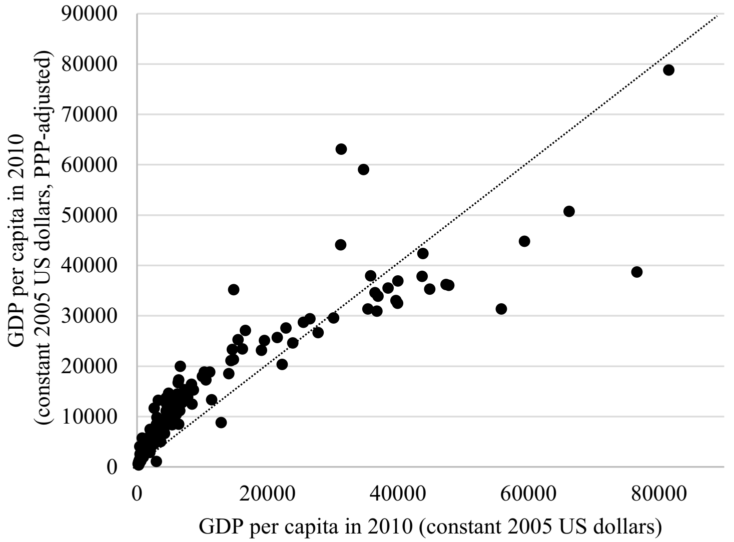

Figure B7.5: Real per capita GDP in 2010 – with and without PPP-adjustment. Sources: World Bank (WDI) and Penn World Table 8.1, series *rgdpe* and *pop* (see Feenstra et al., 2015).

The challenge consists in finding the "correct" exchange rate that allows to compute and compare ***PPP-adjusted*** income levels. The first task in meeting this challenge is to collect price data for many different goods (categories) in a large number of countries. This task is performed by the ***International Comparison Program***, which started in the 1960s at the University of Pennsylvania. In a second step, these price data can be used to compute purchasing power parities, applying one of several alternative approaches, among which the ***Eltetö-Kövec-Szulc (EKS) method*** used by the OECD and the ***Geary-Khamis (GK) method*** used by the ***Penn World Table*** are the most prominent ones. These PPPs are then used to transform national GDP data (adjusted for inflation) into ***PPP-adjusted*** US-dollars.

Figure B7.5 compares the resulting numbers on GDP per capita in 2010 from the Penn World Table (Mark 8.1) to GDP per capita figures in USD dollars that were computed by using the market exchange rate. As the figure suggests, the differences between the two numbers may be substantial. For example, Poland's GDP per capita in 2010, evaluated at market exchange rates, amounted to 10,005 US dollars, while the PPP-adjustment resulted in a per-capita GDP of 17,950 US dollars – an increase of almost 80 percent! The 45-degree line in Figure B7.5 documents that Poland is no exception, and that the use of market exchange rates tends to understate the per-capita incomes of poor economies and to overstate the per capita incomes of rich economies.

VII.4.3 The Dutch Disease

The Balassa-Samuelson model explains real appreciations as a result of productivity increases in the tradable goods industry, which spill over into non-tradable goods prices due to the resulting wage increases and the intersectoral mobility of labor. In this subsection we show that this does not have to be the only reason for an increasing relative price of non-tradable goods and the resulting real appreciation. Another potential cause is an exogenous increase of a country's national income – resulting, e.g. from the discovery of large natural resource supplies (oil, gas, gold etc.). While such windfall gains are usually greeted as a boon, an influential article published in 1982 by Max Corden and J. Peter Neary highlighted that they may have negative medium- and long-run effects on an economy.[18]

We use a simple graph to illustrate the mechanics behind such a development: the (static) production possibilities frontier in Figure 7.7 refers to a small open economy and depicts potential output combinations of tradable (T) goods (manufactures) and non-tradable (N) goods (or services) for a given factor endowment. Domestic residents consume both types of goods. For simplicity, we assume that the *intra*temporal elasticity of substitution between tradable and non-tradable goods is zero, such that domestic residents consume both goods in a constant proportion, regardless of relative prices. This relationship is reflected by the straight line through the origin in Figure 7.7.

[18] The term "Dutch disease" was coined by the English newspaper *The Economist*, which used it in 1977 to describe the problematic structural change in the Netherlands that followed the discovery of vast natural gas resources in 1959.

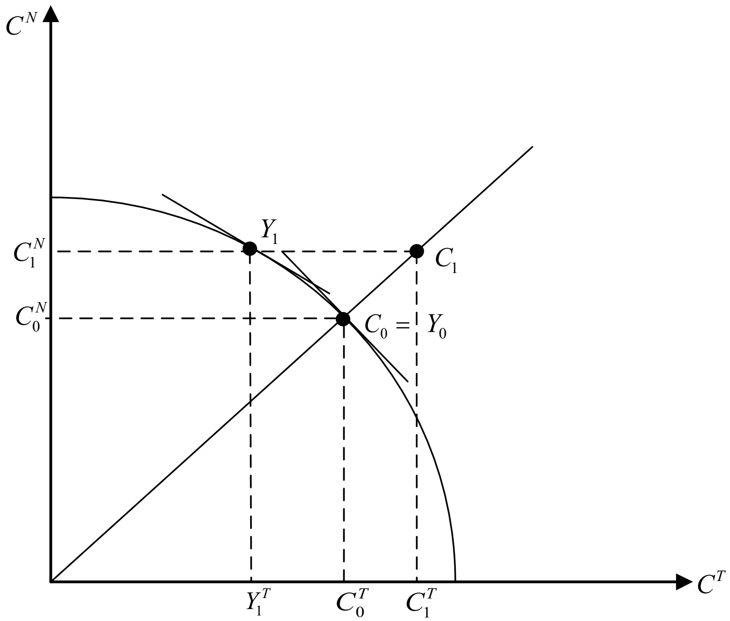

Figure 7.7: The Dutch disease. Effects of an exogenous income increase on the production and consumption of tradable and non-tradable goods.

In the initial equilibrium, consumption $\left(C_0^T, C_0^N\right)$ happens to coincide with production $\left(Y_0^T, Y_0^N\right)$ for both components of the consumption bundle (point $\mathbf{C_0} = \mathbf{Y_0}$), and the relative price of tradable goods in terms of non-tradable goods is reflected by the slope of the tangent in point $\mathbf{Y_0}$. An exogenous income increase – resulting, e.g., from the discovery of oil or gas – expands the consumption possibilities for domestic residents.[19] As a consequence, consumption moves to point $\mathbf{C_1}$ with $\left(C_1^T, C_1^N\right)$ in Figure 7.7. While the additional demand for tradable goods can be satisfied by importing these goods from abroad, the additional demand for non-tradable goods has to be met by an expanding domestic supply. This "spending effect" shifts the production point from $\mathbf{Y_0}$ to $\mathbf{Y_1}$: domestic output of non-tradable goods $\left(Y_1^N = C_1^N\right)$ increases while output of tradable goods contracts. This is associated with an increasing relative price of non-tradable goods – note that the slope of the tangent in point $\mathbf{Y_1}$ is flatter than in point $\mathbf{Y_0}$

[19] We assume that oil or gas extraction does not withdraw labor or capital from other industries – e.g. because it is performed by foreign companies who bring in their own equipment and staff. This assumption eliminates what Corden and Neary (1982) call the "resource movement" effect. Moreover, we assume that the newly- discovered resources are not consumed in the domestic economy, but exported in exchange for manufactured goods.

– and a real appreciation. Finally, in the new equilibrium, domestic production of manufactured goods falls short of domestic consumption.

The term "Dutch disease" suggests that such a development should be assessed rather skeptically. While it must not be forgotten that the "disease" is originally caused by an income gain – and thus an expansion of consumption possibilities – the shrinking of the tradable goods sector may have negative long-term consequences: in the case of resource discoveries, the economy becomes increasingly dependent on this type of income – and thus exposed to the vagaries of international commodity markets. Moreover, technological progress is likely to happen primarily in manufacturing industries, and the "de-industrialization" described by Corden and Neary (1982) may have a negative influence on long-run productivity growth.

VII.4.4 The Terms of Trade and the Real Exchange Rate

Starting from equation (7.12), we have so far assumed that we could ignore the expression $e_t + p_t^{T,F} - p_t^{T,H}$ and focus on the relative price of non-tradable goods – the "internal real exchange rate" – as the crucial determinant of real exchange rate fluctuations. This assumption was based on the notion that the law of one price applies to the tradable part of the goods basket.

However, variations of the real exchange rate may also be driven by variations in tradable-goods prices. To show this, we start by defining a "tradable goods-based" real exchange rate $q_t^T = e_t + p_t^{T,F} - p_t^{T,H}$, which combines the nominal exchange rate (in logarithms) e_t with information on the relative importance of domestically produced and foreign-produced goods in countries' total consumption of tradable goods. For simplicity, we assume that the tradable goods basket consists of two goods. Moreover, we use the ***Armington assumption***, which goes back to a paper by Paul Armington (1969), and which postulates that goods are "…distinguished by place of production". In our case, this implies that there is a "domestic good", which is only produced in country *H*, and a "foreign good", which is only produced in country *F*. Finally, we allow the structure of national goods baskets to differ across countries. Combining all these assumptions yields

$$
\begin{aligned}
q_t^T \quad = \quad & e_t + \left[\theta^F \; p_t^{HF} + \left(1-\theta^F\right) p_t^{FF}\right] \\
& - \left[\theta^H \; p_t^{HH} + \left(1-\theta^H\right) p_t^{FH}\right]
\end{aligned}
\tag{7.21}
$$

In this expression, θ^F reflects the share of the good produced in country *H* in country *F*'s (tradable) goods basket, while θ^H denotes the share of the *same* good in country *H*'s (tradable) goods basket. Accordingly, p_t^{HF} (p_t^{HH}) is the price of the good produced in country *H* that is charged to consumers in country

F (H), while p_t^{FF} (p_t^{FH}) is the price of the good produced in country F that is charged to consumers in country F (H).[20] Note that $\theta^F = \theta^H$ holds if the domestic and the foreign (tradable) consumption bundles have the same structure. Rearranging equation (7.21) yields the following expression:

$$(7.22) \qquad q_t^T = \left(\theta^H - \theta^F\right)\left(p_t^{FH} - e_t - p_t^{HF}\right) \\ + \left(1-\theta^F\right)\left(p_t^{FF} + e_t - p_t^{FH}\right) + \theta^H\left(p_t^{HF} + e_t - p_t^{HH}\right)$$

This equation has a straightforward interpretation: in the first line, the second expression in parentheses represents the domestic ***terms of trade*** vis-à-vis country F. Inverting the expression introduced in Subsection IV.4.5, we define the terms of trade as follows:

$$(7.23) \qquad Q_t^{tot} = \frac{P_t^{FH}}{E_t P_t^{HF}}$$

i.e. as the price that residents of country H have to pay for imports from country F relative to the price that country-F residents have to pay for imports from country H, with the nominal exchange rate E_t transforming the price paid by foreign consumers into domestic currency units. Accordingly, the natural logarithm of the terms of trade is given by $q_t^{tot} = p_t^{FH} - e_t - p_t^{HF}$.

While the terms of trade refer to different goods – domestic imports vs. domestic exports – the expressions in brackets in the second line of equation (7.22) are deviations from the law of one price for the *same* (tradable) good. The first term shows the difference between the price of foreign exports in country F and country H. The second term shows the difference between the price of domestic exports in country F and country H. In both cases, country-specific prices are converted into a common currency using the nominal exchange rate.

The first line of equation (7.22) indicates that variations of the terms of trade have no effect on the real exchange rate if $\theta^H = \theta^F$, i.e. if the good produced in country F and exported to country H has the identical weight in both countries' consumption baskets. By contrast, if $\theta^H > \theta^F$, the good produced in country H attracts a larger share of consumption in country H than in country F, and both countries exhibit a ***home bias in consumption***. In this case, an increase of q_t^{tot} results in an increase of q_t^T: a „worsening" of the terms of trade – i.e. an increasing price of imports relative to the price of exports – is reflected by a real

[20] All this is admittedly cumbersome, but getting used to this notation is an investment that will pay off not only in this chapter, but also in Chapter IX. As a general rule, the first letter in the superscript indicates where a good is produced, the second letter indicates where it is consumed.

depreciation. Given that national goods baskets often assign a greater weight to domestically produced goods, we consider this a very plausible case. The first line of equation (7.22) thus conveys an important message: if individuals exhibit a home bias in consumption, terms of trade fluctuations are a source of real exchange rate fluctuations. However, if there is no home bias – i.e. if $\theta^H = \theta^F$ – the real exchange rate is unaffected by changes in the terms of trade. Note that terms of trade fluctuations may affect the real exchange rate even if the law of one price applies to all tradable goods, i.e. if the expressions in the second line of (7.22) equal zero.[21]

The second line of equation (7.22) indicates that deviations from the law of one price for identical (tradable) goods are an additional cause of real exchange rate fluctuations, regardless of national consumption habits. Whether such deviations can actually be observed depends on a whole range of factors, for example trade costs, as mentioned in Section IV.4. In Chapter IX, we will emphasize another source of deviations from the LOP, namely firms' delayed price adjustment: if firms set their prices in their domestic currency for both domestic and foreign consumers, the law of one price automatically applies, and the foreign price of domestic exports is just the domestic price divided by the nominal exchange rate. If, by contrast, firms set prices for the domestic and the export market in the respective customer's currency, and if they are unable (or unwilling) to adjust these prices in the short run, p_t^{FF}, p_t^{FH}, p_t^{HF} and p_t^{HH} are fixed, and every variation of the nominal exchange rate e_t results in a variation of the real exchange rate.

VII.5 The Real Exchange Rate and Net Exports

VII.5.1 The Marshall-Lerner Condition

The decomposition of the real exchange rate presented in the previous section helps us to understand why fluctuations of the real exchange rate may influence the volume of exports and imports: first, a real depreciation may be driven by a decline of (relative) non-tradable-goods prices. By making it more attractive to produce tradables and thus shifting resources from non-tradable into tradable-goods industries, this raises an economy's potential to export and reduces its reliance on imports. Conversely, a real appreciation, driven by an increase of non-tradable-goods prices, is likely to reduce exports and to raise imports. The

[21] Cashin et al. (2004) present a model that relates real exchange rate fluctuations to variations of the terms of trade without involving a home bias in consumption. In their framework, a "terms-of-trade improvement" results in a Balassa-Samuelson-type real appreciation since the higher price of exported goods pushes up the overall wage level and thus the domestic price of non-tradable goods.

second reason for a positive (negative) relationship between exports (imports) and the real exchange rate is due to the fact that real exchange rate fluctuations may reflect variations of the terms of trade: if domestic exports grow cheaper relative to domestic imports – i.e. if we observe a "worsening" of the terms of trade – the foreign demand for domestic exports is likely to increase, while the domestic demand for imports from abroad is likely to decrease.

Interestingly, the above relationships do not necessarily guarantee that an economy's ***net exports*** – i.e. the value of exports minus the value of imports – increase as a result of a real depreciation. This is because variations in the exchange rate not only affect the *quantities* of exports and imports, but also the *prices* at which these quantities are evaluated. To demonstrate this, we define exports and imports as a function of the real exchange rate, and following the above arguments, we assume that exports (imports) are increasing (decreasing) in the real exchange rate, i.e. $EX = EX(Q)$ with $EX' > 0$ and $IM = IM(Q)$ with $IM' < 0$.[22] Defining net exports NX as the difference between exports and imports *in domestic goods units*, we use the real exchange rate to transform foreign goods units into domestic goods units:[23]

$$NX(Q_t) = EX(Q_t) - Q_t \cdot IM(Q_t) \tag{7.24}$$

Taking the derivative of NX with respect to Q_t and omitting time subscripts for simplicity, we arrive at

$$NX' = EX' - IM - Q \cdot IM' \tag{7.25}$$

This term demonstrates that the relationship between the real exchange rate and net exports is possibly ambiguous: while a real depreciation raises the volume of exports and reduces the volume of imports, net exports may nevertheless decrease since the value of imports increases. This is reflected by the negative expression in the center of equation (7.25). In order to understand the forces that determine which of these effects dominates, we define the price elasticity

[22] For the time being, we ignore the fact that both exports and imports also depend on other magnitudes – e.g. the income level of the domestic economy and of its trading partners. This simplification is acceptable as long as we assume that these other variables are constant.

[23] Note that we are blurring the distinction between the terms of trade and the real exchange rate: while the *real exchange rate* relates the price of a domestic goods bundle – e.g. the goods basket underlying the CPI – to the price of a foreign goods bundle, the *terms of trade* relate the price of domestic imports to the price of domestic exports. The widespread practice of using Q instead of Q^{tot} in equation (7.24) is not accurate, but can be justified by invoking an extremely strong home bias in consumption and the high correlation between the real exchange rate and the terms of trade.

of export demand as $\varepsilon^{EX} = EX' \cdot Q / EX$ and the price elasticity of import demand as $\varepsilon^{IM} = -IM' \cdot Q / IM$.[24] Using these definitions, a real depreciation has a positive effect on net exports $\left(NX' > 0 \right)$ if the following condition is satisfied:

$$(7.26) \qquad \varepsilon^{EX} \cdot \frac{EX}{Q \cdot IM} + \varepsilon^{IM} - 1 > 0$$

If trade is balanced in the initial equilibrium, i.e. if $EX - Q \cdot IM = 0$, (7.26) turns into

$$(7.27) \qquad \varepsilon^{EX} + \varepsilon^{IM} > 1$$

Hence, a real depreciation raises net exports if the sum of export and import demand elasticities is greater than one. The intuition behind this ***Marshall-Lerner condition*** – named after the economists Alfred Marshall (1842 – 1924) and Abba Lerner (1903 – 1982) – is straightforward: high export and import elasticities make sure that the quantity effects of a real depreciation dominate the price effects, such that the value of net exports increases when the real exchange rate increases. Empirical studies suggest that the Marshall-Lerner condition is satisfied, at least in the medium and long run.[25]

By and large, the conjecture that the real exchange rate and net exports are positively correlated is supported by the US American data presented in Figure 7.8. The massive real appreciation of the US-dollar in the early 1980s was clearly associated with a decline in observed net exports (relative to GDP) while the subsequent real depreciation was accompanied by a recovery of net exports. In the late 1990s, we could observe both a real appreciation of the US dollar and a decline of net exports, while the real depreciation of the dollar in the wake of the financial crisis of 2008 was associated with rising net exports.[26] Note, however, that the two time series do not always move in parallel. In fact, some of the real appreciations (depreciations) seem to first result in a further increase

[24] We follow standard practice of defining elasticities in terms of absolute values. Hence, we pre-multiply the (negative) derivative of imports with respect to the real exchange rate by minus one.

[25] While there is a consensus that the Marshall-Lerner condition is satisfied, there is an intensive academic debate about the actual size of trade elasticities. A recent set of estimates for various countries is provided by Imbs and Méjean (2010).

[26] The fact that the recent variations of US net exports are more pronounced than the changes in the 1980s and early 1990s may be interpreted in different ways: first, it may indicate that the underlying structural relationships – in particular, the relevant elasticities – have changed. Alternatively, this observation may be interpreted as evidence that net exports do not only depend on the real exchange rate, but on a host of other determinants, which are not explicitly captured by Figure 7.8.

(decrease) in net exports. A theoretical explanation for the observation that the "correct" reaction of net exports only materializes with some delay is presented in Box 7.6.

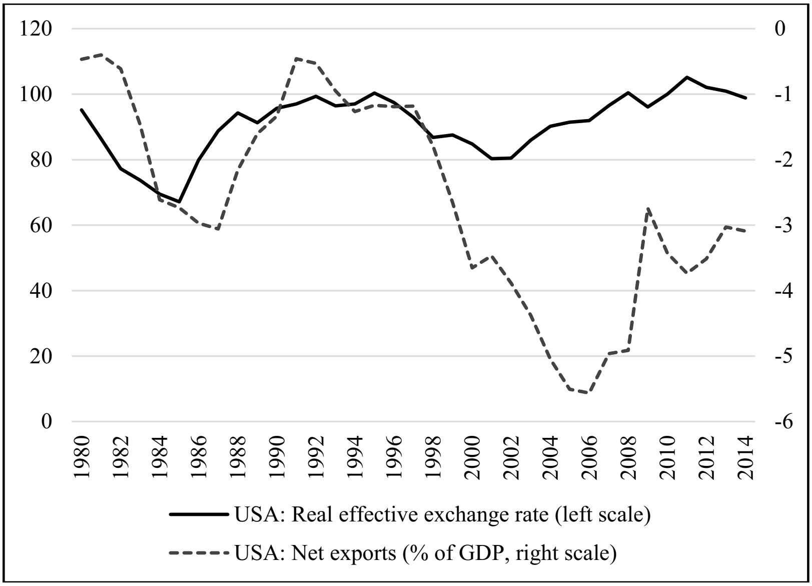

Figure 7.8: Real effective exchange rate and net exports (in percent of GDP) for the USA. Source: IMF (International Financial Statistics). Note that the original time series of the real effective exchange rate (base year 2010) has been inverted in order to be compatible with the price notation used in this book.

Box 7.6: The J-curve

A closer inspection of Figure 7.8 indicates that US net exports often reacted with some delay to variations of the real exchange rate. For example, the real depreciation after 1985 was first followed by a further *decline* in net exports. To explain this observation, we have to return to equation (7.25) and take into account that the quantity and price effects of a real depreciation do not necessarily materialize at the same speed. In fact, it is quite likely that the price effect – i.e. the positive influence of a depreciation on the relative price of imports – occurs in the short run, while the quantity effect – i.e. the adjustment of export and import volumes to the change in relative prices – takes more time. These staggered reactions result in a non-monotonic pattern of adjustment, which is called the ***J-curve***, and which is depicted in B7.6 for the case of a real depreciation.

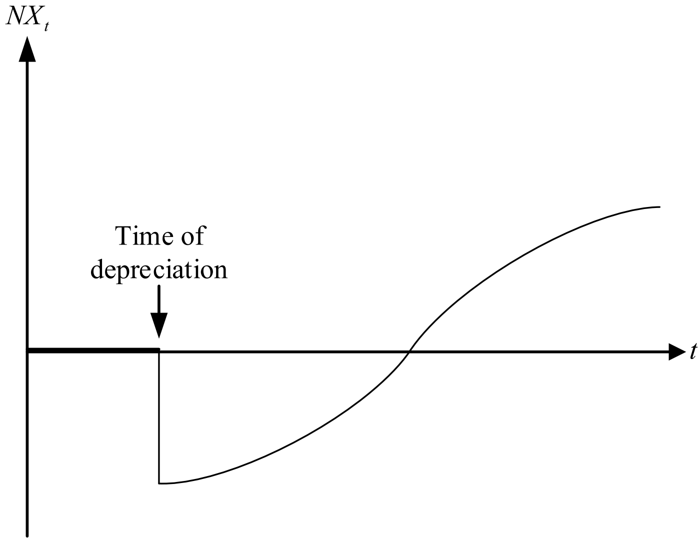

Figure B7.6: The J-curve. Starting from a situation of balanced trade, a permanent real depreciation is first followed by a decreasing value of net exports. In the medium run, the increasing quantity of exports and the declining quantity of imports result in increasing net exports.

VII.5.2. The Real Exchange Rate and a Country's "Price Competitiveness"

The influence of the real exchange rate on net exports suggests that this variable may be interpreted as a measure of an economy's ***price competitiveness***, with a real depreciation indicating that the economy as a whole is becoming "more competitive" and a real appreciation documenting a "loss of competitiveness". While this interpretation has some intuitive appeal, we should not accept it without further scrutiny.

First, our disaggregation in equation (7.12) documents that real exchange rate fluctuations may be driven by variations of the relative price of non-tradable goods. Apart from the fact that increasing prices of non-tradable goods do not necessarily imply a loss of competitiveness – by definition, there is no competition with other countries in markets for non-tradable goods – we have seen that real exchange rate appreciations spurred by an increase of $\left(p_t^N - p_t^T\right)$ may be driven by very diverse causes, some of them associated with windfall income gains (the "Dutch disease") and others associated with productivity increases (the "Balassa-Samuelson model").

But even when we focus on the subset of tradable goods, we have to take into account that terms of trade fluctuations – if they are reflected by the real exchange rate at all[27] – may have different interpretations: if a "worsening" of the terms of trade is caused by an exogenously declining demand for domestic exported goods, it would be naive to interpret the resulting real depreciation as a sign of improved competitiveness. If, by contrast, a declining relative price of exported goods results from an increasing supply – due, e.g., to falling costs of production – this interpretation would make more sense.

Turning to the effect of the nominal exchange rate, we recall that a real depreciation may be caused by a combination of a nominal depreciation and fixed prices – e.g. because domestic exporters choose ***local-currency pricing (LCP)***, setting their prices in foreign currency. Such a constellation does not necessarily raise the volume of exports, but it increases firms' profits for given domestic costs. Whether this can be interpreted as a gain in "competitiveness" is a matter of definition. Conversely, if firms engage in ***producer-currency pricing (PCP)***, fixing their prices in domestic currency units, a nominal depreciation makes domestic goods cheaper for foreign customers – a "worsening" of the terms of trade, which is interpreted as a "gain in competitiveness". But, as indicated in our discussion of equation (7.22), this development is not necessarily reflected by a real depreciation.

Last but not least, we have to be aware that the CPI-based real exchange rate is based on prices of a goods bundle that reflects the choices and habits of domestic and foreign *consumers*, i.e. the relative prices of *investment goods* are not taken into account. However, there is no good reason why the latter should not be relevant for a country's price competitiveness.

All these considerations suggest that the CPI-based real exchange rate may convey a rather limited picture of an economy's actual competitiveness, and that other measures may be more appropriate.[28] To meet the critique that attention should not be restricted to the relative price of consumption goods, we can use the ***GDP deflator*** instead of the CPI.[29] Moreover, to account for the argument that the domestic price of (non-tradable) retail services has no direct implication for competitiveness, we can compute a real exchange rate that is based on ***producer price indices (PPI)***, i.e.

[27] Recall from (7.22) that, if the law of one price holds for all goods, variations in the terms of trade directly affect the real exchange only if there is a home bias in consumption.

[28] Note that we are sidelining an even bigger conceptual question – namely, whether an economy's "competitiveness" is actually reflected by its ability to export more than it imports.

[29] The GDP deflator is the ratio of nominal GDP over real GDP, with the latter measuring domestic output at *constant* prices. Its level thus reflects the prices of all goods and services produced in an economy, including investment goods.

(7.28) $$Q_t^{PPI} = \frac{E_t\, P_t^{PPI,F}}{P_t^{PPI,H}}$$

For some applications, finally, it may be more appropriate to capture a country's ***cost competitiveness*** by computing real exchange rates based on countries' ***unit labor costs (ULC)***. Unit labor costs are determined by dividing a country's total wage sum by real GDP. Accordingly, the ULC-based real exchange is given by

(7.29) $$Q_t^{ULC} = \left(E_t \frac{W_t^F\, L_t^F}{Y_t^F} \right) \Big/ \left(\frac{W_t^H\, L_t^H}{Y_t^H} \right)$$

with W_t^i denoting the average nominal wage, L_t^i denoting total employment, and Y_t^i denoting real GDP in country i (with $i = H, F$). Defining average ***labor productivity*** in country i as the ratio of GDP over employment, i.e. $A_t^i = Y_t^i / L_t^i$, and using lower-case letters to denote (natural) logarithms, we can transform the expression in (7.29) into

(7.30) $$q_t^{ULC} = e_t + \left(w_t^F - a_t^F \right) - \left(w_t^H - a_t^H \right)$$

A real depreciation – i.e. an increase of the ULC-based real exchange rate – thus occurs if domestic wage increases are less pronounced than domestic productivity increases (both relative to the foreign country).

In Figure 7.9, we depict the evolution of the *CPI-based*, *GDP deflator-based* and *ULC-based real effective exchange* rate for the Euro area. It strikes the eye that, despite the very different definitions and conceptual underpinnings, the three time series largely move in parallel. This may have different reasons:

- First, many non-tradable goods serve as intermediate inputs for tradable goods. As a consequence, an increase in $\left(p_t^N - p_t^T\right)$ may raise costs and prices of tradable goods as well.
- In addition, the price of non-tradable goods influences the aggregate price index and thus the real wage. This, in turn, has an effect on the nominal wage demanded by workers – and thus on firms' costs and prices. If the price of the (non-tradable) cost component labor is highly correlated with the price of non-tradable goods, this supports the case for using a CPI-based real exchange rate as an indicator of price competitiveness.
- The distinction between tradable and non-tradable goods is much harder to implement in practice than in theory: economies that are highly reliant on tourism may thus experience a loss of price competitiveness due to increasing services prices, although services are often considered non-tradable.

– Finally, the high correlation of the different real exchange rates may just reflect the fact that each of them is predominantly driven by fluctuations of the nominal exchange rate.

Taken together, most of the arguments that explain the high correlation between the time series in Figure 7.9 vindicate the use of the CPI-based real exchange rate as a measure of price competitiveness.

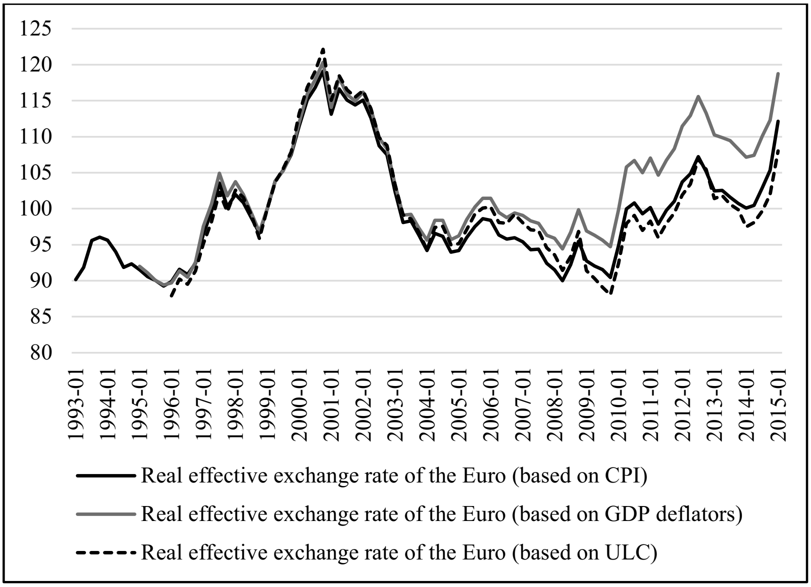

Figure 7.9: Real effective exchange rates of the Euro vis-à-vis 19 trading partners, based on consumer price indices (CPI), GDP deflators, and unit labor costs in the total economy (ULC). Source: Deutsche Bundesbank. Note that the original time series (base period 1999.Q1) have been inverted in order to be compatible with the price notation for exchange rates that we use in this book.

VII.6 The Equilibrium Real Exchange Rate

VII.6.1 Motivation

Figure 7.1 and Figure 7.4 have shown that real exchange rates vary considerably over time. The theory of purchasing power parity interprets these fluctuations as symptoms of temporary "overvaluations" and "undervaluation", which will be corrected in the medium run through an adjustment of nominal exchange rates and/or national price levels. This diagnosis, however, is based on the notion that the ***equilibrium real exchange rate*** is *constant* – an idea that is unlikely to be supported by reality. In fact, the presentation in Section VII.4 has demonstrated that a variation in economic fundamentals – a change of market structure, preferences, or productivity – may result in a variation of relative prices which, in turn, gives rise to a movement of the real exchange rate. Such movements should not be interpreted as over- or undervaluations, but as the outcome of market equilibria. The formidable challenge faced by both researchers and policymakers consists in empirically distinguishing (temporary) deviations from a long-run equilibrium value and variations of the equilibrium value itself. In this section, we will present some approaches that have been developed to meet this challenge.[30]

When it comes to identifying deviations from the equilibrium real exchange rate, practical feasibility may be as important as conceptual accuracy. This is why, in the following subsection, we will return to the theory of purchasing power parity as the simplest possible theory of the equilibrium real exchange rate and discuss how it can be put to use. Subsection VII.6.3 will introduce an approach that explicitly accounts for the various exogenous variables that may influence the equilibrium real exchange rate. The third approach, presented in Subsection VII.6.4, will relate the equilibrium real exchange rate to the current account and will thus establish a link between our analysis of exchange rates and the earlier chapters of this book.

VII.6.2 Putting Purchasing Power Parity to Use

The theory of absolute purchasing power parity postulates that the real exchange rate equals one. As we have detailed above, this claim is very likely to fail if real exchange rates are computed on the basis of national consumer price indices, since the composition of these CPIs differs across countries. To solve this problem, one can use internationally standardized goods baskets to compute national price levels. Box 7.2 introduced the McDonald’s BigMac as a goods bundle whose structure – with some minor exceptions – is identical across coun-

[30] It is important to note that the term „equilibrium“ may have different interpretations, some of which just refer to a situation in which all adjustment processes have taken place, while others describe a *desirable* situation. In the first part of this section, we will stick to the first interpretation, being aware that a real appreciation that is driven by certain fundamental economic changes – a windfall income gain as in the case of the “Dutch disease”, or an excessive increase of government spending – need not be welcome from a normative point of view. In Subsection VII.6.4, we will explicitly address this issue and distinguish between equilibrium values that can be traced back to their fundamental determinants and equilibrium values that are desirable or, at least, appropriate.

tries. In principle, the OECD follows the same approach when it computes purchasing power parities on the basis of a standardized goods basket. Based on the notion that this basket should have the same price in all countries, the OECD computes purchasing power parities for the nominal exchange rate. As in Box 7.2, these hypothetical values can be compared to the actual nominal exchange rate to assess whether a currency is overvalued or undervalued.

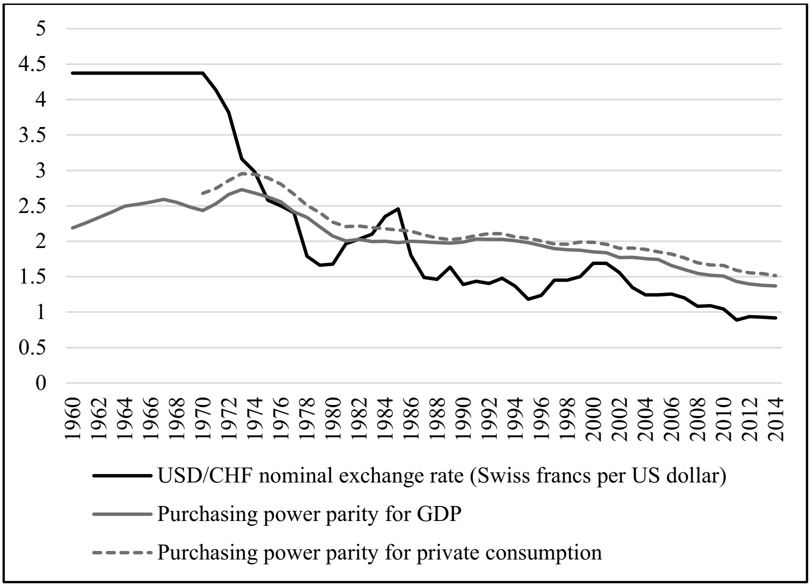

Figure 7.10: USD/CHF nominal exchange rate (Swiss francs per US dollar) and purchasing power parities. Source: OECD.

Figure 7.10 shows the evolution of the Swiss franc/US dollar nominal exchange rate from 1960 through 2014, as well as two purchasing power parities – one referring to a basket of private consumption goods, one referring to total GDP. The theory of absolute purchasing power parity suggests to interpret these time series as evidence that the Swiss franc was undervalued until the early 1970s and overvalued in the more recent past.

As an alternative to its absolute version, we can use the theory of *relative* purchasing power parity, which replaces the claim that the equilibrium real exchange rate equals one with the notion that it assumes a constant value – or, at least, converges to a constant value in the long run. To operationalize this theory, one can follow two approaches: first, one can identify some base year in which the real exchange rate was plausibly at its long-run equilibrium. Alternatively, one can interpret the long-run average of the real exchange rate as its equilibrium. Both approaches obviously have their drawbacks: identifying a point in time at which the real exchange rate was "in equilibrium" is arbitrary unless it is based on solid theoretical and empirical foundations. The long-run average, by contrast, hinges on the observations used to compute it, and a variation of this sample may seriously affect our notion of the equilibrium real exchange rate.

The most important objection against PPP, however, is based on the simple observation that there are many candidate variables that move the real exchange rate away from a fictitious long-run constant. To name just one example, Section IV.4 has shown that an increasing supply of non-tradable goods – driven, e.g. by technological innovations – results in a decreasing price of these goods. Equation (7.12) shows that this results in a real depreciation. An assessment based on the theory of purchasing power parity would erroneously interpret such a change as an undervaluation.

VII.6.3 Reduced-Form Estimates

Once we drop the notion that the equilibrium real exchange rate is constant, there is a whole range of variables that possibly affect this equilibrium value. In the preceding sections, we have met several candidates:

– The Balassa-Samuelson model claims that *productivity increases* in tradable-goods industries result in a real appreciation unless they are dominated by productivity increases in non-tradable goods industries.
– Exogenous movements of the *terms of trade* result in fluctuations of the real exchange rate if there is a home bias in consumption, or if price increases of exported goods spill over into the non-tradable goods sector.
– Following the logic outlined in Section VI.2, a higher *net international investment position* allows a country to run a sequence of primary current account deficits without facing problems of intertemporal solvency. As argued above, net exports – and thus the current account – are positively correlated with the real exchange rate. Hence, the NIIP should have a negative influence on the real exchange rate.
– A large part of *government consumption* is spent on non-tradable goods. Since higher demand has a positive effect on prices, an increase in government consumption should raise P_t^N and thus result in a real appreciation.[31]

[31] Note that this argument requires to assume the existence of some type of market friction. As shown in our presentation of the Balassa-Samuelson model, the composition of demand does not affect the price of non-tradables if goods and factor markets are characterized by perfect competition and if the economy has access to a perfect international capital market.

– The *extent of competition* is another potential determinant of national price levels and thus of the real exchange rate. If the domestic market is characterized by barriers to entry and trade restrictions, this drives up prices, resulting in a real appreciation.

If any of these magnitudes changes, the equilibrium real exchange rate adopts a new value. A proper identification of these fundamental determinants, combined with the correct estimation of their quantitative influence thus allows determining the equilibrium real exchange rate as a (potentially time-varying) predicted value.[32] More specifically, the above arguments define a set of variables that can be used in a (linear) ***regression equation***

$$Q_{it} = \boldsymbol{\beta}' \mathbf{X}_{it} + \varepsilon_{it}, \tag{7.31}$$

where Q_{it} is the real effective exchange rate of country i in period t, $\mathbf{X}_{it}$ is a (column) vector of potential determinants, $\boldsymbol{\beta}'$ is a (row) vector of parameters to be estimated, and ε_{it} is a zero-mean error term.[33] Once one has arrived at a set of estimates $\hat{\boldsymbol{\beta}}$, one can compute the predicted value $\hat{Q}_{it} = \hat{\boldsymbol{\beta}}' \mathbf{X}_{it}$, which can be interpreted as the equilibrium real exchange rate for country i in period t.

VII.6.4 External Balance and the Real Exchange Rate

The approach to identifying the equilibrium real exchange rate that we presented in the preceding subsection went beyond PPP by acknowledging that the real exchange rate is not necessarily constant, even in the long run. Based on this insight, it brought forward a number of candidate determinants that were likely to change a country's relative price structure and thus the real exchange rate. While this procedure may have considerable explanatory power, it suffers from two important shortcomings: first, it does not explicitly account for the fact that – e.g. via its effect on net exports and the current account – the real exchange rate is tied into a system of structural relationships that interact with each other. Second, while the approach is able to identify fundamental driving forces of the real exchange rate, it does not take a stand on whether, at any given point in time, these determinants are at a sustainable or desirable level.

[32] This approach is sometimes called the ***behavioral equilibrium exchange rate (BEER) model*** (see Clark and MacDonald, 1998).

[33] Using such a ***panel data set***, which combines time series on real exchange rates for different countries, comes with numerous advantages. However, it also imposes the constraint that all the currencies that enter the sample are characterized by identical structural relationships with their fundamental determinants. Note also that researchers usually turn variables into logarithms before estimating equation (7.31).

To meet these shortcomings, the International Monetary Fund (IMF) has developed an approach to empirically identify the value of the real exchange rate that is compatible with observed fundamentals – some of which are policy variables – and to derive the value that *should* emerge if these policy variables adopted an "appropriate" level. This approach is integrated into the IMF's ***External Balance Assessment (EBA) methodology***, which is based on the following two equations:[34]

$$S(\mathbf{X}_{\mathbf{S},it}) - I(\mathbf{X}_{\mathbf{I},it}) = CA(Q_{it}, \mathbf{X}_{\mathbf{CA},it}) \tag{7.32}$$

$$CA(Q_{it}, \mathbf{X}_{\mathbf{CA},it}) + KA(\mathbf{X}_{\mathbf{KA},it}) = FA(\mathbf{X}_{\mathbf{FA},it}) \tag{7.33}$$

Equation (7.32) takes us back to the insight that the current account reflects the difference between national savings and national investment. The vectors $\mathbf{X}_{\mathbf{S},it}$ and $\mathbf{X}_{\mathbf{I},it}$ represent the determinants of savings and investment, some of which we have identified in Chapters III and IV. For example, we would expect a country's current account to increase in its relative income level, and to decrease in its government budget deficit and age-dependency ratio. The right-hand side of equation (7.32) accounts for the fact that – in particular, via net exports – the current account balance depends on the real exchange rate. Other variables that have the potential to shift the current account at a given real exchange rate – e.g. exogenous changes in primary or secondary income – are captured by the vector $\mathbf{X}_{\mathbf{CA,it}}$. Equation (7.33) is the balance of payments equilibrium condition and stipulates that the balances on the current and capital accounts have to equal the balance on the financial account. Again $\mathbf{X}_{\mathbf{KA},it}$ and $\mathbf{X}_{\mathbf{FA},it}$ are vectors of variables that shift the capital account and the financial account, respectively – e.g. variations in a country's creditworthiness. Starting from equations (7.32) and (7.33), there are two alternative – but closely related – ways to proceed.

The first approach suggested by the IMF exploits both expressions (7.32) and (7.33) to arrive at a reduced-form equation

$$Q_{it} = Q(\mathbf{X}_{\mathbf{S},it}, \mathbf{X}_{\mathbf{I},it}, \mathbf{X}_{\mathbf{CA},it}, \mathbf{X}_{\mathbf{KA},it}, \mathbf{X}_{\mathbf{FA},it}) \tag{7.34}$$

[34] The EBA methodology builds on the "***macroeconomic balance approach***" used by the IMF in previous analyses, on the reduced-form ("BEER") approach presented in the preceding subsection, as well as on the ***fundamental equilibrium exchange rate (FEER)*** approach advocated by Wren-Lewis (1992) and Williamson (1994). The FEER model, in particular, also suggests to combine insights on the relationship between the real exchange rate and the current account with the notion of external and internal balance.

This expression defines the real exchange rate as a variable that is driven by all the forces that affect national savings, investment, the current account, the capital account and the financial account. It suggests estimating an equation that includes variables which affect the real exchange rate both directly – e.g. the commodity terms of trade – and indirectly – e.g. financial development, population growth etc. As such, this method is quite similar to the "reduced form" approach presented in Subsection VII.6.3. However, there are two crucial differences: first, the set of variables that enters the regression equation explicitly accounts for the fact that the real exchange rate is affected by variables that matter due to their impact on savings and investment as well as the availability of foreign financial resources. Second, the EBA approach distinguishes between the ***residual*** – i.e. the difference between the observed real exchange rate and the level predicted by the regression – and a "***policy gap***". The policy gap, in turn, is the difference between the level predicted by the regression and the level of Q_{it} that emerges for levels of policy variables that are considered "appropriate" – e.g. since they guarantee long-run fiscal sustainability. As such, the IMF goes beyond a mere description of the equilibrium real exchange rate as the value that can be explained on the basis of observable fundamentals, but adds a normative component by relating the equilibrium real exchange rate to the *appropriate* level of these fundamentals. More specifically, the observed real exchange rate is decomposed as follows:

$$Q_{it} = \hat{\boldsymbol{\gamma}}'\mathbf{Z}_{it} + \hat{\boldsymbol{\beta}}'\mathbf{X}^*_{it} + \hat{\boldsymbol{\beta}}'\left(\mathbf{X}_{it} - \mathbf{X}^*_{it}\right) + e_{it} \tag{7.35}$$

In this equation, $\mathbf{Z}_{it}$ represents a column vector of variables that are not under the control of policymakers, and the row vector $\hat{\boldsymbol{\gamma}}'$ consists of the estimated coefficients for these regressors. $\mathbf{X}^*_{it}$ are the *appropriate* levels of the policy variables, and e_{it} are the regression residuals. The deviation of the actual policy variables from their appropriate levels (multiplied by the estimated coefficients) $\hat{\boldsymbol{\beta}}'\left(\mathbf{X}_{it} - \mathbf{X}^*_{it}\right)$ is the policy gap. The observed real exchange rate is thus the sum of its "appropriate" equilibrium level $\hat{Q}^*_{it} = \hat{\boldsymbol{\gamma}}'\mathbf{Z}_{it} + \hat{\boldsymbol{\beta}}'\mathbf{X}^*_{it}$, the policy gap, and the (unexplained) residual e_{it}.

The second approach suggested by the EBA methodology identifies the real exchange rate gap as a function of the ***current account gap***. The current account gap, in turn, is determined by first running a regression that relates the current account balance of country i at time t to a number of potential determinants of savings, investments, and international capital flows – i.e. on the variables that enter equations (7.32) and (7.33). While some of these determinants are exogenously given, others are the result of deliberate policy choices. For the latter set of variables, the IMF defines levels that it considers appropriate. For country i at time t, the current account gap is the difference between the current account that is actually observed (CA_{it}) and the current account that the estimation would predict if all policy variables were at their appropriate levels ($\hat{CA}_{it}^{*,EBA}$) – i.e., once more, the sum of the "policy gap" and the regression residual. Finally, the estimated real exchange rate gap $\hat{Q}_{it}^{gap,EBA}$ for country i at time t is implicitly defined by $\hat{CA}_{it}^{gap,EBA} = CA(\hat{Q}_{it}^{gap,EBA})$, where $\hat{CA}_{it}^{gap,EBA} = CA_{it} - \hat{CA}_{it}^{*,EBA}$ is the estimated current account gap and $CA(Q_{it})$ is a function that relates the current account to the real exchange rate.

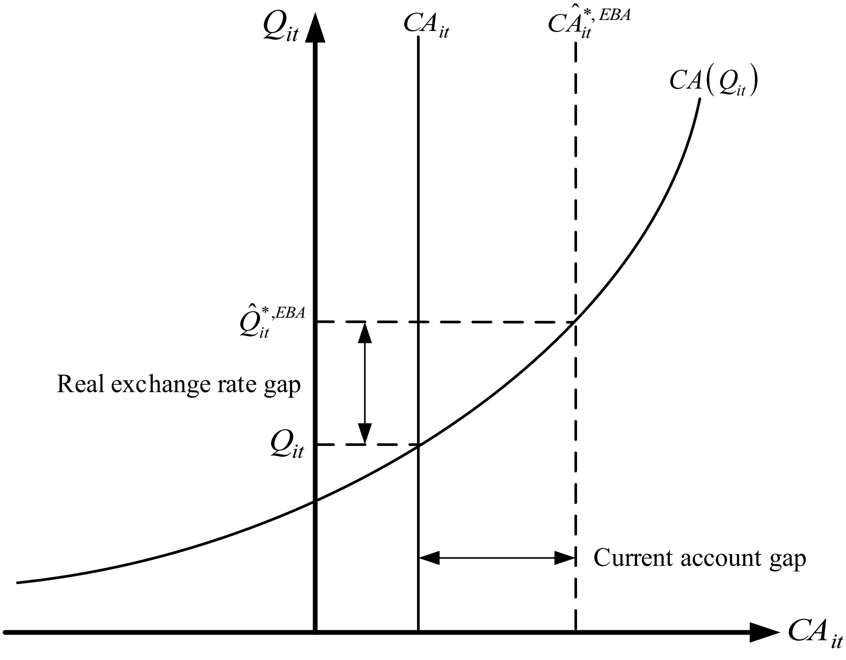

Figure 7.11: Identifying the real-exchange rate gap using the current-account gap.

The essence of this idea is illustrated by Figure 7.11: the difference between the vertical lines CA_{it} and $\hat{CA}_{it}^{*,EBA}$ represents the current account gap. By using the upward-sloping line, which reflects the positive relationship between the real exchange rate and the current account balance, one can identify the sign and size of the real exchange rate gap.[35]

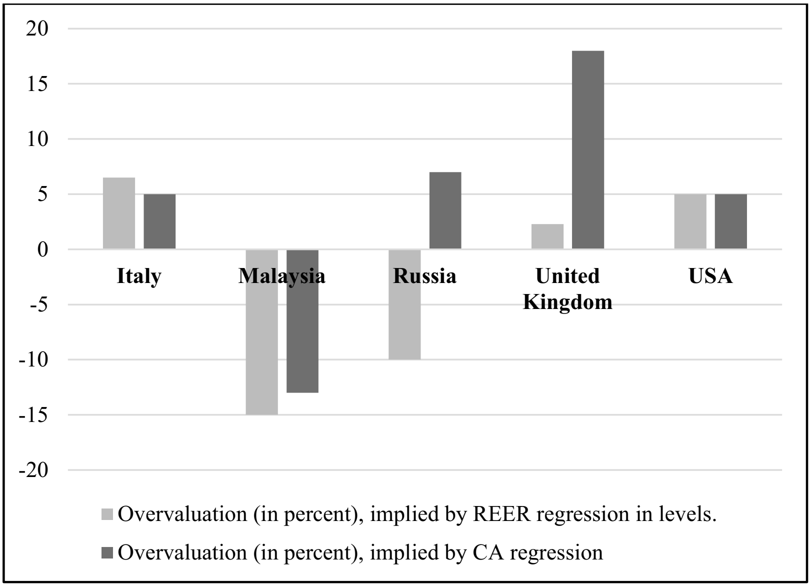

Figure 7.12: Real effective exchange rate (REER) gaps from the IMF's External Balance Assessment (EBA). Gaps are either based on the real exchange rate regression or on the current account regression. Positive values indicate overvaluations (in percent), negative values indicate undervaluations. Source: IMF (2015b)

Figure 7.12 presents the estimated real exchange rate gaps (in percent) based on the two variants of the EBA methodology published by the IMF in its 2015 *External Sector Report*. The numbers refer to the year 2014, and positive (negative) values represent an overvaluation (undervaluation). While the two approaches point in the same direction for some economies, they differ strikingly for others. In particular, the real exchange rate gap based on the REER regression suggests a real undervaluation for the Russian ruble, while the real exchange rate gap implied by the current account gap implies an overvaluation. For the United Kingdom, the two assessments do not differ with respect to their

[35] As a complementary approach to computing $\hat{CA}_{it}^{*,EBA}$ by running a regression and plugging in appropriate policy variables, the IMF suggests to compute the current account that is compatible with "***external sustainability***", i.e. that stabilizes the net international investment position.

sign, but with respect to their size. While this is certainly a confusing observation, the reader should not take it as yet further proof of the dismal state of economics: in many situations, there just isn't a single correct approach to the truth that unambiguously dominates all others. Instead, knowledge should be acquired by adopting multiple perspectives, and we should be ready to accept possibly contradictory pieces of information.

Obviously, the two variants of the EBA methodology also have their specific shortcomings: in particular, they suffer from the fact that the size of the residuals in the real exchange rate and current account regressions crucially depends on the set of variables included in these regressions. While the IMF is careful to motivate the specification of its empirical model, any omission not only results in biased estimates, but also increases the "unexplained" part of the real exchange rate, and thus the real exchange rate gap. In addition, the policy gaps identified for different countries hinge on the IMF's assessment of what is "appropriate". Such a statement, of course, cannot be made on technical grounds alone and opens the door to subjective perceptions and miscalculations. Moreover, the approach that identifies real exchange rate gaps on the basis of current account gaps heavily relies on a robust relationship between the real exchange rate and the current account. Finally, it can be questioned whether it is reasonable to base assessments on the results of a real exchange rate equation and a current account equation whose estimated coefficients are imposed on a very heterogeneous set of countries.

However, the many shortcomings of the EBA methodology should not mask its conceptual virtues: Most importantly, the approach acknowledges that both the real exchange rate and the current account are endogenous variables, which react to the many forces that change the structure of prices within and across countries. Moreover, the approach uses the simple, yet plausible and robust theoretical structure that is summarized by equations (7.32) and (7.33) to identify the potential determinants of real exchange rates. Some of these variables – e.g. the commodity terms of trade – directly emerge from the definition of the real exchange rate, others reflect the fact that the current account is determined by savings, investment and financing decisions, and that, in equilibrium, the real exchange rate has to be compatible with these choices. Finally, the EBA methodology takes into account that an adjustment of the real exchange rate may be necessary even if all its fluctuations may be traced back to fundamental determinants. By splitting the total "REER gap" into the regression residual – the part that cannot be explained – and a "policy gap" that emerges from unsustainable or non-desirable policy choices, it may suffer from mistaken judgements, but it also provides some valuable normative guidance.

VII.7 Summary and Outlook

This chapter has introduced the real exchange rate and analyzed the forces that determine both the level and the rate of change of this important macroeconomic variable. We have presented the theory of purchasing power parity, which stipulates that the real exchange rate equals a constant value – possibly one – at least in the long run. We have then identified several mechanisms – productivity increases, windfall income gains, terms of trade fluctuations – that generate real appreciations and depreciations which cannot be interpreted as temporary deviations from a stable long-run equilibrium. Finally, we have shown that our knowledge about the relationship between the real exchange rate and the current account can be combined with our notion of the current account as a mirror of agents' saving, investment and financing decisions. This approach allowed us to derive an "equilibrium real exchange rate" that is compatible with balance of payments equilibrium. Moreover, it added a normative perspective by determining the real exchange rate that would emerge if all policy variables were at appropriate/desirable levels.

Due to their focus on the *real* exchange rate – i.e. the relative price of "foreign goods" in terms of "domestic goods" – the past sections were closely related to the first chapters of this book. The nominal exchange rate had some rare appearances when we defined the real exchange rate or when we identified nominal exchange rate fluctuations (in combination with delayed price adjustment) as a source of real exchange rate fluctuations. However, we did not explain which policy choices and market mechanisms give rise to a particular nominal exchange rate.

In the following chapter, we will take on this task and focus on the determinants of the nominal exchange rate. In this context, we will analyze the conduct and the effects of national monetary policies and demonstrate that the nominal exchange rate is crucially determined by expectations about the future.

VII.8 Keywords

Appreciation
Balassa Samuelson model
Consumer price index (CPI)
Depreciation
Dutch disease
Effective exchange rate
External Balance Assessment (EBA)
Home bias in consumption
International Comparison Program
J-curve
Law of one price (LOP)
Local currency pricing
Marshall-Lerner condition
PPP-adjustment
Price competitiveness

Price notation
Pricing to market
Producer currency pricing
Producer price index (PPI)
Purchasing power parity (PPP)
Quantity notation
Real exchange rate
Stationarity
Terms of Trade
Unit labor costs (ULC)
Unit root

VII.9 Literature

The decomposition of the real exchange rate presented in this chapter is based on Chinn (2006) and Egert et al. (2006). Dornbusch (1987) and Rogoff (1996) offer classical treatments of purchasing power parity, while Taylor and Taylor (2004) provide a more recent summary of the empirical research on this topic. A fairly comprehensive survey of our theoretical and empirical knowledge about the real exchange rate is offered by Burstein and Gopinath (2014), while Sarno and Taylor (2002) as well as MacDonald (2007) represent excellent monographs on the topic. Lutz (2004) describes the problems involved in international price comparisons and highlights the role of non-tradable goods. Marsh and Tokarick (1996) and Bundesbank (2007) discuss the question of whether the real exchange rate can be used as a measure of price competitiveness. Different approaches to performing international income comparisons are discussed by Neary (2004), Deaton and Heston (2010) as well as Feenstra et al. (2015). Ricci et al. (2013) provide an exemplary empirical analysis of the determinants of the real exchange rate, while Phillips et al. (2013) present the IMF's External Balance Assessment (EBA) methodology. Bussière et al. (2010) survey alternative approaches to compute equilibrium exchange rates, while Schnatz (2011) offers a critique of the IMF's approach.

VII.10 Exercises

7.1. Relative purchasing power parity. Suppose that there are two countries (H and F), whose inhabitants consume two goods (A and B), and whose consumer price indices (CPI) are given by the following equation:

$$P_t^c = \left(P_t^{A,c}\right)^{\gamma_c} \left(P_t^{B,c}\right)^{1-\gamma_c} \qquad \text{with } c = H, F$$

Note that we allow the weights of the two goods to differ across countries. The law of one price does not necessarily hold. However, we assume that price differences are constant over time, i.e.

$$P_t^{j,H} = \varphi^j E_t P_t^{j,F} \qquad \text{with } j = A,\, B \text{ and } \varphi^j \neq 0\,.$$

In this equation, E_t denotes the nominal exchange rate (country-*H* currency units per country-*F* currency unit).

Show that the theory of relative purchasing power parity holds regardless of the values of γ^c and φ^j if within-country *relative* prices $P_t^{A,c} / P_t^{B,c}$ do not vary over time.

7.2. The J-curve. Backus et al. (1994) offer an interpretation of the J-curve that does not focus on delayed quantity adjustments, but on the consequences of real productivity shocks. Try to get the intuition: what are the short-run and long-run effects of a positive productivity shock on the terms of trade and the current account? Use the intertemporal approach presented in Chapters III and IV to develop an answer.

7.3. Price competitiveness and markups. In Subsection VII.5.2, we discussed the possibility to compute the real exchange rate on the basis of producer price indices (PPI) or unit labor costs (ULC). To understand the implications of these alternative choices, assume that the marginal product of labor is constant such that the production function of the representative firm in country c can be written as $Y_t^c = AL_t^c$, with $c = H, F$. In both countries, firms set their prices by multiplying marginal costs with a markup $\left(1 + \mu_t^c\right)$.

a) Use the above assumptions and show that the following equation characterizes the relationship between the PPI-based and the ULC-based real exchange rate:

$$q_t^{ULC} = q_t^{PPI} + \ln\left(1 + \mu_t^H\right) - \ln\left(1 + \mu_t^F\right)$$

b) Assume that all goods are tradable without frictions, such that the LOP applies. What interpretation of an increasing "cost competitiveness" does the expression in part a) suggest?

7.4. The World Bank "Atlas method". The World Bank presents data on countries' per-capita incomes in different versions. The World Bank Atlas method amounts to transferring national per-capita income figures in local currency units (LCU) into US dollars (USD) by using a weighted average of market exchange rates.[36] For country c this implies

$$y_t^{c,USD} = y_t^{c,LCU} / E_t^{c,Atlas}$$

with the "Atlas conversion factor" $E_t^{c,Atlas}$ being based on the following equation:

$$E_t^{c,Atlas} = \frac{1}{3}\left[E_{t-2}\left(\frac{P_t^c}{P_{t-2}^c}\frac{P_{t-2}^{Ind}}{P_t^{Ind}}\right) + E_{t-1}\left(\frac{P_t^c}{P_{t-1}^c}\frac{P_{t-1}^{Ind}}{P_t^{Ind}}\right) + E_t\right]$$

P_t^c represents the GDP deflator in country c, while P_t^{Ind} represents a weighted average of GDP deflators in the Euro area, Japan, the United Kingdom and the USA.

Explain which of the problems that one encounters when performing international income comparisons are solved by this method, and which remain unresolved.

7.5. PPP adjustment in Luxembourg. In Figure B7.5, there is one point that represents a very rich country for which the PPP adjustment lowers per capita GDP by merely three percent. This country is Luxembourg. Explain why it is plausible that the PPP adjustment hardly affects this country's relative income position.

7.6. The Gerschenkron effect. Suppose that there are two countries (H and F) that both produce two goods (A and B). Due to high trade barriers, goods prices differ across countries. The prices P_j^c and quantities produced X_j^c, with $c = H, F$ and $j = A, B$ are $P_A^H = 10, P_B^H = 20, P_A^F = 20, P_B^F = 10$ as well as $X_A^H = 200,\quad X_B^H = 100, X_A^F = 100, X_B^F = 200$.

a) Which country has the higher income if the quantities produced are evaluated at prices prevailing in country H? Which country has the higher income if the prices prevailing in country F are used?[37]

[36] The term ***Atlas method*** refers to the use of the resulting numbers in the World Bank's *Atlas of Global Development*.

[37] The result that international income disparities are the higher, the greater the differences in countries' structure of relative prices, is called Gerschenkron effect, after the Russian economist Alexander P. Gerschenkron, (1904-1978).

b) Interpret your result and describe how the above information can be used to perform international income comparisons without risking the potential distortion revealed by part a).