Chapter 8: International Trade

This Chapter starts by outlining the theory and practice of international trade. It then presents a simple model of trade between one country and the rest of the world, focusing on the determination of exchange rates. Five countries are used as examples, two with floating exchange rates and three in the Eurozone. Four scenarios are examined: inflation, depreciation, exogenous change in demand for exports, and the impact of fiscal policy changes. The model focuses on dynamics. Even this simple model serves to highlight the difficulty of modelling the dynamics of international trade. It also clearly shows the constraints under which Eurozone countries operate.

Key words: capital mobility, closed economy, Eurozone, exchange rates (effective, nominal and real), exchange rate regimes (fixed, floating), interest rate parity, J-curve, open economy, purchasing power parity, Trilemma, UK pounds, US dollars.
Introduction

‘The archaeological record demonstrates that our Ice Age ancestors were already trading tens of thousands of years ago Cro-Magnon sites…contain Baltic amber and Mediterranean seashells transported thousands of miles inland’ (Diamond, 2012, p.60). Today, international trade is vital to the health of the world economy. Exports accounted for 29 per cent of the GDP of the OECD countries in 2012; and for the UK, it was 32 per cent. But there is great variation between countries, as shown in Table 8.1. At one extreme, the USA and Japan are relatively closed economies with low levels of international trade, while at the other extreme, the Netherlands and Belgium are very open economies.

Table 8.1: International imports and exports in goods and services as per cent of GDP (2012).

<table>
<thead>
<tr>
<th></th>
<th>Imports</th>
<th>Exports</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>17</td>
<td>14</td>
</tr>
<tr>
<td>Japan</td>
<td>17</td>
<td>15</td>
</tr>
<tr>
<td>Greece</td>
<td>32</td>
<td>27</td>
</tr>
<tr>
<td>China</td>
<td>25</td>
<td>27</td>
</tr>
<tr>
<td>UK</td>
<td>34</td>
<td>32</td>
</tr>
<tr>
<td>Switzerland</td>
<td>42</td>
<td>52</td>
</tr>
<tr>
<td>Germany</td>
<td>46</td>
<td>52</td>
</tr>
<tr>
<td>Netherlands</td>
<td>80</td>
<td>88</td>
</tr>
<tr>
<td>Belgium</td>
<td>85</td>
<td>86</td>
</tr>
<tr>
<td>Eurozone</td>
<td>43</td>
<td>46</td>
</tr>
<tr>
<td>All EU</td>
<td>43</td>
<td>45</td>
</tr>
<tr>
<td>OECD</td>
<td>30</td>
<td>29</td>
</tr>
<tr>
<td>OECD (2014)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The study of international trade is a vast area exploring why countries trade and how is it managed. In this Chapter, we focus on exchange rates, and in particular, the UK pound, the US dollar and the euro. We start with a brief introduction. (For more introductory level explanations, see Begg et al. (2011); more for advanced material, Feenstra & Taylor (2011) and with particular reference to the Eurozone, Baldwin & Wyplosz (2012).)

Definition of exchange rates

An exchange rate is the price of one currency in units of another currency. We start by explaining how nominal exchange rates are expressed, and how effective and real exchange rates are calculated.
Nominal exchange rates
The term ‘exchange rate’ means the rate at which a given pair of currencies is exchanged. An exchange rate can be expressed in one of two ways, as illustrated in Box 8.1. It is essential to be clear which rate is being used at any one time. The shorthand convention adopted in this Chapter is that, for example, €/£ means the number of euros that can be bought for one pound. This is the exchange rate that people use when they travel.

Box 8.1: Definition of exchange rates.

<table>
<thead>
<tr>
<th>Let us take the exchange rate between the euro (€) and the British pound (£).</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The international value of domestic currency is the quantity of foreign currency per unit of domestic currency: for example, for a UK resident 1.3€/£.</td>
</tr>
<tr>
<td>• The domestic price of foreign exchange is the quantity of domestic currency per unit of foreign currency: for example, for a UK resident, it is £1/1.3€ or £0.77/€.</td>
</tr>
</tbody>
</table>

Example:

- The UK imports a car from, say, Germany, that costs €30 000.
  The exchange rate is the UK domestic price of foreign exchange: £0.77/€.
  The cost of the car in the UK is €30 000 x 0.77 = £23 100.

- Germany imports a car from the UK that costs £23 100.
  The exchange rate is the international value of the UK’s currency: 1.3€/£.
  The cost of the car in Germany is £23 100 x 1.3 = 30 000€.

(For more details, see Begg et al. (2011, pp.549-550) and Feenstra & Taylor (2011, pp.422-425).)

Effective exchange rates
However, for economic analysis the exchange rate between one pair of currencies provides limited information because countries trade with many others. The effective exchange rate takes this into account. It is the average based on a basket of exchange rates in which each rate is weighted according to the extent to which the pair of countries trade. It is therefore a measure of the overall purchasing power of a currency. Of course trading patterns change over time and so the effective exchange rate will vary according to which weights are used. For more on effective exchange rates, see Begg et al. (2011, pp.551-552) and the Bank of England (2014).

Real exchange rates
So far, we have discussed nominal exchange rates. In contrast, the real exchange rate compares the price of a basket of goods and services in two countries by expressing them in the same currency. It is determined by prices in each of the countries and the nominal
exchange rate. If a country’s real exchange rate falls, that country becomes more competitive because its goods are cheaper to buyers in the other country. That can come about if prices fall in that country, if prices rise in its trading partner or if the nominal exchange rate falls. For the real exchange rates to be constant if prices rise in a country, the exchange rate must fall so that its currency buys less foreign currency. Box 8.2 shows an example.

**Box 8.2: Calculation of real exchange rate.**

The real exchange rate is defined as:

\[
\frac{\text{Home prices} \times \text{international value nominal exchange rate}}{\text{Foreign prices}}
\]

Assume that a basket of goods that costs £100 in the UK costs 125€ in the Eurozone and that the international exchange rate is 1.3€ /£.

Expressed in euros the real exchange rate is:

\[
\frac{\text{Price of UK basket in €}}{\text{Price of Eurozone basket in €}} = \frac{\£100 \times 1.3}{125} = 1.04
\]

Or expressed in UK pounds the real exchange rate is:

\[
\frac{\text{Price of UK basket in £}}{\text{Price of Eurozone basket in £}} = \frac{\£100}{125€ \times 0.77} = 1.04
\]

If prices in the UK rose by 10 per cent, and nothing else changed, then the real exchange rate would rise by almost 10 per cent, making the UK less competitive:

\[
\frac{\£110 \times 1.3}{125€} = 1.14
\]

The nominal exchange rate needs to fall by almost 10 per cent to 1.18€ /£ to restore the real exchange rate.

\[
\frac{\£110 \times 1.18}{125€} = 1.04
\]

Such a change in the nominal exchange rate would represent a depreciation in the pound, improving the UK’s balance of trade by reducing the cost of UK products in the Eurozone and making UK’s imports from the Eurozone more expensive.

(For more, see Begg et al. (2011, pp.556-557) or Feenstra & Taylor (2011, pp.462-463).)
**Purchasing power parity**

If the real exchange rate exceeds one, the currency is said to be ‘overvalued, as shown in the example in Box 8.2; when it is less than one, ‘undervalued’. When the real exchange rate equals one, there is said to be purchasing power parity (PPP). In other words, there is said to be PPP when the price of a basket of goods in one country is the same as in another when expressed in a common currency. Mathematically, there is PPP when the nominal exchange rate between two currencies equals the ratio of prices in the two countries. The principle of PPP proposes that prices in trading countries tend to converge over time due to market forces. Box 8.3 explains further and provides an example.

**Box 8.3: Purchasing Power Parity.**

\[
\text{Real exchange rate} = \frac{\text{Home prices} \times \text{international value nominal exchange rate}}{\text{Foreign prices}}
\]

Setting the real exchange rate to 1 and re-arranging gives:

\[
\text{International value nominal exchange rate} = \frac{\text{Foreign prices}}{\text{Home prices}}
\]

For example, if a basket of goods costs £100 in the UK and 120€ in the Eurozone, then there would be PPP if the international value nominal exchange rate of UK pounds was 1.2. This is known as the PPP exchange rate.

(For more, see Begg et al, 2011, p.557.)

The concept of PPP is regarded as useful because if prices are to converge, then the real exchange rate should move towards 1 and this expectation can be used to forecast future exchange rates. However, evidence suggests that in the short run real exchange rates are very variable. This is illustrated in Box 8.4. In the short run, the difference between relative price levels and exchange rates can differ by 20 per cent or more. There are many reasons for this discrepancy: for example, not all goods are traded, there are transport costs and it can take time for contracted prices to adjust. Convergence to PPP is very slow, at 15 per cent a year. (Feenstra & Taylor, 2011, pp.466-468; Rogoff, 1996.)
Box 8.4: Comparative Price Levels.

The table shows a selection of OECD estimates of Comparative Price Levels (CPL) on a monthly basis to provide measures of differences in price levels between countries. CPLs are defined as the ratios of PPPs for private final consumption expenditure to exchange rates. Each column shows the number of specified monetary units needed in each of the countries listed to buy the same representative basket of consumer goods and services. In each case the representative basket costs a hundred units in the country whose currency is specified.

Examples of comparative price levels, September 2014

<table>
<thead>
<tr>
<th></th>
<th>Germany</th>
<th>Greece</th>
<th>Netherlands</th>
<th>United Kingdom</th>
<th>United States</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EUR</td>
<td>EUR</td>
<td>EUR</td>
<td>GBP</td>
<td>USD</td>
</tr>
<tr>
<td>Germany</td>
<td>100</td>
<td>114</td>
<td>93</td>
<td>83</td>
<td>106</td>
</tr>
<tr>
<td>Greece</td>
<td>87</td>
<td>100</td>
<td>81</td>
<td>73</td>
<td>92</td>
</tr>
<tr>
<td>Netherlands</td>
<td>108</td>
<td>123</td>
<td>100</td>
<td>90</td>
<td>114</td>
</tr>
<tr>
<td>United Kingdom</td>
<td>120</td>
<td>137</td>
<td>111</td>
<td>100</td>
<td>127</td>
</tr>
<tr>
<td>United States</td>
<td>95</td>
<td>108</td>
<td>88</td>
<td>79</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: OECD (2014a)

Comparison of prices in the UK and the USA

The column for the UK shows 79 for the USA, meaning that you would spend £79 in the USA to buy a basket of goods and services that would cost £100 in the UK. Conversely, the column headed USA shows that a basket of goods in the USA costing $100, would cost $127 in the UK. This implies that for PPP, the exchange rate should be $1.27 per £. In fact the average daily spot price during that month was $1.63 per £ (Bank of England, 2014).

Comparison of Eurozone prices

The column for the UK shows 83 for Germany, meaning that you would spend £83 in Germany to buy a basket of goods and services that would cost £100 in the UK. Conversely, a basket of goods in Germany costing 100€, would cost 120€ in the UK. This implies that for PPP, the exchange rate should be 1.20€ per £. In fact the average daily spot price during that month was 1.2678€ per £ (Bank of England, 2014), fairly close to the PPP exchange rate.

But for Greece, the position is quite different: you would spend £73 in Greece to buy a basket of goods and services that would cost £100 in the UK, implying a PPP exchange rate of 1.37€ per £. But being in the Eurozone, Greece has the same exchange rate as Germany, 1.2678€ per £.

While prices in Greece are clearly lower than in Germany, prices in the Netherlands are higher: a basket costing 100€ in the Netherlands would cost only 93€ in Germany and 81€ in Greece. Despite all three countries – Germany, Greece and the Netherlands – being in the Eurozone, prices differ markedly.
Interest rate parity

In the same way that trading tends to equalise prices across countries, free movement of capital tends to equalise interest rates. With the free movement of capital, investors will seek to put their money where the return is best. If one country has a higher interest rate than another, funds will flow into the country with the higher interest rate causing the exchange rate to appreciate. Once the exchange rate has risen so high that it is expected to depreciate sufficiently over the term of the investment to offset the gain from the higher interest rate, interest rate parity will have been reached and the capital flows will stop. So when investors consider putting their money in another currency, they must also take into account the possibility of changes in the exchange rate. For example, if an investor could earn 4 per cent in another country and only 2 per cent in their own country, then they will move their funds provided that they did not expect to lose their gain from the higher interest rate through a change in the exchange rate. The market will ensure that interest rate parity is quickly established. (For more, see Baldwin & Wyplosz (2012, p.363); Begg et al. (2011, pp.561-562).)

Exchange rate regimes

Exchange rates are determined by the intersection of supply and demand for currencies. How that works depends on which exchange rate regime is being used. Exchange rate policy options are summarised by what has become known as ‘the Trilemma’. For financial stability, a government can choose two, and only two, of the following three options:

- fix the exchange rate
- set the interest rate
- permit free movement of capital.

If a government tries to have all three, a financial crisis ensues such as happened in the UK in 1992. The UK Government tried to have a semi-fixed exchange rate – by committing the pound to the Exchange Rate Mechanism (ERM), a precursor of the euro – and set its own interest rates and allow capital to move freely. This proved unsustainable and the UK had to leave the ERM.
Currently, in 2014, the UK, the Eurozone and the USA allow their exchange rates to float and permit free movement of capital. This, briefly, is how it works. A firm in the UK wants to import, say, a car from Germany, and the German exporter will want to be paid in euros, so the UK firm has to exchange pounds for euros i.e. to buy euros. Conversely a German firm wanting to import, say, machinery from the UK, exchanges euros for pounds i.e. buys pounds. However, as there is free movement of capital, the demand and supply of currency is not only affected by trade but also by financial flows. Investors seek the best returns globally. So if, for example, a UK investor wants to buy US treasury bonds, the investor will buy US dollars in exchange for UK pounds, increasing the demand for US dollars. Thus the demand for a currency will be determined by those wishing to buy from the country or invest in it and the supply, by those in the country who want to buy goods from or invest abroad. Buyers and sellers are brought together in the foreign exchange market, which is ‘one of the largest and most liquid markets in the world’. The market sets ‘spot’ prices, (or ‘fixes’) to establish the relative value of two currencies. Forty per cent of the global foreign exchange trading takes place in London (FCA, 2014).

With a floating exchange rate, any deficit in the current account will be offset by capital movements on the financial account, as it is in the UK. (See Box 8.5.) If a country has a trade deficit, it can balance its books by its central bank raising interest rates to attract an inflow of capital. To summarise, with floating exchange rate and capital mobility, the country’s central bank fixes its interest rate and the exchange rate is established by the market. However, in 2014 interest rates are close to zero in many countries, including the UK, the Eurozone and the USA and have been since 2008 in order to stimulate their economies and so cannot be used as a policy instrument to manage exchange rates. (For more on these issues, see Feenstra & Taylor, 2011, pp.519-521 & 687-691.)

In the past, fixed exchange rates were more usual in Western economies. Up to the First World War and again at times in the 1920s and early 1930s, many countries were on the Gold Standard. Under the Gold Standard, the value of currencies were expressed in terms of gold. There were no restrictions on the movement of capital and the central banks had no freedom to adjust the money supply – and thus determine their interest rates – because money had to be backed by gold.
After the Second World War the Gold Standard was replaced by the Bretton Woods arrangements that lasted until the early 1970s. Exchange rates were fixed, although subject to occasional revaluations or devaluations. If exchange rates are fixed, and free movement of capital is allowed, the country’s interest rate will be determined by the market as investors seek the best returns globally. Because countries wanted fixed exchange rates and to be able to set their own interest rates, under the Bretton Woods arrangements, capital mobility was severely restricted. Central banks had to buy or sell their currency to ensure that the markets cleared.

While the currency of the Eurozone as a whole floats, the situation of individual states in the Eurozone is different because their exchange rate is fixed. A Eurozone country has to accept whatever value is established in the market by the floating euro, and this is determined by what is happening in all the other Eurozone countries. The European Central Bank sets the interest rate for the Eurozone as a whole and capital can flow freely. Eurozone countries are therefore left with only fiscal policy – public spending and taxation – to manage their economies.

The three options and the various systems that have been used are summarised in Figure 8.1.

(For more on exchange rate regimes and the Trilemma, see, Begg et al. (2011, Chapter 29), Feenstra & Taylor (2011, pp.540-544) and with specific reference to the Eurozone, Baldwin & Wyplosz (2012, pp. 361-363 & 380-381).)
Figure 8.1: The Trilemma.

- Fix exchange rate
- Set interest rates
- Free movement of capital
- Gold standard
- Eurozone members
- Bretton Woods
- UK, USA, Eurozone as a whole
Box 8.5: The UK balance of payments.

The balance of payments account has three parts:
- current account: exports and imports of goods and services and returns on foreign investment
- capital account: the transfer of fixed assets, intangibles (such as patents) and certain other items
- financial account: sales and purchases of stocks and share and other financial assets (ONS, 2014a).

By definition, under floating exchange rates, the balance of payments must balance. In the UK, the capital account is small and the deficit on the current account is offset by the surplus on the financial account. In other words, the UK imported more than it exported and paid by selling financial assets.

An important aspect to note is that the balance on the current account actually represents a small difference between two very large numbers: in 2013, the UK exports of goods and services were worth £511 billion and its imports, £543 billion, both representing around a third of GDP as shown in Table 8.1. Thus the trade balance, being the difference between these two figures, was £32 billion, just 1.8 per cent of GDP. The rest of the current account balance, £40 billion, was accounted for by items such as net investment income.

<table>
<thead>
<tr>
<th>UK’s balance of payments for 2013</th>
<th>£ million</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current balance</td>
<td></td>
</tr>
<tr>
<td>Exports of goods and services</td>
<td>511 275</td>
</tr>
<tr>
<td>Imports of goods and services</td>
<td>543 375</td>
</tr>
<tr>
<td>Balance of trade</td>
<td>-32 100</td>
</tr>
<tr>
<td>Other changes</td>
<td>-40 295</td>
</tr>
<tr>
<td>Current account</td>
<td>-72 395</td>
</tr>
<tr>
<td>Capital balance</td>
<td>530</td>
</tr>
<tr>
<td>Financial account</td>
<td>62 592</td>
</tr>
<tr>
<td>Net errors &amp; omissions</td>
<td>9 273</td>
</tr>
<tr>
<td>Total</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: ONS (2014b)
The experience of the British pound, the US dollar and the Euro

Floating exchange rates fluctuate, especially in the short term, when the underlying fundamentals have little influence (Feenstra & Taylor, 2011, pp.530; Cheung et.al., 2004). Figure 8.2 shows how the exchange rate between the UK pounds and the Euro and the US dollar respectively have fluctuated. The top panel shows how the average annual spot rates have fluctuated since 1999.

- The €/£ exchange rate has fallen from around 1.6 to around 1.2. This drop is said to be a depreciation of the pound against the Euro (but an appreciation of the Euro) and means that UK goods are cheaper in the Eurozone, but Eurozone goods – and holidays – are more expensive for UK residents.
- The US$/£ exchange rate has varied between 1.44 and 2.00.

However, there is considerable fluctuation within years too, as shown in the bottom panel of Figure 8.2: in 2013, the Euro varied from 5 per cent above to 3 per cent below the annual average while the US dollar exchange rate varied from 5 per cent above to 6 per cent below the annual average.

As previously explained, an effective exchange rate is based on a weighted basket of currencies. As calculated by the Bank of England, the UK’s effective exchange rate fell by about a fifth between 2007 and 2013 reflecting the fall in the UK pound against the Euro and US dollar shown in the top panel of Figure 8.2. (The euro currently has a weight of 46.2 and the USA, 17.5 out of a total of 100.) Effective exchange rates for the pound, euro and US dollar are illustrated in Figure 8.3. The effective rates for both the UK pound and the US dollar have fallen while that for the Euro has increased.
Figure 8.2: Fluctuations in the exchange rates of UK pounds.

### Annual average spot exchange rate against the US dollar and Euro since 1999

![Graph showing annual average spot exchange rate against US dollar and Euro from 1999 to 2013.]

- **Exchange rate**
  - **Euro**
  - **US dollar**

### Spot exchange rates in 2013

#### Euro

- **Daily**
- **Annual average**

#### US dollar

- **Daily**
- **Annual average**

Figure 8.3: Effective exchange rates: UK, USA and Eurozone: 2000-2013.

Models

Introduction

All agent-based macroeconomic models of which we are aware have assumed that the economy is closed i.e. there is no international trade. For example, this is the case for both the EURACE model encompassing the whole of the EU (Dawid et al., 2012) and Salle et al.’s (2013) NetLogo macroeconomic model. Agent-based modelling has, however, been used to explore certain aspects of international trade. For instance, Gulden (2013) produced a NetLogo model of two economies interacting, focussing on comparative advantage and De Grauwe & Kaltwasser (2012) used an agent-based model to simulate the behaviour of individual foreign exchange traders. De Grauwe’s work (2012 & 2014) has suggested that instability and even chaos are readily generated in models of exchange rates.

Yet textbook analysis mostly focuses on comparative statics, assuming the system snaps from one equilibrium to another. (See, for example, Begg et al. (2011, pp.571-573) and Feenstra & Taylor (2011, pp.665-687).) The arguments presented are qualitative rather than quantitative, telling ‘stories’. For example, the ‘story’ told about a country with a fixed exchange rate, no capital mobility and a balance of trade deficit goes like this: raise interest rates to reduce output and imports and thus restore the balance of trade.

We have chosen to take a very simple approach to explore some of the underlying dynamics. We focus on the long-term fundamentals, rather than day-to-day fluctuations. Begg et al. (2011, pp.567) asserted that in the long run, the current account determines exchange rates. We take an even narrower view and focus on the balance of trade. For simplicity, we do not include interest rates or capital flows in our model because, as noted above, interest rates in the developed countries are currently being used to stimulate economic activity rather than manage the exchange rates.

In most agent-based models, time is measured in specific periods, such as quarters or years. In this model, the dynamic processes take place in stages. No time period is specified.

Assumptions

There are just two agents, one representing the Home country and the other, the rest of the world, or ‘World’ for short. The exchange rate therefore represents the effective exchange
rate as described above. Following the convention used earlier in the Chapter, the exchange rate means the number of units of World currency exchanged for each unit of Home currency.

In this model, the price of exports is determined by prices in the Home country and prices in the Home country do not affect the overall price level in the World. This is a simplifying assumption because the markets for some products are global and the prices are not set by a single country. Oil is the obvious example: and what can happen to the exchange rate of oil producing countries when the oil price falls was illustrated by the dramatic fall of the Russian rouble in 2014.

The Home country can be set to represent one of five countries:

- UK, which is a fairly open economy with a floating exchange rate
- USA, which also has a floating exchange rate but is a relatively closed economy
- A ‘strong’ Eurozone country, based on Germany, which is a fairly open economy with a fixed exchange rate and a balance of trade surplus.
- A ‘weak’ Eurozone country, based on Greece, which has a similar degree of openness to the UK, but a larger negative trade balance (as a proportion of GDP) and a fixed exchange rate
- An ‘open’ Eurozone country, based on the Netherlands, which has a balance of trade surplus and a fixed exchange rate.

The assumptions and initial calculated values are set out in Table 8.2. Box 8.6 explains how initial exchange rates are calculated from these data. For the Eurozone countries, the exchange rate is calculated for the Eurozone as a whole in the same way as it is for the UK and USA with their floating exchange rates. This rate is then applied to the three Eurozone countries irrespective of their individual circumstances.
Table 8.2: Model assumptions and initial values.

<table>
<thead>
<tr>
<th></th>
<th>UK</th>
<th>USA</th>
<th>Eurozone</th>
<th>Eurozone countries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Floating</td>
<td>Floating</td>
<td>Floating</td>
<td>Strong</td>
</tr>
<tr>
<td>Output (Y)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Export share (X) (1)</td>
<td>32</td>
<td>14</td>
<td>46</td>
<td>52</td>
</tr>
<tr>
<td>Import share (M) (1)</td>
<td>34</td>
<td>17</td>
<td>43</td>
<td>46</td>
</tr>
<tr>
<td>Government spending (G)</td>
<td>50</td>
<td>50</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Private domestic demand (C + I) (2)</td>
<td>52</td>
<td>63</td>
<td>n.a.</td>
<td>44</td>
</tr>
<tr>
<td>Home produced prices (3)</td>
<td>1.2</td>
<td>0.8</td>
<td>n.a.</td>
<td>1.0</td>
</tr>
<tr>
<td>Home prices index (4)</td>
<td>1.18</td>
<td>0.78</td>
<td>n.a.</td>
<td>1.03</td>
</tr>
<tr>
<td>Exchange rate (5)</td>
<td>0.885</td>
<td>1.518</td>
<td>0.935</td>
<td>0.935</td>
</tr>
<tr>
<td>Real exchange rate</td>
<td>1.040</td>
<td>1.178</td>
<td>n.a.</td>
<td>0.965</td>
</tr>
<tr>
<td>Balance of trade</td>
<td>-0.2</td>
<td>0</td>
<td>n.a.</td>
<td>2.8</td>
</tr>
</tbody>
</table>

(1) Based on Table 8.1.
(2) Calculated on the standard national accounting convention: \( Y = (C + I) + G + (X - M) \)
where \( Y \) = GDP, \( C \) = consumption, \( I \) = investment, \( G \) = Government, \( X \) = exports and \( M \) = imports
(3) Based on Box 8.4. World prices standardised to 1.
(4) Weighted average of home price of imports and prices of home produced output.
(5) Calculated as shown in Box 8.8.

n.a. = not applicable
Box 8.6: Determination of exchange rates in the model.

**Nominal exchange rate**

Demand for Home’s currency = value of Home’s exports = \( Q_H^X \times P_H^X \)
where \( Q_H^X \) = volume of Home’s exports and \( P_H^X \) = price of Home’s exports

Supply of Home’s currency = value of Home’s imports = \( Q_H^M \times P_H^M \)
where \( Q_H^M \) = volume of Home’s imports and \( P_H^M \) = price of Home’s imports

But the price of imports depends on the exchange rate and world prices i.e.
\[ P_H^M = \frac{P_W}{E_{W/H}} \]

Where \( P_W \) = world prices and \( E_{W/H} \) is the nominal exchange rate expressed as number of units of world currency exchanged for one unit of Home currency.

To balance \( Q_H^X \times P_H^X = Q_H^M \times \frac{P_W}{E_{W/H}} \)
So
\[ E_{W/H} = \frac{Q_H^M \times P_W}{Q_H^X \times P_H^X} = \frac{\text{Value of Home’s imports at World prices}}{\text{Value of Home’s exports at Home prices}} \]

**Example: UK** (from Table 8.2)
- Volume of imports \( Q_H^M = 34 \)
- World prices \( P_W = 1 \)
- Volume of exports \( Q_H^X = 32 \)
- Home prices \( P_H^X = P_H = 1.2 \) (where \( P_H \) = Home domestic prices)

**Nominal exchange rate:**
\[ E_{W/H} = \frac{Q_H^M \times P_W}{Q_H^X \times P_H^X} = \frac{34 \times 1}{32 \times 1.2} = 0.885 \]

**Real exchange rate**

The price level will be
\[ (\text{price of imports} \times \text{import share}) + (\text{price of home produced} \times (1 - \text{import share})) \]
\[ = \left( \frac{1}{0.885} \times 0.34 \right) + (1.2 \times 0.66) = 1.18 \]
So the real exchange rate is
\[ \frac{\text{Price of Home basket in World currency}}{\text{Price of World basket in World currency}} = \frac{P_H \times E_{W/H}}{P_W} = \frac{1.18 \times 0.885}{1.00} = 1.04 \]

**UK balance of trade**
- Imports: \( Q_H^M \times (P_W \times \frac{1}{E_{W/H}}) = 34 \times (1 \times 1/0.885) = 38.4 \)
- Exports = \( Q_H^X \times P_H^X = 32 \times 1.2 = 38.4 \)

Balance = exports – imports = 38.4 – 38.4 = 0
Four scenarios are specified:

- Inflation (or deflation)
- The effect of a depreciation (or appreciation)
- An exogenous change in demand for exports
- A change in fiscal policy.

The modeller can choose the size of the change and the import and the export price elasticities. All the results quoted below are based on changes of 10 per cent and price elasticities of -1. There is no stochastic element in this model. It is purely deterministic and so there is no need for multiple runs.
Inflation

We start by examining what happens if a country’s rate of inflation is higher than that of its trading partners. If Home prices rise faster than World prices, the impact on trade will depend on whether the exchange rate is floating or fixed.

If it is floating and there is no ‘stickiness’ in the adjustment of prices or the nominal exchange rate, the exchange rate will depreciate so that the World price of exports does not change. But this depreciation will increase the price of imports at Home. The effect on the balance of trade and prices at Home will depend on the price elasticity of imports. Assuming it is \(-1\), so that expenditure remains the same despite the price rise, then the quantity of imports will fall, the balance of trade will improve and output will rise. So for floating exchange rates:

- Stage 1: Export prices and exchange rate adjust
- Stage 2: Import prices rise.

For a worked example based on the UK, see Box 8.7.

However, in a Eurozone country, the exchange rate will not adjust in response to inflation in an individual country. Instead the increase in export prices is passed on to the rest of the world and results in a reduction in demand. So for Eurozone countries

- Stage 1: Export prices rise
- Stage 2: Export volumes fall.
Box 8.7: Effect of inflation with floating exchange rate.

**Initial position**

Taking the example from Box 8.6 based on the UK

- Volume of imports $Q_H^M = 34$
- World prices $P_W = 1$
- Volume of exports $Q_H^X = 32$
- Home prices $P_H^X = P_H = 1.2$ (where $P_H = $ Home prices)

Nominal exchange rate:

$$E_{W/H} = \frac{Q_H^M \times P_W}{Q_H^X \times P_H^X} = \frac{34 \times 1}{32 \times 1.2} = 0.885$$

The world price of Home’s exports is

$$P_H^X \times E_{W/H} = 1.2 \times 0.885 = 1.06$$

And so at the price of imports at Home is

$$P_H^M = \frac{P_W}{E_{W/H}} = \frac{1}{0.885} = 1.13$$

**Price rises**

**Exchange rate falls**

If Home prices rise by 10 per cent and export prices rise by 10 per cent then

$$P_H^X = P_H = 1.2 \times 1.1 = 1.32$$

and all are passed through and the nominal exchange rate adjusts fully then

$$E_{W/H} = \frac{Q_H^M \times P_W}{Q_H^X \times P_H^X} = \frac{34 \times 1}{32 \times 1.32} = 0.805$$

This is a depreciation that keeps the world price of Home’s export’s the same as previously:

$$P_H^X \times E_{W/H} = 1.32 \times 0.805 = 1.06$$

The volume of sales to the World is therefore not affected and so earnings from exports will rise in terms of the Home country's currency: $Q_H^X \times P_H^X = 32 \times 1.32 = 42.24$

... raising import prices

But imports will now cost 10 per cent more at Home:

$$P_H^M = \frac{P_W}{E_{W/H}} = \frac{1}{0.805} = 1.242$$

What happens to the balance of trade depends on how Home’s demand for imports changes as a result of this price rise. If the price elasticity for imports is -1, then the Home country’s volume of imports would fall to 90 per cent of what it was previously and the cost of imports becomes

$$Q_H^M \times \frac{P_W}{E_{W/H}} = (34 \times 0.90) \times \frac{1}{0.805} = 38.01$$

And the balance of trade would be +4.2.

... and raising the real exchange rate

The price level will rise from 1.2 to 1.29:

$$\text{Price of imports } \times \text{ import share} + \text{ Price of home produced } \times (1 - \text{ import share})$$

$$= (1.13 \times 1.1 \times 0.34) + (1.2 \times 1.1 \times 0.66) = 1.29$$

And so the real exchange rate is restored to 1.04:

$$\text{Price of Home basket in World currency } = \frac{P_H \times E_{W/H}}{P_W} = \frac{1.29 \times 0.805}{1.00} = 1.04$$

... and, assuming nothing else changes, raising GDP because imports fall

$$Y = D + G + (X - M) = 52 + 50 + 32 - 30.6 = 103.4$$

(See note (2) to Table 8.2.)
The results for all five countries are shown in Table 8.3. Comparing the experiences of the floating and Eurozone countries, there are two consistent differences:

- In the countries with floating rates, the nominal exchange rates fall so that the real exchange rates are unchanged. In the Eurozone countries there is no change in the nominal exchange rates and the real exchange rates rise, implying they are less competitive.

- GDP rises in the countries with floating exchange rates because the volume of exports is maintained by the drop in the nominal exchange rate, which also reduces imports. However, in the Eurozone countries, output falls as exports fall and as there is no change in imports. (Note 2 to Table 8.3 explains.) Eventually, the fall in exports will, in turn, reduce imports and the inflationary pressures but a fuller model is needed to accommodate these effects. Of course, if the inflation is endemic across the Eurozone, the exchange rate will change in a similar way as it has for the UK and USA.

Within the Eurozone, experience varies according to the extent the economy depends on exports: the higher the export share, the greater the drop in output and the greater the rise in prices.

Figure 8.4 illustrates the dynamics for the UK.

This analysis assumes that full adjustment happens quickly. In practice, that may not be the case and this is explored further in the next scenario.
Table 8.3: Results: Inflation scenario: a 10 per cent increase in prices.

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>UK</th>
<th>USA</th>
<th>Eurozone countries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Strong</td>
</tr>
<tr>
<td>Import price elasticity</td>
<td>-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Export price elasticity</td>
<td>-1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Balance of trade</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial</td>
<td>-0.2</td>
<td>0</td>
<td>2.8</td>
</tr>
<tr>
<td>Final</td>
<td>4.2</td>
<td>1.2</td>
<td>8.0</td>
</tr>
<tr>
<td>% change in</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exchange rate</td>
<td>-9</td>
<td>-9</td>
<td>0</td>
</tr>
<tr>
<td>Real exchange rate</td>
<td>0</td>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>Prices</td>
<td>10.0</td>
<td>10.0</td>
<td>5.2</td>
</tr>
<tr>
<td>Output (1)</td>
<td>3.4</td>
<td>1.7</td>
<td>-5.2</td>
</tr>
</tbody>
</table>

(1) Assuming nothing else changes.
Figure 8.4: Results: Dynamics of the effect of a 10 per cent increase in prices in the UK.

Based on data in Table 8.3.

Value of imports and exports and balance of trade (all at Home prices)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Imports</th>
<th>Exports</th>
<th>Balance</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.75</td>
<td>0.80</td>
<td>0.85</td>
</tr>
<tr>
<td>1</td>
<td>0.90</td>
<td>0.95</td>
<td>1.00</td>
</tr>
<tr>
<td>2</td>
<td>1.05</td>
<td>1.10</td>
<td>1.00</td>
</tr>
</tbody>
</table>

Nominal and real exchange rates

<table>
<thead>
<tr>
<th>Stage</th>
<th>Real exchange rate</th>
<th>Nom. exchange rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.75</td>
<td>1.00</td>
</tr>
<tr>
<td>1</td>
<td>0.80</td>
<td>0.90</td>
</tr>
<tr>
<td>2</td>
<td>0.85</td>
<td>0.85</td>
</tr>
</tbody>
</table>

Graphs showing the dynamics of imports, exports, and balance of trade over stages, and nominal and real exchange rates.
Depreciation

Under fixed exchange rates, step depreciations – often called devaluations – are sometimes allowed to improve the balance of trade by reducing the price of exports, thus boosting demand for them. In the UK, this happened most notably in 1967, under the Bretton Woods exchange rate regime. The Prime Minister Harold Wilson told the nation on television:

> From now on the pound abroad is worth 14 per cent or so less in terms of other currencies. That doesn’t mean of course that the pound here in Britain, in your pocket or purse or bank, has been devalued.

Nevertheless, if the price of imports rises, and demand for imports will fall. Back in 1967, this was to be avoided by people ‘buying British’ and the Government controlling prices and incomes. That was the theory.

But in practice, the story is not quite so straightforward. The initial change in the trade balance may be the opposite to that desired and an effect emerges that is known as the J-curve. It arises because there are time lags, or prices are ‘sticky’ or because the changes are simply not passed on at all. For instance, import prices may not change by as much as the change in the exchange rate. For example, a 2005 study found that a 10 per cent deprecation resulted in a 4 per cent rise in retail prices over one year. This may be due to existing contracts, but it may also be due to the fact that a portion of the price of an imported good will reflect costs incurred between the port at which it arrives and the shop at which it is sold. Likewise the drop in export prices may not be passed on in full. Evidence suggests some of the 14 per cent devaluation of the UK pound in 1967 allowed exporters to increase their profit margin rather than reduce prices. If the quantities of imports and exports respond slowly to the change in the exchange rate, the trade deficit may actually worsen because the demand for exports does not rise and the demand for imports does not fall. (Begg et al. (2011, pp.580-581); Feenstra & Taylor (2011, pp.660).)

To model this we assume the adjustment takes place in three stages:

- **Stage 1:** Import prices rise by half the amount expected as a result of the fall in the exchange rate, but there are no other changes. This rise in price with no fall in demand results in the trade balance worsening.
- Stage 2: Export prices rise and export volumes adjust, but to only half the extent indicated by the price elasticity. The demand for imports falls in response to the price rise in Stage 1. The trade balance improves.

- Stage 3: Import prices rise to fully reflect the depreciation in the exchange rate, and the demand for imports falls. The demand for exports adjusts fully; and the trade balance now shows the full benefit of the depreciation.

Box 8.8 shows the results for the weak Eurozone country demonstrating the J-curve. The rise in prices offsets the fall in the exchange rate so the real interest rate is unchanged but the demand for imports is boosted and the balance of trade improves.
Box 8.8: Results: Effect of a 10 per cent depreciation on the weak Eurozone country.

**Assumptions:**
import demand elasticity = -1
Export demand elasticity = -1

**Value of imports and exports and balance of trade (all at Home prices)**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Value - home prices</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>40</td>
</tr>
<tr>
<td>1</td>
<td>30</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>

**Nominal and real exchange rates**

<table>
<thead>
<tr>
<th>Stage</th>
<th>Real exchange rate</th>
<th>Nom. exchange rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>1</td>
<td>0.95</td>
<td>0.95</td>
</tr>
<tr>
<td>2</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td>3</td>
<td>0.85</td>
<td>0.85</td>
</tr>
</tbody>
</table>

**Summary of changes after full adjustment**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Balance of trade</td>
<td>Initial: -12.6</td>
</tr>
<tr>
<td></td>
<td>Final:  -10.2</td>
</tr>
<tr>
<td>% change in</td>
<td>Exchange rate: -10</td>
</tr>
<tr>
<td></td>
<td>Real exchange rate: -6</td>
</tr>
<tr>
<td>Output</td>
<td>6.2</td>
</tr>
<tr>
<td>Prices</td>
<td>4.4</td>
</tr>
</tbody>
</table>
Exogenous drop in demand for exports

In the inflation scenario, we saw how demand for exports could drop as a result of prices in the Home country rising. But the demand for a country’s exports may also drop for all sorts of other reasons: for instance, tastes may change or another country may become more competitive and gain market share. Here we examine the effect of an exogenous drop in the demand for the Home country’s exports.

If there is an exogenous drop in the demand for exports, and the exchange rate is fixed, the result is that the balance of trade deteriorates, affecting output. That will in turn reduce the demand for imports, which will help to restore output and the balance of trade. It also depends on how the country’s policy makers react; for example, do they reduce taxation to stimulate home demand? A full macroeconomic model is needed to examine these issues.

Here, we confine our examination to countries with a floating exchange rate. There are three stages.

- **Stage 1:** There is an exogenous drop in the demand for exports. Nothing else changes and the balance of trade worsens.
- **Stage 2:** The floating exchange rate adjusts. The demand for the Home currency falls because of the reduction in exports but the Home country’s demand for World currency has not changed. As a result the exchange rate rises. (This may seem counter-intuitive. Demand for the Home currency has fallen and therefore so surely should its price? However, the exchange rate is expressed as the amount of World currency per unit of Home currency. If it were expressed as the amount of Home currency per unit of World currency, it would have fallen as the World wants less of Home’s currency.) This brings the balance of trade back into balance.
- **Stage 3:** The rise in the exchange rate reduces the cost of imports, which boosts demand for them. This causes the balance of trade to move into deficit again.

Table 8.4 shows results for both the UK and USA; and Figure 8.5 illustrates the dynamics for the UK. In practice, these changes are likely to happen simultaneously to some extent and the changes in the exchange rate will be ameliorated by capital flows.
Table 8.4: Results: Effect of exogenous 10 per cent drop in demand.

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>UK</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Import price elasticity</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>Export price elasticity</td>
<td>-1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Balance of trade</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
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<td>0</td>
</tr>
<tr>
<td>Final</td>
<td>-7.3</td>
<td>-2.1</td>
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<table>
<thead>
<tr>
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<th></th>
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</thead>
<tbody>
<tr>
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<td>11</td>
<td>11</td>
</tr>
<tr>
<td>Real exchange rate</td>
<td>7</td>
<td>10</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Prices</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-3.3</td>
<td>-1.4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Output (1)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>-10.0</td>
<td>-4.5</td>
</tr>
</tbody>
</table>

(1) Assuming nothing else changes.
Figure 8.5: Results: Dynamics of effect of exogenous 10 per cent drop in demand: UK.

Based on Table 8.4.

Value of imports and exports and balance of trade (all at Home prices)

Nominal and real exchange rates
Fiscal change

We noted in the introduction that the only policy lever available to Eurozone countries was fiscal policy; and that at present even in countries with floating exchange rates the use of monetary policy is limited. So in this last scenario we examine the possible impact of fiscal policy.

The importance of the government in the economy will determine the impact of changes in fiscal policy: the bigger the government’s share, the larger the impact. OECD (2012) data show that in 2011 general government expenditure was about 50 per cent of GDP in the UK, Germany, Netherlands and Greece, but nearer 40 per cent in the USA. The impact on output is calculated as the product of the percentage fiscal change and the government expenditure as a percentage of GDP. It is assumed that any change in government expenditure does not affect taxation; in other words, it only affects the government’s borrowing requirement. So, for example, if there is a 10 per cent reduction in government expenditure and government expenditure accounts for half of GDP, then output falls by 5 per cent. It is assumed that the marginal propensity to import is the same as the average and that the government’s propensity to import is the same for the country as a whole i.e. the initial share of imports. So, for example, if the share of imports were about one third, a 5 per cent drop in output would reduce imports by 1.6 per cent of output. For countries with a fixed exchange rate, that is the end of the first round effect: the cut in government expenditure would reduce demand for imports.

But for countries with floating rates, the change in imports will change the exchange rate, which will in turn change the prices of imports and exports and thus the demand for them. To sum up:

- Stage 1: the change in government expenditure changes output, which changes the demand for imports and the floating exchange rate.
- Stage 2: the change in the exchange rate will affect the demand for imports and exports.

Table 8.5 shows a set of results for the two countries with floating rates for a 10 per cent cut in government expenditure: the balance of trade improves; and Figure 8.6 illustrates the dynamics for the UK.
Table 8.5: Results: Fiscal policy scenario – 10 per cent cut in government expenditure.

<table>
<thead>
<tr>
<th>Assumptions</th>
<th>UK</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Import price elasticity</td>
<td>-1</td>
<td></td>
</tr>
<tr>
<td>Export price elasticity</td>
<td>-1</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Balance of trade</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td>-0.2</td>
<td>0</td>
</tr>
<tr>
<td>Final</td>
<td>3.9</td>
<td>0.9</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>% change in</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Exchange rate</td>
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<td>-4</td>
</tr>
<tr>
<td>Real exchange rate</td>
<td>-3</td>
<td>-3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Prices</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Output (1)</td>
<td>1.7</td>
<td>0.6</td>
</tr>
<tr>
<td></td>
<td>0</td>
<td>-2.1</td>
</tr>
</tbody>
</table>

(1) Assuming no other changes.
Figure 8.6: Results: Dynamics of the effect of a 10 per cent cut in taxes in the UK.

Based on data in Table 8.5.

| Value of imports and exports and balance of trade (all at Home prices) |
|---|---|---|---|---|
| Stage | Imports | Exports | Balance |
| 0 | 35 | 30 | 5 |
| 1 | 34 | 29 | 5 |
| 2 | 33 | 28 | 5 |

| Nominal and real exchange rates |
|---|---|
| Stage | Real exchange rate | Nom. exchange rate |
| 0 | 1.10 | 1.10 |
| 1 | 1.05 | 1.05 |
| 2 | 1.00 | 1.00 |
Discussion

The theory of international trade is well developed but relies largely on comparative statics and qualitative descriptions. As this Chapter has indicated, international trade is difficult to model and this no doubt explains why modellers tend to confine themselves to closed economies. There also appears to be a dearth of data on reactions to shocks to trade and the impact of policy changes on trade.

So the model produced has been designed to do no more than allow an exploration of the different exchange rate regimes in countries with different circumstances. In that sense it could be said to allow for heterogeneity. It uses simple dynamic processes and there are no stochastic variations. The interactions are between the Home country and the rest of the world. But the key feature is the dynamics. Of course, other assumptions could have been made about the dynamic processes. But the important message is that this way of modelling does provide a useful way to explore these processes. Furthermore, even this simple model highlights the difference between a country with a floating exchange rate and one belonging to the Eurozone, illustrating the problems a Eurozone country faces if its circumstances deviate from the majority of other Eurozone countries.

It also demonstrates just how difficult it is to model an open economy because there are so many interactions between different parts of the economy and so many uncertainties about the timing of the resulting changes. Our simple and limited model may provide the basis for more sophisticated work and there are many suggestions as to what might be done in the ‘Things to Try’ section. Those wishing to take this further would do well to consult de Grauwe’s (2014) *Exchange Rates and Global Financial Policies*. 

34
References


OECD (2012) *Total General Government Expenditure as per cent of GDP*  
[Accessed 28 November 2014].

OECD (2014a) *Factbook: Economic, Environmental and Social Statistics*  


Appendix to Chapter 8: How to do it

Formal description

*Purpose:* To permit the exploration of the dynamics underlying changes in exchange rates and the balance of trade.

*Entities:* 2 agents representing countries: Home and Rest of the World. There are five types of Home country.

*Stochastic processes:* None.

*Initialisation:* Select type of country, the scenario to be investigated, the percentage change and import and export price elasticities.

*Output:* Data on balance of trade and its components, exchange rate, prices and total output. This is shown on-screen and plotted, with the data shown sent to a csv file.

The pseudo-code is in Box A8.1 and a screen shot in Figure A8.1. For the full code see the website: Chapter 8 – International Trade Model.
Box A8.1: Pseudo-code for the International Trade model.

Create world 41 x 41
Create 2 breeds – Home and World – and create one agent of each.

Set initial conditions
Specify the data for each country and the Eurozone (as shown in Table 8.2).
Calculate the exchange rates for the UK, USA and Eurozone as a whole
(as illustrated in Box 8.8).
Allocate the Eurozone exchange rate to the Eurozone countries.
Calculate the real exchange rate, price index and trade balance.

For the inflation scenario
For floating rates:
Stage 1: Export prices and exchange rate adjust (as illustrated in Box 8.7)
Stage 2: Import prices rise
For Eurozone rates
Stage 1: Export prices rise
Stage 2: Export volumes fall
Recalculate the price index, output, real exchange rate and balance of trade.

For the depreciation scenario
Stage 1: Import prices partly change
Stage 2: Export prices and volumes change
Stage 3: Full adjustment.

For the exogenous export change scenario
Stage 1: Volume of exports changes
Stage 2: Exchange rate changes: no volume changes
Stage 3: Volumes change.

For the fiscal policy scenario:
Stage 1: Volume of imports and exchange rate change
Stage 2: Demand for imports and exports changes.

Output stage-by-stage results to the screen and plot the graphs.
At the end print, summary information and the plots to a csv file.
Figure A8.1: Screenshot for the International Trade model.

Things to try using the International Trade model

Explore the effect on the different types of changes on different countries, with different import and export price elasticities.

Advanced – requiring amending the program:

- Amend the characteristics of the countries.
- Extend the model to take into account financial transactions and monetary policy.
- Change the dynamics, adding more stages e.g. to allow prices to be affected by the output gap, see how the exchange rate might move towards PPP.
- Allow some export prices to be determined by global markets.