The Macroeconomics Book

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Chapter 1

National Income Accounts

1.1 Introduction

The principal economic activity of any country is the production of goods and services. National income accounting provides the framework that we use to measure this activity and to explain it theoretically. This entails breaking production into certain sub-groups that are useful for thinking about the generation of economic activity. We call the amount of final output produced within a country in a given year *Gross Domestic Product*, or *GDP* for short, and give it the symbol Y. In a *closed economy* (one that does not trade goods or assets with other nations) we can divide it into three, exclusive categories:

$$GDP \equiv Y = C + I + G \tag{1.1}$$

Here, C refers to the goods that are used for consumption by households (flour, bread, salt, books), G stands for the goods that the government buys (roads, services, airplanes), and I is investment, which represents the goods that firms buy to add to their productive capital (machines, phone lines, tools, inventories) and to replace worn out equipment.[1] These three categories exhaust the possibilities in a closed economy: all goods can be placed in just one of the three categories.[2]

We break GDP into its components in order to understand the decisions of agents that exert demand for goods. Economic activity is the result of constant interaction between agents who produce and those who buy. In later chapters, we deal with both sides of the market to understand how policies and disturbances affect employment and prices.[3]

1.2 Open Economy

For an open economy, we must modify the accounting framework in three ways: (1) there are foreign buyers for our products (X = Exports); (2) we buy goods from abroad (C_f =Imports); (3) some factors of production are owned by residents of other countries (NFI= Net Foreign Income).

[1]What economists mean by "investment" is different from its everyday meaning. Here, it refers to the production and installation of new machinery or inventories, not the acquisition of a financial asset.

[2]Intermediate goods are *not* included separately in GDP, since their value is embedded in the final products.

[3]In this book, like all of economics, we use symbols extensively. See Appendix A for a glossary of terms.

1.2.1 Exports and Imports

Consider the first two extensions to the closed-economy framework. Home residents consume two kinds of goods: home goods, C_d , and foreign imports, C_f . Moreover, we also sell part of our home-good production abroad, a quantity that we call exports, X. The easiest way to modify (1.1) to make it apply to an open economy is to write it as follows:

$$Y = C_d + I + G + X \tag{1.2}$$

Again, these four categories are exhaustive. Any good you can think of that is *produced* here can be placed in just one of them.

Usually, we express (1.2) a bit differently. First, write total consumption C as the *total value in home-good units* of the two kinds of consumption:

$$C = C_d + \frac{C_f}{\Phi} \tag{1.3}$$

The variable Φ is the *relative price of the home good in terms of the foreign good.* Another name for Φ is the *real exchange rate.* It shows the number of units of the foreign good that must be given up to get 1 unit of the home good. Perhaps an example would help. Let's say you had a basket that had in it 50 apples and \$150. How much is your basket worth? To answer, we must know the price of apples. Say, $p_{apple} = \frac{\$0.75}{apple}$. Then, we could say your basket is worth $p_{apple} * 50\,apples + \$150 = \$187.50$ or you could say your basket is worth $50\,apples + \frac{\$150}{p_{apple}} = 250\,apples$. Both are correct. They differ by the *units* with which we measure value.

The measurement of consumption in (1.3) is a bit more complex because Φ is not a dollar price or euro price: it is a *relative* price or *real* price. It is a *barter* price. For example, let us say that

$$\Phi_1 = 2.45\frac{FG}{HG}$$

This says that the price of one unit of the *home good* is 2.45 units of the *foreign good*. Notice that the numerator good – foreign goods – is playing the part of the money here; and the denominator good is the thing whose price we are defining.

As we shall see, the price Φ is one of the most important concepts in this course. When Φ is out of line, the economy experiences unemployment or inflation.

It will be most useful to measure everything in terms of the home good. In Equation (1.3), we divide C_f by the relative price Φ to express imports in units as the home good.

Now add and subtract $\frac{C_f}{\Phi}$ to the right hand side of (1.2) to get:

$$Y = \left(C_d + \frac{C_f}{\Phi}\right) + I + G + \left(X - \frac{C_f}{\Phi}\right) \tag{1.4}$$

We will write (1.4) as:

$$Y = C + I + G + NX \tag{1.5}$$

where $NX = X - \frac{C_f}{\Phi}$ is called *net exports* or the *trade balance*.

1.2.2 Gross National Product

We now deal with the last extension to the open economy. Residents of every country (with the possible exception of North Korea) hold assets in other countries. Define B_t to be the home country's *net foreign assets held at the beginning of year t*. You may think of the "B" as standing for *bonds*: a bond is an asset for the holder and a debt for the issuer. The home country's net foreign income (NFI) for year t is the income earned by those assets:[4]

$$NFI_t = rB_t \tag{1.6}$$

Here, r is the *real interest rate* – more generally, the real rate of return – so net foreign income in year t is the interest (and dividend) income on the nation's net foreign assets held in year t. There is no reason that B_t and NFI_t have to be positive. Nations that have borrowed more than they have lent would have a negative value for B_t and NFI_t.

The home country's *Gross National Product* or GNP in year t is defined as:

$$GNP_t = GDP_t + NFI_t \tag{1.7}$$

which we may write as:

$$GNP_t = Y_t + rB_t \tag{1.8}$$

A country's GNP can exceed or fall short of its GDP; it depends on whether or not the country is a net creditor ($B_t > 0$) or net debtor ($B_t < 0$) with

[4] We think of the income being paid out continuously over year t. The commitment is incurred, however, at the beginning of year t. Also, NFI includes wages paid to home citizens working abroad. For the US, this is a small number.

respect to the rest of the world. In what follows, it is easiest to think of B_t as positive, but for many countries the opposite has often been true. The first row of Table B-107 in *The Economic Report of the President* shows the data for B_t for the US over time.

Economic systems must be consistent in their accounting. This means that the *value of output* produced by the residents of a country equals the *value of the income* that accrues to those residents. Think of a baker selling her bread: the value of what she sells (say, $4,000/week) must equal what she receives as gross income. Her *net income* might only be $1,500 after she pays her suppliers $2,500 for flour – but the latter figure constitutes the income of those suppliers. So if we add all income together we must come up with the value of output produced. That is why we sometimes refer to Y as "output" and sometimes as "income". We return to this idea in Chapter 2 when we discuss the consumption function.

1.2.3 The Current Account and Saving

A country's *current account balance* is defined to be the sum of its trade balance and net foreign income:

$$CA_t \equiv NX_t + rB_t \tag{1.9}$$

From the definition of Y in (1.5), we can also express the current account balance as:

$$CA_t = Y_t + rB_t - C_t - I_t - G_t \tag{1.10}$$

From this perspective, we see that the current account balance registers the *excess of income over spending by residents of the home country.* The actual number for CA_t in any year may be positive or negative.

Let's take an example: assume that $CA_t = \$11$ billion. This means that the home country has generated more income – through producing and selling things and from earning interest on its assets held abroad – than it has spent. The difference is \$11 billion. What do they do with those funds? They use them to buy even more foreign assets: B rises by \$11 billion. Current account surpluses always increase the country's net foreign assets.

This reasoning allows us to write:

$$B_{t+1} = B_t + CA_t \tag{1.11}$$

which may be expressed as:

$$CA_t = B_{t+1} - B_t \tag{1.12}$$

The above is valid whether or not $B_t > 0$ or $CA_t > 0$.

Another important concept is *national saving*, S^N. It is defined as follows:

$$S^N \equiv Y + rB_t - C - G \tag{1.13}$$

Saving is the difference between what is earned and what is spent on *current operations* by both the private and government sectors. By convention, no government expenditure is counted as capital investment. Using (1.10) and

(1.12) we can express national saving as:

$$S_t^N = I_t + CA_t = I_t + B_{t+1} - B_t \tag{1.14}$$

A nation's saving flows into domestic machinery and buildings (I_t) and into foreign assets (CA_t). Countries with more investment than saving will necessarily have a current-account deficit. They must borrow abroad to finance the investment. Countries that save more than they invest will always have a current account surplus.

1.3 Net Foreign Assets

In today's global economy, immense amounts of wealth are held by residents of one country within the borders of another. In several places, we have mentioned B_t, a nation's net foreign assets held at the start of a particular year t. Net assets are the difference between home wealth held abroad and foreign wealth held in the home country:

$$B_t = CL_t - CL_t^* \tag{1.15}$$

where:

CL = sum of **Home** Residents' Claims on Foreign Residents

CL^* = sum of **Foreign** Residents' Claims on Home Residents

"Claims" are any legally binding commitment by one party to pay another party. All of the claims in B_t – bonds, stocks, land titles, bank accounts, etc. – are owed *across borders*. For example, if Ms. Elliot, a resident of New

York, held €50,000 of French Treasury bills, that would be part of CL. That is, the French government owes her (an American resident) €50,000. It does not matter that the claim is on a foreign government (official) agency; if the claim had been on a private firm, it would still have been part of CL. What matters is *who holds the claim*.

In our discussion of the current account balance in (1.11) we noted that a surplus ($CA > 0$) would *raise* B from one year to the next. Referring to (1.15), we see that such an increase can be accomplished in one of two ways. The surplus could be used to do one of the following:

- **buy new claims** on foreign residents ($\Delta CL_t > 0$)

- **pay off old debts** to foreign residents ($\Delta CL_t^* < 0$)

The notation "ΔCL_t" means "an increase in CL from t to $t + 1$". That is, $\Delta CL_t = CL_{t+1} - CL_t$.

A combination of the two is possible, too. For example, if Spain had a current account surplus of $15 billion, it might buy $6 billion in new claims (i.e. assets) abroad and use $9 billion to reduce foreign resident's claims on them (that is, buy back bonds, or stocks, that foreign residents had been holding in Spain). In this case, letting Spain be the home country, we have:

$$\begin{aligned} \Delta CL_t &= 6 \\ \Delta CL_t^* &= -9 \end{aligned}$$

As you know, $6 - (-9) = 15$.

Below, we will inspect the asset positions of the US and its creditors.

1.4 Capital Flows

In the press, we often hear of "capital inflows" and "capital outflows". The definition is somewhat confusing. Here, we discuss capital flows and the "balance on capital account".

The amount of the *change* in B_t from one year to the next is called the "capital flow" for the country in question. If $\Delta B_t > 0$ it is called a *capital outflow*. If $\Delta B_t < 0$ it is a *capital inflow*. The reason for this terminology is that B_t measures the home country's net wealth held in foreign countries. So, when B_t rises, more of the home country's wealth is in the form of foreign assets – hence, "capital flows out". If B_t *falls* from one year to the next – a capital *inflow* – it is because we have less wealth abroad (or foreign residents own more assets here).

Let KA be the "Balance on Capital Account". By definition, the following must hold each period:

$$CA_t + KA_t = 0 \tag{1.16}$$

A nation that has a current account surplus ($CA > 0$) *necessarily* has a capital account deficit ($KA < 0$). It experiences capital outflows. If a nation has a capital inflow one year, then it must have a current account deficit.

1.5 US Data

Data for the United States is on the website of the *Economic Report of the President* `http://www.gpoaccess.gov/eop/` .

The first table we will look at is **Table B-2**. It shows the yearly value (in *real terms*, or inflation-adjusted terms) of GDP (Y), Consumption (C), Investment (I), Government consumption (G), and Net Exports (NX). It gives the actual numbers over time for Equation (1.5) for the US. Notice that Y has grown strongly over time. Also note that the largest part of GDP is consumption spending by households.

The next table to discuss is **Table B-103**, which provides information on the international transactions of the US. The first page of that table shows all current account transactions for select years since 1946. The current account is divided into four sub-accounts: *Goods*, *Services*, *Income*, and *Transfers*. Before we continue, we point out that the international transactions summary is like an income statement and thus has entries that are credits (+) and those that are debits (-). Credit items are those that raise CA in (1.9); a debit item reduces it. For example, exports are credit items.

The columns on the first page of **Table B-103** show the current transactions of the United States. Here we find exports, imports, foreign income (rB_t), and the current account balance (among other sub-items).

The column labeled "Unilateral current transfers, net" is the net amount that US residents (including resident aliens) gave to those living in other countries, as well as military grants. The value for NFI is not shown in the table but we can easily calculate it as the sum of income and transfers.

Then, CA is calculated as in (1.9).[5] This is shown in the last column of the first page of **Table B-103**.

We now turn to the "financial account" or the "capital account" on the second page of **Table B-103**. Look at the columns labeled:

- US-owned assets abroad: Total [Column 2]
- US-owned assets abroad: US official reserve assets [Col. 3]
- Foreign-owned assets in the US: Total [Col. 6]
- Foreign-owned assets in the US: Foreign official assets [Col. 7]

All of these measure *changes* in either CL or CL^* over the year in question. The easiest to understand is Column 6: the numbers there show the value of new assets acquired in the US (new claims acquired on the US) by foreign residents over the year. That is, Column 6 measures ΔCL^*. The numbers are recorded as positive numbers because such purchases by foreign residents are *inflows* or *credits* for the US capital account. That is, KA for the United States rises when $\Delta CL^* > 0$. The part of the change that was by foreign *governments* is shown in Column 7: it is generally a sizable fraction of Column 6. Foreign governments have been increasing their claims on the US strongly in recent years.

In Column 2 the entries are typically negative. A *negative* number here means that US residents *acquired new claims* on foreign residents – they *increased* their asset holdings in other nations. Column 2 measures $-\Delta CL$.

[5]Transfers are *not* part of NFI but *are* part of GNP in the official national accounts system. They are treated as gifts, not factor payments, even though we know that a large part of them are wages sent home (and thus should be in rB_t). Transfers are included in CA_t in (1.9).

It is negative when the US acquires more assets abroad (i.e. if $\Delta CL > 0$) because the acquisition of such claims is a *capital outflow* or *debit* item for the US capital account.[6]

Adding Column 6 to Column 2 – algebraically – gives you the *net capital inflow* or balance on capital account for the US, KA. This measures the amount by which B_t *declined* over the year. It is fairly close in *absolute value* to the current account deficit found above. By equation (1.16), the two should be exactly the same – if a nation spends more than it earns, it must borrow from abroad. The difference is due to measuring errors and imperfections in the process for gathering data. This is reflected in the "Statistical discrepancy" in the next-to-last column plus the "Capital account transactions, net" in the first column. If you sum them up, you get exactly the difference between the measured current account balance and measured net new borrowing.

1.6 International Reserves

Many, if not all, governments choose to hold some of their wealth in the form of foreign assets. In most nations, it is the central bank that holds these foreign claims. In the US, the central bank is called the Federal Reserve System, which we abbreviate to "The Fed". We will have a lot more to say about the Fed in subsequent chapters.

Central banks typically hold short-term bonds of foreign governments

[6]The numbers in Column 4 refer mostly to trade credits, which are US Dollar loans made to countries to enable them to buy US goods. Thus, they are claims on foreign residents by the US government, but are *not* claims in foreign currency.

("T Bills" for "Treasury Bills"), although at times they will hold accounts in foreign commercial banks or hold foreign governments' long-term debt.

These *claims on other countries held by governments* are what we mean when we talk about the *international reserves* of a country. Most central banks (besides the United States) hold their international reserves in dollar form, but the euro is gaining in popularity. A significant portion of the US national debt is held by foreign governments (like Germany, China, and Japan) as part of their international reserves.

In **Table B-107**, we see the *actual stocks of assets* (claims) held across borders at the end of the year. Consider the following rows:

- US Official reserve assets (*US international reserves*; official part of CL)
- US private assets (private part of CL)
- Foreign official assets in the US (official part of CL^*)
- Other foreign assets (private part of CL^*)

Of the total US-owned assets, private asset holdings are far greater than official holdings (international reserves). This is also true of foreign-owned assets in the US, although the difference is not as big. The line that has people worried is that labeled "Foreign official assets in the US: U.S. Government securities". These are the US T-Bills held by foreign governments, notably China. They are essentially loans from the Chinese government to the US government. Some worry that the Chinese government at some point will sell them off on world markets and then buy euros.

1.7 Central Banks and the Exchange Rate Regime

At this point we introduce the exchange rate. The exchange rate is the price of one money in terms of another. We usually work with euros and dollars in the examples in this course, so the exchange rate usually will be the dollar-price of the euro. We will let S (for "spot exchange rate") stand for the *home-currency price of the foreign currency.* For example, in a typical example used in class, the US is the home country and Europe is the foreign economy. Then, we would use:

$$S = 1.462 \frac{\$}{€}$$

which is the dollar price of the euro. If we were considering a problem between Brazil and Argentina, we would first declare a home country (Brazil, say) then define $S = .372 \frac{Réais}{Peso}$.

At times, we will want to use the inverse of S, which is the value – that is, price – of the home money in terms of the foreign currency. We call this E. For example, if the US is the home country, then $E = \frac{1}{S} = .684 \frac{€}{\$}$ is the price (value) of the dollar in terms of euros. Generally, it is best to think in terms of S.

Central banks adopt different policies – or *regimes* – with respect to their exchange rates. The most common are *flexible* and *fixed*.

In a flexible rate system, the government and the central bank stay out of the currency market. Chapters 3 4, and 5 provide a theoretical framework for the flexible rate case.

Under a fixed rate (or ”pre-determined”) system, the government offers to buy or sell foreign currency at a fixed price $\bar{S}$. They do this either directly through the central bank, or by continuous intervention on the market. If the government chooses, it can *change* the “fixed” price so one must be careful! The price $\bar{S}$ is really just ”set” or ”pre-determined” until the government decides to change it. Chapters 6 and 7 explain the workings of the economy with a fixed exchange rate.

Often, the government will adopt a fixed rate, but then impose controls over the transactions it allows. Usually capital flows are quite restricted. The *fixed-with-controls* system has been popular in LDCs, since it gives the government control over the foreign currency market, but it often leads to corruption and inefficiency.

Even when the currency is basically flexible, central banks will intervene selectively to influence the currency price. This is called a *managed float*.

Today, the industrial nations like the United States, Great Britain, Japan, and the European Union all have flexible rates with respect to each other. Relatively few nations have a fixed exchange rate. China is something of an exception, but even they have allowed the yuan to move upward in value slowly in recent years. Recent experience, especially in Argentina in 2001, but also in Asia in 1998, and Europe in 1993, has led most nations to switch over to more flexible arrangements. We will look at the reasons for this in detail later.

1.8 The Nominal Exchange Rate and the Real Exchange Rate

The *nominal* exchange rate S is the price of one *currency* in terms of another. The *real* exchange rate Φ is the price of one *commodity* in terms of another. How are they related?

Let P be the dollar price (more generally, the home-money price) of the home good. As an example, let $P = 2,000\frac{\$}{computer}$. On the other hand, let P^* be the foreign-money price of the foreign good: for example, $P^* = 1,000\frac{€}{suit}$.

The formula relating the two exchange rates is:

$$\Phi = \frac{P}{SP^*} \tag{1.17}$$

Letting $S = 1.4614\frac{\$}{€}$, if you do the calculation, you get $\Phi = 1.36855\frac{suits}{computer} = 1.36855\frac{EuroGoods}{USGoods}$.

The real exchange rate – the relative (barter) price of the home good – is the number of units of the *foreign good* that must be exchanged to get one unit of the *home good*. Here, the foreign-good price of the home good is 1.368.

People rarely barter. Nevertheless, the relative price Φ has great significance in macroeconomic theory.

1.9 Conclusion

In this chapter we have introduced some of the basic definitions and relationships that characterize a modern international economy. These concepts are important in their own right – to understand current economic events and policy proposals – and indispensable for mastering the theory that we set forth in the following chapters.

Chapter 2

The Basic Model

2.1 Introduction

In this chapter we construct a model of a national economy operating in the world economy. Our task eventually is to understand how a few key variables, including monetary and fiscal policy, affect output, employment, the price level, and the exchange rate. As we shall see in later chapters, the effects depend on whether or not the economy has a flexible or fixed exchange rate.

The model has two markets: the Goods Market and the Money Market. In this chapter, we explain the construction of each market separately and show how they determine equilibrium.

2.2 The Market for the Home Good

To begin, we consider the world market for the home country's good. This is the collection of goods produced domestically, which are assumed to have a definite character that makes them different from the goods of other nations. To simplify matters, I assume that the home good is *produced only in the home country* although it is *consumed all over the world*.

2.2.1 Aggregate Supply of the Home Good

We begin with the production or *supply of the home good*. Letting output in year t be ${Y^S}_t$, we may write the general relationship between inputs and output in functional form as follows:

$$ {Y^S}_t = A_t F\left(\overset{+}{K}_t, \overset{+}{N}_t\right) \tag{2.1} $$

The variable A_t stands for the state of "technology" or "productivity" in year t and $F(\ldots)$ is an unspecified function. The two inputs are K_t, the capital stock (basically machinery), and N_t, the labor force. The signs over the inputs indicate that the effect of raising K or N is to increase Y^S. We call $AF(K, N)$ the economy's "production function".[1]

The economy is "fully employed" when unemployment is about 5% of the labor force. This is due to normal job search. Define N_{eq} to be the amount of labor working when we have normal unemployment. When $N = N_{eq}$ then

[1] One common production function is $Y = AK^{\alpha}L^{1-\alpha}$, where $\alpha < 1$. We will assume that there are diminishing returns to each factor separately, but will not use any particular function.

we have "full-employment output". That is:

$$Y_{eq} = AF\left(K, N_{eq}\right) \tag{2.2}$$

The economy need not be at full employment. If $N < N_{eq}$ then there is *unemployment* and ${Y^S}_t < Y_{eq}$. If $N > N_{eq}$ then there *over-employment* and ${Y^S}_t > Y_{eq}$.

2.2.2 Aggregate Demand for the Home Good

The demand for the home good comes from the home country *and* from other countries all over the world. World demand for the home good – including that from home residents – is called *aggregate demand* for the home good. It is useful to think of aggregate demand as coming from the four sectors that we defined in Chapter 1: ${Y^D}_t = C_t + I_t + G_t + NX_t$. Each of these sectors depends on the behavior of independent agents, who make decisions in their personal interest.

Now, we examine each component in turn, beginning with G.

2.2.2.1 Government Spending

Government spending G will be considered *exogenous* – which means that we take its current level and any changes to be determined outside the model. Changes in government spending are the major part of what is known as *fiscal policy*. An increase in G is called *expansionary* fiscal policy. A fall in G is *contractionary* fiscal policy.

How is government spending financed? There are two ways: taxes and borrowing. Each year, some portion of federal spending is paid for by each method. Thus:

$$G_t = T_t + D_{G,t} \tag{2.3}$$

where T stands for taxes and D_G stands for new borrowing (or the government deficit).

Does it even matter how G is paid for? That is, if the government borrows to spend, sooner or later the debt will have to be paid – by taxpayers – with interest. The present value of those future obligations just equals the tax necessary to balance the budget today. So perhaps households worry most about the spending itself, not the method of payment.

2.2.2.2 Investment Spending

Investment demand (the demand for newly produced capital goods by firms in the home country) depends on two things: (1) the real interest rate, r; and (2) the *expected future productivity* of new technologies A_F.

Think of a business – a fishing operation – that has a clear profit of $1 million and is considering its options. One thing it can do is buy a bond. *This is not investment!* The purchase of a bond is the main *alternative* to investment. The *real interest rate* r on the bond is given by:

$$r = R - \Delta p^e \tag{2.4}$$

where R is the nominal (market) interest rate and Δp^e is the "expected rate of inflation" – the rate at which people expect prices in general to be rising. The real interest rate is the *return to bonds expressed in real terms.*

We almost always assume that the actual inflation rate and the expected inflation rate are the same: $\Delta p = \Delta p^e$. That is, on average, people's expectations turn out to be correct. In what follows, we use the two terms interchangeably most of the time.

So if buying a bond is not investment, what is investment? It is the purchase of a new boat, a new pier, a new canning facility, a new delivery truck, etc. (note the word "new" everywhere). All of these goods are currently-produced "physical capital" K.

We write the investment function, as:

$$I_t = \tilde{I}\left(\overset{-}{r}_t, \overset{+}{A}_F\right) \tag{2.5}$$

The minus sign above the r means that the effect of r on I is *inverse*. The plus sign over A_F means that future technology A_F has a *direct* effect on I.

Consider technology first. When a new idea comes along, it will raise next year's technology relative to the current year. Firms will invest – that is, buy new machinery and factories – to capitalize on the new idea. The greater is A_F, the bigger is investment in the current year.

Higher real interest rates r_t, on the other hand, *discourage* investment. Why? Because if bonds are paying you a high real return r you will not risk your capital by investing in new machines.

Why should our fishing firm base its decision on r and not R? If the market interest rate were 10% ($R = .10$) but the prices of fish and other goods were growing at 10% also ($\Delta p = .10$) then the real interest cost is essentially zero ($r_t = 0$). *A firm would undertake any project that resulted* *in a net increase in its fish output, even one fish a year.* Why? Because *the alternative is to buy a bond* that has a zero net gain in real terms. One extra fish is better than no extra fish. In this case, the firm would invest a lot, taking on many projects, even those that did not yield high flows of new output.

Now let R rise to 0.15 but keep inflation at $\Delta p = .10$, so r rises to .05. Firms would reduce their investment outlays. In this case, they would only invest if a project that had an "internal rate of return" – which measures the *productivity of capital* – in excess of 5%, because you can always obtain 5% in *real* terms by buying a bond.[2]

Again, we use the term "invest" to mean "build a factory" or "buy a new machine" and *not* "buy a bond". The latter is not investment; it is a form of saving. The real interest rate r is the return to saving, not investing.

2.2.2.3 Consumption Spending

Consumption theory is very complicated because it involves decisions that affect future utility as well as current utility. We are going to simplify and assume that consumption demand by residents of the home country depends primarily on output ${Y^S}_t$. Moreover, assume that the *consumption function* is linear:

$$C_t = c_0 + c_1 {Y^S}_t \tag{2.6}$$

[2]Ask yourself this question: if I give up 100 bananas today, how many bananas can I consume next year? The answer is $100\,(1 + r)$. This trade through time would involve selling bananas today, putting the money in the bank at interest R, and re-buying bananas next year when the price may be higher ($\pi > 0$) or lower ($\pi < 0$).

It makes sense that the higher is output – recall that income is always equal in value to output – the more we consume.

This consumption function ignores other variables that are also important, like future technology and wealth A_F, taxes T, the real interest rate r, government debt, and wealth held in other countries B. We deal with these in detail in Appendix C but we do not integrate them into the basic model. However, you should think of these as entering the model through the term c_0. In particular, an increase in A_F makes people wealthier in the future and may very well lead them to spend more on consumption today.

2.2.2.4 Net Exports

Net exports are the last component of aggregate demand. Recall that NX is the difference between exports and the home-good value of imports:

$$NX = X - \frac{C_f}{\Phi} \tag{2.7}$$

Let Y^* be the output and income of the rest of the world, the people who buy our exports. We assume that we have the following *net export function*:

$$NX_t = \widetilde{NX}\left(\overset{-}{\Phi}_t, \overset{+}{Y^*}_t\right) - n_1 C_t \tag{2.8}$$

where n_1 is a constant – say, $n_1 = .20$. Net exports *fall* with Φ and *rise* with Y^* as indicated by the signs over each argument. They also fall with domestic consumption C.

We explain these effects as follows.

The variable $\Phi = \frac{P}{SP^*}$ was explained in Chapter 1. It is the real exchange rate – or relative price of the home good. When Φ rises – when our good gets more expensive *relative* to the foreign good – foreign residents demand fewer exports X. We assume that the term $\frac{C_f}{\phi}$ hardly changes when Φ rises, since both the denominator and numerator rise when Φ increases — the increase in Φ induces home residents to buy more C_f.

An increase in Y^* raises X because wealthier foreign residents buy more of our products.

An increase in our total consumption C, leads to more imports: a fraction n_1 of the increase in C is in the form of imports $\frac{C_f}{\Phi}$. This means NX falls as C rises.

2.2.2.5 Aggregate Demand

The aggregate demand for the home good – or spending on the home good – is the sum of the separate demands specified above. Thus:

$$Y^D{}_t = C_t + \tilde{I}(r_t, A_F) + G_t + \widetilde{NX}\,(\Phi, Y_t^*) - n_1 C_t \tag{2.9}$$

Consumption by households C_t itself depends on the amount currently produced $Y^S{}_t$ according to (2.6). So we can re-write (2.9) to eliminate C_t. This gives us:

$$Y^D{}_t = (1 - n_1)\left(c_0 + c_1 Y^S{}_t\right) + \tilde{I}(r_t, A_F) + G_t + \widetilde{NX}\,(\Phi, Y_t^*) \tag{2.10}$$

which we can express more compactly as:

$$Y^D{}_t = b_0 + b_1 Y^S{}_t + \tilde{I}(r_t, A_F) + G_t + \widetilde{NX}\,(\Phi, Y_t^*) \tag{2.11}$$

where $b_0 \equiv (1 - n_1)\, c_0$ and $b_1 \equiv (1 - n_1)\, c_1 < c_1 < 1$.

2.2.3 Goods Market Equilibrium

One of the two key insights of John Maynard Keynes (pronounced "Canes") is embodied in equation (2.11). That insight is that the *demand for output depends on its supply*: the more the economy produces – so the greater the income generated – the more that people will wish to spend on home goods.

The second great insight – the consistency condition – is that the value of national goods produced *must equal* the value of spending on those goods. What is sold must be bought. That is:

$$Y^D{}_t = Y^S{}_t = Y_t$$

From now on, we use Y to refer to all of these concepts: national product (GDP), national income, and expenditure on the home good. We know they all must be equal. That is:

$$Y = national\, product = national\, income = expenditure\, on\, home\, goods$$

This does *not* mean that the economy is always at full employment. Y can be below Y_{eq} or above it – at least in the short run.

Substitute Y for both Y^D and Y^S in (2.11) and then solve to get:

$$Y_t = \frac{1}{1-b_1}\left[b_0 + \tilde{I}(r_t, A_F) + G_t + \widetilde{NX}\left(\Phi, Y_t^*\right)\right] \tag{2.12}$$

where we note that $\frac{1}{1-b_1} > 1$. We now simplify this expression by taking a log-linear approximation:

$$y = d_0 + d_1 g + d_2 y^* - d_3 r - d_4 \phi \tag{2.13}$$

This is the definition of *Goods Market Equilibrium*. It must hold at all times. **This is our first equilibrium condition**. We are going to use this equation again and again in the rest of the course.

In Equation (2.13), r is the real interest rate, as before, but the other lower case letters refer to the *natural logarithm* of the variable. That is: $y = \ln Y$, $g = \ln G$, and $\phi = \ln \Phi$. If you are not familiar with the natural logarithm, do not worry about it. It is a transformation that is similar to the square root. The meaning of Equation (2.13) does not depend on the idea of the natural log. It tells us what national GDP will be, *given* the values of government spending, income in the rest of the world, the real interest rate, and the real exchange rate. It incorporates notions of both demand and supply.

In **Figure** 2.1 the downward sloping line labelled IS is the representation of Equation (2.13). The name "IS" stands for "Investment = Saving".[3] Think of it as the set of pairs (y, r) — given values for g, y^*, and ϕ — such that the goods market is in equilibrium. Three variable changes can shift the

[3]This curve was first derived in a closed economy setting so the current account was not an issue.

position of the IS curve:

- $\Delta g > 0$ shifts IS to the **right** by the amount $d_1 \Delta g$
- $\Delta y^* > 0$ shifts IS to the **right** by the amount $d_2 \Delta y^*$
- $\Delta \phi > 0$ shifts IS to the **left** by the amount $d_4 \Delta \phi$

Changes in y and r do *not* shift the IS curve, since these variables appear on the axes. The first term in Equation (2.13), the variable d_0, stands for other important influences on demand that we may talk about at times – like a war, a crop failure, the expectation of future income A_F, or taxation now and in the future – that might influence *today's* actions. We do not, however, build these influences into the model explicitly. However, a change in d_0 would move the IS curve, too.

2.3 A Digression on Logarithms

A word about the use of logarithms is necessary. The log of any expression that only involves multiplication and division – like Φ – has a very simple form:

$$\phi = \ln \Phi = \ln \frac{P}{SP^*} = p - s - p^* \tag{2.14}$$

where $p = \ln P$, $s = \ln S$, and $p^* = \ln P^*$. The original expression of multiplication and division is transformed into one of addition and subtraction! An implication of this is that if the *change* in, say, p is .05 then that means the *percentage change* in P is approximately .05. In symbols:

$$\frac{\Delta P}{P} \approx \Delta p \tag{2.15}$$

The two sides of Equation (2.15) are two measures of what we mean by the "rate of inflation". The term $\frac{\Delta P}{P}$ is the *discrete* percentage change in the price level P. The term Δp is the exponential – continuously compounded – change in the price level. The two are approximately equal.

The approximation is very good when the change is small. The distinction here is the same as that between simple, discrete percentage interest, and exponential continuously compounded interest. If you put money in the bank at 3% per year you will want to know if it is compounded monthly, weekly, daily, instantly, or not at all. The same with changes in variables like prices or GDP. If you put $100 in the bank at 3% interest with *no compounding* at all, you end up with $103 at the end of the year. If compounding is *continuous*, you end up with $\$103.045 = e^{.03}$.

We are going to use the continuously compounded (exponential) rates of change for all variables.[4]

2.4 The Market for the Home Money

2.4.1 The Supply of Money

What is money and where does it come from?

The stock of home money M is the sum of cash and bank deposits de-

[4]In the case of inflation, the precise formula that relates changes is $1 + \frac{\Delta P}{P} = e^{\Delta p}$. Try that on your calculator with $\Delta p = 1.0$ and interpret the result.

nominated in home currency units held by private citizens and corporations around the world.[5]

Home money is created by the central bank. In the United States, our central bank is called the Federal Reserve System or just “The Fed”. Like all central banks, it creates something called “base money” (M_{Base}) which serves as cash and as the reserves of the commercial banking system. Essentially, base money is cash. Because of our fractional reserve banking system, the money stock M is a multiple μ of the amount of base money in existence. The commercial banking system creates money as a by-product of its lending activities.

To create base money, the central bank buys two kinds of financial asset and *pays with new cash*. They buy US Treasury Bills (DC, for ”Domestic Credit”) and they buy Foreign-government Treasury Bills (IR, for ”International Reserves”). When the Fed acquires either as a new asset, it creates new cash which ends up in the banking system. Thus, the stock of base money always has the same value as DC and IR together:

$$M_{Base} = DC + IR \tag{2.16}$$

The stock of money is a multiple μ of the monetary base:

$$M = \mu M_{Base} \tag{2.17}$$

where $\mu = 3$, or so. Since base money serves as banking system reserves,

[5]There are two main definitions of money: M1 includes cash and demand deposits (checking accounts); M2 adds time deposits (savings accounts).

there can be approximately three times more money (mostly customer deposits) than cash in the vault (base money M_{Base}).[6]

The central bank controls M by buying or selling government bonds, as noted above. These transactions are called *open-market operations.* An *open-market purchase (of bonds)* directly *raises* M_{Base} and then M. An *open-market sale (of bonds) reduces* the base and the supply of money.

2.4.2 The Demand for Money

People demand wealth in many forms. One of the most important forms of wealth is money. The demand for money – as opposed to other kinds of wealth – depends on the price level P, current real income Y, the nominal or market interest rate R, and other factors, in the following way:

$$M^D = PL\left(\overset{+}{Y}, \overset{-}{R}, \overset{+}{\Omega}\right) \tag{2.18}$$

where L is an unspecified function whose properties are indicated by the signs over each variable.

When people have greater real income Y or the general level of prices P is higher, the demand for money rises because there are more transactions at higher values to undertake. On average, people want to hold more cash and bank deposits (the basic definition of money) when Y and P are higher. Moreover, money demand rises in the same *proportion* as the rise in P.

[6] In response to the overwhelming financial and banking crisis of 2008, the money multiplier collapsed to less than 1. To keep money supply high, the Fed increased the monetary base tremendously by buying all kinds of non-traditional assets including mortgages and equity and long-term Treasury bonds. After three years, they still held many of these assets.

Higher market interest rates R, on the other hand, lead people to substitute bonds for money: money demand falls. The effect of a change of R on money demand is inverse. Money demand depends on R and not r because the former is the *difference* between the return to a bond and the return to money.[7] It is this difference that motivates people to switch between assets.

The parameter Ω stands for all other effects that increase money demand – and, by implication, reduce the demand for other forms of wealth like bonds or stocks that pay a return. A prime example of a rise in Ω is a financial panic. We can think of episodes of political instability or an uptick in the drug trade also as increases in Ω : they raise the demand for liquid forms of wealth. The development of financial technologies like ATMs, internet banking, and credit cards, on the other hand, all reduce the demand for money (a fall in Ω).

2.4.3 Monetary Equilibrium

The economy is in monetary equilibrium if $M = M^D$:

$$M = M^D = PL\left(\overset{+}{Y}, \overset{-}{R}, \overset{+}{\Omega}\right) \tag{2.19}$$

which is usually written as:

$$\frac{M}{P} = L\left(\overset{+}{Y}, \overset{-}{R}, \overset{+}{\Omega}\right) \tag{2.20}$$

[7] It does not matter if you consider the difference in nominal or real returns to these two assets: it is always the same number as R.

This says that the money market is in equilibrium if the *real* supply of money is equal to the *real* demand for money — or “liquidity”. As before, we are going to write this expression in log-linear form:

$$m - p = y - \beta_1 R + \beta_2 \Omega \tag{2.21}$$

This is the *Money Market Equilibrium Condition.* It, too, must hold at all times. **This is our second equilibrium condition.** We use this condition repeatedly in what follows.

Lower case letters are in logs, as before. That is, $m = \ln M$. We have defined the others already. The interest rate R is *not* in logs, nor is Ω. Notice that we will assume from now on that the effect of Y on money demand is proportional: that is why the coefficient on y is 1.

In **Figure** 2.1, the LM curve represents monetary equilibrium. It is the set of pairs (y, R) that establish the equality of money supply and money demand. It is drawn for given values of m, p, and Ω. Consider the meaning of the LM curve. If y increased, real money demand would also rise, so monetary equilibrium would no longer hold unless something happened to reduce demand again. If R rose, real money demand would fall, and equilibrium would be restored.

Three variables shift the LM curve:

- $\Delta m > 0$ shifts the LM curve to the **right** by the amount Δm
- $\Delta p > 0$ shifts the LM curve to the **left** by the amount Δp
- $\Delta \Omega > 0$ shifts the LM curve to the **left** by the amount $\beta_2 \Delta \Omega$

Changes in y and R do *not* shift the LM curve, since these variables appear on the axes.

2.5 World Capital Market

We will assume that the home country is small in terms of the world capital market, so that the *world real interest rate* r^* is given and independent of any action taken with the home country. This assumption is quite reasonable for many countries. While it may not be so reasonable for the US or Europe, it is a good place to begin our analysis even in those cases.

2.6 Exogenous and Endogenous Variables

Economic models seek to explain why and how prices and quantities change. In any model, there are two kinds of variables. *Exogenous* variables are taken as given, coming from outside the system or model. They have an affect *on* the system, but are not affected *by* it. *Endogenous* variables, on the other hand, only change as a result of a prior change in an exogenous variable. They are determined by the model under consideration.

In our model of the economy, the following variables are *always exogenous*: g, Ω, y_{eq}, y^*, r^*, and p^*. We can also add A_F to the list, but it is not a variable that we routinely consider.

The following are *always endogenous*: y, ϕ, p, and r.

Two variables are sometimes exogenous and sometimes endogenous: m and s.

We will explain all of this in detail below.

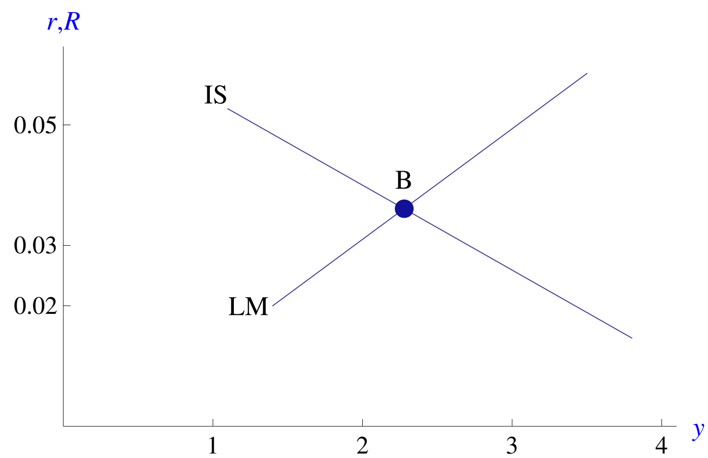

Figure 2.1: Short-Run Equilibrium

2.7 Equilibrium

2.7.1 Short-run Equilibrium

The economy is always in "short-run equilibrium", which means that Equations (2.13) and (2.21) are always satisfied. This does *not* mean, however, that the economy is at full employment.

In **Figure** 2.1 we show both curves and the point where they intersect, Point A. This point determines the economy's short-run equilibrium.

We have drawn both the IS and LM curves on the same graph even though the former depends on r and the latter on R. If there is no inflation, this is fine, since $r = R$, when $\Delta p = 0$. We will generally make that assumption. If, however, $\Delta p \neq 0$, then we must adjust either IS or LM and settle on either r or R for the vertical axis. We discuss inflation across countries in Chapter 4.

2.7.2 Long-run Equilibrium

When there is full employment of labor[8], we say that the economy is in "long-run equilibrium" or "full-employment equilibrium". For this, we have two extra conditions.

The first condition is that:

$$y = y_{eq} \tag{2.22}$$

As noted above, when $N = N_{eq}$, then $y = y_{eq}$.

The second condition is that the home and world real interest rates be the same:

$$r = r^* \tag{2.23}$$

We are assuming that the home country has no capital controls, so eventually – and perhaps quickly – interest rates are equalized with those in the world capital market. Given time to adjust, the home interest rate will converge to the world level.

Full-employment output y_{eq} and the world interest rate r^* are both exogenous. This allows us to solve the model and begin to explain the workings of the economic system in the long run.

[8] As we have noted before, "full employment" corresponds to about 5% measured unemployment due to dynamics of industry creation and the lag in job switching.

2.8 Conclusion

In this chapter, we have constructed the basic model of the economy. In the chapters to come, we show how we use it to understand the fundamental forces in all industrial countries. We explain what makes prices rise, why currencies rise or fall in value, and why economies have unemployment.

Chapter 3

Flexible Exchange Rate and Full Employment

3.1 Introduction

Most countries have a flexible exchange rate. And most countries operate at or near full employment most of the time. Our first application of the model is, accordingly, to a small country with a flexible exchange rate operating at full employment. Later, we shall make an argument that the natural state of all economies – whether with a flexible or fixed exchange rate – is a state of full employment, but that it might take time to arrive there.

Inflation is zero in this chapter: $\Delta p = 0$. In later chapters we deal with inflation.

The purpose of our economic model is to help us to understand the world better. Our approach is to assume that *one exogenous variable changes* at a time and then look at each of the endogenous variables in turn to see if they change and, if so, how they change.

3.2 Model Shocks and Equations

We define a "shock" or a "disturbance" to be a change in any one of the *exogenous* variables. We form three groups for the exogenous variables and shocks. In what follows we confine ourselves to the following variables for close analysis.

- **Supply Shock** : A permanent change in technology A (that is, a simultaneous increase in both current A_t and future A_F) that changes y_{eq} permanently.

- **Demand Shock**s: A change in government spending g, or foreign output y^*, or the foreign price level p^*.

- **Monetary Shock**s: A change in m, or Ω.

Our objective in constructing the model is to be able to explain the effects of each disturbance, considered separately, on the *endogenous* variables of the model: ϕ , y, p, and s.

The model contains three equations: the IS curve, the LM curve, and the definition of the (log) of the real exchange rate. We assume that $y = y_{eq}$ and $R = R^* = r = r^*$ at all times in this chapter. Making these substitutions, we write the full model in the following three equations:

$$[\mathit{Goods}\,\text{IS}] \qquad y_{eq} = d_0 + d_1 g_t + d_2 y_t^* - d_3 r^* - d_4 \phi_t \tag{3.1}$$

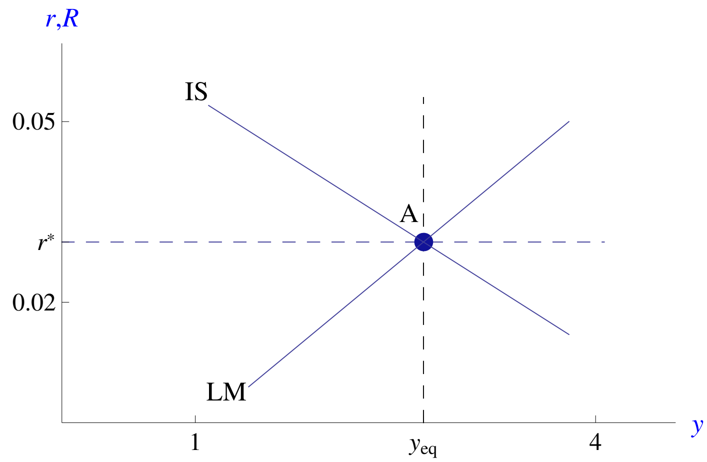

Figure 3.1: Long-Run Equilibrium

$$[Money\,\text{LM}] \qquad m_t - p_t = y_{eq} - \beta_1 R^* + \beta_2 \Omega_t \tag{3.2}$$

$$[Real\ Exchange\ Rate] \qquad \phi_t = p_t - s_t - p_t^* \tag{3.3}$$

The initial full-employment equilibrium is shown in **Figure** 3.1. We begin all of our shocks from Point A — where $r = r^*$ and $y = y_{eq}$.

Each endogenous variable has a role to play. The *relative price* ϕ adjusts to clear the goods market. The *price level* p adjusts to clear the money market. The exchange rate s takes on whatever value is necessary to make sure the other two prices are consistent – that is, it adjusts to make sure (3.3) is satisfied.

Given these adjustments, it may be more useful to solve each equation above for the variable that adjusts in the long run to make sure the economy achieves full employment. The same system, expressed to highlight the variables that adjust to establish long-run equilibrium is:

$$[Goods\ \text{IS}] \qquad \phi_{eq} = \frac{d_0}{d_4} + \frac{d_1}{d_4} g_t + \frac{d_2}{d_4} y_t^* - \frac{d_3}{d_4} r^* - \frac{1}{d_4} y_{eq} \tag{3.4}$$

$$[Money\ \text{LM}] \qquad p_{eq} = m_t - y_{eq} + \beta_1 r^* - \beta_2 \Omega_t \tag{3.5}$$

$$[Exchange\ Rate] \qquad s_{eq} = p_{eq} - \phi_{eq} - p_t^* \tag{3.6}$$

Our method boils down to this: for every disturbance to an exogenous variable, what change in ϕ is necessary to make sure the IS curve goes through Point A in **Figure** 3.1? What change is necessary in p to make sure the LM curve goes through Point A in **Figure** 3.1? And, finally, what change in s is then necessary to make sure the first two can happen? These are the equilibrium values of the three prices.

We now use the model by analyzing a very important shock: an increase in the supply of money in the home country.

3.2.1 Monetary Policy

We begin by describing the effects of a permanent increase in M, the money supply. This is an example of an expansionary monetary policy. Assume, then, that the Fed increases the money supply M by 20% and holds it at the higher level forever.

The shock is: $\Delta m = .20$.

What are the effects of this?

First, note that there are no effects on the goods market – the variables that move the IS curve are not changed. The LM curve, however, *does*

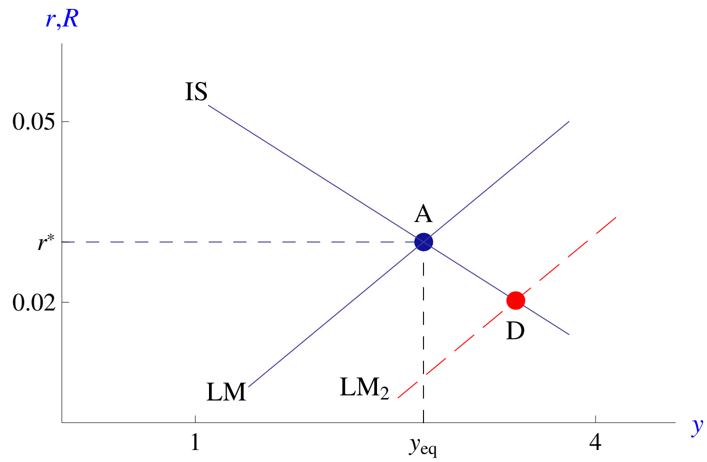

Figure 3.2: Expansionary Monetary Policy

move: it moves to the right, as shown in **Figure** 3.2. The new intersection is Point D, but that is not a long-run equilibrium. To clear the market and restore full-employment equilibrium, p must also increase by .20. This causes the LM to *move right back to its original position.* Expansionary monetary policy is inflationary if the economy is at full employment. This is evident in Equation (3.5).

That is not the end of the story, however. The value of the foreign currency s must *also rise* by .20. This is the same as saying the home currency must *depreciate* by 20%.[1] What is the reason, in terms of the underlying economics, for the fall in the value of the home money? Because that is the only way that ϕ can remained unchanged, as it must to keep the IS curve in its original position. If s did not fall, but p rose to clear the money market, then our goods would become too expensive in a relative sense – ϕ would be too high – to support full employment.

[1]Here, we are thinking in terms of exponential changes.

To summarize:

$$\Delta s = \Delta p = \Delta m$$

where the shock is the change in m. Causality runs from the right to the left.

Expansionary monetary policy is the fundamental cause of persistent inflation and currency depreciation. In the next chapter, we investigate this issue in more detail in a two-country setting. At this point, we provide some data to support the basic theory. **Figure** 3.3 uses US data to show what has happened to the money supply, the price level, the value of the British pound $S\frac{\$}{£}$, and the money wage over time.

Most of these variables have trended upward together, although the exchange rate has demonstrated considerably more volatility and virtually no upward trend. That s has not risen on average is probably due to British monetary policy that was just as expansive as that of the United States during most of this period.

The shock is symmetric. That is, if $\Delta m = -.20$ so that the money stock fell by 20%, then the LM would move to the left and eventually both p and s would decline by .20. This case is illustrated in **Figure** 3.4. Point B cannot be a long-run equilibrium, so p eventually declines and so must s in order to keep ϕ at its equilibrium value.

If there were a financial panic, Ω would rise. This would have the opposite effect as the rise in m. That is, increases in Ω act like declines in m and vice versa.

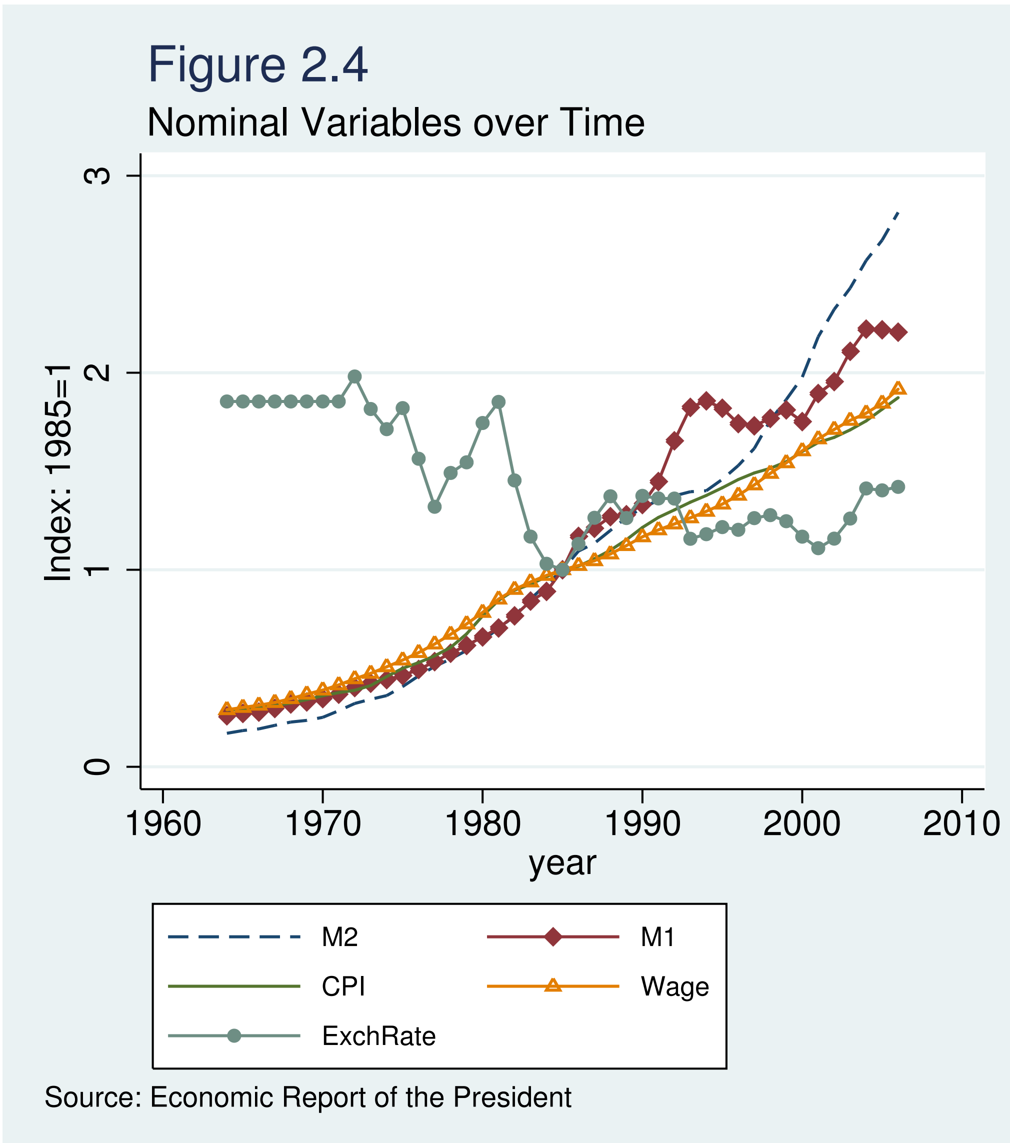

Figure 3.3: Nominal Variables over Time

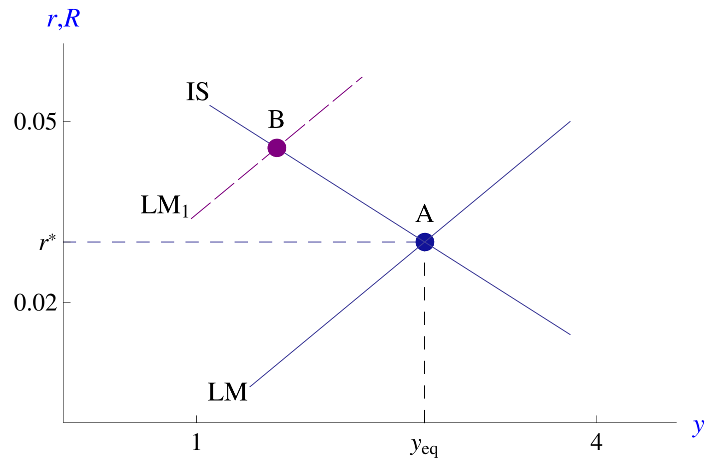

Figure 3.4: Contractionary Monetary Policy

3.2.2 Fiscal Policy

We now examine expansionary fiscal policy, an increase in g. This shock moves the IS curve out, as illustrated in **Figure** 3.5. The new intersection is at Point C, but this is clearly not a full-employment equilibrium position.

To return the economy to the original position, ϕ must *rise*. In the new equilibrium, home goods must become more expensive relative to foreign goods, but not necessarily in terms of dollars. There must be a higher *relative* price because there is a surge of demand for the home good by the government, but the supply of the home good in the world cannot increase because the home country is already at full employment. Remember that the home good is unique and produced only in the home country. The rise in ϕ moves the IS curve back to its original position.

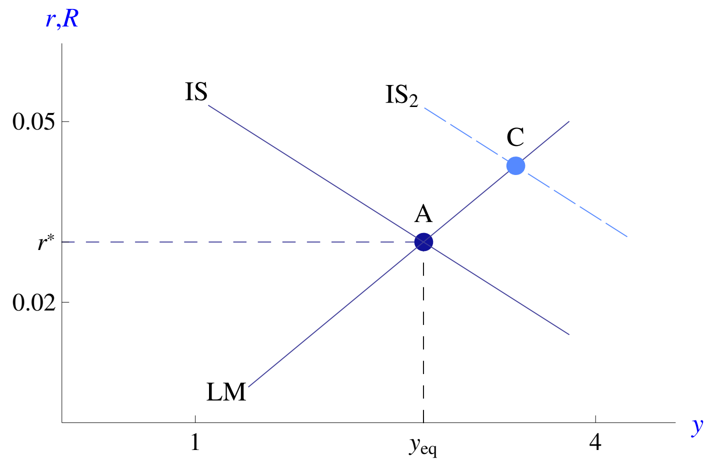

Figure 3.5: Expansionary Fiscal Policy

From Equation (3.4) we see that the increase in ϕ is given by:

$$\Delta\phi = \frac{d_1}{d_4}\Delta g$$

Turning to the money market, we see that m, y, and R have not changed. Fed policy did not change, output is the same as before ($y = y_{eq}$), and the interest rate still equals the world level ($R = r^*$). Thus, according to (3.5) there can be *no change* in the long-run equilibrium price level p. It follows that s must *fall*, by (3.6) meaning that *the home currency appreciates*. The dollar rises in value as a result of the increase in government expenditure. Such an appreciation is the only way that the relative price can increase, since monetary conditions keep p the same. From (3.6) the change in s is:

$$\Delta s = -\Delta\phi = -\frac{d_1}{d_4}\Delta g$$

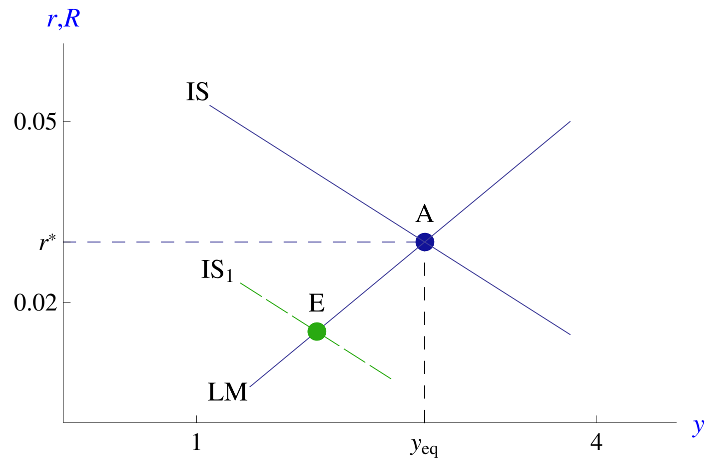

Figure 3.6: Contractionary Fiscal Policy

Although there is no change in aggregate output y as a result of the increase in g, there is a change in the *composition* of output. In particular, C and NX will fall to accommodate the rise in g. These fall because the higher real exchange rate (relative price) ϕ leads consumers at home and abroad to curtail their spending on the home good and shift spending to imports. NX falls, "crowded out" by government spending.

What if g fell? The effects are completely symmetrical: the IS curve would move back and the intersection would be Point E in **Figure** 3.6. To return to full employment – that is, to move the IS back to its original position – ϕ would *fall* – the home good would get relatively cheap – and s would *rise* – the home currency would depreciate.

If y^* changed – if there was growth in the rest of the world that increased demand for our products – the effects would be virtually identical. In the long run, demand growth, from whatever source, leads to an increase in ϕ and a fall in s. Our currency appreciates and our goods get expensive.

Finally, foreign inflation only affects s, as we see in Equation (3.6) above. Neither IS nor LM move in this case.

3.2.3 Supply Shocks

Now we consider a particular kind of supply shock. We assume that there is a permanent increase in technology, so A_t and A_F both rise. This kind of technological progress has characterized the world for centuries: it is what we call "Economic Growth". The main effect of this shock in our model is to increase y_{eq}: now at full employment there is more output in the home country. Let us say that the new value of full-employment output is $\hat{y}_{eq} = y_{eq} + 1.0$, so that $\Delta y_{eq} = 1.0$ and there has been a doubling in actual output Y.[2]

The effects of this shock are shown in **Figure** 3.7. The new equilibrium is at Point F, where $r = r^*$ and $y = \hat{y}_{eq}$. What must happen to move the IS and LM curves to that point? We know that ϕ must fall – to move the IS to the right – and p must fall – to move the LM to the right.

From equation (3.5), we see that:

$$\Delta p = -\Delta y_{eq}$$

so prices *fall* by 50%. And by (3.4) the relative price falls by:

$$\Delta \phi = -\frac{1}{d_4} \Delta y_{eq}$$

[2]The simple percentage change in Y is really more like 172%. You may wish to think of this increase as taking place over a relatively long time. In the US, output went from $4.3 trillion in 1970 to $11.5 trillion in 2003.

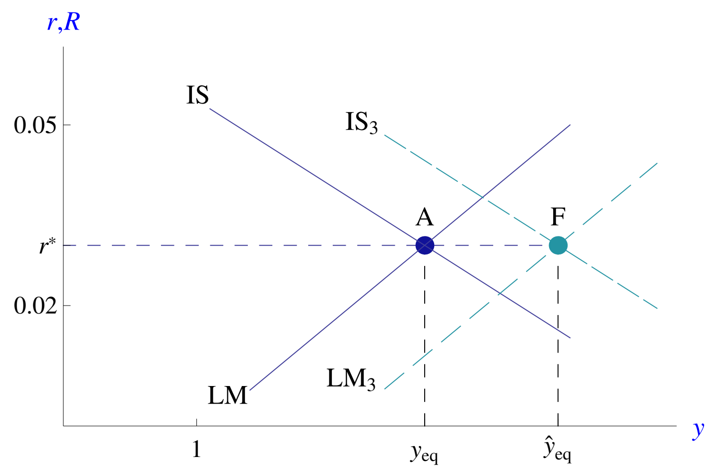

Figure 3.7: Growth: A Positive Supply Shock

What about the exchange rate? From (3.6), we cannot tell what happens to s. The equation tells us that:

$$\Delta s = \left(\frac{1}{d_4} - 1\right) \Delta y_{eq}$$

It depends upon the size of d_4. Most people think that the home currency would appreciate. If so, then that means $\Delta s < 0$, so that $d_4 > 1$. Is that reasonable? It means that a 10% change in the relative price of our goods leads to a fall in output that is *greater* than 10%. That does not seem reasonable.

3.3 Conclusion

In this chapter, we looked at an economy with a flexible exchange rate. We also assumed that the economy was always at full employment. As we shall see later, this means that we are looking at a time period over which prices p have had time to adjust to clear all markets.

Chapter 4

Dynamic Equilibrium

4.1 Inflation

We are often interested in the *rate of growth* as well as the *level* of many of the key variables in the economy. Examples include the inflation rate (the rate of growth of P) and the rate at which the currency is depreciating (the rate of increase in S) or appreciating (if S is falling). This chapter shows how these rates are determined from the rate of monetary expansion and the underlying growth rate of the economy's real output. This extends a result of the last chapter by considering continuous growth rates over long periods of time and between two large countries or regions that use different currencies.

Assume that M and Y_{eq}, but not Ω or R, are rising at steady rates year after year. From our discussion in Chapter 2, we know that rates of change in any variable are related to the simple change in the log of the variable. So we now assume that Δm and Δy_{eq} are constants year after year. For example, assume that:

$$\begin{aligned} \Delta m &= .09 \\ \Delta y_{eq} &= .04 \end{aligned}$$

Equation (3.5) in the last chapter tells us that inflation must be:

$$\Delta p = \Delta m - \Delta y_{eq} = .05 \tag{4.1}$$

In plain English, (4.1) says that the inflation rate of any country is determined by the difference between its money growth rate (set by the Central Bank) and its real growth rate (which is determined by fundamentals like the growth rate of K and A).

In terms of our graphical model, the money growth means that the LM curve is moving out steadily. If y_{eq} were not growing at all, then p would have to grow at the same rate as m to keep the LM curve at Point A. But y_{eq} *is* growing. If it were growing at the same rate as m, then p would not have to change at all: the point where LM crosses r^* is the equilibrium point. Our equation (4.1) tells us that, depending on which is growing faster, p might rise or fall. What is happening is that the increasing y keeps raising money demand which might be enough to absorb all of the new supply.

One more thing: in this chapter we are assuming that ϕ is *not* moving. One way to justify this is to assume that foreign output y^* is rising, too; and at just the speed to offset the rising supply y_{eq}. See Equation (3.4).

4.2 Interest Rates: Nominal and Real

Inflation reduces the real value of future payments of money. Because of this, the market interest rate will reflect the inflation rate along with the real interest rate, which depends on other, fundamental determinants of time valuation, such as impatience and productivity. As we saw in Chapter 2:

$$R = r + \Delta p^e \tag{4.2}$$

where R is the market (or nominal) interest rate and r is the real interest rate. As we did in Chapter 3, we will assume that $r = r^*$ and take it to be given in the world capital market. Equation (4.2), (which is known as the "Fisher Relation" after the famous economist Irving Fisher) then determines R once we know the home inflation rate. If inflation is expected to be a steady 5% per year – so $\Delta p^e = .05$ – lenders will require that this be added to the real return obtainable on international capital markets – say, $r = .03$ – or they will refuse to lend. The market rate would then be $R = .08$. Thus, high inflation leads to a *high* market interest rate, but not a *rising* one.

The growth rates of money and output, Δm and Δy_{eq}, which are exogenous, determine Δp by (4.1) which then determines R through (4.2), if we continue to assume that expectations are correct.

Notice that if the Central Bank increases the rate of money growth Δm this will raise both the rate of inflation Δp and the market interest rate R. This may run counter to your intuition, but it should be kept in mind that Δm is the *rate at which the stock of money is growing*, not the amount of

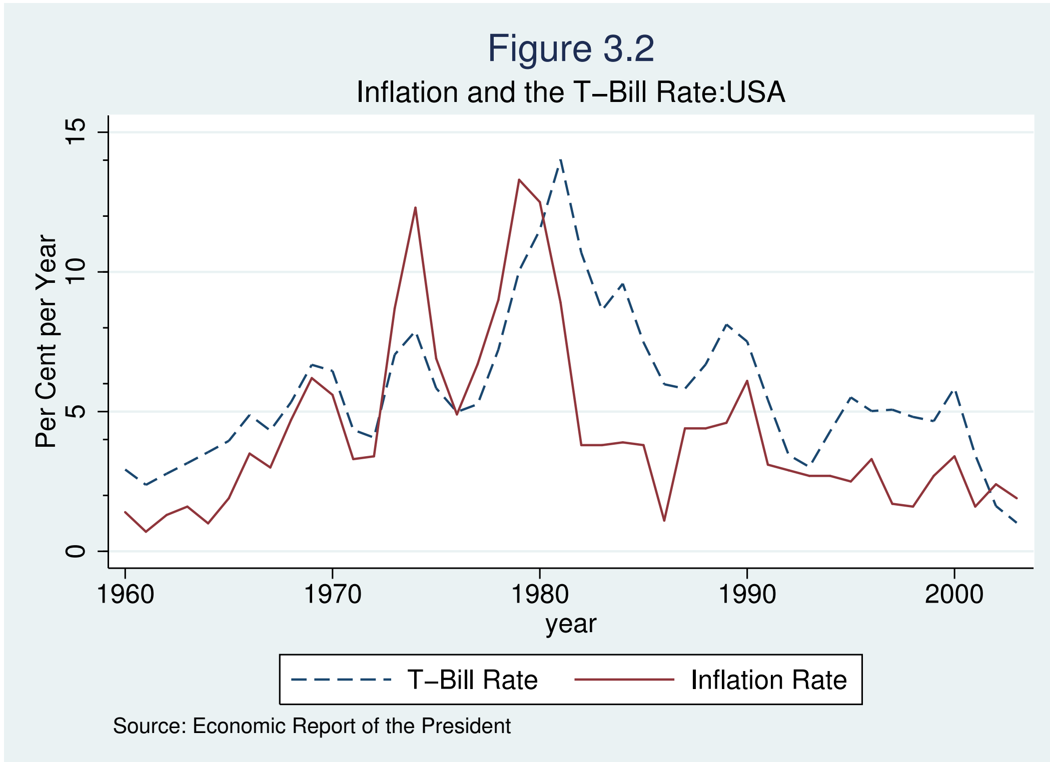

Figure 4.1: Inflation and T-Bill Rate: USA

money in existence M. Later, in Chapter 5, we will discuss the short-run relation between the level of the money stock M and the value of R.

There is support for this theory in the data. Figure 4.1 shows what happened to the market interest rate and inflation rate for the USA in the recent past. There is a clear, positive association between the two, just as predicted by (3.4), the Fisher Relation.[1]

[1]The data in Figure 4.1 is a three-year, centered moving average of the annual growth rate.

4.3 Interest Parity

Now assume that there are two economies, the US and Europe, and that capital and goods are fully mobile between them. We shall always assume that the real interest rates in the two countries are the same and equal to the world real interest rate. For example, let $r^{US} = r^{Eur} = r^* = .03$. Also, assume that real output growth is the same in the two countries: $\Delta y_{eq}^{US} = \Delta y_{eq}^{Eur} = .04$. Monetary policies, however, are different. In particular, we assume that the US is creating money at the rate $\Delta m^{US} = .09$, while Europe is printing money at $\Delta m^{Eur} = .06$ per year. Given this data, and our two equations (4.1) and (4.2), we can calculate the equilibrium values of inflation and market interest. US inflation is $\Delta p^{US} = .05$ while European inflation is $\Delta p^{Eur} = .02$. Market interest rates are: $R_{US} = .08$ and $R_E = .05$.

We now introduce a fundamental relationship in international economics and finance. This is the principle of (uncovered) *interest parity*:

$$R_{US} = R_E + \Delta s^e \tag{4.3}$$

where Δs^e is the *expected rate of euro appreciation* (growth rate of S). In this chapter, and most of the course, we assume that agents' expectations are correct, so that $\Delta s = \Delta s^e$. The foreign currency appreciation turns out to be what people expected.

Using our data from above, we see that $\Delta s = .03$: there is 3% *appreciation of the euro every year.*

The idea behind interest parity is that traders would willingly hold both assets *only* if they believed that the steady appreciation of the euro was exactly enough to compensate for the market interest rate differential.

Another way to say this is that the interest plus "capital gain" on holding euro assets must be the same as the return from holding dollar assets.

The construction of Equation (4.3) assumes that all rates are continuous (exponential). This means that the dollar price of a euro $S\frac{\$}{€}$ is can be expressed as the following function of time:

$$S(t) = S_0 e^{\Delta s * t} \tag{4.4}$$

It follows that we can express the value of the dollar over time E €/\$ as:

$$E(t) = \frac{1}{S(t)} = \frac{1}{S_0 e^{\Delta s * t}} = \left(\frac{1}{S_0}\right) e^{-\Delta s * t} = E_0 e^{-\Delta s * t} \tag{4.5}$$

So, in continuous terms, *the rate of dollar appreciation v is exactly the same as the* ***negative*** *of the rate of euro appreciation.*

4.4 The Inflation Gap

As long as the real interest rates are the same in the two countries, as we assume, Δs is also equal to the difference in inflation rates. To see this, use the Fisher Relation with interest parity:

$$\Delta s = R_{US} - R_E = r^* + \Delta p^{US} - \left(r^* + \Delta p^{Eur}\right) \tag{4.6}$$

If the real interest rates are the same, this reduces to:

$$\Delta s = \Delta p^{US} - \Delta p^{Eur} \tag{4.7}$$

Whichever country has the higher inflation rate (caused by the higher money growth) will have the higher nominal interest rate, and its currency will *depreciate* relative to the other country's currency at a rate equal to the difference in market interest rates or inflation rates.

4.5 Conclusion

The purpose of this short chapter has been to extend the basic, *static*, long-run results to a *dynamic* setting; that is, to a situation in which the money stock is growing at a steady rate over time. Other things equal, we can say that an increase in the rate of money growth leads to an increase in the rate of inflation, the market interest rate, and the rate of currency depreciation.

Chapter 5

Flexible Exchange Rate: Short Run Adjustment

5.1 Price Adjustment and Disequilibrium

In this chapter we begin to deal with the phenomenon of disequilibrium: both unemployment and over-employment. Every modern society experiences some episodes of unemployment. Many are relatively short but some, like those in Japan and Spain, are chronic. Although there are many proximate causes of unemployment, the reason that these spells last a long time is the lack of price and wage flexibility. When a shock occurs that requires price level change, the complete adjustment takes a long time. Until that adjustment is made, all of the markets in the economy cannot be in equilibrium. This raises many interesting questions. Which markets are out of equilibrium? How is equilibrium re-established?

In this chapter we continue to assume that the exchange rate is completely flexible.

Prices adjust slowly, especially downward, because firms face uncertainty about the state of the market. If price adjustment is costly, firms will be reluctant to change. **Figure** 5.1 shows how p moves over time in response to a permanent decrease in m that takes place at time t_0. The *equilibrium price level* declines immediately (and in proportion to the fall in m) but the *actual price level* takes a long time to fully adjust downward to the new equilibrium level. The entire phase lasting until time t_2 is called "The Short Run". At the end of the short run, full-employment equilibrium is once again established. Indeed, our definition of the short run will be""the time it takes for the economy to return to full-employment (long-run) equilibrium following a shock". The short run may contain an initial phase during which the price level stays completely fixed. At the end of this interval – time t_1 in **Figure** 5.1 – prices begin to adjust toward their new equilibrium, but it still takes considerable time for them to get there. The short run may be anywhere from a couple of months to a few years, depending on the monetary and financial experience of the country. For convenience, we assume that it takes exactly one year.

5.2 How the Fed Determines the Interest Rate

The Federal Reserve can set the interest rate in the short run, but not in the long run. In fact, if the economy is open, it is hard to affect the interest rate even in the short run.

To see how m and R are related, recall that the money market is in equi-

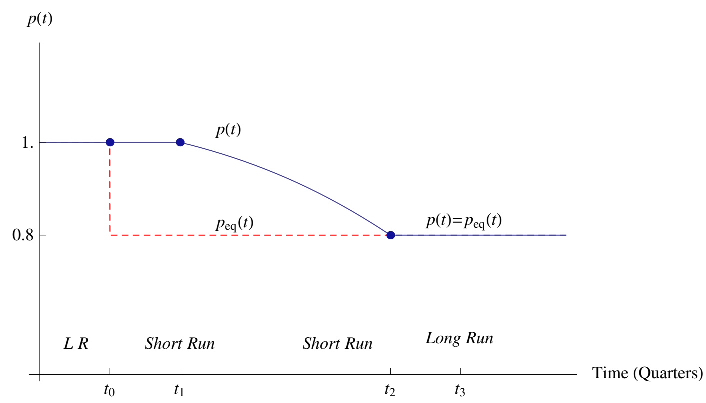

Figure 5.1: Price Adjustment Path

librium if the supply of money equals the demand for money. In this section, we are going to focus only on the money market in a *closed economy* and set aside any consideration of output change or the international economy. We return to both soon, but in the very short run period, neither is important.

We can write our monetary equilibrium condition as follows:

$$m - p = y - \beta_1 R + \beta_2 \Omega \equiv L^d \tag{5.1}$$

As before, the term on the left is the (log of) the "real money supply"; that is, the amount of money in terms of the goods it could purchase. The term on the right – now labeled L^d for graphing purposes – is real money demand, or "liquidity demand". This is the (log of the) amount of money people would like to hold in real terms; that is, in terms of the goods that form of wealth could buy.

Now, let m change. Since p is inflexible at first, some other variable must adjust to clear the money market. For reasons that we explain shortly,

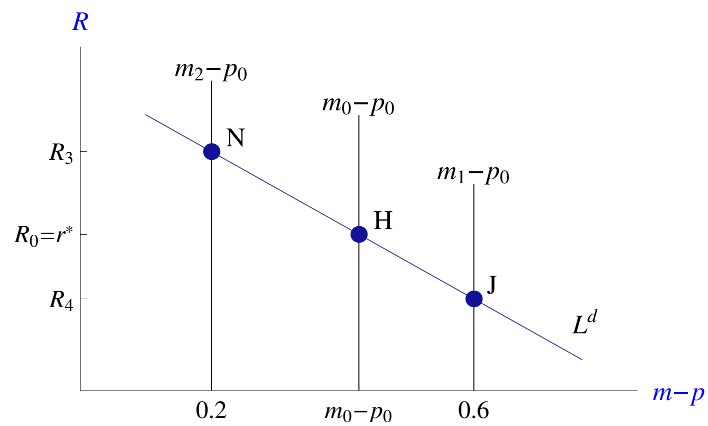

Figure 5.2: Monetary Equilibrium in the Short Run

the adjusting variable is R, the market interest rate. **Figure** 5.2 shows the money market. The interest rate R is on the vertical axis, since it adjusts to clear the market. The real money demand line – labeled L^d – slopes downward, since a lower R encourages people to hold more money. Its position changes with y and Ω. The vertical lines in the graph represent three different levels of the real supply of money $m - p$. The initial equilibrium is given by Point H, which corresponds to our previous points of long-run equilibrium.

To find the short-run equilibrium value for R, solve (5.1) for R to get:

$$R = \frac{1}{\beta_1} \left(y + \beta_2 \Omega - (m - p) \right) \tag{5.2}$$

If we knew the values of $m - p$, y, and Ω, we could solve for R in the short run.[1]

Now consider an increase in m. The principal way that this would happen

[1] Of course, we also have to know the parameters, β_1 and β_2.

would be via an "open market purchase": the Central Bank buys T-Bills on the open market and pays with new money that adds to the monetary base. Since p is fixed in the short run, the real money supply $m - p$ also rises. The vertical supply line in **Figure** 5.2 moves to the right, which causes R to fall (see Point J). We can see from Equation (5.2) that

$$\Delta R = -\frac{1}{\beta_1}\Delta m \tag{5.3}$$

What are the economics behind the fall in R?

The Federal Reserve action has given people more money than they would like to have, *relative to other forms of wealth.* Therefore, they buy more bonds and other assets, driving bond prices up, and their yields R down. We see this in **Figure** 5.2 at Point J. Monetary policy affects interest rates because it leads people to re-balance their portfolios of assets.

Now consider a fall in m, an "open market sale" of T-Bills. This shifts the real money supply curve to the left, to $m_2 - p_0$. Again, this has no immediate effect on p but instead causes R to *rise* to keep Equation (5.2) satisfied. Think of it this way: a smaller supply of money leads people to sell off bonds, in an attempt to restore their liquidity, which makes bond prices fall and their yields (i.e. R) rise. When the real money stock falls from $m_0 - p_0$ to $m_2 - p_0$ in **Figure** 5.2, the interest rate rises to $R_1 = r_1$ at Point N. We are assuming that expected inflation Δp^e is zero.

How often do we hear that the Fed "sets the interest rate"? The process illustrated with **Figure** 5.2 is the way – *the only way* – that the Fed controls market interest rates: by creating or destroying *base money* through its open market operations it can achieve rather fine control over the economy's rate of interest. When, every sixth Tuesday, we hear that the Fed has decided to, say, "raise the Federal Funds rate by a quarter of a percentage point", what that really means is that the Fed has set a new target for R, and will adjust m by buying or selling T-Bills to keep R near that target. Why is constant adjustment needed? Because there is a steady stream of shocks to *money demand* coming through y and Ω.

In the Spring of 2009 the Fed experienced its most severe challenge since the 1930s. The money multiplier collapsed (μ fell dramatically) in response to the financial panic brought on by the decline in house prices in the presence of extreme leverage on the part of households and financial institutions. This would have caused $m - p$ to fall strongly had the Fed not acted to raise the monetary base M_B. They did so by purchasing massive amounts of non-traditional assets – mortgages, equities, and junk bonds. Keeping $m-p$ steady was necessary to keep R from really rising and causing an even bigger recession.

5.3 The Open-Economy Model in the Short Run

Now we return to our full model of the open economy. The equations are as before, but since prices are rigid in the short run, y adjusts and p remains at its original value.

$$\tilde{y} = d_0 + d_1 g + d_2 y^* - d_3 r - d_4 \tilde{\phi} \tag{5.4}$$

$$m - \overline{p} = \tilde{y} - \beta_1 R + \beta_2 \Omega \tag{5.5}$$

$$\tilde{\phi} = \overline{p} - \tilde{s} - p^* \tag{5.6}$$

$$R = r + \Delta p^e \tag{5.7}$$

$$R = R^* + \Delta s^e \tag{5.8}$$

We are familiar with all of these equations. There are two differences from what we have seen before: there is a "bar" over the p to indicate that prices are fixed in the short run and cannot adjust, at least for a while. In essence, the adjustment is forced onto y from p. The tilde "˜" sign over variables indicates that these are the ones that adjust to establish short-run equilibrium.

Expectation formation is very difficult to explain and to model. We are going to make a very simple assumption: that people do not expect either prices or the exchange rate to change. This means that $\Delta p^e = \Delta s^e = 0$ and we can then see that $R = r = R^* = r^*$ even in the short run. We justify this in the following way. Although we assume they know the shock that has just hit the economy, they do not know if a new and opposite shock might hit tomorrow or next week. It is best, then, just to assume that the price level and the exchange rate are not going to change. Moreover, once the economy has returned to the long-run equilibrium, there will be no changes in either p or s.

5.4 Monetary Shock in a Closed Economy

Let us now return to the main theme of this chapter: what are the effects on the whole economy when m changes? To be precise, we will consider a *decline* in m. We shall not inquire too closely about the *reason* for the decline. The fall in m might have been a conscious decision by the central bank to reduce the monetary base M_B. Or, as during the recent financial crisis, it might have come about through a fall in the money multiplier μ.

Also, we will begin by assuming our economy is a *closed* economy. The next section deals with an open economy. Practically, this means that ϕ no longer is in the model so p does not affect the IS curve; p continues to affect the LM curve.

We analyze the shock with **Figure** 5.3, which is basically the same graph as **Figure** 3.4 in Chapter 3. At time t_0 the Fed reduces m, which moves the LM curve back to LM_1. At first, in the very short run (say, a month) y does *not* change so to clear the money market R rises strongly to R_3: this is Point V and it corresponds to Point N in **Figure** 5.2.

High interest rates in the economy *reduce the demand for investment (capital) goods*. Fairly quickly, within a few months, firms begin to reduce investment I – new spending on capital goods – and this leads to layoffs of workers who produce them. These layoffs lead to even lower demand for goods as consumption C falls. The process of multiple rounds of layoffs causes output y to fall significantly: it ends up at y_1. The new, short-run equilibrium is Point B.

The economy is not at full employment at Point B, but it will eventually

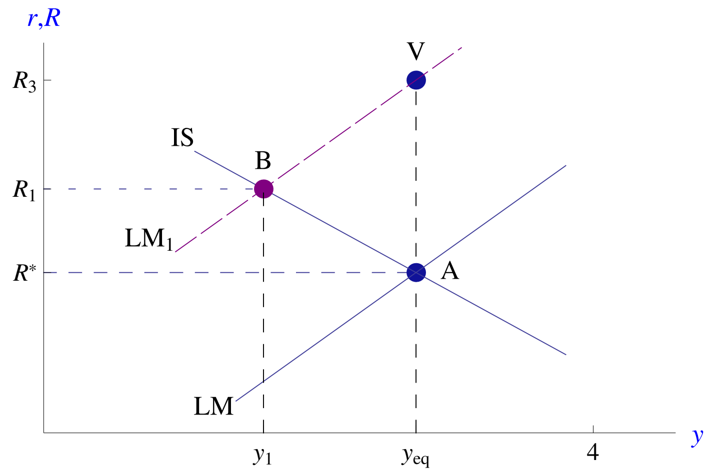

Figure 5.3: Contractionary Monetary Shock: Closed Economy

move there. How does that happen? Over time, the unemployment causes workers to offer to work for less so wages start to fall. As wages fall, it becomes easier for firms to reduce their prices. So eventually, p falls, too, so $m-p$ rises. The fall in $m-p$ pushes the LM curve out to its original position: more money – rather, more money in *real terms* – in the short run reduces interest rates. The economy ends up at Point A, exactly where it began: the interest rate and output recover their original values, R^* and y_{eq}. The only difference is that m and p are both *lower* by the same amount.

An *expansionary* monetary policy – $\Delta m > 0$ – would have similar, but opposite effects. Consult **Figure** 3.2 in Chapter 3. The short-run equilibrium is at Point D in **Figure** 3.2: interest are lower and output is higher. In fact, output rises *above* y_{eq} *in the short run.* How is this possible? Remember that "full employment" means that the economy has normal unemployment of about 5%. If unemployment falls below that, then output will be higher than the level at which it can be sustained.

Eventually, p would rise by exactly the increase in m and economy would return to Point A.

5.5 Monetary Shock in an Open Economy

We now consider the negative monetary shock for the open economy.

The effects are very much the same as in a closed economy, except for one thing: the value of the home currency appreciates, which makes the recession worse.

The shock, which is illustrated in **Figure** 5.4, begins the same way that it did in the closed economy. In particular, the interest rises to R_1 to establish the short-run equilibrium at Point B in **Figure** 5.3. We also see Point B in **Figure** 5.4. Unemployment would arise as before.

Now, however, since $R = R_1$ is above R^*, while at the same time $\Delta s^e = 0$ so that people do not expect the foreign currency to change value, capital will flow to the home country. This causes the *home* currency to *appreciate* – that is, s falls – since people must buy the home currency before they buy assets. According to (5.6), the fall in s causes the relative price of home goods $\phi = \overline{p} - s - p^*$ to *rise*, since p is fixed in the short run. Our goods get more expensive relative to foreign goods so people around the world demand fewer of them. The rise in ϕ from the exchange rate change (the fall in s) causes the IS curve to move back to IS_5 and the equilibrium moves to Point W. The output level falls to y_5, which is far below the full-employment level of y_{eq}.

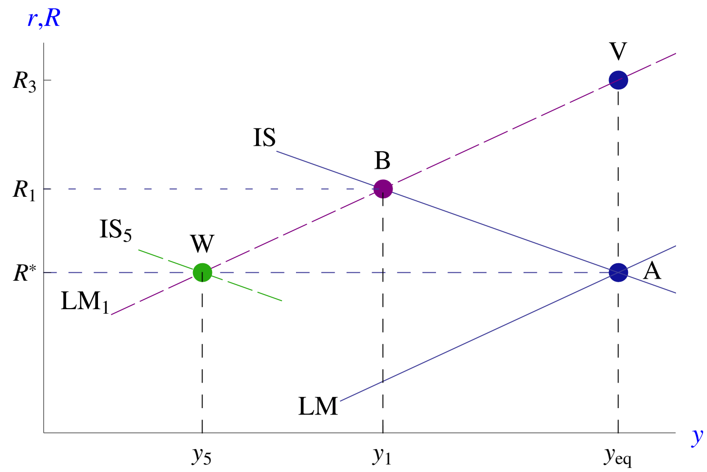

Figure 5.4: Contractionary Money Shock: Open Economy

The rise in ϕ, along with the increase in R – even though it may not last long – causes the amount demanded to fall considerably from its original level. That is why the economy settles at a short-run equilibrium at Point W. We can calculate the short-run value of y from the LM equation (5.5). Calling the short-run equilibrium value $\tilde{y}$ in general, we have:

$$\tilde{y} = (m - p) + \beta_1 R^* - \beta_2 \Omega \tag{5.9}$$

In the example, the output value $y_5 = \tilde{y}$. In this case, monetary policy is very powerful, and changes output proportionally.

Bad as the situation is, it is temporary. Sooner or later, the unemployment and excess inventories must lead to reductions in prices and wages. That is, at some point p finally begins to decline below $\overline{p}$ where it was originally stuck. As p falls but m stays the same (at its new, low level, m_2) the supply of money in real terms, $m - p$ would *rise*. This causes the LM curve to move to the right. The IS curve also moves to the right, because as p falls, other things equal, ϕ falls which raises demand for the home good. As the two curves move rightward, y moves back to its full-employment level y_{eq}.

What happens to the value of the the foreign currency s as the economy moves from Point W back to Point A? It depends on the value of d_4 the coefficient in the IS curve. You should be able to prove to yourself that if $d_4 < 1$ then s rises (the home currency depreciates). This, however, is not of much importance. We know that the *net* change in s, after all is said and done, is equal to the change in m and p.

In the long run, then, the results of the model hold exactly as described in Chapter 3: there is no permanent effect on R or y , there is no unemployment, and p and s fall proportionally to the initial decline in m. The price level p must fall to the point that the new real money supply is equal to the original one:

$$m_2 - p_2 = m_0 - p_0$$

If not, the LM curve would not return to its original position, and there would not be full employment.

Expansionary monetary policy would work in just the opposite manner. At first, R would decline and the currency would depreciate – s would rise – because people sell home money to buy foreign money in order to buy foreign assets (capital outflows). Both changes cause y to rise to a short-run, over-employment equilibrium. This case is illustrated in **Figure** 5.5. The closed-economy short-run equilibrium would be Point D; and the open-

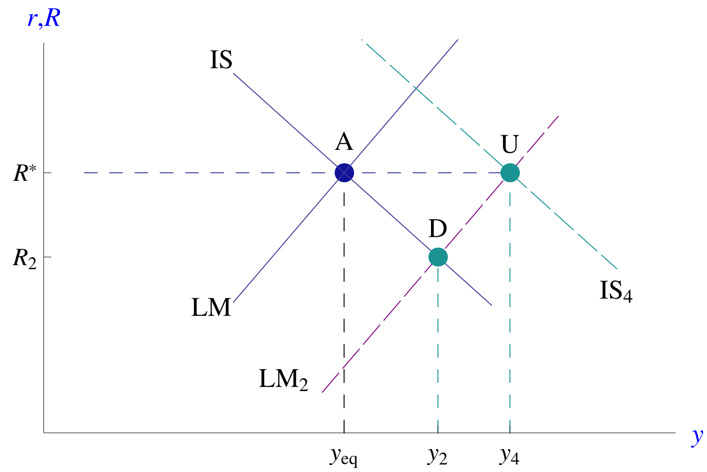

Figure 5.5: Monetary Expansion

economy short-run equilibrium is Point U.

Monetary shocks can also come from the money demand side. A change in Ω will also move the LM curve and have the same effect on the economy's equilibrium – just in reverse.

5.6 Fiscal Policy

A fall in g would move the IS curve to the left. We saw this in Chapter 3. This case is illustrated in **Figure** 5.6, which is very similar to **Figure** 3.6.

If the economy were *closed*, then Point E would be the short-run equilibrium: the interest rate R would fall, as would y.

In the open economy, however, things are *better*. The fall in R causes capital to flow out, and the home currency to *depreciate*. That is, s rises and an important side product of that is that ϕ falls, which causes the IS curve to move quickly and automatically back to its original position.

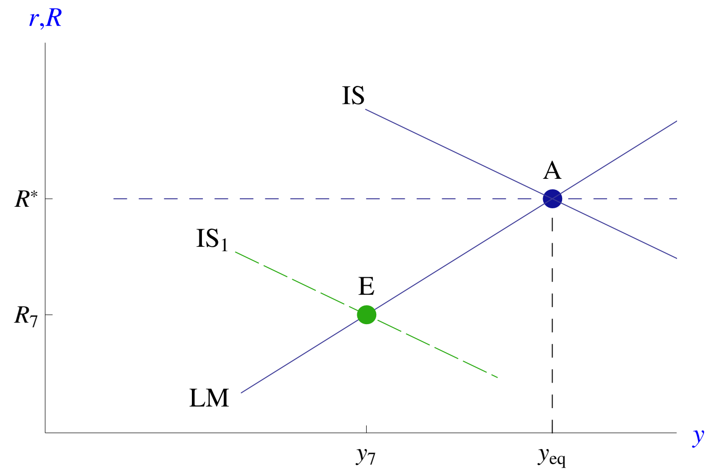

Figure 5.6: Demand Shock: Contractionary

There is virtually no recession at all. Export demand makes up for the lack of domestic government demand quickly.

The reason adjustment is so easy is that the home price level p does not have to change. The original level $\overline{p}$ is still the equilibrium price level p_{eq} once the currency depreciates.

An expansionary fiscal policy - an increase in g – is symmetrical and opposite in its effects. In a closed economy, the short-run equilibrium is Point C in **Figure** 3.5 of Chapter 3. Output and interest rates rise temporarily and there is over-employment. This hardly lasts, however, as the currency appreciates (capital flows in) and s falls (making ϕ rise). The higher relative price of the home good offsets the positive demand effect of higher government spending. Exports are crowded out.

One lesson: demand-side shocks to the home economy are well neutralized by a floating (flexible) exchange rate.

5.7 Foreign Inflation

If the foreign price level p^* were to rise, adjustment in the home country would be very quick also. The money market is not disturbed by this shock, so the *actual* domestic price level p is remains the *equilibrium* price level p_{eq}. All that must occur is that the home currency must *appreciate* to keep ϕ at its original level: the *rise* in p^* must be offset by an equal *decline* in s. Solve Equation 5.6 for s to get:

$$\tilde{s} = \bar{p} - \tilde{\phi} - p^* \tag{5.10}$$

Again, we use the tilde over the variable to indicate an equilibrium value.

A flexible exchange rate insulates a nation from imported inflation, in the sense that there are no effects other than the currency appreciation, in either the long run or the short run.

5.8 Technology and Growth

Ever since the Luddites in the early 19th Century, technical change has been blamed for unemployment. In Chapter 3 we saw that progress in living standards occurs through real growth, a permanent increase in technology A that raises y per person in current and all future years. No serious economist believes that there is any long-run increase in unemployment rates as a result of better technology – the data over 200 years is clear on this – but in the short run it is a different story. In fact, the short-run effect of better productivity on unemployment is an important topic of current research in economics.

Look back at **Figure** 3.7 in Chapter 3. Output is higher in the new long-run equilibrium. In the short run, it is unclear how firms react to the higher productivity of each worker. Some firms may hire more people, produce more, and cut prices to sell the extra product. They can reduce prices now without worrying about the wage bill since workers produce more with the new technology. Other firms may lay off some workers and produce the same amount.

Let us assume that there is some immediate fall in p, so both the LM and IS move out, but not so far as to intersect above the new y_{eq}. The exchange rate may rise or fall during this phase to keep $R = R^*$. There is, therefore, some unemployment because some firms have decided to lay off workers. If so, eventually prices will fall even more as firms realize that they can improve profit by hiring workers and selling at lower prices. They can only do this because workers are more productive than they were before the shock.

Technical change improves living standards in the long run, but may cause some unemployment in the short run. Such unemployment, however, is minor and temporary. Growth is a tremendous benefit for people in all income classes.

5.9 Conclusion

If prices and wages were perfectly, instantly flexible, monetary shocks would have no real effects: they would only change the price level and the exchange rate. That was our assumption in Chapter 3. Now, as we expand our model to deal with the case of imperfect price flexibility, we see that monetary disturbances do have real effects. Although these effects are temporary, they may be very strong. The main shock that we analyzed here, the fall in m, led to high real interest rates – at least temporarily — and currency appreciation causing recession and unemployment before the adjustment back to long-run equilibrium took place. Not all shocks have short-run consequences. To see if they do, one need only answer the following question: in Chapter 3, did the shock result in a change in p_{eq}? If the answer is No, then there is no unemployment or short-run adjustment period.

Chapter 6

Fixed Exchange Rates

6.1 Types of Fixed Exchange Rates

Many countries do not let their currencies fluctuate unhindered in the market. Rather, through a variety of mechanisms, they act to keep the currency value fixed. The term "fixed exchange rate" is itself ambiguous and potentially misleading, and refers to at least four different arrangements. These are, from most restrictive to least, the following.

1. *Dollarization.* In this case, the home country uses the currency of another country (usually the US Dollar) as its own legal tender. For example, Panama, El Salvador, and Ecuador use the US Dollar for most transactions, and Mexico and Argentina have considered switching in the past.

2. *Currency Board.* Bank reserves in home currency (the monetary base M_B) are 100% backed by foreign currency. For example, in Argentina

from April 1991 until December 2001, the supply of money was determined by international reserves only (that is, DC was basically fixed).

3. *Central Bank Administered.* The home currency is "backed" by foreign currency reserves, but at far less than 100% of the monetary base. This is called "fractional reserve" pegging of the exchange rate. Usually, citizens deal with officially licensed commercial banks who, in turn, deal with the central bank directly. Examples here include many developing countries.

4. *Target Bands.* The exchange rate is set on a free market, but the central bank intervenes forcefully, buying or selling foreign currency to keep the rate within (sometimes very narrow) bands. This system was used during the Gold Standard, the Bretton Woods System, and the European Monetary System.

In all of these cases, one thing is the same: as long as the system remains credible (more on this later) the exchange rate S is set at a pre-determined value. The central bank sets the price of the foreign money, usually the US dollar. Most countries that fix their exchange rate – or "peg" their rate – do so to a major currency like the dollar, the euro, or the yen. It is, therefore, most reasonable in the fixed-rate case to think of the home country as a smaller, developing country. And now S will typically be the price of the dollar in terms of the home currency unit.

Unlike our model of previous chapters, there can now be no market adjustment in S. It is set by the government and kept there indefinitely through a policy of buying and selling foreign currency at that price in whatever quantities are offered.

We will refer to the fixed exchange rate as $\bar{S}$ and to its log as $\bar{s}$. If the home country is Chile, for example, and it has a fixed exchange rate, then $\bar{S} = 3.78\frac{pesos}{\$}$.

It is very important to realize that while the exchange rate may be temporarily "fixed" by the government, at any time it can be changed to a new value. For example, Chile could *devalue the peso* by unilaterally *raising* the price of the dollar to $\bar{S} = 5.00\frac{pesos}{\$}$. Or it could *revalue the peso* by *reducing* the price at which it will buy or sell dollars. It is important to realize exactly what is meant by devaluation and revaluation of a "fixed" exchange rate.

6.2 The Model

The structural model is the same as before, but the variables adjust in different ways. Most importantly, *the money supply is now endogenous and the exchange rate is exogenous.* The model equations are by now familiar. We repeat them here, using $\bar{s}$ to remind us that s cannot move unless the government changes it, and using $\bar{p}$ to remind us that prices are temporarily fixed in the short run. Together, these mean that ϕ cannot move in the short run, either, so we use $\bar{\phi}$ for it. We put a tilde "~" over the variables that adjust in the short run.

$$\tilde{y} = d_0 + d_1 g + d_2 y^* - d_3 r - d_4 \bar{\phi} \tag{6.1}$$

$$\tilde{m} - \bar{p} = \tilde{y} - \beta_1 R + \beta_2 \Omega \tag{6.2}$$

$$\bar{\phi} = \bar{p} - \bar{s} - p^* \tag{6.3}$$

$$R = r + \Delta p^e \tag{6.4}$$

$$R = R^* + \Delta s^e \tag{6.5}$$

In this chapter, we are going to analyze the short run and long run together. This means that at first we will hold p fixed and find a new equilibrium. After that, we let p adjust to establish full employment. The exchange rate $\bar{s}$, however, will be held fixed at all times – unless the government decides to devalue or revalue the currency.

We will also assume that expected inflation and the expected change in the currency value are both zero: $\Delta p^e = \Delta s^e = 0$. The second assumption is natural with a fixed exchange rate that is credible. When we make this assumption, we see that $R = r = R^* = r^*$ virtually all the time. That leaves the first three equations to worry about.

In the long run, what adjusts? The endogenous variables p, m, and ϕ.

6.3 Monetary Policy

Monetary policy is very different now. Recall that the money stock is equal to a multiple of the monetary base:

$$M = \mu \left(DC + IR \right)$$

The central bank can now change DC but it cannot permanently change M if the economy is at full employment. We now show that an increase in DC will very quickly lead to an offsetting fall in IR so that M does not change.

6.3.1 The Short Run

Using the basic model, the increase in DC leads to an immediate increase in m so the LM curve moves out as in **Figure** 6.1. This creates (or would create) a short-run equilibrium at Point D, as we have seen many times already, and interest rates start heading down to R_2. However, before R can get too far, capital flows out: people buy foreign currency at the central bank in order to buy foreign assets that pay the higher yield R^*. Now, this cannot cause the currency to depreciate, since $\bar{s}$ is fixed. Instead, the central bank loses reserves: IR falls and m falls, ending up just where it began. The LM curve quickly moves back to its starting position. The price level did *not* change! The money stock rose with DC then fell with IR, to end up just where it began.

A decline in DC would have the opposite effects. The interest rate would start rising, but capital would flow in, causing IR to rise enough to offset the fall in DC and keep m the same. The LM curve would move back briefly, but return to its original position.

Monetary policy is ineffective, *even in the short run,* to change anything except international reserves. In fact, if a country has a fixed exchange rate and is low on international reserves, reducing DC would be a good policy. It would not change p, or y, or ϕ (let alone $\bar{s}$), even if the economy began in a position of unemployment. It would, however, raise IR.

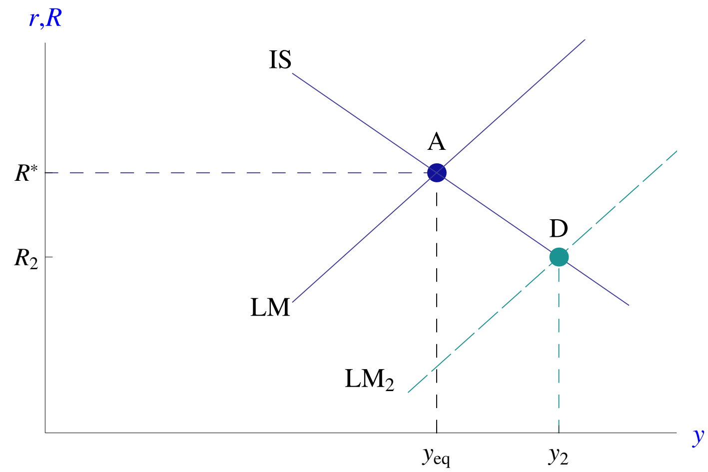

Figure 6.1: Monetary Policy: Expansionary

6.3.2 The Long Run

Money is endogenous in the long run. To see this, set $R = R^*$ and $y = y_{eq}$ in Equations (6.1) and (6.2). The former uniquely defines ϕ, which is allowed to adjust in the long run to establish the IS at full-employment y_{eq}. Equation (6.3) then uniquely determines p – which adjusts to establish the LM at y_{eq} – because $s = \bar{s}$: only s is *always* fixed. Finally (6.2) fully determines m.

Consider, next, an increase in Ω. This is an increase in the demand for money, coming from, perhaps, a financial panic, a war scare, or a political collapse (the Soviet Union). According to the model, in Equation (6.2), the only affect of this is to increase m. In the new equilibrium, $\Delta m = \beta_2 \Delta\Omega$. The *supply* of money adjusts to equal the *demand* for money. Graphically, the LM curve moves back (as it did, for example, in **Figure** 3.4 in Chapter 3). As interest rates rise above R^*, capital flows in, the central bank buys foreign currency (IR) and prints new money which enters the monetary base and raises m. This happens fast. There is little difference between the short run and the long run.

The fixed exchange rate means the supply of money *cannot be controlled by the central bank* once it has set $\bar{s}$.

6.4 Fiscal Policy

Fiscal policy, in contrast, is very powerful when the exchange rate is fixed. We begin with expansionary policy – $\Delta g > 0$ – which drives the IS curve out to the right.

6.4.1 The Short Run

If the economy were closed, the short-run equilibrium would be Point C in **Figure** 6.2, which is essentially the same as **Figure** 3.5 in Chapter 3. Interest rates would be higher and output would be above full employment.

In an open economy with a fixed exchange rate, the effects are even *stronger*. Although the exchange rate is fixed at $\bar{s}$ and cannot change, the higher R brings in capital – IR rises and money flows into the economy: the LM curve moves out to intersect IS at Point T. This is the new short-run equilibrium, but it cannot last.

6.4.2 The Long Run

The economy is seriously overheated at Point T. People are working overtime and production is much greater than normal. People will soon demand higher wages, and firms will respond by setting higher prices. As p rises

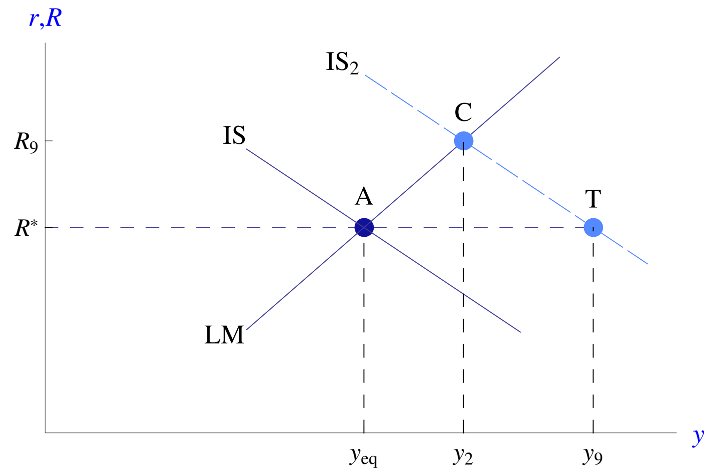

Figure 6.2: Fiscal Policy: Expansionary

over time, both the LM and the IS move back to the left. Eventually, they return to intersect at Point A, the long-run equilibrium.

Contractionary fiscal policy has the opposite effects. In particular, the economy enters a recession and prices and wages eventually fall. In the next chapter, we discuss a decline in government spending and other negative demand shocks when the exchange rate is fixed.

We note, finally, that changes in y^*, foreign income, have the same qualitative effects on the home economy as does government spending. When income abroad rises, our output also rises – at least in the short run. Eventually it will cause inflation. When y^* falls, our economy enters a recession.

6.5 Devaluation or Foreign Inflation

A devaluation of the home currency means an *increase* in $\bar{s}$. Remember, a "fixed exchange rate" is not really completely fixed forever! The government can change it whenever it pleases. The key is that it is *set* by the government and not determined in the market.

A devaluation is expansionary like government spending. The devaluation — the increase in $\bar{s}$ – reduces the relative price of the home good ϕ [see Equation (6.3)]. This makes people want to buy our goods in greater quantities so the IS curve moves out [Equation (6.1)], just as it did in **Figure** 6.2. The path is pretty much the same: Point C, to Point T quickly, then back to Point A as the price level p rises.

Devaluations from equilibrium are *inflationary*, in the sense that they cause a one-time upward movement in the price level of the same percentage amount. One good example is that of Indonesia, which was forced into a large devaluation of its currency in 1998 and as a result suffered a major inflation. And in 2002, Argentina experienced considerable inflation following the collapse (devaluation) of the peso. The price level there rose about 70% between January and July of 2002. In the previous decade, total inflation was not that high.

Foreign inflation works very much like a devaluation, in that it makes the home good relatively cheap at first, and leads to inflation at home later. This phenomenon is called "imported inflation" and was instrumental in derailing the Bretton Woods international monetary system in the late 1960s. In Chapter 8, we will look at the Bretton Woods system in more detail.

The eventual inflation is of the same percentage amount as the devaluation – or the foreign inflation. To see this, note that by Equation (6.1), ϕ cannot change in the long run, since $R = R^*$ and $y = y_{eq}$. Therefore, by (6.3), we know that $\Delta p = \Delta \bar{s}$ to keep the relative price the same. Foreign

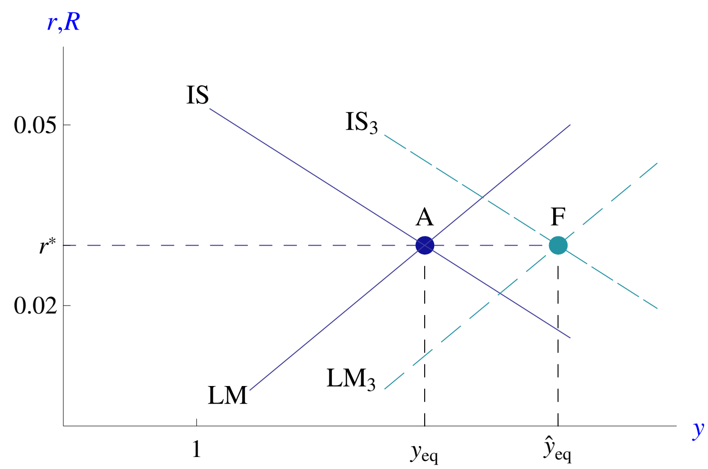

Figure 6.3: Technology and Growth

inflation has the same eventual effect on home prices: $\Delta p = \Delta p^*$. If Mexico is pegging its currency to the dollar, and the US has inflation of 12% one year, then Mexico will also have inflation of 12%. In both cases – devaluation and foreign inflation – can you tell what happens to the money supply m in the long run?

6.6 Technology and Growth

In Chapters 3 and 5, we considered a permanent rise in A that increased output y_{eq}. We analyze the same disturbance now in the fixed rate case. This case was first illustrated in **Figure** 3.7 in Chapter 3. That figure is reproduced here as **Figure** 6.3.

The story of adjustment is similar now with the fixed exchange rate: we know, however, that $s = \bar{s}$ at all times, so m must adjust as the economy moves from Point A to Point F. Here, the equations are useful, especially for long-run analysis. We know that y_{eq} is higher so ϕ must eventually be lower by (6.1) to raise demand to equal the greater supply. By (6.3), this can only be accomplished by a lower p since $s = \bar{s}$. Now look at (6.2). Does m rise or fall in the long run? We cannot tell: p fell, but y rose, so it again depends on the magnitude of d_4 relative to 1. (Exercise: find the condition for a rise in m.)

6.7 Conclusion

If the home country is already at full employment, an expansionary policy like devaluation or increased government spending is not particularly useful – it simply creates higher prices. On the other hand, if the economy is already in a recession – that is, experiencing a lack of demand – such policies can be very helpful to raise employment.

Even at full-employment, however, these policies have one benefit: they bring in international reserves. If the country's government is low on reserves, this can be very useful. The same is true of reduction in domestic credit DC.

There has long been an active debate about the relative merits of fixed and flexible exchange rates. How do we choose which is best? One criterion is the ability of the economy to adjust to shocks, both domestic and foreign.

For example, what if there were foreign inflation, in the sense of a rise in p^*? There are two alternatives: are either a rise in the home price level (if s is fixed) or an appreciation of the home currency (if s is flexible). Many would prefer the currency appreciation to the "imported inflation", so the government may choose a flexible rate on this basis.

What if the government decided to create new domestic credit (print new money)? Under a flexible rate this would raise p and s. Under a fixed rate, however, the price level p will not change, and s is fixed by definition. The central bank instead loses international reserves. In the short run, the lack of inflation may seem good, but in the long run reserves are gone and, in the worst case, the country is forced off the fixed rate anyway.

We will have more to say about the relative merits of the two regimes in Chapter 7. We conclude with the observation that fixed rates force adjustment of ϕ onto the price level p: the exchange rate s can no longer help the relative price to adjust. This can be more difficult to bear, since there are many prices and some are set by long-term contracts. Some advocate fixing the exchange rate precisely because the adjustment can be hard. They reason that it imposes a discipline on a government that may otherwise be tempted into excessive spending and lax monetary policy.

Appendix: Balance-Sheet Effect

As noted in the text, we expect a devaluation to boost home-good demand by reducing ϕ, if only temporarily. But this seems at odds with some recent history. In Argentina in late 2001, for example, the currency devaluation deepened the already severe recession. In 1997-98 Indonesia, Thailand, the Philippines and South Korea experienced sudden devaluation of their currencies that coincided with severe downturns in their economies.

The reason may lie in the so-called "balance-sheet effect" or "wealth effect". The idea is that a devaluation, in addition to its positive effect through ϕ, also has a negative effect on wealth *if a nation has large net debts in foreign currency.* Recall the consumption function (2.7) in Chapter 2:

$$C_t = c_0 + c_1 Y$$

Now assume that c_0 depends, at least in part, on B_t, "net foreign assets". In the cases we are now interested in – developing nations – B_t is usually negative, in some cases very negative. In our theory, B_t refers to the *real (home-good) value of net foreign assets.* So if the country is a net debtor, $B_t < 0$.

Let us take Argentina as an example. The real value of their debt can be decomposed into the following expression:

$$B_t = \frac{\bar{S}_t Q_t}{P_t}$$

where Q is the *dollar value of Argentina's total debt to US agents* (private or official), $\bar{S}_t$ is the peso/dollar exchange rate, and P_t is the home-good price (Pesos/Home Good), all at time t. Begin by assuming that Argentina has dollar debts of $Q_t = \$20\,billion$, the exchange rate was $\bar{S}_t = 1\frac{peso}{\$}$ and that the home price level is $P_t = 10\frac{peso}{Arg-goods}$. This means the debt in *real terms* is 2 billion units of goods, so $B_t = -2HG$.

Now consider a peso devaluation in which $\bar{S}$ is increased from 1 to 2. This *doubles* the real value of the debt to 4 billion units of home goods! If c_0 is sensitive to the value of B this could have a major negative effect on consumption.

Chapter 7

Collapse of Fixed Exchange Rates and Other Monetary Problems

7.1 Fragility and Deflationary Shocks

Fixed exchange rate systems hardly ever last more than a couple of years. This is true both for countries that unilaterally peg to another currency (usually the dollar or the euro) like China, Malaysia, and Venezuela, and for systems designed by groups of nations to keep their rates aligned, like the European Monetary System (in the 1970s and 1980s) or the Bretton Woods system (1950s and 1960s). Even the Euro Block of countries is showing signs of stress in 2012. The exceptions are few. The fact is that fixed rates are fragile and often cannot resist shocks that may appear at first to be fairly minor. Argentina, Chile, Mexico, Russia, and Brazil are among the countries whose fixed exchange rate regimes collapsed in recent years.

This fragility appears for two reasons. First, a shock occurs that can only be accommodated by a reaction in the home country that is difficult to deal with, like deflation or loss of international reserves (these are the cases on which I will concentrate). Second, people realize the political difficulty of absorbing the full force of the shock, and also believe that devaluation will fix the problem with far less pain. These traders assume the government reasons in the same manner, so they begin to attack the currency (i.e. sell it for another currency) with no fear of losing money from a revaluation. At some point it becomes clear that *there is virtually zero chance of a revaluation of the currency*, so speculation is a one-way bet: there is no downside to a gamble against the currency. This is why fixed exchange rates are fragile in a way that flexible rates are not.

The rest of this section elaborates on this idea.

The home price level in full-employment equilibrium is given by the following simple expression when the country has a fixed exchange rate:

$$p_{eq} = \bar{s} + \phi_{eq} + p^* \tag{7.1}$$

This equation comes directly from Eq (6.3). The price level in full-employment p_{eq} depends on the fixed exchange rate $\bar{s}$, the relative price of home goods in equilibrium ϕ_{eq}, and the foreign price level.

Consider a shock that reduces demand for the home good without affecting the supply. This could be a decline in another country's output, a fall in government expenditure, a rise in taxes, or a tariff from a large trading partner. All of these move the IS curve back to the left.

The new short-run equilibrium is shown at Point Z in **Figure** 7.1. This is the opposite of the expansionary fiscal policy shock we saw in **Figure** 6.2 of Chapter 6.

Falling demand, if it is large, can lead to a severe recession with very high levels of unemployment. At the short-run equilibrium Point Z, y is far below its full employment value y_{eq}. How will the economy recover from this recession? It can be very difficult because the fundamental problem is that ϕ is too high. That is, $\phi > \phi_{eq}$. The relative price of the home good in the *short-run* equilibrium is above the relative price that guarantees full-employment equilibrium.

Recall that Equation (6.3) is:

$$\phi = p - \bar{s} - p^* \tag{7.2}$$

which is the definition of the relative price.

If the exchange rate is maintained at its original level of $\bar{s}$, then the only way for the adjustment in ϕ downward can be made is through a fall in p. That is, a *general deflation in the economy is necessary.* But even a small decline in money prices (and money wages) can be a very difficult task, requiring years of lagging sales and high unemployment before producers and unions agree to the reductions. A good example of this is Great Britain during the early 1920's. To set the stage for a successful return to the Gold Standard required a substantial deflation of money prices and wages. After

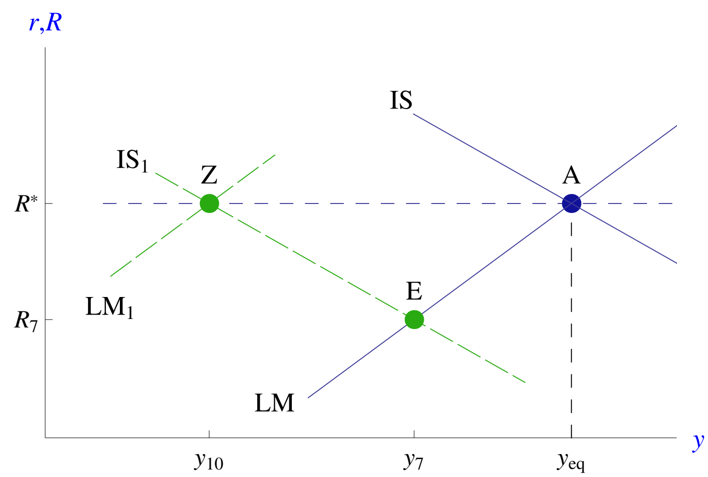

Figure 7.1: Deflationary Shock with a Fixed Exchange Rate

a few years of economic depression, the attempt was abandoned and the pre-war standard was never achieved. Argentina from 1998 to 2001 presents a similar case of stubbornly high unemployment with a rigid fixed exchange rate. Deflationary shocks of the type shown in Figure 7.1 can be very difficult for countries that maintain a fixed exchange rate.

Greece is only the most recent example: their currency, the euro, is fixed to the currency of Germany, the euro. Greek prices and wages will have to fall if they remain in the euro zone.

In general, however, there is a relatively fast and painless way to achieve the long-run equilibrium back at Point A. The government can *devalue*, that is, to raise $\bar{s}$. We see in Equation (7.2) that a devaluation would reduce ϕ *immediately*: if sufficiently large, it would clear the goods market without the pain of unemployment and idle factories. If the devaluation is of the right size it would *not* be inflationary; it would be a way of allowing the relative price adjustment that is necessary to restore equilibrium. The price level p stays the same. The devaluation makes the original p the equilibrium p_{eq}, even after the deflationary shock. [1]

7.2 Speculation

Strong governments may be able to stay the course, keep S fixed and endure the spell of deflation and high unemployment. Argentina tried this from about 1998 to the end of 2001 but ultimately abandoned the standard. The point I want to make here is that in any country in this position, no matter how strong, speculators will soon begin to bet against the currency. Why? Because they cannot lose. They may not win; but they cannot lose (except for small transactions costs).

If you were an Argentine resident you might say to yourself: "I'm going to sell my Argentine bonds, my Argentine stocks, my house, my car, and my precious textbooks. With the pesos I receive, I will buy dollars at the current fixed exchange rate. If I am right and the government devalues, I can buy the pesos back cheaper than I sold them! That's a great profit for a day (see below). If I am wrong and the government stays firm, I haven't lost a thing. It is not conceivable that they will revalue the peso, since that would *raise* ϕ and worsen the depression!"

This no-lose, one-way speculation makes it extremely difficult to defend the currency, since once the heavy speculation begins the government's reserves get depleted quickly. Once they are gone, the government has no

[1] This discussion ignores the wealth effect that operates in the opposite direction, and may reduce demand. This was discussed in the appendix to Chapter 6.

choice and must stop fixing its rate. This is a good example of the extreme capital outflows called "capital flight". This is the purchase of official assets (i.e. "international reserves") by a country's citizens, who then use them to acquire their own, private assets abroad. It is a conversion of official to private international claims.

7.3 Rates of Return

Can the government do anything to keep speculators at bay? The remedy often tried is for the government to raise interest rates, sometimes to astronomical levels, to entice investors to keep the funds in home-country bonds, and not foreign assets. If they can stop the private capital outflow, they can keep the currency value at its original level.

To see how hard this is, consider a devaluation of only 5%. If you think of it, this is like getting a return of 5% in a single day. The time period is crucial since official interest rates and other rates of return are calculated on an annual basis. Devaluations happen instantly, but we have to assume that one has to tie up her capital for some period of time, no matter how short. Assume, first, that it only takes one day to earn the 5%. To convert from a daily basis to an annual basis (compounded daily), we use the following formula:

$$1 + r_A = (1 + r_D)^{365} = 1.05^{365} = 5.4212 \times 10^7 \qquad (7.3)$$

This means that the annual gross rate of return is 5,421,118,000%! To take a less extreme case, assume that interest is compounded only weekly and it took a week with your capital tied up to get the 5% return from the devaluation. Then the annualized return would be $1.05^{52} - 1 = 11.6428 \Longrightarrow$ $1,164.28\%$.

Looked at another way, a 100% *annual* rate of interest (which Sweden actually tried briefly in 1992) would correspond to a *daily* compounded rate given by:

$$r_D = (1 + r_A)^{\frac{1}{365}} - 1 = 2^{\frac{1}{365}} - 1 = 0.0019 \tag{7.4}$$

This would only prevent a devaluation of 0.19%, which is barely noticeable. In practice, devaluations are much larger than this.

Even though one cannot get the 5% every day for a year, in order to make the correct comparison with yearly rates, one must either express the daily rate on a yearly basis, or the yearly rate on a daily basis. Viewed in this light, we can see why it is so difficult for a nation to use interest rates to stop a speculative capital outflow. They would have to charge extraordinarily high interest rates to make the return comparable to a quick return you can get from a devaluation. There is a limit to how high the government can push the interest rate upwards because high interest makes life very hard for businesses trying to borrow for expansion and for individuals with variable-rate debt. We saw in Chapter 5 that a high interest rate shock (from a reduction in m) can cause severe recession in any economy.

7.4 What To Do About China?

Should the US pressure China to revalue the yuan? For many years, China held its exchange rate fixed at $\bar{S} = \frac{8.2765Y}{\$}$. This began to change in 2005 as China slowly revalued the yuan in a controlled manner. By the summer of 2011 the rate had fallen to $\bar{S} = \frac{6.474Y}{\$}$. This decline in the price of the US dollar represents an *appreciation* of the Yuan of about 22%.[2] Still, the US government argues that the appreciation should be larger. Why is this such a huge issue?

The political answer is simple: the US has a huge trade deficit with China. It seems like everything you purchase in the US these days is made in China. For the typical US consumer, this is very good: we get high quality goods at low prices. For many US producers – who have more political clout – this situation is not so good. The Chinese goods are directly competitive and reduce US prices and erode US corporate profits. It also has an impact on some segments of the labor market. If US firms are doing poorly they might lay off some workers. Even if their jobs are not lost, their money wages may decline as demand falls.

So why is the US demanding revaluation? If we think of Equation (7.2) as applying to China, then by asking China to reduce $\bar{s}$, we are really asking them to raise their ϕ, at least in the short run. We want them to make their goods more expensive for us to buy. Then, we would not buy so many Chinese televisions and our trade deficit with China would get smaller and firms in the US would do better. US consumers, however, would do worse.

The US does not make this demand of every country with which it has a trade deficit so it is interesting to ask why this issue is so hot now. There are two reasons:

1. most countries do not have a fixed exchange rate;

[2] That is, the dollar is worth about 78% of its previous yuan value.

2. most countries are far smaller than China.

Interestingly, a revaluation may actually be in China's own interest. The liberalization of the Chinese economy, the opening to foreign trade, and the enormous increase in public expenditure on infrastructure all have created a sizable rightward shift in both the y_{eq} and the IS curves for China. There can be little doubt that there has been a huge rise in both supply of China's goods and the demand for China's goods both within China and around the world. The question is: has the increase in IS outstripped the considerable increase in y_{eq}? Looking at **Figure** 7.2 , we may ask: has the IS moved out to IS_{11} or out to IS_{12}? [3]

The key point here is that if indeed IS has moved more than y_{eq} – that is, to IS_{12} – then the Chinese economy is in a state of $\phi < \phi_{eq}$. The relative price is *too low*. China will begin to feel inflation in goods prices as the adjustment is made to the new equilibrium at Point F. That is, p will rise to enable ϕ to clear the goods market.

This, I think, is the claim made by some respectable economists who favor a revaluation, since a revaluation – see Equation (7.2) – would allow immediate adjustment to Point A in **Figure 7.2** by raising ϕ directly. Those opposed to revaluation say that the IS curve has not moved as far as y_{eq} – that is, only to position IS_{11} – so a revaluation would be a disaster, leading to excess supply, unemployment, and eventual deflation. Who is right? It is difficult to tell. On the one hand, inflation has been a growing problem in China, suggesting that the economy is above point F. On the

[3] We do not have to worry about the LM curve. The money stock m will adjust to make sure it goes through the intersection of the IS and y_{eq}.

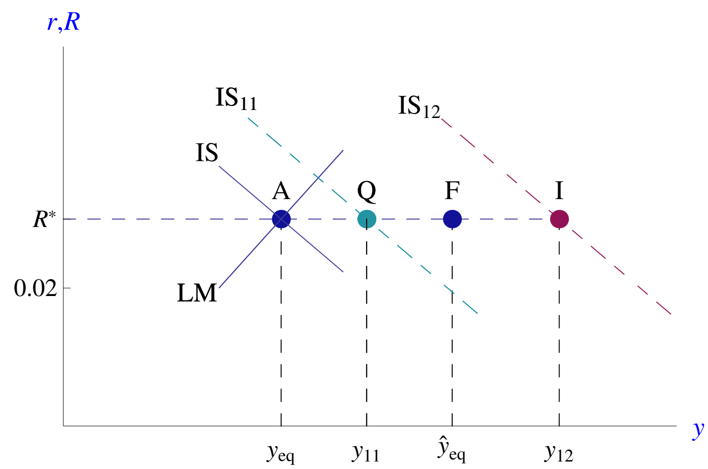

Figure 7.2: China circa 2012

other hand, there is still a lot of unemployment in China, and while that may well be structural, due to the switch from Communism to capitalism, a revaluation will only make it worse. On top of everything, the banking system is holding lots of dollar assets so a revaluation of the yuan would be a de facto devaluation of a huge store of dollar wealth.[4]

The yuan is not completely fixed as it was a couple of years ago. It is, however, being managed tightly by the Chinese government, who jumps into the market and sells yuan (i.e. buys dollars with yuan) whenever the price of the dollar falls too much in the free market. By propping up the dollar, they are keeping the yuan cheap. Interestingly, this is a case of no-lose speculation in the opposite direction of the normal case: if you had to bet, you know the yuan will not be devalued. We all know that it will rise in value, either a little bit or a lot.

[4]This is the opposite of the Argentine case we saw in the Appendix to Chapter 6.

7.5 Inconsistent Monetary Policy

The deflationary shock noted above may originate from abroad or from home. Another common source of devaluation pressure on fixed exchange rates is very different. It is an inconsistent, over-expansionary monetary policy at home. We saw earlier that an increase in domestic credit by the home central bank would result in a loss of international reserves.

Once the process begins and agents know that reserves are falling, and if they see no credible policy on the horizon to reverse it, they will begin to speculate against the home currency in exactly the same manner as above. This, of course, makes the reserve loss much worse, and hastens the day of devaluation.

In contrast to the first shock, a devaluation resulting from inconsistent monetary policy *does raise the price level.* The reason is that at the time of the devaluation $\phi = \phi_{eq}$.

Consider Equation (7.1) again. Now ϕ_{eq} and p^* are constant, and an increase in $\bar{s}$ – the devaluation – would raise eventually raise p_{eq} but this would take a long time. In the short run, as we noted in the last chapter (see Figure 6.1) and can infer from Equation (7.2), the devaluation would reduce the relative price ϕ below it's equilibrium level of ϕ_{eq} (which is not changed here) creating the excess demand that will eventually drive p up.

Expansionary monetary policy will not raise the price level in a fixed-rate regime if people feel that the government is credible and the increase in m is temporary. If, however, they think that the increase in m will continue indefinitely, they are likely to start betting against the currency. The no-lose speculation may well cause the country to devalue, or drive the country off the fixed rate entirely, at which point prices will rise.

7.6 Panics

In 1997, several currencies in Asia collapsed, among them those of Indonesia, Thailand, and South Korea. The accounts of those episodes do not explicitly refer to shocks of the types noted above: neither excess money creation at home nor deflationary shocks from any source were mentioned as possible culprits. Instead, we heard mainly of "panic", "unstable capital flows", "an irresponsible press", and "corruption". It can't be denied, moreover, that what brought the currencies down in every case was heavy speculation against them.

Fixed exchange rate regimes, however, *always* collapse in a flurry of speculation, no matter what the root cause. The Asian crises could have been caused by either of the two shocks analyzed earlier in this chapter.

Interestingly, there may be a third culprit. We cannot rule out a "self-fulfilling prophecy": changes in prices based purely on expectation that become self-perpetuating – up to a point. Bubbles in prices happen all the time. In 2008, we saw "irrational" buying driving up the price of oil. In 2010 and 2011 prices commodities of all kinds – particularly gold – rose to new highs. From 2000 to 2006 house prices sky-rocketed. As prices rises, traders' expectations of rising prices are fulfilled, leading to even more buying. However, since the fundamentals do not support the huge increases, prices eventually fall. Many lose vast sums of wealth when the crash occurs, especially those who went into debt to acquire the now-cheapened asset.

In terms of currency markets, sentiment might turn against a particular currency due to false information. If everyone begins selling that currency (i.e. speculating on the other currency) it is possible that the fixed rate could collapse even if the fundamentals were sound.

Here's why such a scenario can almost never be totally ignored. Bank of America is a well-run, solvent bank with absolutely no chance of bankruptcy. But if we all wanted to take out our deposits simultaneously, Bank of America could not accommodate us, and would have to appeal to the Federal Reserve for loans of new cash (which they simply create out of thin air). So any kind of rumor that the bank was in trouble, leading people to pull their funds out, would be self-fulfilling and drive it to disaster, if there were no Fed. This is simply the nature of fractional reserve banking. At the national level we avoid such crises with a "lender of resort" and deposit insurance, both of which calm depositors considerably.

At the international level, we do have the IMF, but this organization is not well-suited to the rapid response necessary to save a nation's currency.

7.7 The IMF and Its Discontents

Currency crises are often accompanied by IMF "bail-outs" in which the International Monetary Fund provides new loans to a country and imposes various kinds of conditions and restrictions on economic policy. In 2010-12, for example, the IMF lent the European Union billions of dollars to help bailout Ireland, Portugal, Greece, and Spain. In some cases, such new financing is appropriate and helpful, but in many instances some people, not the least the citizens of the countries that are in trouble, believe that it would be better if the IMF did not become involved at all.

The problem is that of "Moral Hazard". The fundamental idea is that the stream of bail-outs creates the incentive for foreign banks to lend dollars *regardless of risk*, since they know that they will be made whole in the event of a default. If true, it means that lenders are not doing "due diligence" to unearth the risks inherent in their loans, while they are collecting huge interest payments that are so big only because they contain a risk premium for the probability of default. To take an example, in 2001 Argentine bonds were paying interest of 30% per year in pesos, even though the peso was "fixed" to the Dollar at 1 to 1. At the same time, interest rates in the US were only about 2%. The difference was there to cover the twin risk of default and devaluation. As long as the peso peg (fixed rate) lasted, this was an incredibly good deal for those who held the bonds (US and European Mutual Funds, small investors in both regions, banks in the US and Europe, etc.) since they collected their huge interest payment then converted them back to dollars. These bonds were, moreover, "guaranteed" by the Argentine government. It seemed ideal. When the collapse came, not only did the peso fall to about 3 to the Dollar, but there was a massive default on the debt. Holders of Argentine bonds eventually received about $.30 for every $1.00 of debt they held, but some creditors did not go along with the settlement. Although default is rarely a good solution, it is hard to work up much pity for middle class Americans and Germans demanding full payment from poor Argentine taxpayers when they have already enjoyed several years of extraordinary returns.

7.8 Conclusion

Fixed rates are fragile. They do not last long since shocks often lead to speculation that magnifies the intensity of the initial problem. Capital flows around the world very easily these days, which makes it that much harder to defend a fixed rate. Many people question whether we have adequate international financial institutions to deal with crises when they erupt. It is probably best for every country to have a flexible exchange rate.

Chapter 8

A Brief Monetary History of the World

8.1 Introduction

Almost all countries in the world have a unique national currency. We have seen already that this requires each country to decide whether to have a flexible exchange rate or a fixed one. If the latter is chosen, then they must decide to which foreign currency they will peg.

Paper money is a relatively recent invention. Until the mid-18th century, money was made of commodities with intrinsic value, mainly gold or silver. This was not efficient, either for individuals and businesses – who had high costs of transacting and storage – or for governments, who could not increase the money supply when necessary. Banking and paper money solved these problems, but created another one: inflation. When governments realized that they could "tax" their citizens by creating and spending money, many of them did so, creating inflation, instability, and eroding confidence in public institutions.[1]

The solution was to use paper money, but to "back it" with gold. Great Britain was the first to do this. It created confidence in the Pound and led to London's becoming the world's financial center. It also led to the first international monetary system: the Gold Standard.

8.2 The Gold Standard

8.2.1 Basics: The Price of Gold

Great Britain made the pound "convertible" into gold by establishing a fixed price for gold. The government stood ready to buy or sell gold at that price (in pounds sterling) to anyone who wanted to transact. This is what is meant by "backing a currency" with gold. Just as there is a fixed money-price for gold, there is a fixed gold-price for money.

Let us consider an example. Say that Britain set the price of an ounce of gold at:

$$p_g^{\pounds} = \frac{4.24779\,\pounds}{oz} \tag{8.1}$$

This meant that people could count on the value of a pound being:

$$p_{\pounds}^{gold} = \frac{.23542\,oz}{\pounds} \tag{8.2}$$

This is the sense in which the pound was backed by gold: everyone knew

[1] Before paper money, governments accomplished the same thing by "debasing" their currency: reducing the gold content of any given category of coin (e.g. a pound).

that they could "redeem" their paper money for gold at any time and *always* receive .2354 ounces of gold in exchange. Britain famously held the gold price fixed for many years.

When other countries saw Britain's success, they began to fix their currencies to gold, too. The United States eventually fixed the price of gold at:

$$p_g^{\$} = \frac{20.6718\,\$}{oz} \tag{8.3}$$

From about 1870 - 1910 many countries joined the Gold Standard system by setting a price for gold in terms of their own currency.

8.2.2 Implicit Exchange Rates: The Mint Par

When two countries peg to the same commodity, there is an implicit exchange rate between them. Take the ratio of (8.3) and (8.1) to get:

$$S_M{}^{\$}_{£}, = \frac{p_g^{\$}}{p_g^{£}} = \frac{4.86649\$}{£} \tag{8.4}$$

This rate was called the "mint par" exchange rate.

Free currency markets were also operating in London and New York. The market exchange rate $S^{\$}_{£}$ had to be close to the mint par. If it were *greater*, then people could buy gold in the US with dollars, ship the gold to London, then sell the gold for pounds, and finally turn around and buy dollars at the rate $E = \frac{1}{S}$. If the market rate exceeded the mint par, the above sequence would produce a profit, ignoring transactions costs. The formula for calculating the dollars you end up with, $\$B$, assuming that you begin with $\$A$, is

$$\$B = \$A * \frac{S_{£}^{\$}}{S_{M}{}_{£}^{\$}} \tag{8.5}$$

Gold would flow to London whenever the market rate S exceeded the mint par S_M, and would flow to New York if the opposite happened. In practice, the cost of shipping gold allowed some slippage so that there did exist small differences in the market rate and the mint par.[2]

With several countries pegging to gold, the system worked like a general fixed-rate system in which all countries were linked to the British Pound. It is safe to think of the mint par rates as the normal fixed rates. People came to regard these rates as historical or natural norms.

8.2.3 Money Supply and the Price Level

The monetary sector worked just as in our previous analysis, with one exception. The monetary base, M_{Base} was equal to the stock of gold owned by the Central Bank. That is, each country limited the actual money supply to some multiple of the amount of gold in its vault. So we can write:

$$M = \mu p_g M_G \tag{8.6}$$

for the money supply equation, where M_G is the amount of monetary gold. Equation (8.6) replaces (2.17). As before, given monetary equilibrium – $M = M^D$ – the price level is proportional to the money supply. As in

[2]These differences gave rise to the so-called the "gold points": the boundaries within which the market rate E fluctuated freely.

(2.20), we may express this as:

$$P = \frac{\mu p_g M_G}{L(Y, R, \Omega)} \tag{8.7}$$

This price equation can be thought of as applying at different political levels. That is, we can think of it as applicable to the whole world (at least to all the countries on the Gold Standard) or to individual countries. It works best for a closed system like the world, but since capital did not flow as quickly back then, each country was more isolated economically, and prices could be determined by internal monetary conditions for long periods.

In any case, if the gold supply increased, it would increase the monetary base and the money stock itself. Prices would rise. If, on the other hand, there was a period of high real growth in Y, without an increase in gold, then prices would fall. It is possible to interpret US monetary history from 1873 - 1913 in this light.

The supply of gold in the world was not constant, of course. There were many instances of "gold rushes" throughout history. In fact, there was an automatic mechanism to ensure that gold would increase whenever it was needed the most. We discuss this mechanism next.

8.2.4 Gold Supply and the Relative Price of Gold

We now define q to be the *relative price of gold*:

$$q \equiv \frac{p_g}{P} = p_{gold}^{Goods} \tag{8.8}$$

This relative price was the key to the increase in the world money supply. When economic growth was high (that is, the increase in A_t led to an increase in Y_t) we see from (8.7) that the price level would be falling. This means, from (8.8) that gold was getting more valuable, in terms of the goods it would buy.

The rise in the value of gold encouraged people to go look for it, to mine it, and to join a Gold Rush once it was found. This, in turn, caused M_G to rise as the new supplies found their way into the monetary system. The money supply would increase, as would the price level P in (8.7).

In this manner, there was a natural mechanism to keep the price level more or less stable, even though this mechanism was not very efficient. It took a long time to operate to stabilize P. It is much easier to have paper money and let the Central Bank increase M in pace with Y to keep P steady.

8.3 The US and Great Britain Before WW I

Great Britain maintained the Gold Standard nearly continuously from about 1820 (the end of the Napoleonic Wars) to 1914 (the beginning of the First World War).

The United States, on the other hand, had a much odder and less consistent system. Before the Civil War (1860 – 1865) the US was on a bi-metallic standard. Both gold and silver were minted (that is, the government established fixed dollar prices for both) and the money supply depended on both the quantity of gold and silver held by the Treasury (as well as their dollar prices).

The Civil War changed all of that. The US abandoned the gold and silver standards in 1860 and did not return until 1873. At that time, the US decided that only gold would be monetized. This created a huge controversy between the East (gold only) and the West (both) that became acute as deflation gripped the nation between 1885 and 1898.

8.4 The Interwar Years

During the First World War, which began in 1914, the Gold Standard system fell apart. The needs of war finance dominated all other considerations: the governments of Europe and the US delinked their currencies from gold so they would not have to worry about losing their gold reserves. The war was financed by a combination of borrowing (War Bonds) and printing money.

After the war, it was difficult to put the system back together. The reason can be seen from Equation (8.8). Consider the case of Great Britain. Because of wartime inflation, P was very high, so q would be very low if reckoned at the original gold price. Gold, relative to goods, would have been incredibly cheap at the original fixed price $p_g^{£}$. The Bank of England would not have kept any gold if it had been forced to sell it at a cut-rate relative price q.

This left the government two choices to restore q to a reasonable range. They could either *deflate* the economy (that is, drive $P_{Goods}^{£}$ down) or *devalue* the currency (that is, raise the money price of gold $p_g^{£}$). Both options had their critics, but eventually the former path was chosen. As a result, throughout the 1920's and into the 1930's Great Britain was in a state of depression as the government carried out contractionary monetary policy to try to drive the price level down. This was a kind of deflationary shock as described in Chapter 7.

John Maynard Keynes, the great economist, favored a devaluation of the pound sterling (a rise in p_g) but Winston Churchill argued against that and prevailed.

8.5 The Bretton Woods System

When the Second World War ended there was a general feeling that some restoration of the world monetary order was a priority. It was recognized that the Gold Standard had its faults, so world monetary leaders gathered in Bretton Woods, New Hampshire in 1946 to plan a new system. The result was the Bretton Woods System.

The rules were the following:

1. the US had to peg to gold at a fixed price – $p_g = 35\frac{\$}{oz}$ – as under the Gold Standard;
2. only central banks could buy gold from the Fed at that price; private debts could not be written in terms of gold;
3. all other countries had to peg their currencies to the US dollar at a fixed price, such as $5.12\frac{FF}{\$}$.

The idea was that this would provide the Fed a powerful incentive to stabilize the US price level, because it would be in the US's own interest to stabilize q. If they did not, foreign central banks would buy the gold in Fort Knox.

Second, the fixed rates would stabilize *foreign* prices if the US price level remained stable. This follows directly from the properties of the fixed-rate system that we first analyzed in Chapter 6.

This system worked for about twenty years, but then collapsed because the US found that it needed to print money to pay for the Vietnam War and the Great Society. Like all fixed-rates, this one, too, fell apart.

8.6 The European Monetary System

After the collapse of the Bretton Woods system, almost all of the large industrial countries adopted a floating exchange rate. Europe's common currency, the euro, however, grew out of a system of fixed rates called the European Monetary System (linking each currency to a fictitious currency called the ECU). German Unification led to the demise of the EMS in the early 1990's – an episode much like the fall of the Bretton Woods System – but by 2002 the euro was installed as a single currency controlled by a single central bank, the European Central Bank (ECB) which functions like the Federal Reserve System in the US. Even so, the euro is under strain today in 2012 as the periphery countries of Europe face public debts they cannot pay.

At present, the US dollar, the euro, the Japanese yen, the Swiss franc, the British pound, and the Canadian dollar, all float unhindered. Small countries sometimes peg, either to the US dollar or to the euro.

8.7 Conclusion

The world has seen many monetary systems come and go. A system of independent floating rates is the current norm and is likely to remain that way.

Appendix A

Glossary of Notation

We have used a lot of notation in this course. Tables A.1 and A.2 in this appendix provide a reference for the most common symbols.

Table A.1: Symbols Used in the Text

Symbol	**Definition**
A_t	State of technology presently
A_F	Expected future state of technology
B_t	Net foreign assets held at the beginning of year t
C	Consumption demand by home residents
CA	Current Account balance
C_d	Consumption demand by home residents for **home** goods
C_f	Consumption demand by home residents for **foreign** goods
CL	Home residents' claims on foreign residents
CL^*	Foreign residents' claims on home residents
D_G	New government borrowing; fiscal deficit
DC	Domestic credit (T-Bills) of the central bank
E	Exchange rate: price of the **home** currency ($\frac{€}{\$}$)
Φ (ϕ)	Real exchange rate: relative price of the home good – in terms of foreign goods (natural logarithm)
G (g)	Government expenditure (natural logarithm)
I	Investment demand (new capital)
IR	International Reserves
K	Capital stock (machinery, factories, inventories)
L	Liquidity Demand (Real Money Demand)

Table A.2: Symbols Used in the Text (continued)

Symbol	**Definition**
Ω	Exogenous components of money demand
M (m)	Stock of money (natural logarithm)
N	Labor Force (and Population)
NFI	Net foreign income
NX	Net exports
P (p)	Price level ($\frac{\$}{Home\,Good}$) in the home country (natural logarithm)
P^* (p^*)	Price level ($\frac{Euro}{Euro\,Good}$) in the foreign country (natural logarithm)
Δp	Inflation rate
r	Real interest rate at home
r^*	Real interest rate on the world capital market
R	Nominal (market) interest rate at home
R^*	Nominal (market) interest rate on the world capital market
S (s)	Exchange rate: Price of foreign currency ($\frac{\$}{€}$) (natural logarithm)
Δs	Continuous rate of appreciation of the foreign currency (euro)
S^N	National saving
X	Exports
T	Total taxes net of transfers
Y	National Product = National Income = Expenditure on the Home Good (when $Y^S = Y^D$)
Y^D	Aggregate demand for the Home Good
Y^S	Aggregate Supply (production) of the Home Good
Z_F	Expected future available income

Appendix B

Logarithms

We use logarithms a lot in this book. The "natural logarithm of X" is a function of X that transforms it to a more useful object for analysis.

The easiest way to understand the logarithm may be in terms of the exponential function, e^X. Let X be a small number like .12. Then, if you do the calculation you get $e^{.12} = 1.1275$. One way to interpret this is as follows: If you put $1 in a bank at 12% *continually compounded interest*, you will have $1.1275 in *one year*. But there are other ways.

Interestingly, e is just a number, one of those natural constants like π, whose value we do not know perfectly. The approximate value is $e = 2.71828$.

We can define the natural logarithmic function as the function that "reverses" the exponential function. That is:

$$\ln e^{.12} = .12$$

or:

$$\ln e^X = X$$

And the exponential function reverses the log:

$$e^{\ln X} = X$$

This might seem very confusing, but there is a familiar analogue: the square root. It just reverses the square. Thus:

$$\sqrt{X^2} = X$$

just as

$$\left(\sqrt{X}\right)^2 = X$$

Figure B.1 illustrates the relationships between X, e^X, and $\ln X$.

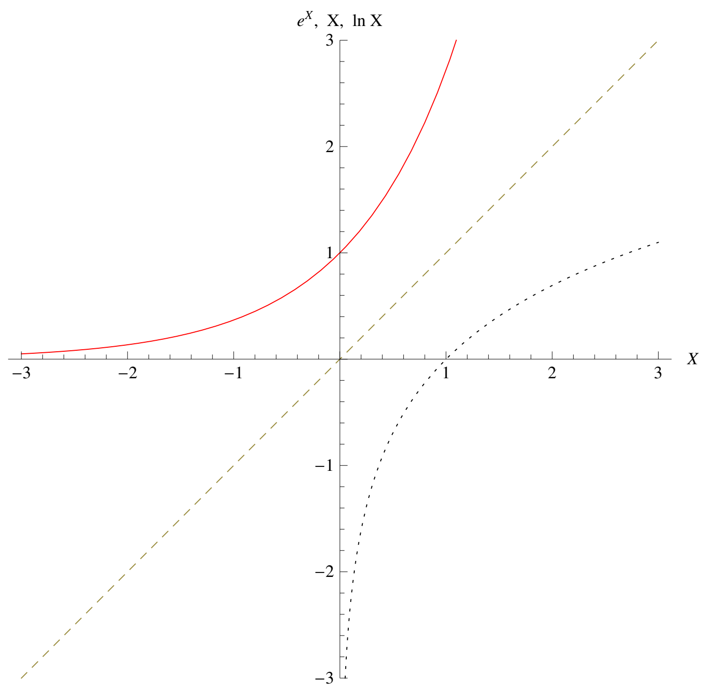

Figure B.1: The Natural Log Function

Appendix C

Consumption Theory

C.1 Consumption and Wealth

Consumption theory is subtle and complex, since it involves wealth and the future in an important way. This appendix is an introduction to modern thinking about what determines how much people consume.

Begin by establishing the basic environment. Assume it is January 1, 2011 (time t). You are considering how much to consume this year (i.e. between this January and next January, time $t+1$). That is C_t. A key concept is the *present value of your wealth* over your entire lifetime. If, for example, you had \$10 million at t, and no prospect of ever working in the future, or receiving any more wealth, then your PVW ("present value wealth") is \$10 million. If you begin t with zero wealth and work all year and get paid \$150,000 at the end – and will never work again – then your $PVW = \frac{150{,}000}{1+r}$.

Capital markets make it feasible – and it is optimal under certain conditions – to consume *in every period of your life* the following amount:

$$C = r * PVW \tag{C.1}$$

It does not matter when or how you received the wealth (whether it was a gift in the past, or you earn it in the future): you can borrow and lend to realize this constant consumption path.[1]

It is useful to break PVW down into components that we recognize. The first component is your actual wealth at time t, which we have been calling B_t. This is given from past behavior so it cannot be changed. The second component is what we might call "wage-wealth": it is the present value of all your future available income. Call this W_t. So:

$$PVW = B_t + W_t \tag{C.2}$$

and wage-wealth can be written as:

$$W_t = \left(\frac{1}{1+r}\right) \sum_{s=t}^{\infty} \frac{Z_s}{(1+r)^{s-t}} \tag{C.3}$$

This requires some explanation. It is the present value of all the income we expect to earn into the future, starting with the current year ($s = t$). Let us divide W_t into current ($s = t$) and all future ($s > t$) income. This yields:

$$W_t = \left(\frac{1}{1+r}\right) Z_t + \left(\frac{1}{1+r}\right) \sum_{s=t+1}^{\infty} \frac{Z_s}{(1+r)^{s-t}} \tag{C.4}$$

[1]This assumes that r does not change, and that you predict the future perfectly. Obviously, these are very strong assumptions that will normally hold only approximately.

We have to discount even current income because it takes a year to produce output before it can be consumed.

To simplify the expression, we define:

$$Z_F \equiv r \sum_{s=t+1}^{\infty} \frac{Z_s}{(1+r)^{s-t}} \tag{C.5}$$

This is the interest income on the present value of future wealth. It is motivated by the fact that if $Z_s = \bar{Z}$ for all $s > t$ then we can show that $\sum_{s=t+1}^{\infty} \frac{\bar{Z}}{(1+r)^{s-t}} = \frac{\bar{Z}}{r}$. This means that if your income was going to be constant at $\bar{Z}$ beginning next year, then $Z_F = \bar{Z}$.

This definition allows us to write the consumption function in a a simple form. The last term in (C.4) can be written as $\left(\frac{1}{1+r}\right)\frac{Z_F}{r}$, so that:

$$W_t = \left(\frac{1}{1+r}\right) Z_t + \left(\frac{1}{1+r}\right) \frac{Z_F}{r} \tag{C.6}$$

To get the consumption function in the text, we place (C.6) into (C.2), and put the result in (C.1). This gives us:

$$C_t = rB_t + \left(\frac{r}{1+r}\right) Z_t + \left(\frac{1}{1+r}\right) Z_F \tag{C.7}$$

In the text we defined $c_1 \equiv \frac{r}{1+r}$ and $c_2 \equiv \frac{1}{1+r}$.

C.2 An Example of Future Income

In the text we gave an example stream of income. Assume the interest rate is $r = .05$.

Current income is, in the example, $Z_0 = 10$. (We begin time at $t = 0$ in this example.) Future income is: $Z_t = Z_1 (1+g)^t$ for $t > 0$, where $Z_1 = 80$. By the definition (C.5) we may write:

$$Z_F = r \sum_{t=1}^{50} \frac{Z_1 (1+g)^t}{(1+r)^t} \tag{C.8}$$

You can express this in a more recognizable fashion as:

$$Z_F = r * \left\{ \frac{Z_1 (1+g)}{(1+r)} + \frac{Z_1 (1+g)^2}{(1+r)^2} + \frac{Z_1 (1+g)^3}{(1+r)^3} \dots \frac{Z_1 (1+g)^{50}}{(1+r)^{50}} \right\} \tag{C.9}$$

Using numerical methods and plugging in the numbers yields the numbers in the text.

Appendix D

Aggregate Demand

We derived the Aggregate Demand curve and expressed it as (2.9). The problem is that C_t and, therefore, NX_t depend on Y_t. This matters because, to be consistent, it must always be true that $D_t = Y_t$: the value of spending on purchasing output must equal the value of goods sold.

To deal with this, first linearize (2.9) to get:

$$D_t = b_0\left(G_F, A_F\right) + b_1 G_t + b_2 Y_t^* - b_3 r^* - b_4 \phi + b_5 Y_t \qquad \text{(D.1)}$$

This looks a lot like (2.12) but it has an extra term for Y_t. This term arises because of the importance of current income in the determination of consumption and imports.

To get (2.12), we take (D.1) and set $D_t = Y_t \equiv {Y_t}^D$ and solve for ${Y_t}^D$ to reveal:

$${Y_t}^D = \frac{b_0}{1-b_5}\left(G_F, A_F\right) + \frac{b_1}{1-b_5} G_t + \frac{b_2}{1-b_5} Y_t^* - \frac{b_3}{1-b_5} r^* - \frac{b_4}{1-b_5} \phi \qquad \text{(D.2)}$$

This is exactly (2.12) with each coefficient $d_j = \frac{b_j}{1-b_5}$ in the above.