Survey of Foreign Exchange Rate Models and Forecastability Comparison

by

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During the summer and autumn of 2000 when I wrote this paper, I got great help from my supervisor, professor Emmanuel Apel at the University of Ottawa. Professor Marc Lavoie corrected my writing errors with great patience and also gave me comments and suggestions. So I would like to take this opportunity to thank their help with my sincerity.

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Abstract

This paper conducts a survey of the main foreign exchange rate forecasting models and then does a comparison between these models. It is found that some models are theoretically sound, but not good at forecasting foreign exchange rates practically. By contrast, some other models without a solid theoretical basis can forecast well. Reasons for this phenomenon are discussed in the paper. Suggestions for future development of foreign exchange rate forecasting models are given in the paper.

Part I Introduction

Since the collapse of the Bretton Woods System in the early 1970s, foreign exchange rates have undergone substantial fluctuations. A large number of papers have been published on exchange rates and

> There have been three main strands of empirical research in international finance. The first and largest has been concerned with the determination of floating exchange rates; the second has addressed the issue of the efficiency of foreign exchange market efficiency and uncovered interest parity; the most recent has dealt with the characteristics of explicitly managed exchanged rates (Frankel & Rose, 1994, p.1).

In this paper, we mainly survey the exchange rate forecasting models and a related issue, their forecastability under freely floating exchange rate regimes. Then we discuss foreign exchange market efficiency.

With the increased globalisation of the world economy, international trade has contributed a larger and larger ratio of total GNP and hence has become more and more important in the world economy. Over the last decade, the world trade growth rate is significantly larger than its corresponding GDP growth rate as shown in Figure 1.1. So the ratio of international trade over GDP has increased as well over the same period as shown in Table 1.1.

With the increase of international trade, the demand for foreign exchange has increased as well. Foreign exchange markets are becoming larger and larger. Froot & Thaler (1990, p.180) had a comparison: "As of mid-1989, the average volume of trading activity (adjusted for double counting) was about $430 billion per day. To get a sense for just how big this number is, consider that daily U.S. GNP is about $22 billion. And daily world trade in goods and services is about $11 billion."

Figure 1.1

Source: Chart II.1, Annual Report 2000, World Trade Organization, http://www.wto.org/english/res_e/anrep_e/anrep_e.htm

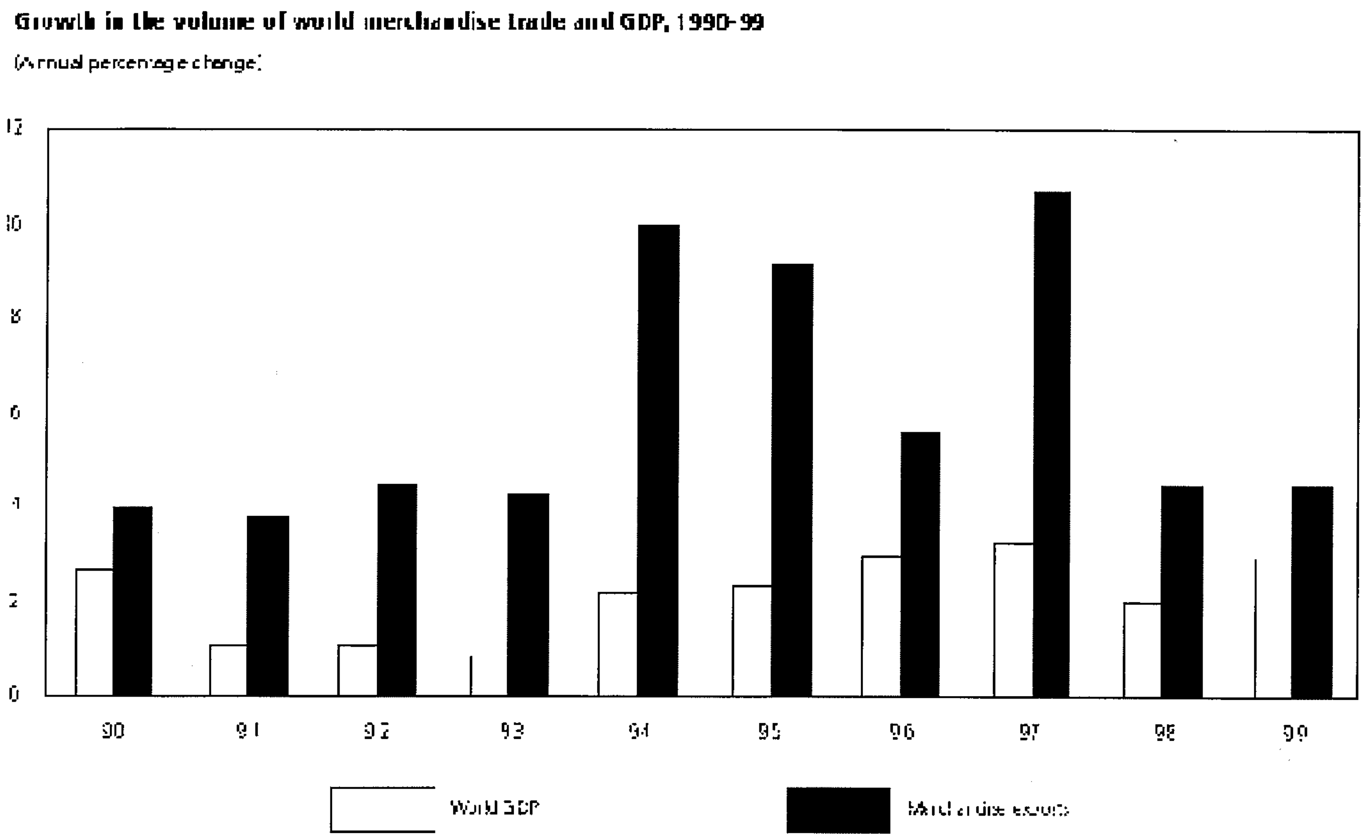

Table 1.1 Ratio of Trade in Goods Over GDP

	% of PPP GDP [a]	% of goods GDP [b]
1988	21.2%	71.9%
1998	28.3%	92.1%

Source of original data: Table 6.1, Integration With the Global Economy, World Bank, http://www.worldbank.org/data/databytopic/databytopic.html

a: Trade in goods as a share of PPP GDP is the sum of merchandise exports and imports measured in current U.S. dollars divided by the value of GDP converted to international dollars using purchasing power parity rates.

b: Trade in goods as a share of goods GDP is the sum of merchandise exports and imports divided by the value of GDP after subtracting value added in services, all in current U.S. dollars.

Froot & Thaler's (1990) data is out of date. In order to show a more recent picture, we have collected some data and put them in table 1.2.

Table 1.2 Comparison of Foreign Exchange Turnover with Other Variables

Items measured in $ billions	1980	1990	1998	Annual % change
Foreign Direct Investment [a]		198	619	15.3%
World Merchandise Exports [b]	1,901		5,397	6.0%
World GDP [c]	10,960		28,736	5.5%
Foreign Exchange Turnover World Wide [d]			1,500	

a: Source: Table 6.7, World Bank. See Appendix 3.
b: Source: Table 4.5, World Bank. See Appendix 3.
c: Source: Table 4.2, World Bank. See Appendix 3.
d: Source: http://www.deanlebaron.com/book/ultimate/chapters/forex.html. It is daily trading volume.

Due to the increase of international trade and foreign currencies transaction, forecasts of foreign exchange movements become inevitable for many purposes, such as keeping value of currencies, speculating. Exchange rate forecasts are necessary especially for, but not limited to, multinational firms, whose business happens in more than one nation. In his book, Shapiro (1982, p.35) said:

> Forecasting exchange rate changes has become an occupational hazard for financial executives of multinational firms. In fact, a 1975 survey by Jilling and Floks of 107 U.S. multinationals disclosed that only three of the firms had no real currency forecasting capabilities. Furthermore, 59.8 percent of the firms surveyed reported a significant increase in corporate resources devoted to forecasting since 1970.

This paper is organised as follows. In part II, we survey and review the main exchange rate forecasting models. In part III, we compare forecastability of different exchange rate forecasting models. In part IV, we give a summary and conclusion.

Part II: Survey and Review

Section II.A Brief Survey

Since an enormous amount of papers have been published to discuss foreign exchange rate forecasting models, it is better to classify them into several groups in order to conduct the survey more efficiently. Goodman (1979, p. 417) divided forecast methods into three groups:

> 1) Those that rely on an overall subjective evaluation of economic and/or technical factors to predict future spot exchange rates, 2) those that rely in whole, or in large part, on economic models, and 3) those that rely fully, or almost so, on technically-oriented decision rules...

Madura (1998) categorized forecasting techniques into four general groups: (1) technical models, (2) fundamental models, (3) market-based models, and (4) mixed models. I prefer Madura's classification. In market-based models, I will do forecastability of forward rates and put it in the section of technical models. Mixed models have not been developed into mature stage, so it is difficult to find references. In this paper, I will survey those papers in the following order: fundamental models and then technical models.

In this paper, fundamental models of exchange rate include purchasing power parity (PPP) models[1]; monetary models (here monetary models can be further divided into flexible price models[2], sticky price models[3] and real interest rate differential models[4]) and interest rate parity models[5].

Technical models of exchange rate forecast are more diversified and hence more difficult to survey. But the main argument concerned with technical models is the random walk model and forward rate as a predictor of future spot rate. So we will cover them in that section.

In the process of survey, some theory, concepts and definition will be used throughout; for instance, purchasing power parity, interest rate parity, covered and uncovered interest rate parity and market efficiency. We will give relevant definitions in detail whenever it is necessary.

Section II.B Review of Fundamental Models

II.B.1 Purchasing Power Parity Model.

Since Cassel (1916a, 1916b) published his earliest paper concerned with the relationship between exchange rate and inflation, the famous theorem of purchasing power parity (PPP) was born. Since then, numerous papers have been written to deal with this issue. Many scholars have tried to test whether PPP holds by using econometrics, others gave qualitative analysis. So far most authors have reached the consensus that PPP does not hold in the short run (see Abuaf and Jorion (1990), Adler and Lehmann (1983), Edison (1987), Kilian and Zha (1999)). Whether PPP holds in the long run is still in being argued. Some researchers, e.g., Patel (1990), Edison (1987), argue that PPP only holds in the long run under some conditions. Fisher and Park (1991) claim that PPP holds in the long run only for traded goods. This part of the paper focuses on whether PPP can be used to forecast future exchange rates, so whether PPP holds becomes a crucial point to this part. Obviously, if PPP does not hold, then it can not be used to forecast exchange rates.

Purchasing power parity theory is based on the law of one price. The law says that if there is no transaction cost, the price of the same commodity should be the same everywhere in the world under a free trade regime. If we use notations to describe it, there should be

$$P = S \times P^{*} \qquad (2.2.1)$$

Here S is the exchange rate defined as the domestic price of each unit of foreign currency, P is the domestic price level, P^{*} is the foreign price level. Rearranging it, we can get the determination of the exchange rate as

$$S = P/P^{*} \qquad (2.2.2)$$

In order to conduct empirical tests, we need to take logarithms on both sides of (2.2.2) to transfer it into a linear function as

$$s = p - p^{*} \qquad (2.2.3)$$

Here the lower case notations represent the logarithm of its corresponding original variable in (2.2.2).

Since the publication of Cassel's (1916a, 1916b) paper, many researchers have tested (2.2.3). But unfortunately, most of them find and agree with the viewpoint that (2.2.3) does not hold in the short run due to reasons summarised at the end of this part and this section. So I will not iterate here and will not argue with this viewpoint. Hence PPP will not be used to forecast exchange rates in the short run. But how about the forecastability of exchange rates by PPP in the long run?

Whether PPP holds in the long run has been studied by different researchers using quantitative and/or qualitative methods. The main quantitative method is the econometric regression and test. Patel (1990) claimed that PPP does not hold in the long run due to the different composition of price indices in different countries. Fisher and Park (1991) claimed that due to the existence of nontradable goods, PPP does not hold in the long run. Some other researchers have concluded that PPP holds conditionally in the long run. Edison (1987) said PPP holds in the long run only when there is no structural change.

Even though PPP holds in the long run and hence can be used to forecast exchange rates, the so called long run may be too far from now and thus becomes less useful in reality. Abuaf and Jorion (1990) claimed that "there are substantial short-term deviations from PPP, which take on average three years to be reduced in half". However, Kilian and Zha (1999) argued that there is only a 33% probability that the half-life is contained in the range of 3-5 years. So it seems that PPP can be used to forecast exchange rates only for later years. This becomes less useful in practice.

Since no consensus can be reached on the forecastability of PPP, some researchers pay attention to the difference between absolute and relative forms of PPP. The absolute form of PPP is described by (2.2.2) or (2.2.3) in logarithm. We have discussed its robustness in the above. The relative form of PPP, as stated by Shapiro (1982, p.40) is that, "in comparison to a period when equilibrium rates prevailed, changes in the ratio of domestic and foreign prices would indicate the necessary adjustment in the exchange rate between any pair of currencies". Mathematically, we have the relative form of PPP in the following:

$$S_t/S_o = (P_t/P_0)/(P_t^*/P_0^*) \qquad (2.2.4)$$

Where S_t and S_o are exchange rates in period t and 0 respectively defined as the domestic price of each unit of foreign currency, P_t and P_0 represent the domestic price level at time t and 0 respectively; P_t^* and P_0^* are their foreign counterparts. In the mean time, the price change between time t and 0 reflects inflation/deflation. So if we adopt this concept, we can have the following relations:

$$P_t/P_0 = 1+\pi_t \qquad (2.2.5)$$

and

$$P_t^*/P_0^* = 1+\pi_t^* \qquad (2.2.6)$$

Where π_t, π_t^* are the inflation rates at home and abroad respectively. Substitute (2.2.5) and (2.2.6) into (2.2.4), we get

$$S_t/S_o = (1+\pi_t) / (1+\pi_t^*) \qquad (2.2.7)$$

Subtract 1 from both sides of (2.2.7), we get

$$(S_t/S_o)-1 = [(1+\pi_t) / (1+\pi_t^*)] -1 \qquad (2.2.8)$$

After simple mathematical manipulations, we have

$$(S_t-S_o)/S_0 = (\pi_t - \pi_t^*) / (1+\pi_t^*) \qquad (2.2.9)$$

When foreign inflation rate is small relative to 100%, we have

$$(1+\pi_t^*) \approx 1 \qquad (2.2.10)$$

So (2.2.9) becomes

$$(S_t-S_o)/S_0 \approx (\pi_t - \pi_t^*) \qquad (2.2.11)$$

The left hand side of (2.2.11) is the percentage change in the exchange rate between time period 0 and period t. The right hand side of it is the inflation rate differential at time t between the home country and the foreign country. So (2.2.11) tells us that the percentage change in the exchange rate is equal to the inflation rate differential at home and abroad during the same time period. This is the simplified relative form of PPP.

Many authors argued that if PPP does not hold in the long run in absolute form, it should hold in relative form, as either (2.2.4) or (2.2.11). Actually, when we go back to review Cassel's article in 1916 (a), we find that Cassel did not say that the price for the same goods in different countries should be the same measured in the same currency. In his paper, Cassel only calculated and compared the relationship between exchange rates and inflation rates, and found that exchange rate changes are proportional with those of inflation rates. Balassa (1964) also concluded that PPP holds only in relative form. So Balassa is consistent with Cassel. Abuaf and Jorion's (1990) empirical results "cast doubt on the hypothesis that the real exchange rate follows a random walk"[6]. If PPP holds, then the real exchange rate is equal to 1 (see 2.2.2) plus a random term. From empirical evidence, Abuaf and Jorion (1990) doubt that the real exchange rate is a constant with a random term; they conclude in their paper that "long-run PPP might indeed hold" in relative form rather than in absolute form.

Huang (1987) tested relative PPP for eleven countries and rejected it for most of these countries. Sercu and Uppal (1995) summarized different arguments and conclude as follows:

> The conventional claim that 'PPP holds in the long run' ought to be taken with a lot of scepticism. In fact, common sense says that if there is real exchange risk in the short run, there definitely is real exchange risk in the long run. The uncertainty about PPP deviations can hardly become smaller the longer the time horizon. Rather, all we can observe is that the variance of PPP deviations increases less than proportionally with time - which is far from saying that the relationship becomes near-perfect in the long run.

Pilbeam (1992) tested PPP using graphical evidence. He compared graphically the realized exchange rate with out-sample forecasted exchange rate by PPP[7]. He found that those two exchange rates do not fit to each other very well for dollar-pound, deutschmark-dollar, yen-dollar and yen-deutschmark. But they fit very well for French franc-deutschmark, lira-deutschmark and deutschmark-pound. Because, as Pilbeam (1992, p.147) explained:

> The lira and French franc have since the adoption of floating spent much of the time linked to the deutschmark in the Snake and European monetary system which has restricted their movements against the deutschmark. More importantly, transport costs and trade barriers between France, Italy and Germany are small because of their geographical proximity and membership of the European Economic Community which prohibits the use of trade barriers between its members. These conditions facilitate the goods market arbitrage that PPP is so heavily dependent on.

But on viewing all those graphs, Pilbeam (1992, p.152) thought that PPP can be used to forecast exchange rate in the long run. So he concluded that:

> It is noticeable in all the plots that although the exchange rate is frequently far from PPP it does have a tendency to go back to the PPP rate over the longer run. This provides some evidence that PPP may be a useful guide for the determination of the long-run exchange rate.

From the above review, we can say that PPP can not hold very well without any condition. Especially in the short run, it does not hold very well. The most frequently mentioned reasons by different researchers for the deviation of exchange rate from PPP are summarized in the following.

Actually there are lots of assumptions underlying the theory of PPP. But in reality some of these assumptions may not hold. The possible reasons for violation of PPP mentioned by different researchers include[8]: commodities from different countries are heterogeneous rather than homogeneous; the existence of tariffs and/or subsidies; other trade restrictions; the existence of nontradable goods; capital flow control; imperfect markets, such as monopolies; different structures of price indices. For example, *The Economist* sold in different countries has different prices if converted into the same currency as listed on its front cover, because there is no perfect substitute for it. Sercu and Uppal (1995, p.396) also found that "nontraded goods such as services represent 60 to 80 percent of GNP in the OECD", so if the measurement of PPP includes both traded and nontraded goods, deviations from PPP can be expected.

Balassa (1964) also had a good qualitative analysis. He used the concept of productivity. He reasoned as follows: If PPP holds, then the price should be the same for traded goods in different countries. But price equals marginal cost, so the marginal cost should be the same in different countries. Meanwhile, in the high productive country, the marginal product of labor is higher than that in the low productive country, and the wage rate should equal the marginal product of labor. So the wage rate in the high productive country is higher than that in the low productive country. But inside every country, 'the internal mobility of labor will tend to equalize the wages of comparable labor", so the result is that in high productive countries, the wage rate is higher in nontraded sectors than that in low productive country. But the productivity differences in nontraded sectors in different countries, such as services, are much smaller than those in traded sectors. So the conclusion is that the prices in nontraded sectors in high productive countries are higher than that in low productive countries. Hence PPP does not hold in absolute form.

If there were no above reasons for violation for PPP, we could expect that PPP would hold much better. Some authors, such as Sercu and Uppal (1995, p.362), claimed that PPP holds for "easily traded, homogenous commodities such as oil, gold and silver". Considering the existence of transaction cost, some scholars argue further that PPP holds only at F.O.B price.

Based on the above arguments, if we go back to table 1.2, we can find that world merchandise exports are very small relative to world foreign exchange turnover; their ratio is approximately 1.4% if we count 250 transaction days every year. We have said above that the existence of nontradable goods will imply weak empirical support for the PPP model. So by observing that the world merchandise exports are so small a proportion of foreign exchange transactions, it is no surprise that PPP does not hold if we include both tradable and nontradable goods in the model. If we include only tradable goods in PPP model, we can expect that it will hold much better. Pollock (1990) used wholesale price index as a proxy for tradable goods in the PPP model. He found that the forecastability of PPP model is better than that of PPP model using a consumer price index, better than that of uncovered interest rate parity models and better than that of the forward rate[9].

Briefly, so far, most scholars have agreed that PPP does not hold in short run[10]. I did not find any author who agrees that PPP holds in the long run without any condition. PPP only holds in the long run with some conditions.

II.B.2 Uncovered Interest Rate Parity (UIRP) Model.

Assume that there are only two currencies in the world, the Canadian dollar and the US dollar. Investors, who are risk neutral, can choose freely to invest in any asset denominated in either of these two currencies. When they invest, they will consider the interest rate differentials and the expected rate of appreciation/depreciation of the currency. In equilibrium, if investors invest in assets denominated in different currencies, their expected rate of return should be the same for the same length of maturity when the expected rate of return of their investment is calculated in a single currency, provided there is no transaction costs and no capital flow restrictions. Using notations and equations, we show how UIRP works:

If an investor invests a certain amount of capital, say A, in an asset denominated in the domestic currency, then the total return at maturity is A(1+i), where i is the domestic interest rate. If he invests in an asset denominated in foreign currency, the total expected return at maturity, converted back to domestic currency, should be: $(A(1+i^*)/S_t)\bar{S}_{t+n}$, where S_t is the current spot exchange rate, denoted in domestic price of each foreign currency unit, $\bar{S}_{t+n}$ is the expected exchange rate n periods later, i^* is the foreign interest rate for the same period. In equilibrium, the two investment plan should have same expected return, so we have

$$A(1+i) = (A(1+i^*)/S_t)\,\bar{S}_{t+n}$$

Rearrange it, we get

$$\bar{S}_{t+n}/S_t = (1+i)/(1+i^*) \qquad (2.2.12)$$

If we subtract 1 on both sides of (2.2.12), then we can get

$$\bar{S}_{t+n}/S_t - 1 = (1+i)/(1+i^*) - 1 \qquad (2.2.13)$$

After rearrangement, it becomes

$$(\bar{S}_{t+n} - S_t)/S_t = (i-i^*)/(1+i^*) \qquad (2.2.14)$$

The left hand side of (2.2.14) is the expected appreciation/depreciation of the exchange rate depending on its sign. If i^* is not high relative to 100%, then $1+i^* \approx 1$, so we have

$$(\bar{S}_{t+n} - S_t)/S_t = (i-i^*) \qquad (2.2.15)$$

The above equation says that in equilibrium the interest rate differential at home and abroad is equal to the expected appreciation/depreciation of the exchange rate. This is the uncovered interest rate parity.

When the two sides of equation (2.2.15) are not equal to each other, there will be an adjustment process. For example, if the right hand side of (2.2.15) is larger than the left hand side, i.e., if there is an excess of domestic interest rate over foreign interest rate, investors will rush to buy Canadian dollars. In this case, the Canadian dollar will appreciate in the short run, and so will depreciate more in the long run. So the left hand side of (2.2.15) will increase until the new balance of the two sides is reached.

II.B.3 Monetary model.

II.B.3.1 Flexible Price Monetary Model of Exchange Rate.

This kind of model assumes that all prices will change instantaneously to the change in the money supply; domestic and foreign assets are perfect substitutes (see Calvo & Rodriguez (1977), Frankel & Rose (1994)). These models also use the assumption of purchasing power parity and start with traditional money demand functions for the domestic country:

$$m-p = \alpha y-\beta i \tag{2.2.16}$$

where m is money in log, p is price level in log, y is real income in log, i is the nominal interest rate, α and β are parameters. For a foreign country, there is a similar equation distinguished by an asterisk:

$$m^{*}-p^{*} = \alpha y^{*}-\beta i^{*} \tag{2.2.17}$$

Given the assumption of purchasing power parity, the exchange rate between the two countries is defined by equation (2.2.3). For convenience, we write it again:

$$s = p- p^{*} \tag{2.2.18}$$

where s is the exchange rate in log, defined as the domestic price of each unit of foreign currency as before. Now substitute equation (2.2.16) and (2.2.17) into (2.2.18). We get:

$$s = m - \alpha y + \beta i - (m^{*}- \alpha y^{*} + \beta i^{*}) = (m-m^{*}) - \alpha(y-y^{*}) + \beta(i-i^{*}) \tag{2.2.19}$$

In order to conduct empirical investigation, an error term will be added to the above equation.

Because the nominal interest rate i is composed of two parts: real interest rate and inflation rate, we have

$$i = r+\pi \tag{2.2.20}$$

$$i^* = r^* + \pi^* \tag{2.2.21}$$

here r, r^* are the real interest rates, π and π^* are the inflation rates at home and abroad respectively. We assume the two countries have the same real interest rates. Substitute (2.2.20), (2.2.21) into (2.2.19), we get,

$$s = m - \alpha y + \beta\, i - (m^* - \alpha\, y^* + \beta i^*) = (m-m^*) - \alpha(y-y^*) + \beta(\pi - \pi^*) \tag{2.2.22}$$

After empirical investigations, no strong evidence has been found for the robustness of equation (2.2.19)[11]. Actually in reality, prices are not flexible. So the empirical failure of equation (2.2.19) is not surprising. Hence some authors modified the above model with a sticky price assumption.

II.B.3.2 Sticky Price Monetary Model of Exchange Rate: Overshooting.

The classic paper of the monetary model of exchange rate with sticky prices is Dornbusch's (1976), then followed by Frankel's (1979).

The most important difference between the flexible price exchange rate model and the sticky price exchange rate model is that in the latter model, prices change slowly in the short run responding to the change of money supply rather than instantaneously as in the flexible price exchange rate model. The main idea of Dornbusch's (1976) model is as follows.

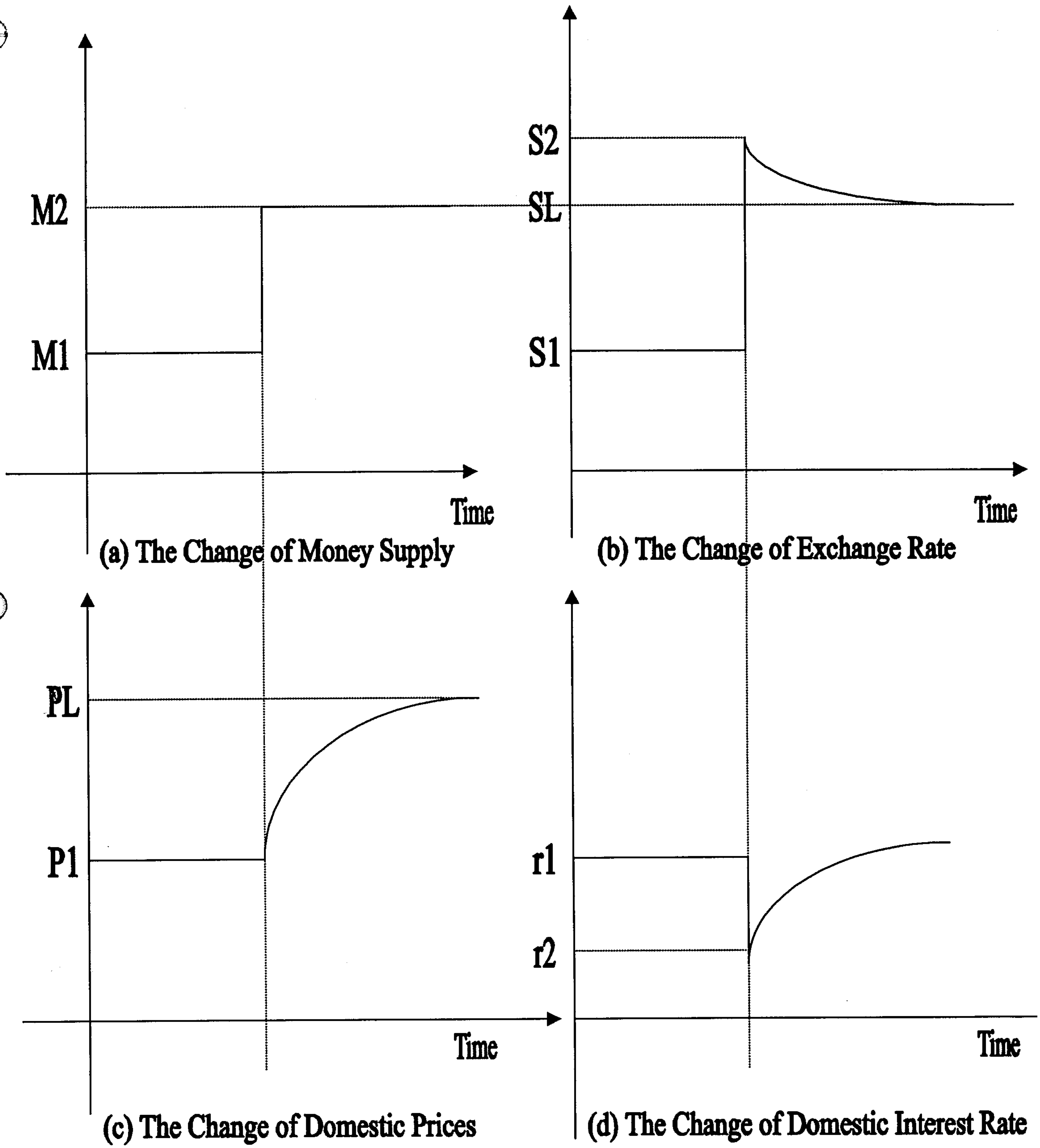

Figure 2.1 Dynamics of Sticky Price Model with Overshooting

pointed out that "at first, empirical tests of exchange rate models with price stickiness met with success… subsequently, however, results began to fall apart, even in-sample", and the sticky price model also has a bad performance on out-of-sample forecast. Moreover, Dornbusch focused on the short run; he did not consider the other factors determining the exchange rate in the long run, such as the inflation rate.

II.B.3.3 Real Interest Rate Differential Monetary Model.

Flexible price models work better in the long run than in the short run, because in the long run there is enough time for price to reach its new equilibrium whatever it should be. So prices are flexible in the long run. But in the short run, prices may be sticky. So sticky price models may be better than flexible price models in the short run. Obviously, the two models have their own advantages in the long run and the short run respectively. So Frankel (1979) combined them and developed a real interest rate differential model.

Beyond those factors considered in flexible and sticky price models of exchange rate determination, Frankel (1979) thought that the long run exchange rate is also determined by the inflation rate differential at home and abroad. So compared with Dornbusch, Frankel's expected rate of depreciation is a function of both "the gap between the current spot rate and an equilibrium rate, and of the expected long-run inflation differential between the domestic and foreign countries:"

$$d = -\theta(s-s_L) + \beta(\pi-\pi^*) \quad (2.2.24)$$

where π and π^* represent inflation rates at home and abroad respectively, other variables are defined as before.

This is the main difference between Dornbusch and Frankel. Frankel's other steps are the same with the flexible price model. After mathematical manipulation, Frankel finally got the equation determining exchange rate as:

$$s = (m-m^*) - \alpha(y-y^*) + \alpha(i-i^*) + \sigma(\pi-\pi^*)-[(i- \pi)- (i^*-\pi^*)]/\theta \qquad (2.2.25)$$

If price is regarded as flexible in the short run, then the adjustment speed parameter θ will be infinite, and real interest rates at home and abroad will be the same. So equation (2.2.25) will collapse to equation (2.2.22) by substituting (2.2.20) and (2.2.21) into (2.2.25). So the flexible price model is only a special case of Frankel's model. A finite θ represents a finite adjustment speed of exchange rate to its new equilibrium; that means price is sticky. When price is sticky and given an increased money supply, domestic real interest rates will be lower than that in the foreign country due to an excess money supply, so $[(i- \pi)- (i^*-\pi^*)]$ will be negative. Hence $-[(i- \pi)- (i^*-\pi^*)]/\theta$ will be positive. So Frankel's exchange rate in the short run is higher than that obtained by the flexible exchange rate model, which is also the exchange rate in the long run. (The exchange rates are the same in the short run and in the long run in flexible price models). Because here the exchange rate is defined as the domestic price of each unit of foreign currency, a higher exchange rate represents a more depreciated domestic currency. So Frankel's model also depicts the "overshooting" in the short run. Thus we can see that flexible price and sticky price exchange rate models are all included in Frankel's model.

Obviously, Frankel has made another advance based on flexible and sticky price models. In his model (equation 2.2.25), he has considered money, income, interest rates and inflation rates. However, in reality the assumption of perfect substitutability between domestic asset and foreign asset may not hold sometimes. This may weaken its robustness under empirical test[12].

So far, we have covered three monetary models. They are the flexible price model, the sticky price model, and the real interest rate differential model. The sticky price model has considered the real situation and is one step ahead of the flexible price model. The real interest rate differential model has not only considered the difference between real macroeconomic variables at home and abroad, but also has considered the inflation rates differential. So theoretically it is an achievement based on flexible and sticky price model and hence should be the best among different monetary models. In addition, all these monetary models have incorporated the idea of purchasing power parity[13]. So monetary models should be new developments based on PPP and theoretically they should perform better than PPP models. But in part III of this paper, when we do a forecastability comparison, we will find that the empirical test results are inconsistent with these theoretical anticipations.

Generally speaking, some frequently used assumptions and simplifications underlying those monetary models and the problems they may bring about are:

1. Non-perfect substitutability between different currencies[14]. Perfect substitutability between different currencies is an important and frequently used assumption for monetary exchange rate forecast models. But as a matter of fact, few currencies are perfect substitute. Residents of a country prefer to hold more domestic currency than foreign currency because of many reasons, such as the convenience of daily consumption, especially for cash at hand.
2. Information is important for the empirical test results of monetary models. For instance, the exchange rate in equation (2.2.20) depends on the money supply, income

level, interest rates and inflation rates at home and abroad. But if some investors can not get the latest news about these factors, they will have biased expectation about exchange rates. When many market participants have wrong information, their investment decisions will deviate exchange rates from what they should be as defined in (2.2.25)

3. Capital flow controls are not unusual, due to political and economic reasons. This will also obstruct the equilibrium of the supply and of the demand for currencies.

The actual exchange rate process is a dynamic process rather than a static one. There are frequently unexpected events which can cause the fluctuation of exchange rate. Fundamental theories should be able to determine exchange rates in equilibrium, but they may not be always effective in determining exchange rates in dynamic processes due to different kinds of shocks. This is another reason why those fundamental models sometimes can not be supported by empirical investigations.

The above reasons explain why the forecastability of those fundamental models in the short run is not very strong. Hence scholars turned their attention to technical models and developed some technical models to forecast foreign exchange rates in the short run, as shown in the next section.

Section II.C Review of Technical Models

II.C.1 Random Walk Model

Random walk models are the easiest but most frequently argued technical model of foreign exchange rate forecasting. Frankel & Rose (1994, p.2) have said: "The simple random walk model of the exchange rate has become the standard benchmark for empirical exchange rate performance, no matter how uninteresting it is per se".

In economics, usually the fluctuation of many economic variables, such as GDP, exchange rate, will display trends. That means successive values of those variables tend to move fairly close together. It looks like the current value is based on the previous values. So some authors have tried to find the relationship between the current value and its previous value and developed the so-called autoregressive model as follows:

$$S_t = a + bS_{t-1} + u_t \qquad (2.3.1)$$

In the above model, the dependent variable S in the current period regresses only on itself in the previous period. If the parameter b is equal to 1, the autoregressive process is said to have a unit root. In addition, if a is equal to zero, then we call the variable S a random walk. If a does not equal zero, then we say S is a random walk with a drift.

If the above variable S represents the exchange rate and if it is a random walk without a drift, then we can get the following equation (2.3.2) after rewriting equation (2.3.1):

$$S_t = S_{t-1} + u_t \qquad (2.3.2)$$

And then we take conditional expectations on both sides of equation (2.3.2):

$$E(S_t) = E(S_{t-1}) + E(u_t) = E(S_{t-1}) + 0 = E(S_{t-1}) = S_{t-1} \qquad (2.3.3)$$

That means the expected current value of the exchange rate is equal to its previous value. So some authors claim that the current spot rate is the best predictor of the future rate. If this is true, all the past information of exchange rates will be useless in predicting future rates. Only current information will be useful in forecasting future exchange rates.

In reality, exchange rates in two successive periods are rarely the same. Random walk models only mean that the current spot rate is the best predictor of future rates. It does not say that the future rate will be the same as the current rate. So the random walk model means the future rate can not be forecasted accurately; the future rate will be a "random walk" based on the current rate. If this is true, the foreign exchange market will be an efficient market; nobody can earn higher-than-market-average profit in this market.

The discovered triumph at short and medium horizons of the random walk model over fundamental models triggered the argument and discussion over the exchange rate forecasting accuracy between those two different kinds of models.

Besides Meese and Rogoff, many other researchers also have tested the forecasting performance of random walk models[15]. Ahking & Miller (1987) investigated exchange rates of Canada, France, Germany, Italy, Japan, Switzerland and the United Kingdom versus the United States and concluded that (p500): "Of the seven bilateral spot exchange rates examined, six are adequately modelled as random walks".

However, when we look at the graphs of the Canadian dollar versus the exchange rates of several main industrial countries, such as US dollar, British Pound, Japanese Yen and German Mark in Appendix 2 of this paper, we can find that the exchange rate between Canadian dollar and US dollar, Japanese Yen and German Mark display long swings trends. Only the exchange rate between Canadian dollar and British Pound displays roughly a random walk without drift. But if we look at the graph of Canadian dollar versus British Pound in segmented periods, we can also find apparent trends without too much difficulties. For instance, the trend from year 1975 to 1976 was downward sloping, and then it went up until 1980, then another down trend until 1984-1985. All these obvious trends seem to contradict the random walk model without drift, not to mention the exchange rates between Canadian dollar and other three foreign currencies. So the graphical examination and econometric empirical examination seem to be not consistent. Then what is wrong?

According to econometric theory, the more data are used for econometric regression, the higher the regression quality. However, the more data are used, the longer time span will be covered. Then there a problem may arise. Within a short time period, the movements of exchange rates of different currencies may have the same background, such as similar political regimes, same economic policies. But in a long time period, this background may change. Usually governments in western democratic countries are elected every four years. Then different governments may have different economic policies which will of course influence exchange rates theoretically. When we look at exchange rate historical graphs, we can also find that the long run exchange rate movement is composed of some different up or down trends in different time periods. And the more data are used, the more different trends of exchange rate movements in sub-periods will be covered. When we regress exchange rates on some other variables over long time periods with these different policy backgrounds, the so-called time inconsistency of parameters may arise[16]. When we use these parameters obtained from a regression using a group of data in one period, and forecast exchange rates for another period with different economic policy, bias on prediction should be expected. In addition, usually the linear model is the mostly used model when doing regressions. But when linear models are used to do this, the effects of these up trends and down trends will cancel each other to some extent. So the final regression result may show a random walk effect. On the other hand, when we use fundamental models to forecast exchange rate, due to the existence of lags and expectations and other factors as explained in the section of fundamental models, the real exchange rate data may not fit those fundamental models very well. Considering the above reasons from two directions, it is possible that fundamental models are not better than random walk model in predicting exchange rate. Having mentioned the fact that different up and down swings (cycles) are cancelled to each other in long time span, we may expect that if we narrow the time span to the shorter one, the random walk model may not hold. Engel and Hamilton (1990) have shown this. They divided the long movement of exchange rates into several periods and in each period, the exchange rates show an obvious up or down trend. Then after testing, they "reject the null hypothesis that exchange rates follow a random walk in favor of our model of long swings" (Engel & Hamilton, 1990, p.689). And "the segmented trends model reduces the within sample mean forecast error by 9-14 percent at horizons from two quarters to a year for all three currencies, relative to a random walk specification" (Engel & Hamilton, 1990, p.691). This test supports our qualitative analysis to some extent that the long time span covering different exchange rate trends will counterbalance the effects of those different trends and hence let the final regression result shows a better performance of random walk over fundamental models.

Random walk models of exchange rate forecasting without drift means that in the long run, the exchange rate will be regarded as the same as its value in the current period even though there will be some great changes taking place in the economy. Clearly this will be hard to be believed. Economic theory tells us that the exchange rate is determined by fundamentals, such as money supply differentials, economy growth rate differentials, interest rate differentials at home and abroad. If one or many of these fundamentals have changed, but the prediction of future exchange rate is still equal to current rate, then we can say that it will be a very bad forecast. Usually in the long run, there is enough time for fundamentals to change. So random walk models without drift may result in a large bias in forecasting exchange rates for long time horizons.

Section II.C.2 Review of Forward Rate as Predictor of Future Spot Rate

The forward exchange rate is the domestic price of foreign currency or the foreign price of domestic currency delivered on a specific date in the future. In this paper, we define the forward exchange rate as the domestic price of each unit of foreign currency.

Forward exchange rate is available 24 hours a day like the spot rate. Because it is a future's market, it gives foreign exchange market participants an indication of the movement of the foreign exchange rates in the future. If they think the forward rate is correct, then they can use it to help them make investment decisions to make money or reduce the possibility of losses. So whether or not the forward rate is an unbiased predictor of the future spot rate is a key point in this section.

A large number of papers have been published on testing the unbiasedness of the forward exchange rate. Different or even contradictory conclusions have been obtained on testing the unbiasedness of forward exchange rates. Most authors conclude that the forward rate is not the best predictor of future spot rates, or that forward exchange market is not efficient[17]. In this part, I survey those relevant papers starting from the simple tests, then go to the complicated tests.

The early test of unbiasedness of forward exchange rates is just regressing the expected future spot rate on the forward rate delivered at the same time, see, for example, Frenkel (1977). The regression equation is as follows:

$$\bar{s}_{t+n} = \alpha + \beta f_{t+n} + u_{t+n} \qquad (2.3.4)$$

Here $\bar{s}_{t+n}$ is the expected spot exchange rate at time t+n defined as the domestic price of each unit of foreign currency; f_{t+n} is the forward exchange rate determined at time t and delivered at time t+n. Here both the spot rate and the forward rate are in logarithms. The null hypothesis of unbiasedness of the forward rate is $\alpha=0$, $\beta=1$.

Frenkel's (1977) tested German Mark/Pound Sterling for the period of February 1921 to August 1923 using model (2.4.1). He used one-month ahead forward exchange rate. His result shows that $\alpha=-0.45$, $\beta=1.09$, and "The joint hypothesis that the constant term is zero and that the slope coefficient is unity is rejected at the 95 percent confidence level". (Frenkel, 1977, p.655). Frenkel has rejected the null hypothesis of unbiasedness of forward rate, but the more important thing is that some researchers have found that neither the spot rate nor the forward rate are stationary. Given the non-stationarity of spot and forward rates, according the econometric theory, the test can not be conducted directly using OLS for the above equation, and "the usual asymptotic theory invoked to construct hypothesis tests becomes inapplicable" (Clarida & Taylor 1993, p.2). So some researchers developed a new model to solve the problem of non-stationarity.

The modified test of the unbiasedness of forward exchange rate is a first order difference equation, as follows:

$$\bar{s}_{t+n}-s_t=\alpha+\beta(f_{t+n}-s_t)+u_{t+n} \qquad (2.3.5)$$

and the null hypothesis is $\alpha=0$, $\beta=1$.

Many scholars have tested the above model. Unfortunately, no one has got the exact result of $\beta=1$[18]. Some authors[19] concluded that $\beta\neq1$. Others even got the result of $\beta<0$, such as Froot and Frankel (1989), and Byers and Peel (1991). So they concluded that the forward exchange rate is not an unbiased predictor of the future spot rate. Then what is wrong?

The most believed reason for the biasedness of forward rates is the existence of a risk premium. Cumby & Obstfeld (1981) found the risk premium by testing the Fisher hypothesis[20]; Jacobs (1982) used an ARMA model as a proxy for market expectations of the future spot rate, and tested the relationship between the forward rate and the future spot rate. He found that there is a risk premium in the term structure of forward rates. Sibert (1989) employed Lucas's asset-pricing model and found a risk premium. Canova & Ito (1991) concluded to the existence of a risk premium from a VAR model. Obstfeld & Rogoff (1998) developed an "explicitly stochastic new open economy macroeconomics model" and provided a sticky-price alternative to Lucas's exchange rate risk premium model. They showed that the "level risk premium in the exchange rate is potentially quite large and may be an important missing fundamental in empirical exchange rate equations". But Froot & Thaler (1990, p.189-190) argued that "risk premia are unobservable directly, how can the explanation ever be disproven? This type of thinking can lead to a false sense of security, because clever researchers often think of ways of testing such untestable propositions". And then they concluded that:

> Indeed, the conclusion we draw from the tests completed so far is that there is no positive evidence that the forward discount's bias is due to risk (as opposed to expectational errors). Risk premia which are derived from economists' asset pricing models show no sign of being systematically related to the predictable excess returns derived from econometricians' regressions.
>
> In addition, there is positive evidence which suggests the reverse: that the bias is attributable to expectational errors and not to risk. Attempts to separate the forward discount into expected depreciation and a risk premium using survey data on exchange rate expectations suggest that the bias is entirely due to expectational errors and that none is due to time-varying risk.

McCurdy & Morgan (1991, p.587) had a parallel argument as follows:

> Most existing models of time-varying risk premia in foreign currency markets have met with limited empirical success. Since the unbiasedness hypothesis jointly maintains no risk premium and the particular model or asset-pricing paradigm used to generate the expected future spot rates, its rejection could be explained by a time-varying risk premium or by several other hypotheses, such as rational learning about stochastic regime switches, speculative bubbles, the 'peso problem', or the failure of the maintained rational expectations assumption.

Besides the above arguments, some researchers developed a new theory. Fama (1984) divided the difference between the forward rate and the spot rate (called the premium or discount depending on the sign) into two parts as follows:

$$F\text{-}S = (F - \overline{S}_{+1}) + (\overline{S}_{+1} - S) \qquad (2.3.6)$$

In words, as said by Boyer & Adams (1988, p.637), "the forward premium is equal to the sum of the risk premium (the forward rate minus the value of the spot rate expected to prevail next period) and the expected rate of appreciation of the foreign currency (the value of the spot rate expected to prevail next period minus its value this period)". But Froot & Frankel (1989) did not find any risk premium with application of survey data, so they concluded that "changes in the forward discount reflect, one-for-one, changes in expected depreciation" (p.160).

Beyond the above reasons for the biasedness of forward exchange rates, there are also some other arguments. One of them is the peso problem and time inconsistency. The exchange rate of any currency will vary under a certain exchange regime. Given the same regime, the fluctuation of exchange rates will have common characteristics. But when transferred into another different regime, the variation of exchange rate may have another different characteristics. Then the regime inconsistency problem, known as peso problem, will happen. Longworth (1981) used semi-strong-form tests to find that the risk premium exists only for some periods, not for the entire tested period. So it is a time inconsistency problem. Kaminsky's (1993) paper supports the peso problem more clearly. His switching-regime model can even "explain about 75 percent of the bias implied by the forward market and the survey data".

Cornell (1989) argued that the biasedness of forward rates is due to measurement errors. But Bekaert & Hodrick (1993) rejected Cornell's views. Hodrick (1987) found the conditional heteroskedasticity which violates the traditional assumption underlying the usage of OLS and hence may cause the biased test of β. Engel (1995, p.27) argued that the left hand side and right hand side of equation (2.3.5) may have different degrees of integration. If they had the same degree of integration and:

> If $s_{t+1}-s_t$ is stationary, then the null hypothesis (6) (here equation 2.3.5) actually requires that the forward discount be stationary. The null hypothesis can be written $f_t-s_t=E_t(s_{t+1})-s_t=s_{t+1}-s_t-\varepsilon_{t+1}$, where ε_{t+1} is the forecast error. The forecast error must be stationary under rational expectations --- if it were not, it would be predictable from past values. If $s_{t+1}-s_t$ is stationary, then f_t-s_t must be also. If one were to conclude the forward discount were non-stationary, then given the stationarity of $s_{t+1}-s_t$, one could reject the null of forward rate unbiasedness. (Engel (1995, p.25)).

Then Engel (1995, p.30) presents a detailed summary regarding cointegration and stationarity as follows:

> To summarize the tests for stationarity and cointegration of s_t and f_t, and s_{t+1} and f_t: Some have found s_t-f_t is I(0); some have found it is I(1); some have found it is fractionally integrated. Some have found s_{t+1} and f_t are cointegrated with cointegrating vector [1,-1]; some have found they are cointegrated but not with cointegrating vector [1,1]; and some have found they are not cointegrated. These conflicting results hold on tests for the same set of currencies. To some extent these conflicts may arise from different sampling periods, but more likely they result from different properties of the various test statistics employed.

So Engel (1995, p.1) finally concluded that

> "The conclusions of the survey can be summarized as: First, empirical tests routinely reject the null hypothesis that the forward rate is a conditionally unbiased predictor of future spot rates. Second, models of the risk premium have been unsuccessful at explaining the magnitude of this failure of unbiasedness".

So far, many authors have tested the efficiency of the forward rate as a predictor of future spot rates. Most of them have rejected the null hypothesis of unbiasedness of the forward rate. Some of them have given some reasons for the biasedness of the forward rate. Now let me summarize these reasons and give a brief analysis. Here I will only mention those reasons specifically for the biasedness of the forward rate. For the other reasons common to forward rate unbiasedness test and other exchange rate forecasting model forecastability test, I will summarize and analyze in the conclusion part of this paper.

- As I have said before, the most mentioned and believed reason of the biasedness of forward rate is the risk premium. But many scholars argue about that, such as Froot & Frankel (1989).
- There is the issue of the degree of integration of the left hand side and right hand side of equation (2.4.2), as argued by Engel (1995).

Coulbois and Prissert (1974) argue the forward exchange rates from another view point. They "contend that the theoretical interpretation of the forward exchange market given by the majority of economists is a misleading one" (p.283). Their conclusions, "which are in complete contradiction to the academic theory, arise from the cambist theory" are: "equilibrium on the forward exchange market is not brought about by the intervention of arbitrageurs, but simply by that of banks" (p.290). They thought that the forward exchange rates are determined exactly by interest rate differential in the covered interest rate parity. So such determined forward exchange rates have no relationship with the future spot rates. That means they think the forward exchange rate is not a predictor of future spot rate in any sense.

Part III: Forecastability Comparison of Different Models

So far, we have conducted a survey of the main exchange rate models in different sections. In order to have a clear idea about the forecastability of each model, we put those main conclusions together and summarise them in table 3.1.

Table 3.1 Qualitative Summary and Comparison of Different Models

Models	Main characteristics and conclusions
PPP model	PPP is the earliest and basic theory determining exchange rate. But it needs many assumptions to support it. Hence in reality it does not hold well in the short run. But it can used to forecast exchange rates in the long run.
Flexible Price Monetary Model	Flexible price assumption is not realistic. So it does not forecast exchange rates very well.
Sticky Price Monetary Model	Sticky price assumption is more realistic compared with the flexible price model. But it does not incorporate inflation rates into the model. So it needs more improvement.
Real Interest Rate Differential Monetary Model	This model is the most complete theoretical model of exchange rate determination. It is a new achievement based on flexible and sticky price models. It considers almost all economic real factors which will influence exchange rates. So theoretically it should be the best model to forecast exchange rates. But under empirical comparison, it does not have minimum forecast error compared with other models [a]. Perhaps it is due to the unrealistic assumption of perfect substitution between domestic and foreign currencies.
Random Walk Model	Random walk model is the least economic theory based model, but it performs better than other theoretical models using traditional root mean squared error.
Forward Rate as a Predictor of Future Spot Rate	Forward rate is not an unbiased predictor of spot rate. The difference between it and the expected future spot rate is called the risk premium.

a: See Table 3.4

In this section, we compare the forecast results of Meese & Rogoff (1983), Pollock (1990) and Pilbeam (1992) as shown in Table 3.2, 3.3 and 3.4 respectively.

Table 3.2 Forecastability Comparison In Terms Of Root Mean Squared Error by Meese & Rogoff[a]

Exchange Currency	Forecast Horizon	Random Walk Model[b]	Forward Rate[c]	Flexible Price Model [d]	Sticky Price Model [e]
$/mark	1 month	3.72	3.20	**3.17**	3.65
	6 months	**8.71**	9.03	9.64	12.03
	12 months	12.98	**12.60**	16.12	18.87
$/yen	1 month	**3.68**	3.72	4.11	4.40
	6 months	**11.58**	11.93	13.38	13.94
	12 months	**18.31**	18.95	18.55	20.41
$/pound	1 month	**2.56**	2.67	2.82	2.90
	6 months	**6.45**	7.23	8.90	8.88
	12 months	**9.96**	11.62	14.62	13.66

a: Extracts from Meese & Rogoff (1982, p.13). Bold font means the minimum forecast error among all models in each case.
b: See equation (2.3.1)
c: The model is not given in their paper. Meese & Rogoff (1982) just said "Bilateral forward rates of one, three, six and twelve month maturities are drawn from the same day of the month as the spot rates".
d: Model is based on (2.2.19) and then is modified using Fair's (1970) instrumental variable technique to correct for first-order serial correlation.
e: The original model is $s = a0+a1(m-m^*) + a2(y-y^*) + a3(r-r^*)+a4(\pi^e-\pi^{e*})$. Here π^e and π^{e*} are expected inflation rate at home and abroad respectively. Other variables are defined as before. Then Meese & Rogoff used Fair's (1970) instrumental variable technique to correct for first-order serial correlation.

Table 3.3 Forecastability Comparison Using Different Measurements By Pollock[f]

Models	RMSE	MAE	ME
PPP model using Consumer Price Index [g]	4.408	3.367	-0.420
PPP model using Wholesale Price Index [g]	**3.952**	**2.958**	0.106
Uncovered Interest Rate Parity Model [h]	4.479	3.196	-0.601
Forward Rate [i]	4.517	3.262	-0.057
Random Walk Model [j]	4.417	3.155	**0.043**

f: Extracts from Pollock (1990, p.549). Bold font means the minimum number among different models
g: Equation (2.2.4)
h: See equation (2.3.6)
i: Model is equation (2.3.5)
j: Pollock's model is defined by equation (2.3.2) without a drift term.

Table 3.4 Comparison Of Forecasted Exchange Rate With Actual Exchange Rate By Pilbeam [a] And Forecastability Comparison In Terms Of Root Mean Squared Error

	Raw Data by Pilbeam			Data in Natural Logarithm		
Period	Flexible Price Model	Real Interest Differential	Actual	Flexible Price Model	Real Interest Differential	Actual
1979q1	1.9981	1.9888	2.0688	0.6922	0.6875	0.7270
1979q2	2.1120	2.0954	2.1684	0.7476	0.7397	0.7740
1979q3	2.1019	2.0884	2.1976	0.7428	0.7364	0.7874
1979q4	2.1866	2.1789	2.2240	0.7823	0.7788	0.7993
1980q1	2.2065	2.2577	2.1668	0.7914	0.8143	0.7733
1980q2	2.1481	1.9965	2.3620	0.7646	0.6914	0.8595
1980q3	2.3588	2.3897	2.3883	0.8582	0.8712	0.8706
1980q4	2.3192	2.3307	2.3850	0.8412	0.8462	0.8692
1981q1	2.3578	2.3547	2.2442	0.8577	0.8564	0.8083
1981q2	2.2105	2.2136	1.9428	0.7932	0.7946	0.6641
1981q3	1.9287	1.9147	1.8005	0.6568	0.6496	0.5881
1981q4	1.7940	1.7911	1.9080	0.5844	0.5828	0.6461
1982q1	1.9412	1.9654	1.7817	0.6633	0.6757	0.5776
1982q2	1.7749	1.7746	1.7383	0.5737	0.5736	0.5529
1982q3	1.7474	1.7409	1.6927	0.5581	0.5544	0.5263
1982q4	1.7306	1.7340	1.6145	0.5485	0.5504	0.4790
1983q1	1.6492	1.6509	1.4790	0.5003	0.5013	0.3914
1983q2	1.4641	1.4638	1.5304	0.3812	0.3810	0.4255
1983q3	1.5609	1.5610	1.4957	0.4453	0.4453	0.4026
1983q4	1.4949	1.4946	1.4506	0.4021	0.4019	0.3720
1984q1	1.4490	1.4497	1.4426	0.3709	0.3714	0.3664
1984q2	1.4298	1.4284	1.3527	0.3575	0.3566	0.3021
1984q3	1.3631	1.3622	1.2480	0.3098	0.3091	0.2215
1984q4	1.2440	1.2416	1.1565	0.2183	0.2164	0.1454
1985q1	1.1630	1.1630	1.2430	0.1510	0.1510	0.2175
1985q2	1.2177	1.2163	1.2951	0.1970	0.1958	0.2586
1985q3	1.3465	1.3523	1.4010	0.2975	0.3018	0.3372
1985q4	1.4108	1.4159	1.4445	0.3442	0.3478	0.3678
1986q1	1.4483	1.4509	1.4853	0.3704	0.3722	0.3956
1986q2	1.5148	1.5124	1.5303	0.4153	0.4137	0.4255
1986q3	1.5239	1.5305	1.4500	0.4213	0.4256	0.3716
1986q4	1.4865	1.4862	1.4745	0.3964	0.3962	0.3883
1987q1	1.4278	1.4250	1.6050	0.3561	0.3542	0.4731
1987q2	1.6476	1.6482	1.6100	0.4993	0.4997	0.4762
1987q3	1.6159	1.6161	1.6297	0.4799	0.4800	0.4884
1987q4	1.6130	1.6131	1.8715	0.4781	0.4782	0.6267
1988q1	1.9464	1.9482	1.8798	0.6660	0.6669	0.6312
1988q2	1.8681	1.8681	1.7093	0.6249	0.6249	0.5361
1988q3	1.6390	1.6400	1.6855	0.4941	0.4947	0.5221
RMSE	0.1075	0.1195	0.1232	0.0617	0.0665	0.0594
RMSE%				6.17%	6.65%	5.94%

a: Raw data is obtained from Pilbeam (1992, p.239). Flexible price model is equation (2.2.19), real interest differential model is equation (2.3.6), random walk model is referred to equation (2.3.2)

In table 3.2, Meese & Rogoff (1992) used seasonally unadjusted monthly data over the period March 1973 to June 1981 to forecast the exchange rate between US dollar and pound, dollar and yen, dollar and mark for different time horizons as shown in that table. Their forecast errors are measured in relative (or percentage) form rather than in absolute form. This idea will be covered later in this part of the paper.

Pollock (1990, p.538) had a clear and detailed description of the data he used on doing forecastability comparison:

> The exchange rate data used in this study are quarterly series of the end-of-period, middle closing, spot and forward lira/pound-sterling exchange rates, in London. The period extends from 1973 Q1 to 1989 Q1. The data comes from the Central Statistical Office (CSO) Macro-Economic Databank. The data are transformed by taking natural logarithms.
>
> The interest rate data used are obtained from the J.P. Morgan publication <<World Financial Markets>>. The series used are the representative money market rates on three month interbank deposits for the United Kingdom and Italy.
>
> The price data used are obtained from the International Monetary Fund publication <<International Financial Statistics>>. The series used are the producer and consumer price indices for the United Kingdom and Italy with a base period of 1980=100. The values of the price series in the month of the quarter are used, instead of the period-average series, to obtain series that are more consistent with the exchange rate data.

Pollock's (1990) forecasting horizon is one quarter. He also took natural logarithms for his data. So his forecast errors are in percentage as shown in table 3.3. Thus his forecast errors measured by RMSE should be able to be compared with that of Meese & Rogoff's with the same forecast horizon given the same forecast models. But Meese & Rogoff had no forecast horizon of one quarter. Instead, they had forecast horizons of only one month, six months and twelve months. One quarter is between one month and six months. So we expect that Pollock's (1990) forecast for one quarter ahead should be in the range of Meese & Rogoff's forecast for one month and six months using same models, as it is.

Pilbeam (1992) compared the forecastability for the dollar-pound exchange rate for the period 1979:1 to 1988:3 using a quarterly data set. "For the purpose of forecasting the exchange rate in time t+1, the actual values of the exogenous (right-hand side) variables in time t+1 were used" (Pilbeam, 1992, p.236). He used a "rolling regression" method to do forecast. It means he did a new regression each time up to the period which is one period earlier than the forecasting period and then forecasted for one period ahead each time. For example, he used data from 1973:1 to 1978:4 to do a regression and forecast exchange rate of 1979:1, and then he did regression again using data from 1973:1 to 1979:1 to forecast exchange rate of 1979:2 and so on. So his forecast horizon is one quarter ahead as Pollock (1990) did. And his forecast errors measured in relative (or percentage) form of RMSE are consistent with those of Meese & Rogoff's, just as the consistency of Pollock's with Meese & Rogoff's. The absolute form and relative form of RMSE will be explained later.

From the above Meese & Rogoff's comparison in table 3.2, we can see that in 7 out of total 9 cases, random walk models outperform other models. In Pollock's comparison, the random walk is also the best in terms of ME. Pilbeam's (1992) comparison needs more explanation. I use his forecast results to calculate RMSE defined in equation (3.3). I calculate RMSE in both absolute form and in relative form (by taking natural logarithms). In relative form, the random walk model is the best one. But in absolute form, the flexible price model is the best. We will talk about the relative form and absolute form of error measurement in details later in this paper.

The PPP model is the most basic exchange rate forecasting fundamental model. But as said in part II of this paper, it does not perform very well under empirical investigation due to some reasons, such as the existence of non-tradable goods. Considering these factors, Pollock(1990) used both the consumer price index and the wholesale price index to forecast exchange rates, because the latter index consists of much less non-tradable goods than the former. His forecasting results show that the PPP model using the wholesale price index is much better than when using the consumer price index and it is the best forecasting model in terms of RMSE and MAE compared with other models as shown in table 3.3. This result is not inconsistent with our analysis in part II and hence is not surprising.

The forecastability of the forward rate among different researchers is controversial. The forward rate is the best exchange rate forecaster in terms of RMSE for the 12-month forecast horizon for dollar/mark done by Meese & Rogoff (1983). However, it is the worst predictor in terms of RMSE and is the second worst in terms of MAE compared with other models, as shown by Pollock (1990). In explaining the bad performance of the forward rate on forecasting exchange rate, Pollock (1990) said:

> However, the direct comparison of the econometric models with the forward rate model is made difficult by the fact that official announcements of the figures for econometric indicators, such as price indices and trade flows, are not made at the end of the quarter in which they occur, but some time after. Hence, the end-of-period forward rate would not be expected to include information on these variables until their figures are announced.

Overall, in the above three forecastability comparison cases, random walk model performs very well. The PPP model using the wholesale price index is the second best. These quantitative investigation results are not contradictory with our qualitative survey in part II of this paper.

However, some of the above forecastability comparison results are not consistent with economic theory. For instance, the real interest rate differential model is developed based on the flexible price model. So it should forecast better than the latter. Unfortunately it is not true as shown in table 3.4. However, the bad performance of some forecasting models does not necessarily mean the models themselves are wrong. There are many possible reasons. Some of them have been mentioned in part II of this paper, so we will not repeat them again. Here we just analyze some uncovered reasons in part II.

First of all, in order to do forecastability comparison effectively, the methodology is very important. The accuracy and robustness of forecastability comparison depends on many factors, such as the consistency of empirical investigation methods, error measurements, time span covered by data. Inconsistency of these factors over different forecast models may cause unreliable and weak comparisons of forecastability. However it is very hard to find more than one author who uses everything which are exactly the same to forecast exchange rates. Usually some author will use his own preferred model and methodology to forecast exchange rate. Others will use not only different models, but also different methodologies or different data. So in this case, it is very hard to compare directly the forecastability of different models used by different researchers. To put it briefly, when we do comparisons, we need to be sure that they are comparable.

One of the most important issues in doing forecastability comparison is the method of measurement of forecast errors. In their paper, Meese & Rogoff (1982) gave three forecast error measurements in the following:

$$\text{Mean Error (ME)} = \text{sum of forecast errors/number of observations} \tag{3.1}$$

$$\text{Mean Absolute Error (MAE)} = \text{sum of absolute value of errors/number of observations} \tag{3.2}$$

$$\text{Root Mean Squared Error (RMSE)} = [\text{sum of square of errors /number of observations}]^{1/2} \tag{3.3}$$

Obviously, these three methods are different and usually they will result in different forecast errors even given the same model and same data. So we can not compare ME with MAE. We need to use the same error measurements to compare forecastability.

Of the above three error measurements, the ME method has the biggest disadvantage. For instance, if there are two models which yield forecast errors as 1,-1 and 10,-10 respectively for the same observations of independent variables, then the ME equals zero in both cases and hence it is the same for both models. But the magnitudes of those errors are different and the latter are bigger than the former. So ME seems not to be a good forecast error measurement. However, it can be used to ascertain whether a model systematically over- or under-predicts, as said by Meese & Rogoff (1982).

MAE is a better error measurement in that it can solve the above mentioned problem. Given the above example, MAE=1 in the former case and MAE=10 in the latter case. So the value of MAE tells us that the former is a better forecast. RMSE can solve the same problem as well. So in this context, MAE and RMSE are better than ME. But all these three methods measure the absolute magnitude of forecast errors rather than relative/percentage magnitude. This is their disadvantage. In order to show this point, we give an example in table 3.5.

Table 3.5 Comparison of Absolute Error Measurement with Percentage Error Measurement of Exchange Rate Forecast

	Realised Exchange Rate	Forecasted Exchange Rate	ME	MAE	RMSE	% Error*
Forecast 1	1	3	2	2	2	200%
Forecast 2	10	3	-7	7	7	70%

* The relative error is calculated using realised exchange rate as denominator.

From the above table, we can see that forecast 2 is better than forecast 1. But if we adopt error measurements of ME, MAE or RMSE, then forecast 1 is better. So in this case, it is better to use percentage error measurement. From this made-up example, we can see that different error measurements usually will bring about different forecastability comparison conclusions. In table 3.4, Pilbeam's (1992) real data can also show that different error measurements will give rise to different conclusions.

In table 3.4, we have raw data of actual exchange rates, exchange rates forecasted by the flexible price model and the real interest differential model respectively done by Pilbeam (1992). The left side of that table shows the original data of exchange rates of dollar-pound. So the forecasting errors calculated from them can not be compared with that of table 3.2 and 3.3 where exchange rates are in logarithm. In order to let them be comparable, we take the logarithm for all data on the left side of table 3.4 and put them on the right side of the same table. Then we calculate their RMSE using equation (3.3) for both sides of table 3.4 and put them at the bottom of the table as shown there. The RMSE at the bottom of the right half side of table 3.4 is in relative or percentage form which can be compared with that of table 3.2 and 3.3. The explanation is as follows.

Let $\overline{\overline{S}}$ be the forecasted exchange rate, S is the actual exchange rate, and lower letters are their corresponding numbers in logarithm. So we have

$$\overline{\overline{s}} - s = \ln \overline{\overline{S}} - \ln S = \ln(\overline{\overline{S}}/S) \quad (3.4)$$

If the forecasted rate and the actual rate are very close to each other, then we have $\overline{\overline{S}}/S$ being very close to 1. So we can use the Taylor Series centered at 1 to expand (3.4) as

$$\ln(\overline{\overline{S}}/S) = (\overline{\overline{S}}/S-1) + (1/2)(\overline{\overline{S}}/S-1)^2 + (1/3)(\overline{\overline{S}}/S-1)^3 + (1/4)(\overline{\overline{S}}/S-1)^4 + \ldots \quad (3.5)$$

Because $\overline{\overline{S}}/S$ is very close to 1, $\overline{\overline{S}}/S-1$ is very close to zero. So $(\overline{\overline{S}}/S-1)^2$, $(\overline{\overline{S}}/SR-1)^3$, $(\overline{\overline{S}}/S-1)^4$......are higher order smaller numbers relative to $(\overline{\overline{S}}/S-1)$. Hence we have the approximation:

$$\ln(\overline{\overline{S}}/S) = \overline{\overline{S}}/S-1 \quad (3.6)$$

After a simple manipulation, we get

$$\ln(\bar{\bar{S}}/S)=(\bar{\bar{S}}-S)/S \qquad (3.7)$$

The right hand side of (3.7) is just the relative forecasting error or forecasting error in percentage form. So when we go back step by step to (3.4), we can find that $\bar{\bar{s}}$-s is the forecasting error in relative form. We input all these errors into RMSE calculation definition (3.3), then we can get RMSE in relative form as shown at the bottom of the right side of table 3.4.

From the results, we can see that by using raw data, we conclude that the flexible price model is the best forecast model in terms of RMSE, which is 0.1075. But by using error measurement in percentage, we find that the random walk model is the best forecast model in terms of RMSE, which is 5.94%. So the above claim that different error measurements will usually cause different conclusions can be shown here by a real example.

In addition to the reason of error measurement, there are many other possible reasons. One of them is that exchange rate and other macroeconomic variables have a two-way causality. The exchange rate is on the left hand side of a forecast equation, but in other cases, it is on the right hand side of the equation. For example, when government considers to adjust the money supply or interest rates, it also has to consider the stability of exchange rates. So we say that there is a two-way causality. Meese & Rogoff (1983, p.6) also have a similar idea:

> Variables such as relative money supplies and relative incomes are typically treated as exogenous variables in the underlying theoretical models, but may be more realistically thought of as endogenous variables. Other variables, such as the short-term interest differential, are generally endogenous in these same theoretical models.

Ahking & Miller (1987, p.499) had similar view point:

> The exchange rate equation should be treated as one equation in a system of simultaneous equations, including real incomes, the nominal interest rates, and the cumulative trade balances as endogenous variables and nominal money stocks and possibly other explanatory variables as exogenous variables.

So in mathematics and econometrics, probably we have to use simultaneous equations rather than a single equation to represent such kind of mutual causality. Then the model constructed under these considerations will be much more complex than those we have surveyed in this paper.

Assumptions and simplifications of models may cause forecast bias. In order to study an issue in real life, usually scholars will develop a model. In doing this, almost all scholars will make some assumptions and/or simplifications. Nobody can consider and include everything in his model. Based on these assumptions and simplifications, models can be developed and used relatively easily. But in the mean time, the more simplifications are made, the further the model is away from reality. Thus more bias may occur on forecasting. Besides those mentioned before, other frequently used assumptions which may bring about problems are: rationality and homogeneity; perfect market[21].

The non-stationarity of exchange rates has also been extensively recognised by economists. If we want to solve the problem by using difference equations, we need to be sure that the left hand side and the right side of equation have the same degrees of integration.

One of the other reasons is that the wrong estimates are used in forecasting. So "it is important to emphasise that for the purposes of forecasting it was the regression estimates of coefficients that were employed and that these rarely corresponded to the theoretical values" as said by Pilbeam (1992, p.236). That means if we use theoretical values of coefficients rather than estimated values, the forecast results should be better.

Exchange rates forecast models do not perform very well as explained by the above reasons. However they would perform well, as Hansen & Hodrick (1980, p.830) assumed, "If economic agents are risk neutral, costs of transaction are zero, information is used rationally, and the market is competitive, the foreign exchange market will be efficient in the sense that the expected rate of return to speculation in the forward exchange market will be zero". In this case, exchange rate would be a random walk and hence all forecast models except random walk model would lose their values.

Foreign exchange market efficiency has been argued for long time. Mandelbrot (1971, p.225) explained: "Roughly speaking, a competitive market of securities, commodities or bonds may be considered efficient if every price already reflects all the relevant information that is available". Goodman (1979) has the following definition about market efficiency:

> The market is efficient in that the major participants are believed to have access to, and have digested, all current information that may impact on price and, consequently, this information is already reflected in the price (strong efficiency) or that --- at the very least --- the historical record of exchange rates contains no information which can be used by market participants to accurately forecast future spot exchange rates (weak efficiency).

Hansen & Hodrick (1980, p.829) have a similar statement: "By the efficient-markets hypothesis, we mean the proposition that the expected rate of return to speculation in the forward foreign exchange market conditioned on available information is zero". Shapiro's (1982, p.83) definition is: "a financial market is said to be efficient if it is composed of numerous well-informed participants, with ready and cheap access to new information, whose trading activities cause prices to rapidly adjust to reflect all available information." From these explanations of foreign exchange market efficiency, we can see that an efficient market means that the expected profit of investing in foreign currency market is zero by forecasting its movement in the future. That means an efficient market means the movement of exchange rates should display a random walk, i.e., the exchange rate can not be forecasted. Otherwise, the expected profit will not be zero and hence the market will not be efficient.

Shapiro (1982) related the concept of efficient market to random walk. He thought that if a foreign exchange market is efficient, the foreign exchange should follow a random walk. Because in an efficient market, "price changes at any moment must be due solely to the arrival of new information. Since new information that is useful for forecasting arrives randomly (otherwise it would be neither new nor useful), price changes follow a random walk. This implies that the best prediction of tomorrow' price is the price today (adjusted for any know trends based on the opportunity cost of funds). In other words, price changes from one period to the next are independent of past price changes and are no more predictable than is new information"

So the above researchers discussed the relationship between market efficiency and random walk. From their viewpoints, efficient market means the exchange rate movement will display a random walk and vice visa. Whether or not the foreign exchange market is efficient, or whether or not exchange rate is a random walk is still in argument. But theoretically exchange rates should be determined by fundamentals. Random walk model may be good at forecasting exchange rate at short to medium time horizons as concluded by Meese and Rogoff (1983). But in the long run, structural models may be better than random walk model. Otherwise, economic theory will really become useless in forecasting exchange rate.

Exchange rate forecasting is not an easy job. Forecastability comparisons, which are based on exchange rate forecasting, are thus not easy as well. Besides some possible unrealistic assumptions, there are also some other reasons for the bad forecastability of some models, such as unpredictable things or things which can not be modeled, such as psychological factors. Pollock's statement can also strengthen this point:

> Nevertheless, it must be pointed out that the amount of variation explained by these models is relatively small. This is invariably the case for most exchange rate forecasting models: it is to be expected in any forward-looking market. It is the author's view that successful exchange rate forecasting requires, in addition, some subjective input from currency experts who can anticipate events that are impossible to model.

Part IV: Summary and Conclusion

Even though there are arguments about most exchange rate models, academic research has made great progress in this area. So far, lots of efforts have been made on forecasting exchange rates. Although no model is perfect, great achievements have been made. For instance, testing for the unbiasedness of forward exchange rate has evolved from equation (2.4.1) to equation (2.4.2). A new research direction focuses on microstructure of exchange rate[22] explained by Lyons (1993), "The literature on microstructure highlights two channels through which trading volume generates price movements". The two channels are information channel and inventory-control channel. The trading volume gives the market information which will influence the market participants' expectation, and hence influence their quotes. This is the information channel. In the meantime, they will also adjust their inventory by using price adjustment mechanisms. This is the inventory-control channel. The research focusing on microstructure of exchange rates intends to find out how the trading volume influences the exchange rate through the above two channels.

In retrospect of those models in part II, we find that different models have their own advantage, even though none is perfect. So we can naturally come to our mind the idea of combining those models. For example, we may want to try to forecast long run exchange rates using fundamentals model and forecast short run exchange rates using technical models. When people expect that the exchange rats will change in future, usually they will react in advance. So the current exchange rates actually are determined by both technical aspects in the short run and fundamentals aspects in the long run. The latest economic theory also tells us that the current exchange rate will be influenced by rational expected value of future variables. When people expect that economic variables, such as GDP, inflation rate, will take some values in future, they will use these values in advance to determine current value of exchange rates. That means they will include advanced variables in the right hand side of the exchange rate determination equation. Hence another possible future development is to add advanced variables into forecasting equations. In this case, if we only use current and lagged variables on the right hand side of this equation, bias can be expected.

Shapiro (1982, p.83) had a similar idea as well:

> In the present floating rate system, spot and forward rates adjust almost instantaneously to new information regarding inflation rates, changes in money supplies, trade balances, and the like. Hence, to successfully forecast floating currencies, it is necessary to determine the future values of these key economic parameters and establish the relationship between them and future exchange rates. But, it does not seem any less difficult to estimate, say, future interest rates, than it is to project future exchange rates.

Meese (1990) also had the following equation:

$$S(t) = F[H(t), E(S(t+1)|I(t))] \qquad (4.1)$$

He explained that "where the exchange rate S(t) is a function of a set of explanatory variables denoted by H (t) and the conditional expectation denoted by the symbol

E(S(t+1)|I(t)) of the next period spot rate given period t information, I(t)". So Meese also thought that the current exchange rate is not only determined by current explanatory variables, but also by future expected values. And he spelt out that "the current spot rate is the expected discounted sum of all future market fundamentals" (Meese, 1990, p.122). Pilbeam (1992, p.240) had a similar idea, but he realised the difficulties of the exchange rate forecasting due to the difficulties of the expectation determination in the following:

> The theoretical literature on exchange-rate determination since the advent of floating exchange rates had made it abundantly clear that the current exchange rate depends not only upon the present fundamentals but also upon the expected future course of those fundamentals. For this reason, new information which halters perceptions about the future course of these fundamental factors will have an impact upon the current exchange rate. It is extremely difficult to identify and model changes in new information and how they are discounted into the current exchange rate.

Harvey (1993) has done research more deeply in this direction. He developed ten models to forecast exchange rates. His main points are that exchange rates are determined by both fundamentals aspects and technical aspects. The fundamental aspects determine exchange rates in the long run. But when investors expect that exchange rates will change in future, they will react to the future change currently. So exchange rates will be influenced by fundamentals. In the meantime, technical aspects determine exchange rates in the short run. Some fluctuations in the short run which can not be explained by fundamental aspects can be explained by technical aspects. For instance, technically, the more some currency is over sold , the more likely the currency will be bought, and vice verse. Intuitively, our life experience also tells us that exchange rates should be determined by both fundamental aspects and technical aspects. So Harvey's research seems to be on a correct track and should result in good achievements. He used R^2 to measure the goodness of his models instead of using those forecasting error measurements used in part III of this paper. So we can not compare forecastability of his models with that of other models directly mentioned in part II. But Harvey has his own comparison of his models with other models, and he concluded that:

> Using the forward rate as the predictor gives a negative adjusted R^2 and an insignificant regressor, as does the random walk model. The adjusted R^2 in the Post Keynesian model (his own model), on the other hand, shows almost 30 percent of the variation explained in both cases.

But here one thing we need to be careful with is that Harvey (1993) compared explanatory ability of different models rather than forecastability of different models, and the two concepts are not exactly the same even though there is close relationship between them. But this will not impair Harvey's (1993) research direction to be an interesting and good one.

In the end, exchange rate forecast is not an easy job. The prediction of exchange rate is as difficult as that of a stock index. Whenever some exchange rate model can predict exchange rates exactly, by the same token, stock market index will be forecasted exactly as well. And there will be no fluctuations in both the exchange rate market and the stock market. It is difficult for this to happen in the short run according to the development pace of human being's knowledge. So we can expect that some newly developed models will not be supported again by some empirical investigations in the recent future. Meese (1990, p.132) has also realised that as follows:

> Economists do not yet understand the determinants of short- to medium-run movements in exchange rates. Neither models of exchange rates based on macroeconomic fundamentals nor the forecasts of market participants as embodied in the forward rate or survey data can explain exchange rate movements in the post-Bretton Woods era significantly better than a naïve alternative such as a random walk model. Worse yet, exchange rate changes are hard to explain after the fact, even with the knowledge of actual future values of fundamental variables.

Meese (1990, p.117) even thought pessimistically that: “The proportion of (monthly or quarterly) exchange rate changes that current models can explain is essentially zero”. And at the end he added that:

> Thus far these models have not provided an improved ability to explain currency fluctuations; it has proven difficult to identify which real factors (typically unobservable) buffeted exchange rates over what periods of the post-Bretton Woods regime.

Endnotes

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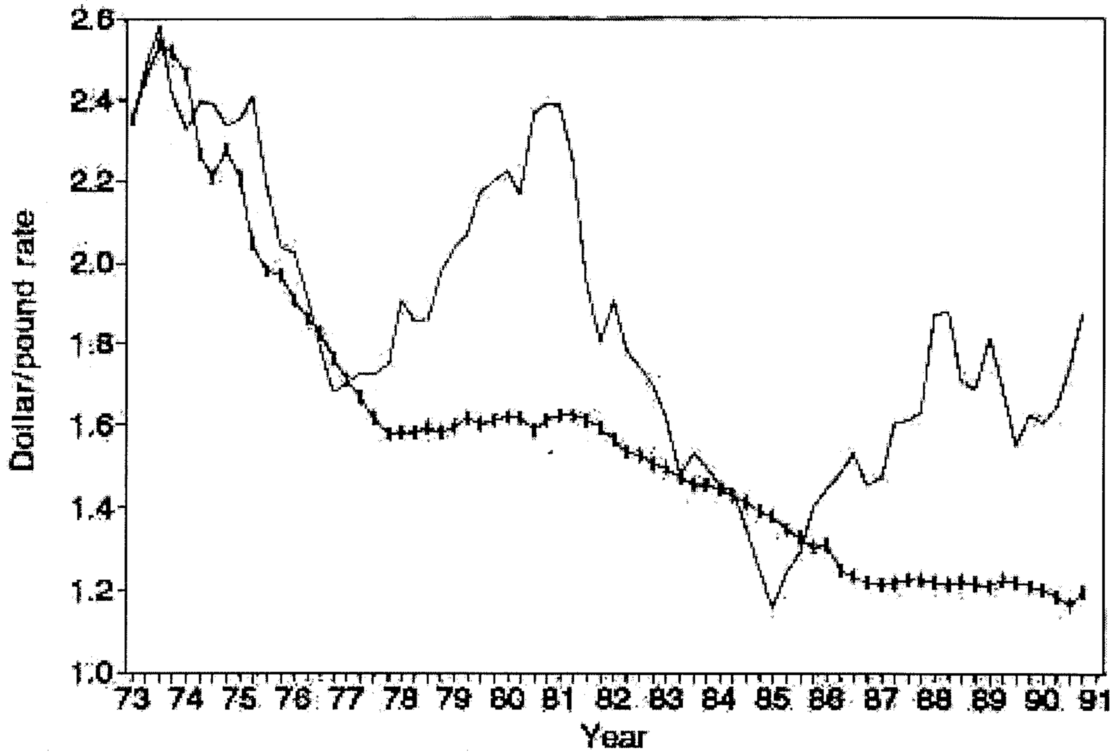
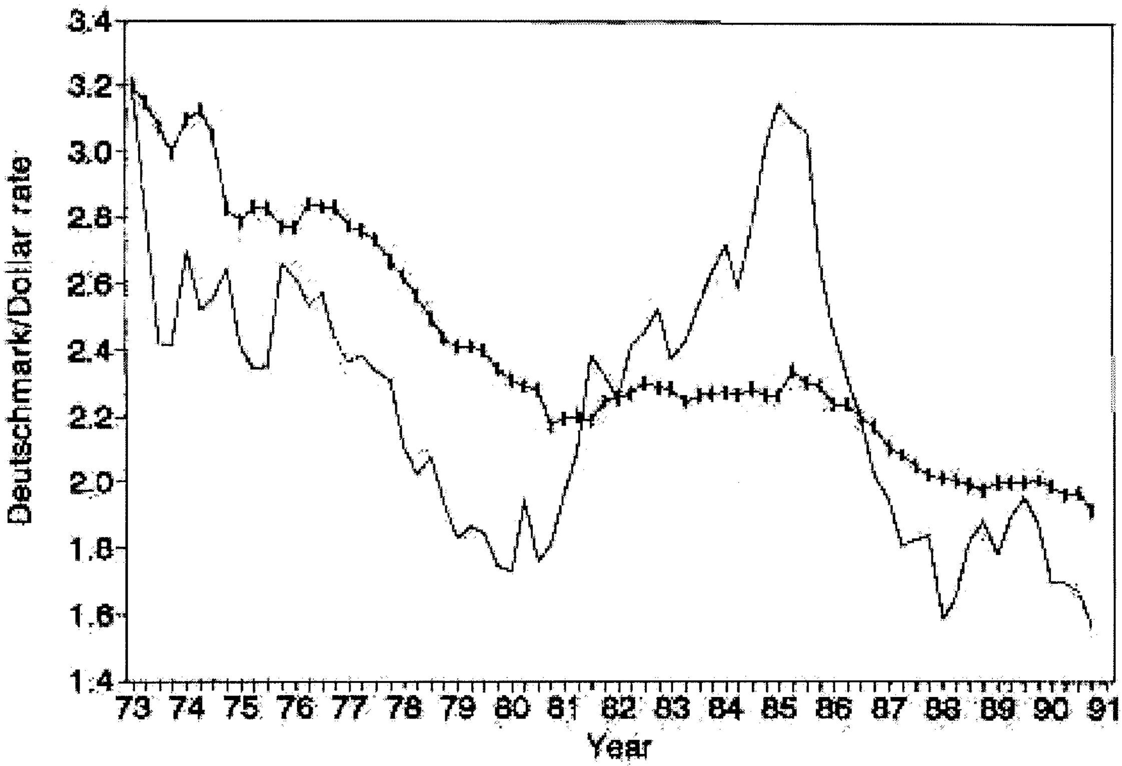
[1] See Cassel (1916a, 1916b), Balassa (1964), Shapiro (1982), Adler & Lehmam (1983), Edison (1987), Huang (1987), Abuaf & Jorion (1990), Patel (1990), Fisher & Park (1991), Sercu & Uppal (1995), Kilian & Zha (1999)
[2] Calvo & Rodriguez (1977), Frankel & Rose (1994)
[3] The classic theoretical paper is Dornbusch's (1976), Frankel (1979).
[4] Frankel (1979)
[5] Examples are Stoll (1972), Cumby & Obstfeld (1981), Meese & Rogoff (1988), McCurdy & Morgan (1991)
[6] The description of random walk model is in section II.C of this paper.
[7] See Appendix I
[8] See Shapiro (1982)
[9] See Table 3.3 in part III of this paper. The descriptions of other models are in other relevant sections of this paper.
[10] See Abuaf and Jorion (1990), Adler and Lehmann (1983), Edison (1987), Kilian and Zha (1999).
[11] See Frankel and Rose (1994)
[12] Table 3.4 in part III of this paper is a reference. The table shows that real interest rate differentials model is worse than flexible price model which is contradictory to theory.
[13] Refer to equation (2.2.14) and (2.2.15).
[14] Evidence is Obstfeld (1980)
[15] Such as Pollock (1990), Pilbeam (1992).
[16] Discussion of time inconsistency can be found from Kaminsky (1993)
[17] Such as Upson (1972), Hansen & Hodrick (1980), Bilson (1981), Fama (1984), Korajczyk (1985), Froot and Frankel (1989), Byers and Peel (1991), Backus, Gregory and Telmer (1993), Bekaert and Hodrick (1993).
[18] See Froot & Thaler (1990, p.182)
[19] Examples are Bilson (1981), Fama (1984), Bekaert and Hodrick (1993), Backus, Gregory and Telmer (1993)
[20] Their description of the Fisher hypothesis is "The Fisher hypothesis states that when two bonds are similar in all respects except currency of denomination, asset-market equilibrium requires that any nominal rate-of-return differential between them be offset by an expected exchange rate change over the holding period".
[21] Explanations in details can be found in Shapiro (1982)
[22] Example is Lyons (1993).

Appendix 1 Graphical Examination of Forecastability of the PPP Model

The graphs on page 58-61 are borrowed from Pilbeam (1992) in order to examine the forecastability of the PPP model.

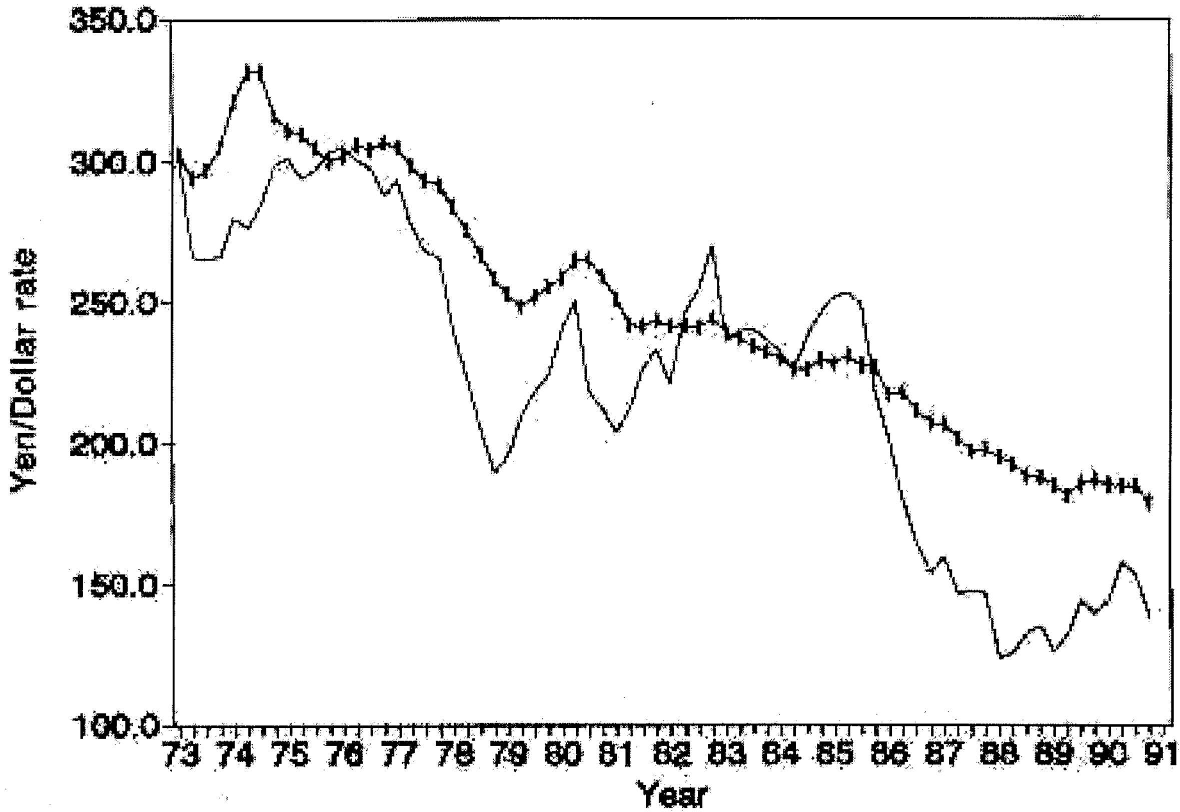


(a) The dollar–pound rate and PPP

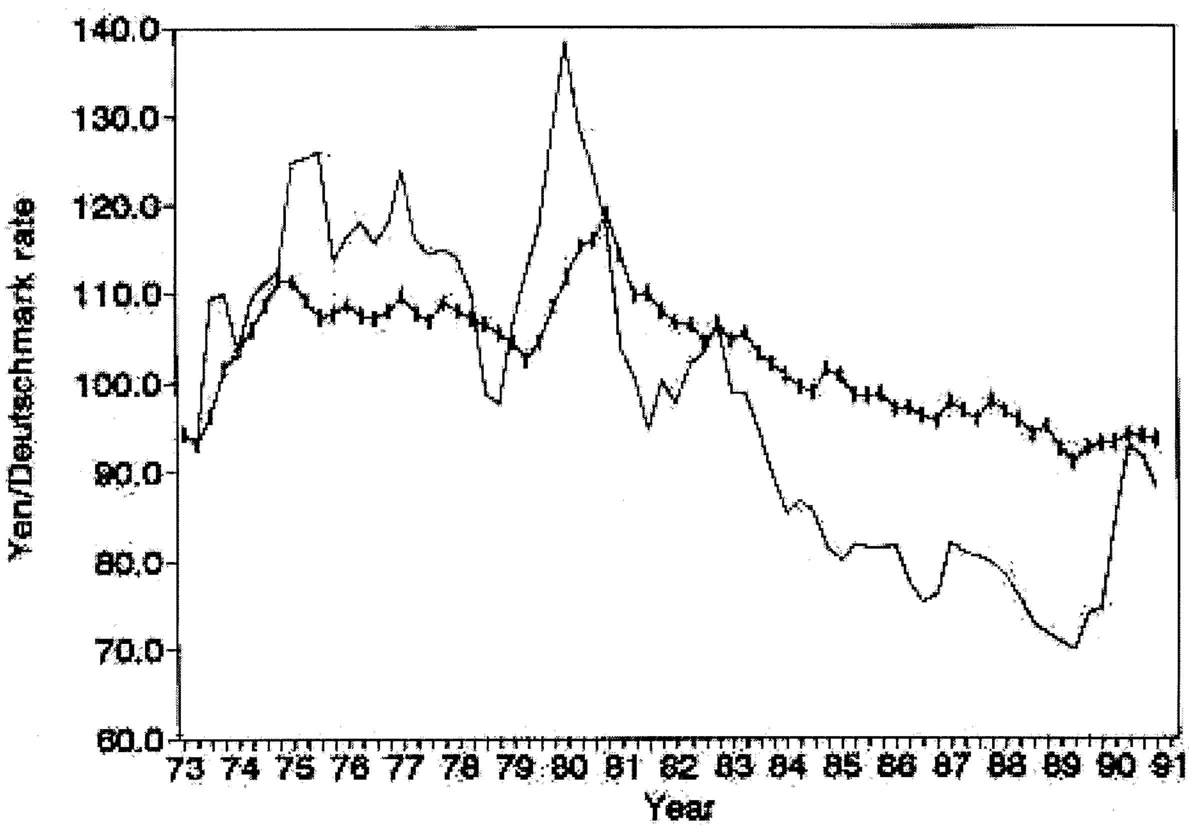


(b) The deutschmark–dollar rate and PPP

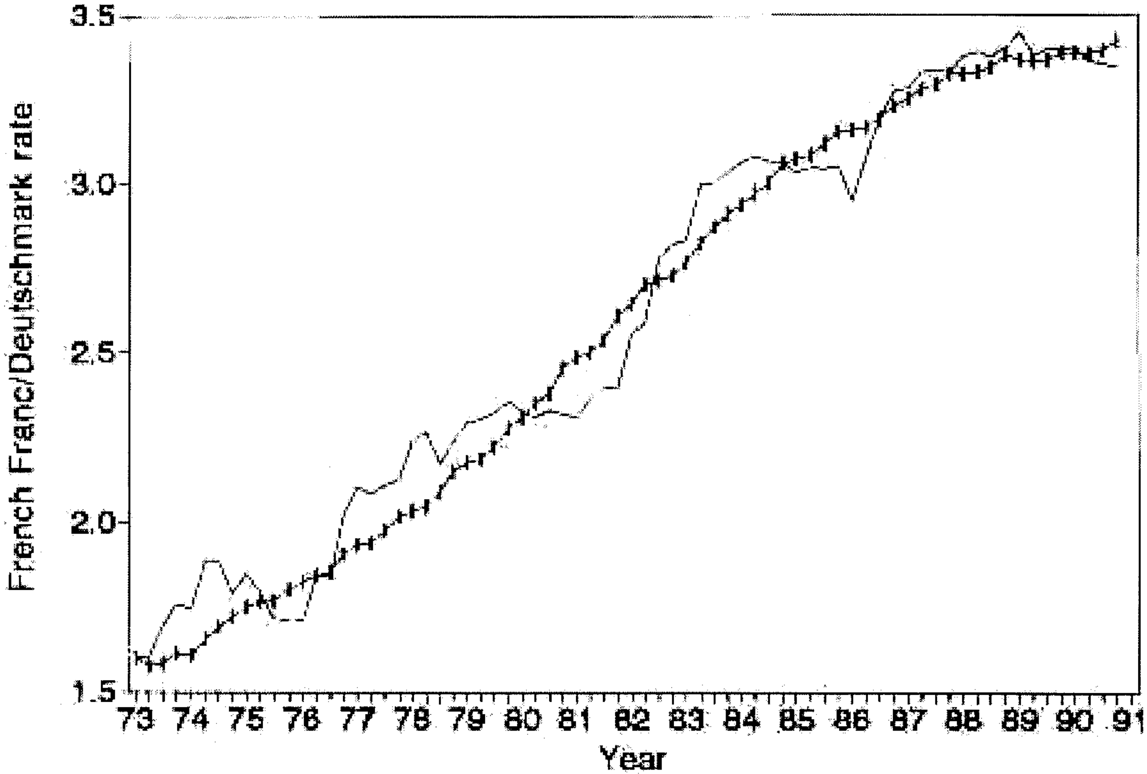
Figures 6.1 (a)–(g) *The actual (——) exchange rate and the PPP (+++) exchange rate*



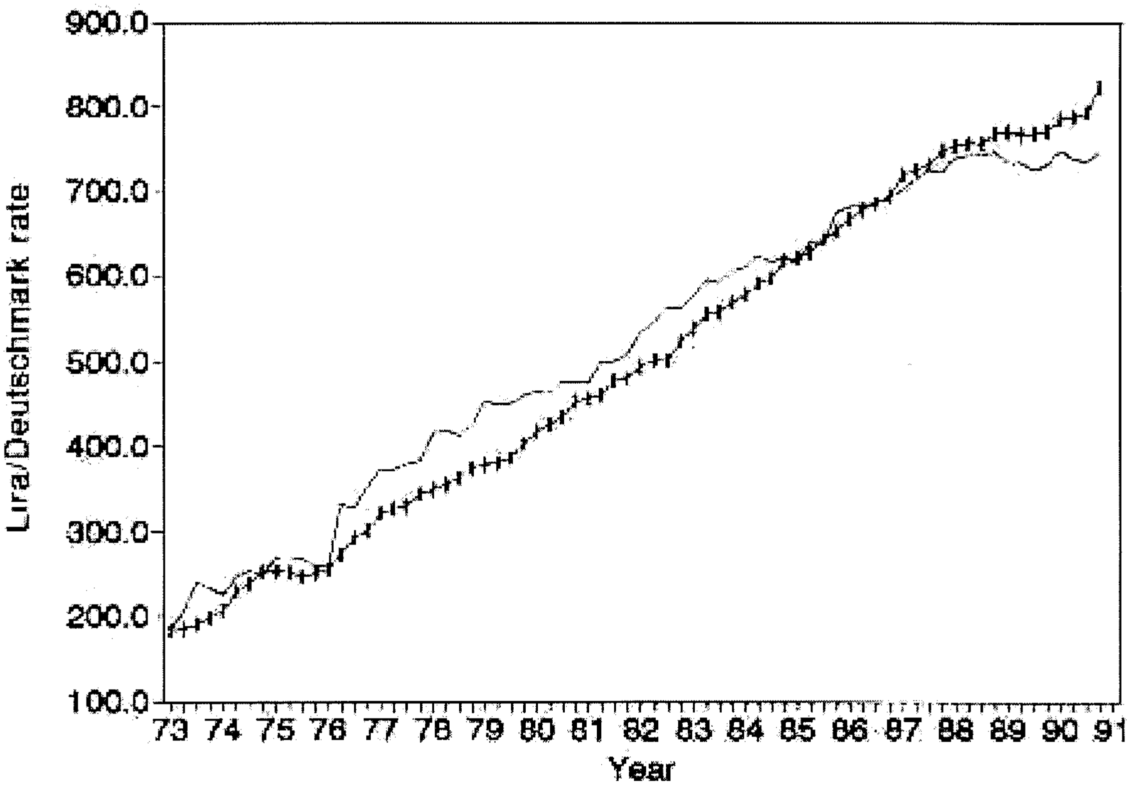
(c) The yen–dollar rate and PPP



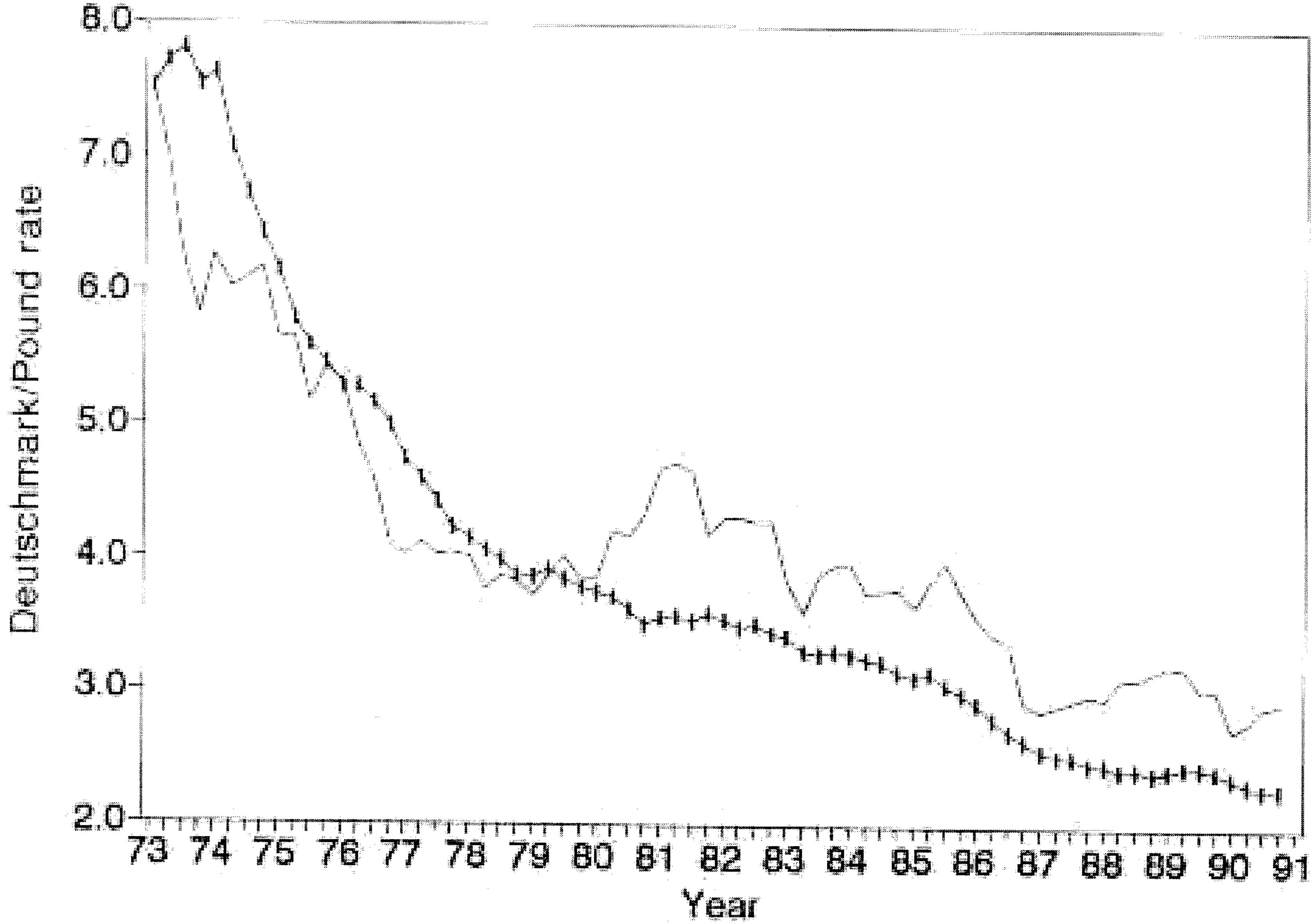
(d) The yen–deutschmark rate and PPP



(e) The French franc–deutschmark rate and PPP



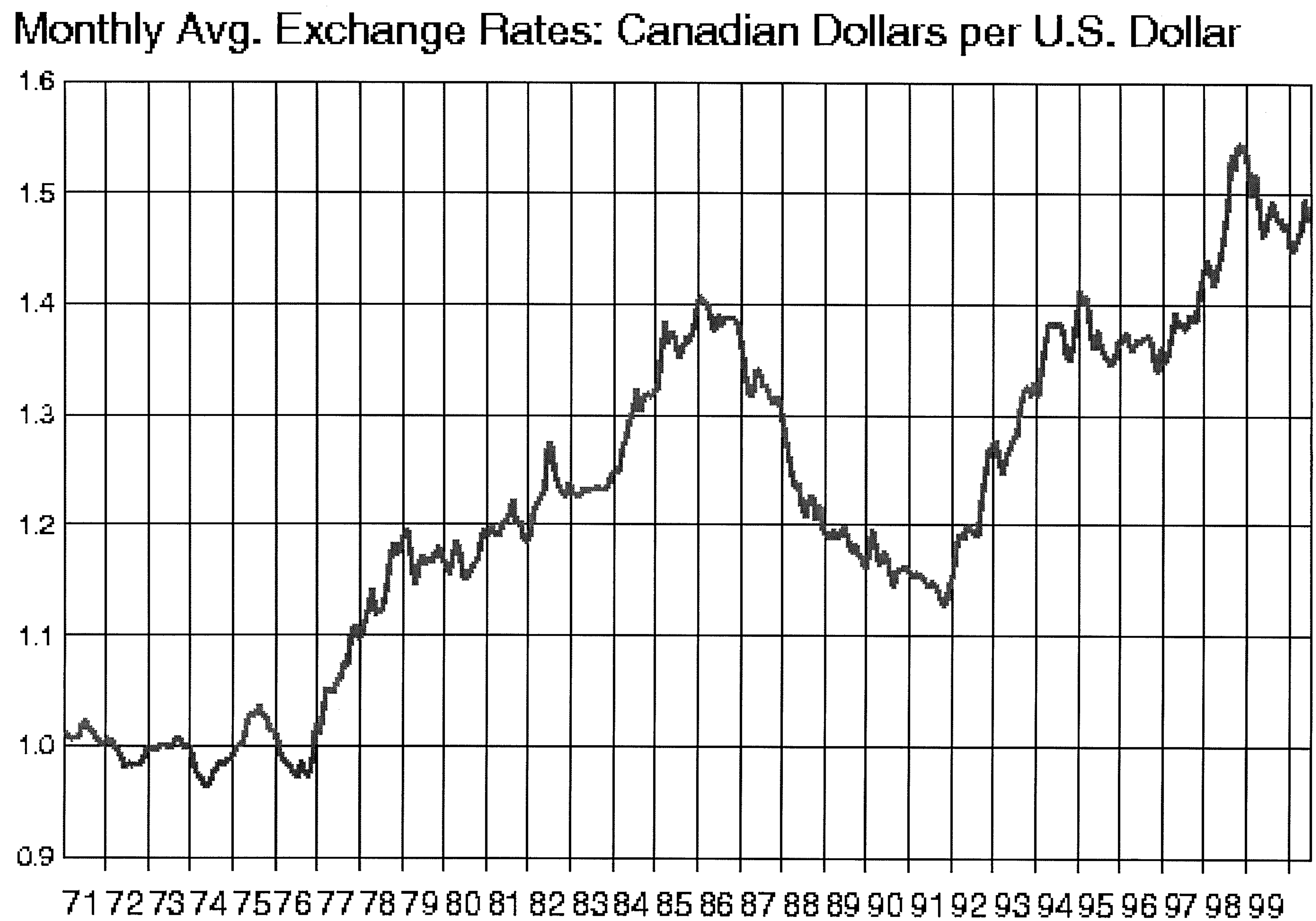
(f) The lira–deutschmark rate and PPP



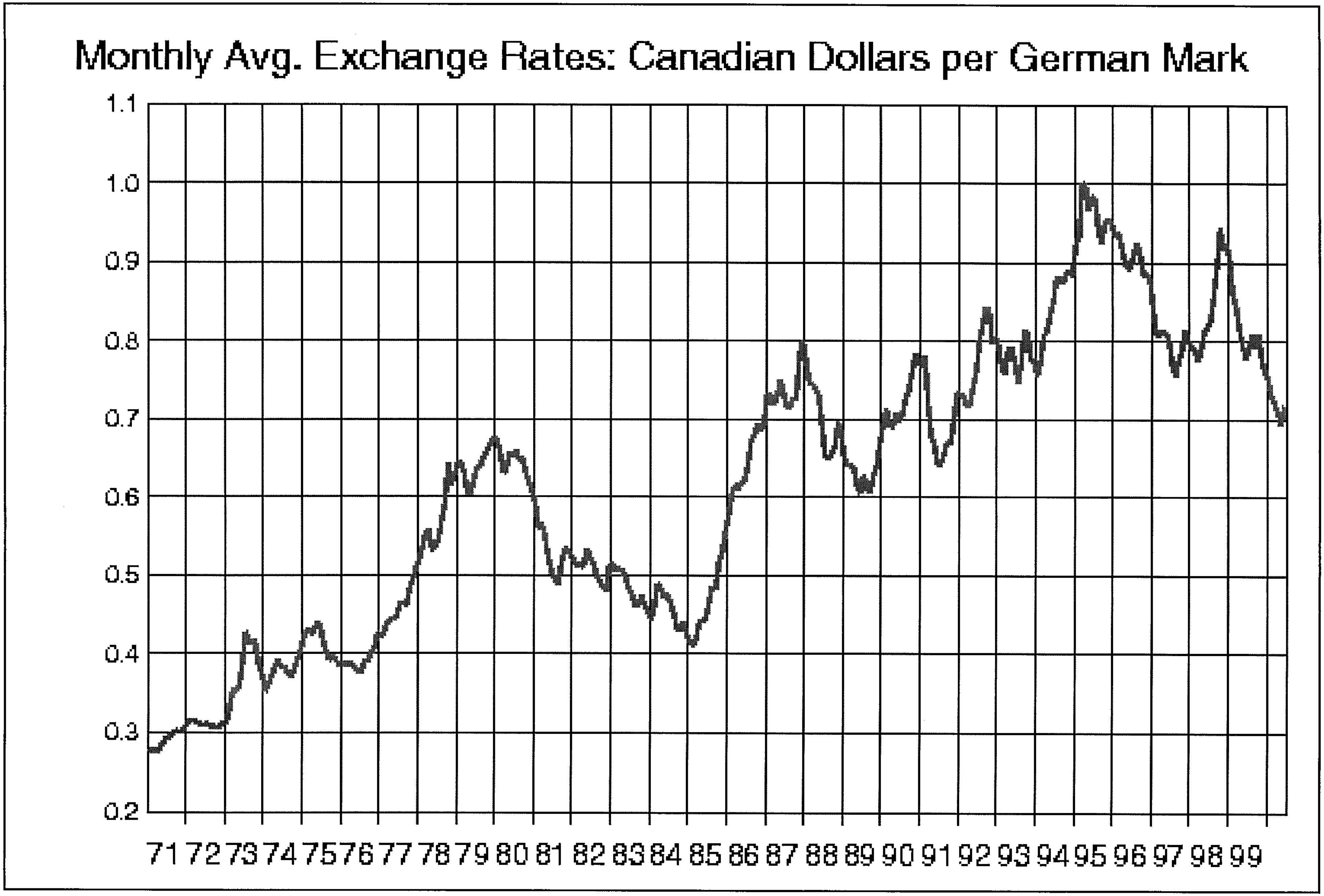
(g) The deutschmark–pound rate and PPP

Appendix 2 Historical Exchange Rates Graphs

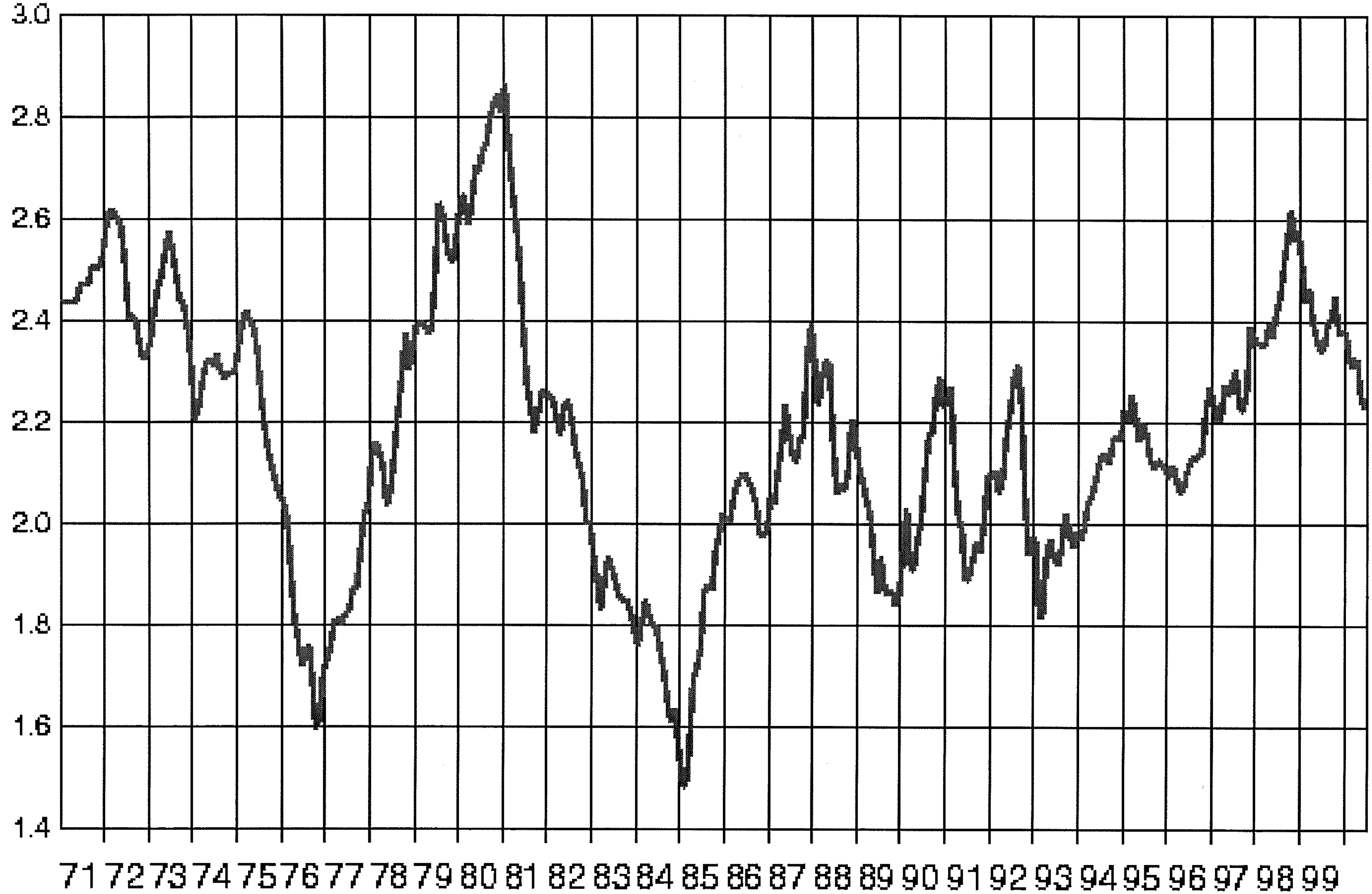
Printer from internet. The web address is http://pacific.commerce.ubc.ca/xr/plot.html


Monthly Avg. Exchange Rates: Canadian Dollars per U.S. Dollar
1.6
1.5
1.4
1.3
1.2
1.1
1.0
0.9
71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99

Monthly Avg. Exchange Rates: Canadian Dollars per Japanese Yen


Monthly Avg. Exchange Rates: Canadian Dollars per German Mark
1.1
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95 96 97 98 99

Monthly Avg. Exchange Rates: Canadian Dollars per British Pound



Appendix 3 Data from World Bank

4.2 Structure of output

	Gross domestic product		Agriculture value added		Industry value added		Manufacturing value added		Services value added	
	$ millions		% of GDP		% of GDP		% of GDP		% of GDP	
	1980	1998	1980	1998	1980	1998	1980	1998	1980	1998
Albania	..	3,047	34	54	45	25	..	..	21	21
Algeria	42,345	47,347	10	12	54	47	9	11	36	41
Angola	..	7,472	..	12	..	51	..	6	..	36
Argentina	76,962	298,131	6	6	41	29	29	19	52	66
Armenia	..	1,900	..	33	..	32	..	22	..	35
Australia	160,109	361,722	5	*3*	36	*26*	19	*14*	*58*	*71*
Austria	78,539	211,858	4	*1*	36	*30*	25	*20*	*60*	*68*
Azerbaijan	..	3,926	..	20	..	39	..	22	..	41
Bangladesh	17,430	42,702	38	22	24	28	18	18	38	50
Belarus	..	22,555	..	13	..	46	..	39	..	40
Belgium	119,979	248,184	2	*1*	34	*28*	21	*18*	64	*71*
Benin	1,405	2,306	35	39	12	14	8	8	52	48
Bolivia	2,750	8,586	..	15	..	29	..	17	..	56
Bosnia and Herzegovina	..	..	..	..	..	..	..	..	..	..
Botswana	1,130	4,876	11	4	45	46	5	5	44	50
Brazil	235,025	778,209	11	8	44	29	33	23	45	63
Bulgaria	20,040	12,258	14	19	54	26	..	17	32	56
Burkina Faso	1,709	2,581	33	33	22	27	16	21	45	39
Burundi	920	885	62	54	13	16	7	8	25	29
Cambodia	..	2,871	..	51	..	15	..	6	..	35
Cameroon	6,741	8,701	31	42	26	22	10	11	43	36
Canada	266,003	580,623	4	..	38	..	19	..	58	..
Central African Republic	797	1,057	40	53	20	19	7	9	40	29
Chad	1,033	1,694	45	40	9	14	..	13	46	46
Chile	27,572	78,738	7	7	37	30	21	15	55	62
China	201,687	959,030	30	18	49	49	41	37	21	33
Hong Kong, China	28,496	166,440	1	*0*	32	*15*	24	*7*	67	*85*
Colombia	38,900	102,896	22	13	26	25	18	13	51	61
Congo, Dem. Rep.	14,922	6,964	25	*58*	33	*17*	14	..	42	*25*
Congo, Rep.	1,706	1,961	12	12	47	50	7	8	42	39
Costa Rica	4,831	10,479	18	15	27	24	19	19	55	61
Côte d'Ivoire	10,175	11,005	26	26	20	23	13	19	54	51
Croatia	..	21,752	..	9	..	32	..	21	..	59
Cuba	..	..	..	..	..	..	..	..	..	..
Czech Republic	29,123	56,379	7	4	63	39	..	..	30	57
Denmark	67,791	174,870	5	..	29	..	20	..	66	..
Dominican Republic	6,631	15,853	20	12	28	33	15	17	52	56
Ecuador	11,733	18,360	12	13	38	35	18	24	50	52
Egypt, Arab Rep.	22,912	82,710	18	17	37	32	12	26	45	50
El Salvador	3,574	11,870	38	12	22	28	16	22	40	60
Eritrea	..	650	..	*9*	..	*30*	..	*16*	..	*61*
Estonia	..	5,202	..	6	..	27	..	15	..	67
Ethiopia	*5,179*	6,544	*56*	50	*12*	7	*8*	..	*32*	44
Finland	51,306	123,502	10	*4*	40	*34*	28	*25*	51	*62*
France	664,596	1,426,967	4	*2*	34	*26*	24	*19*	62	*72*
Gabon	4,279	5,518	7	7	60	60	5	5	33	32
Gambia, The	241	416	31	27	15	14	6	6	54	59
Georgia	..	5,129	24	26	36	16	28	16	40	58
Germany	..	2,134,205	..	*1*	..	..	..	*24*	..	*44*
Ghana	4,445	7,501	58	10	12	7	8	2	30	83
Greece	48,613	120,724	14	..	25	..	16	..	61	..
Guatemala	7,879	18,942	25	23	22	20	17	14	53	57
Guinea	..	3,598	..	22	..	35	..	4	..	42
Guinea-Bissau	111	206	44	62	20	13	..	9	36	25
Haiti	1,462	3,871	..	30	..	20	..	7	..	50
Honduras	2,566	5,371	24	20	24	31	15	18	52	49

Structure of output 4.2

	Gross domestic product		Agriculture value added		Industry value added		Manufacturing value added		Services value added	
	$ millions		% of GDP		% of GDP		% of GDP		% of GDP	
	1980	1998	1980	1998	1980	1998	1980	1998	1980	1998
Hungary	22,164	47,807	19	*6*	47	*34*	..	*25*	34	*60*
India	186,392	430,024	38	29	24	25	16	16	38	46
Indonesia	78,013	94,156	24	20	42	45	13	25	34	35
Iran, Islamic Rep.	92,664	113,140	18	*25*	32	*37*	9	*15*	50	*38*
Iraq	47,562	..	..	..	..	..	..	..	..	..
Ireland	20,080	81,949	..	..	..	..	..	..	..	..
Israel	21,781	100,525	..	..	..	..	..	..	..	..
Italy	449,913	1,171,865	6	*3*	39	*31*	28	*20*	55	*67*
Jamaica	2,652	6,418	8	8	38	34	17	15	54	58
Japan	1,059,254	3,782,964	4	*2*	42	*37*	29	*24*	54	*61*
Jordan	3,962	7,393	8	3	28	26	13	14	64	71
Kazakhstan	..	21,979	..	9	..	31	..	..	..	60
Kenya	7,265	11,579	33	26	21	16	13	11	47	58
Korea, Dem. Rep.	..	..	..	..	..	..	..	..	..	..
Korea, Rep.	62,543	320,748	14	5	40	43	28	31	46	52
Kuwait	28,639	25,171	0	..	75	..	6	..	25	..
Kyrgyz Republic	..	1,704	..	46	..	24	..	18	..	30
Lao PDR	..	1,261	..	53	..	22	..	17	..	25
Latvia	..	6,396	12	5	51	29	46	20	37	66
Lebanon	..	17,229	..	12	..	27	..	17	..	61
Lesotho	368	792	24	11	29	42	7	*17*	47	47
Libya	35,545	..	2	..	76	..	2	..	22	..
Lithuania	..	10,736	..	10	..	33	..	19	..	57
Macedonia, FYR	..	2,492	..	11	..	28	..	..	..	60
Madagascar	4,042	3,749	30	31	16	14	..	*11*	54	56
Malawi	1,238	1,688	44	36	23	18	14	14	34	46
Malaysia	24,488	72,489	22	13	38	44	21	29	40	43
Mali	1,787	2,695	48	47	13	17	7	4	38	36
Mauritania	814	989	30	25	26	30	..	9	44	46
Mauritius	1,132	4,199	12	9	26	33	15	25	62	58
Mexico	223,510	393,508	8	5	31	27	21	20	61	68
Moldova	..	1,615	..	29	..	31	..	23	..	40
Mongolia	..	1,042	*15*	33	*33*	28	..	..	*52*	40
Morocco	18,821	35,546	18	17	31	32	17	17	51	51
Mozambique	3,526	3,893	37	34	34	21	..	11	28	45
Myanmar	..	..	47	53	13	9	10	6	41	38
Namibia	2,262	3,092	11	10	55	34	9	14	34	56
Nepal	1,946	4,783	62	40	12	22	4	10	26	37
Netherlands	171,861	381,819	3	..	32	..	18	..	64	..
New Zealand	22,395	52,845	11	..	31	..	22	..	58	..
Nicaragua	2,144	2,007	23	34	31	22	26	15	45	44
Niger	2,509	2,048	43	41	23	17	4	6	34	42
Nigeria	64,202	41,353	21	32	46	41	8	*5*	34	27
Norway	63,419	145,892	4	*2*	35	*32*	15	*11*	61	*66*
Oman	5,982	14,962	3	..	69	..	1	..	28	..
Pakistan	23,690	63,369	30	26	25	25	16	17	46	49
Panama	3,810	9,144	10	8	21	18	12	9	69	74
Papua New Guinea	2,548	3,746	33	24	27	42	10	9	40	33
Paraguay	4,579	8,608	29	25	27	26	16	15	44	49
Peru	20,661	62,745	10	7	42	37	20	23	48	56
Philippines	32,500	65,107	25	17	39	32	26	22	36	51
Poland	56,789	158,574	..	*5*	..	32	..	19	..	*62*
Portugal	28,730	106,697	..	..	..	..	..	..	..	..
Puerto Rico	14,436	..	3	..	39	..	37	..	58	..
Romania	..	38,158	..	16	..	40	..	30	..	43
Russian Federation	..	276,611	..	7	..	35	..	..	..	57

4.2 Structure of output

	Gross domestic product		Agriculture value added		Industry value added		Manufacturing value added		Services value added	
	$ millions		% of GDP		% of GDP		% of GDP		% of GDP	
	1980	1998	1980	1998	1980	1998	1980	1998	1980	1998
Rwanda	1,163	2,024	50	47	23	21	17	13	27	31
Saudi Arabia	156,487	128,892	1	7	81	48	5	10	18	45
Senegal	2,987	4,682	19	17	15	24	11	16	66	59
Sierra Leone	1,199	647	33	44	21	24	5	6	47	32
Singapore	11,718	84,379	1	0	38	35	29	23	61	65
Slovak Republic	..	20,362	..	4	..	32	..	23	..	64
Slovenia	..	19,524	..	4	..	39	..	28	..	57
South Africa	80,544	133,461	6	4	48	32	22	19	46	64
Spain	213,308	553,230	..	*3*	..	..	..	*18*	..	*25*
Sri Lanka	4,024	15,707	28	21	30	28	18	17	43	51
Sudan	7,617	10,366	33	39	14	18	7	9	53	43
Sweden	125,557	226,492	4	..	34	..	23	..	63	..
Switzerland	107,474	263,630	..	..	..	..	..	..	..	..
Syrian Arab Republic	13,062	17,412	20	..	23	..	..	..	56	..
Tajikistan	..	2,164	..	6	..	30	..	..	..	65
Tanzania[a]	..	8,016	..	46	..	15	..	7	..	39
Thailand	32,354	111,327	23	11	29	41	22	32	48	48
Togo	1,136	1,510	27	42	25	21	8	9	48	37
Trinidad and Tobago	6,236	6,382	2	2	60	48	9	10	38	51
Tunisia	8,743	19,956	14	12	31	28	12	18	55	59
Turkey	68,790	198,844	26	18	22	25	14	16	51	57
Turkmenistan	..	2,367	..	25	..	42	..	29	..	34
Uganda	1,245	6,775	72	45	4	18	4	9	23	38
Ukraine	..	43,615	..	14	..	34	..	29	..	51
United Arab Emirates	29,625	47,234	1	..	77	..	4	..	22	..
United Kingdom	537,383	1,357,197	2	*2*	43	*31*	27	*21*	55	*67*
United States	2,709,000	8,230,397	3	*2*	33	*26*	22	*18*	64	*72*
Uruguay	10,132	20,578	14	8	34	27	26	18	53	64
Uzbekistan	..	20,384	..	31	..	27	..	13	..	42
Venezuela, RB	69,377	95,023	5	5	46	34	16	15	49	61
Vietnam	..	27,184	..	26	..	33	..	..	..	42
West Bank and Gaza	..	3,589	..	7	..	26	..	15	..	67
Yemen, Rep.	..	4,318	..	18	..	49	..	11	..	34
Yugoslavia, FR (Serb./Mont.)	..	..	..	..	..	..	..	..	..	..
Zambia	3,884	3,352	14	17	41	26	18	11	44	56
Zimbabwe	6,679	6,338	16	19	29	24	22	17	55	56
World	10,960,147 t	28,736,978 t	7 w	*4* w	38 w	*32* w	25 w	*21* w	55 w	*62* w
Low income	811,234	1,880,673	31	23	38	39	27	27	30	38
Excl. China & India	451,833	463,829	29	26	32	33	13	19	39	41
Middle income	2,322,822	4,312,567	12	9	42	33	24	22	46	58
Lower middle income	..	1,477,327	15	11	41	34	..	*22*	44	54
Upper middle income	1,164,279	2,838,231	11	8	42	32	26	22	47	60
Low & middle income	3,137,067	6,193,861	18	13	41	35	25	23	42	52
East Asia & Pacific	503,584	1,693,340	24	15	42	45	30	32	33	41
Europe & Central Asia	..	1,003,000	..	12	..	33	..	..	..	55
Latin America & Carib.	787,863	2,028,359	10	8	40	29	28	21	50	64
Middle East & N. Africa	409,860	583,374	10	*14*	53	*43*	9	*14*	37	*43*
South Asia	237,289	565,131	37	28	24	25	16	16	39	47
Sub-Saharan Africa	271,814	333,865	18	17	38	29	16	15	44	54
High income	7,936,135	22,543,577	3	*2*	37	*30*	25	*21*	59	*65*
Europe EMU	..	6,457,663	..	*2*	..	..	..	*21*	..	*58*

a. Data cover mainland Tanzania only.

Structure of output 4.2

About the data

A country's gross domestic product represents the sum of value added by all producers in that country. Value added is the value of gross output of producers less the value of intermediate goods and services consumed in production, excluding the consumption of fixed capital in the production process. Since 1968 the United Nations System of National Accounts has called for estimates of value added to be valued at either basic prices (excluding net taxes on products) or producer prices (including net taxes on products paid by the producers, but excluding sales or value added taxes). Both valuations exclude transport charges that are invoiced separately by the producers. Some countries, however, report such data at purchaser prices—the prices at which final sales are made (including transport charges)—which may affect estimates of the distribution of output. Total GDP as shown in the table and elsewhere in this book is measured at purchaser prices. Value added by industry is normally measured at basic prices. When value added is measured at producer prices, this is noted in *Primary data documentation.*

While GDP estimated by the production approach is generally more reliable than estimates compiled from the income or expenditure side, different countries use different definitions, methods, and reporting standards. World Bank staff review the quality of national accounts data and sometimes make adjustments to increase consistency with international guidelines. Nevertheless, significant discrepancies remain between international standards and actual practice. Many statistical offices, especially those in developing countries, face severe limits in the resources, time, training, and budgets required to produce reliable and comprehensive series of national accounts.

Data problems in measuring output

Among the difficulties faced by compilers of national accounts is the extent of unreported economic activity in the informal or secondary economy. In developing countries a large share of agricultural output is either not exchanged (because it is consumed within the household) or not exchanged for money.

Agricultural production often must be estimated indirectly, using a combination of methods involving estimates of inputs, yields, and area under cultivation. This approach sometimes leads to crude approximations that can differ from the true values over time and across crops for reasons other than climatic conditions or farming techniques. Similarly, agricultural inputs, which cannot easily be allocated to specific outputs, are frequently "netted out" using equally crude and ad hoc approximations. For further discussion of the measurement of agricultural production see *About the data* for table 3.3.

Industrial output ideally should be measured through regular censuses and surveys of firms. But in most developing countries such surveys are infrequent, so survey results must be extrapolated using an appropriate indicator. The choice of sampling unit, which may be the enterprise (where responses may be based on financial records) or the establishment (where production units may be recorded separately), also affects the quality of the data. Moreover, much industrial production is organized in unincorporated or owner-operated ventures that are not captured by surveys aimed at the formal sector. Even in large industries, where regular surveys are more likely, evasion of excise and other taxes lowers the estimates of value added. Such problems become more acute as countries move from state control of industry to private enterprise, because new firms enter business and growing numbers of established firms fail to report. In accordance with the System of National Accounts, output should include all such unreported activity as well as the value of illegal activities and other unrecorded, informal, or small-scale operations. Data on these activities need to be collected using techniques other than conventional surveys.

In industries dominated by large organizations and enterprises, such as public utilities, data on output, employment, and wages are usually readily available and reasonably reliable. But in the service industry the many self-employed workers and one-person businesses are sometimes difficult to locate, and their owners have little incentive to respond to surveys, let alone report their full earnings. Compounding these problems are the many forms of economic activity that go unrecorded, including the work that women and children do for little or no pay. For further discussion of the problems of using national accounts data see Srinivasan (1994) and Heston (1994).

Dollar conversion

To produce national accounts aggregates that are internationally comparable, the value of output must be converted to a common currency. The World Bank conventionally uses the U.S. dollar and applies the average official exchange rate reported by the International Monetary Fund for the year shown. An alternative conversion factor is applied if the official exchange rate is judged to diverge by an exceptionally large margin from the rate effectively applied to transactions in foreign currencies and traded products.

Definitions

• **Gross domestic product** at purchaser prices is the sum of the gross value added by all resident institutional units engaged in production plus indirect taxes and minus any subsidies not included in the value of their products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. The residency of an institution is determined on the basis of economic interest in the territory for more than a year. • **Value added** is the net output of an industry after adding up all outputs and subtracting intermediate inputs. The origin of value added is determined by the International Standard Industrial Classification (ISIC) revision 3. • **Agriculture** corresponds to ISIC divisions 1–5 and includes forestry and fishing. • **Industry** comprises value added in mining, manufacturing (also reported as a separate subgroup), construction, electricity, water, and gas (ISIC divisions 10–45). • **Manufacturing** refers to industries belonging to divisions 15–37. • **Services** correspond to ISIC divisions 50–99.

Data sources

The national accounts indicators for most developing countries are collected from national statistical organizations and central banks by visiting and resident World Bank missions. The data for high-income economies come from Organisation for Economic Co-operation and Development (OECD) data files; see the OECD's *Main Economic Indicators* (monthly). The United Nations Statistics Division publishes detailed national accounts for United Nations member countries in *National Accounts Statistics: Main Aggregates and Detailed Tables;* updates are published in the *Monthly Bulletin of Statistics*.

	Merchandise exports		Food		Agricultural raw materials		Fuels		Ores and metals		Manufactures	
	$ millions		% of total		% of total		% of total		% of total		% of total	
	1980	1998	1980	1998	1980	1998	1980	1998	1980	1998	1980	1998
Albania	367	208	..	10	..	9	..	1	..	13	..	68
Algeria	13,652	..	1	..	0	..	98	..	0	..	0	..
Angola	..	..	..	..	..	..	..	..	..	..	..	..
Argentina	8,021	26,434	65	51	6	2	3	8	2	3	23	35
Armenia	..	229	..	*11*	..	*5*	..	*1*	..	*26*	..	*54*
Australia	21,892	55,839	34	22	11	7	11	20	17	17	22	29
Austria	17,227	62,826	4	5	8	2	2	1	4	3	83	83
Azerbaijan	..	678	..	..	..	..	..	..	..	..	..	..
Bangladesh	793	5,141	12	7	19	2	0	0	0	0	68	91
Belarus	..	7,123	..	9	..	3	..	0	..	1	..	76
Belgium[a]	57,573	153,160	..	..	..	..	..	..	..	..	..	..
Benin	164	..	62	..	25	..	4	..	1	..	3	..
Bolivia	942	1,104	8	30	3	6	24	8	62	26	3	30
Bosnia and Herzegovina	..	..	..	..	..	..	..	..	..	..	..	..
Botswana	545	2,061	..	..	..	..	..	..	..	..	..	..
Brazil	20,132	51,136	46	30	4	4	2	1	9	10	37	55
Bulgaria	8,091	4,299	..	*14*	..	*3*	..	*8*	..	*11*	..	*61*
Burkina Faso	161	..	41	..	48	..	0	..	0	..	11	..
Burundi	..	..	..	..	..	..	..	..	..	..	..	..
Cambodia	..	*705*	..	..	..	..	..	..	..	..	..	..
Cameroon	1,657	..	48	..	16	..	31	..	2	..	4	..
Canada	67,532	217,238	12	8	11	7	14	8	14	5	48	66
Central African Republic	147	..	31	..	43	..	*0*	..	0	..	26	..
Chad	71	..	4	..	81	..	0	..	0	..	15	..
Chile	4,705	14,831	15	29	10	9	1	0	64	43	9	17
China†	..	183,527	..	7	..	1	..	3	..	2	..	87
Hong Kong, China[b]	19,743	173,996	1	2	1	0	0	0	1	1	96	95
Colombia	3,986	11,363	72	32	5	5	3	30	0	1	20	32
Congo, Dem. Rep.	..	..	..	..	..	..	..	..	..	..	..	..
Congo, Rep.	911	..	1	..	2	..	90	..	0	..	7	..
Costa Rica	1,001	5,547	64	39	1	4	1	0	0	1	28	56
Côte d'Ivoire	3,013	4,575	64	..	28	..	2	..	0	..	5	..
Croatia	..	4,613	..	11	..	4	..	6	..	2	..	76
Cuba	..	..	..	..	..	..	..	..	..	..	..	..
Czech Republic	..	26,395	..	5	..	2	..	3	..	2	..	88
Denmark	11,807	47,829	33	23	5	3	3	3	2	1	55	65
Dominican Republic	962	4,981	73	11	0	0	0	0	3	0	24	8
Ecuador	2,520	4,203	33	63	1	5	63	21	0	0	3	10
Egypt, Arab Rep.	3,854	4,403	7	12	16	6	64	30	2	6	11	44
El Salvador	1,075	2,451	47	47	12	1	3	4	3	2	35	47
Eritrea	..	..	..	..	..	..	..	..	..	..	..	..
Estonia	..	2,690	..	*16*	..	*9*	..	*6*	..	*3*	..	*66*
Ethiopia	419	568	74	..	18	..	7	..	0	..	0	..
Finland	14,070	43,394	3	2	19	6	4	2	4	3	70	86
France	109,691	301,702	16	13	2	1	4	2	4	2	73	80
Gabon	*2,084*	..	..	..	..	..	88	..	12	..	..	..
Gambia, The	48	..	98	..	0	..	..	..	*3*	..	*7*	..
Georgia	..	300	..	..	..	..	..	..	..	..	..	..
Germany[c]	191,162	539,993	5	5	1	1	4	1	3	2	85	86
Ghana	1,104	1,813	78	..	4	..	0	..	17	..	1	..
Greece	4,175	..	26	..	2	..	16	..	9	..	47	..
Guatemala	1,520	2,847	53	61	16	4	1	2	5	1	24	33
Guinea	..	693	..	..	..	..	..	..	..	..	..	..
Guinea-Bissau	..	..	..	..	..	..	..	..	..	..	..	..
Haiti	216	299	31	*15*	1	*0*	0	*0*	4	*0*	63	*84*
Honduras	860	2,017	75	79	5	2	0	0	6	2	12	17
† Data for Taiwan, China	19,696	110,178	9	*3*	2	*1*	1	*1*	0	*1*	88	*93*

Structure of merchandise exports 4.5

	Merchandise exports		Food		Agricultural raw materials		Fuels		Ores and metals		Manufactures	
	$ millions		% of total		% of total		% of total		% of total		% of total	
	1980	1998	1980	1998	1980	1998	1980	1998	1980	1998	1980	1998
Hungary	..	20,747	..	11	..	1	..	2	..	2	..	82
India	8,303	34,076	28	*18*	5	*2*	0	*1*	7	*3*	59	*74*
Indonesia	..	50,371	..	11	..	5	..	19	..	4	..	45
Iran, Islamic Rep.	12,338	12,982	1	..	1	..	93	..	0	..	5	..
Iraq	..	..	..	..	..	..	..	..	..	..	..	..
Ireland	8,229	65,032	37	10	2	1	1	0	3	0	54	84
Israel	5,946	22,972	12	4	4	2	0	1	2	1	82	92
Italy	78,106	242,572	7	6	1	1	6	1	2	1	84	89
Jamaica	963	1,613	14	*24*	0	*0*	2	*0*	21	*6*	63	*70*
Japan	126,740	374,044	1	1	1	1	0	0	2	1	95	94
Jordan	575	1,802	25	..	1	..	0	..	40	..	34	..
Kazakhstan	..	5,839	..	8	..	2	..	39	..	26	..	23
Kenya	1,431	2,013	44	59	8	7	33	9	2	3	12	24
Korea, Dem. Rep.	..	..	..	..	..	..	..	..	..	..	..	..
Korea, Rep.	17,245	132,122	7	2	1	1	0	4	1	2	90	91
Kuwait	20,633	9,614	1	*0*	0	*0*	89	*85*	0	*0*	10	*14*
Kyrgyz Republic	..	535	..	*28*	..	*11*	..	*15*	..	*6*	..	*38*
Lao PDR	..	*342*	..	..	..	..	..	..	..	..	..	..
Latvia	..	2,011	..	10	..	27	..	2	..	3	..	58
Lebanon	..	..	..	..	..	..	..	..	..	..	..	..
Lesotho	58	193	..	..	..	..	..	..	..	..	..	..
Libya	21,919	..	0	..	0	..	100	..	0	..	0	..
Lithuania	..	3,962	..	14	..	4	..	19	..	2	..	61
Macedonia, FYR	..	..	..	..	..	..	..	..	..	..	..	..
Madagascar	436	538	80	*54*	4	*6*	6	*3*	4	*7*	6	*28*
Malawi	281	..	91	..	2	..	0	..	0	..	6	..
Malaysia	12,963	71,974	15	10	31	3	25	6	10	1	19	79
Mali	205	..	30	..	69	..	*0*	..	0	..	1	..
Mauritania	196	359	16	..	1	..	0	..	83	..	0	..
Mauritius	434	1,738	72	26	0	0	0	0	0	0	27	73
Mexico	18,031	117,459	12	6	2	1	67	6	6	2	12	85
Moldova	..	644	..	72	..	1	..	0	..	1	..	25
Mongolia	..	462	..	*2*	..	*28*	..	*0*	..	*60*	..	*10*
Morocco	2,450	7,144	28	*31*	3	*3*	5	*2*	41	*15*	24	*49*
Mozambique	281	248	68	*69*	7	*9*	2	*1*	5	*4*	18	*17*
Myanmar	429	1,171	40	..	33	..	9	..	10	..	7	..
Namibia	..	1,278	..	..	..	..	..	..	..	..	..	..
Nepal	102	485	21	*10*	48	*1*	..	..	0	*0*	30	*77*
Netherlands	73,230	171,271	20	17	3	3	22	6	4	2	50	70
New Zealand	5,394	12,156	48	47	26	13	1	2	4	5	20	32
Nicaragua	450	579	75	88	8	3	2	1	1	1	14	8
Niger	576	..	11	..	1	..	1	..	85	..	2	..
Nigeria	25,945	8,971	2	..	0	..	97	..	0	..	0	..
Norway	18,649	40,637	7	10	3	1	48	43	10	9	32	30
Oman	3,748	..	1	..	0	..	96	..	0	..	3	..
Pakistan	2,628	8,658	24	14	20	2	7	0	0	0	48	84
Panama	2,519	6,325	67	77	0	0	23	4	1	2	9	17
Papua New Guinea	*985*	*1,773*	*33*	..	*7*	..	*0*	..	*50*	..	*3*	..
Paraguay	400	3,824	38	*72*	50	*13*	*0*	*0*	*0*	*0*	12	*15*
Peru	3,916	5,735	16	26	4	2	21	5	43	42	17	24
Philippines	5,788	29,496	36	7	6	1	1	1	21	2	21	90
Poland	14,043	32,467	6	11	3	2	13	5	7	5	61	77
Portugal	4,668	26,016	12	7	9	3	6	1	2	1	70	87
Puerto Rico	..	..	..	..	..	..	..	..	..	..	..	..
Romania	11,024	8,302	..	5	..	4	..	5	..	5	..	81
Russian Federation	..	74,799	..	2	..	3	..	38	..	16	..	28

	Merchandise exports $ millions 1980	1998	Food % of total 1980	1998	Agricultural raw materials % of total 1980	1998	Fuels % of total 1980	1998	Ores and metals % of total 1980	1998	Manufactures % of total 1980	1998
Rwanda	134	65	82	..	7	..	0	..	10	..	0	..
Saudi Arabia	101,574	39,772	0	*1*	0	*0*	99	*90*	0	*0*	1	*9*
Senegal	470	..	43	..	3	..	19	..	20	..	15	..
Sierra Leone	227	..	24	..	1	..	0	..	34	..	40	..
Singapore[b]	19,430	110,379	8	3	10	1	25	8	2	1	47	86
Slovak Republic	..	10,720	..	4	..	2	..	3	..	4	..	84
Slovenia	..	9,096	..	4	..	2	..	1	..	4	..	90
South Africa[d]	25,698	29,234	9	12	2	4	4	8	7	10	18	54
Spain	20,547	109,814	18	15	2	1	4	2	5	2	72	78
Sri Lanka	1,062	4,735	47	..	18	..	15	..	1	..	19	..
Sudan	689	596	47	*68*	51	*28*	1	*0*	1	*0*	1	*3*
Sweden	30,662	85,179	2	3	10	5	4	1	5	3	78	82
Switzerland	41,708	93,859	3	3	1	1	0	0	5	3	90	93
Syrian Arab Republic	2,112	3,135	4	*17*	9	*7*	79	*65*	1	*1*	7	*10*
Tajikistan	..	..	..	..	..	..	..	..	..	..	..	..
Tanzania	583	589	58	*65*	18	*23*	5	*0*	5	*0*	14	*10*
Thailand	6,449	52,747	47	*19*	11	*4*	0	*2*	14	*1*	25	*71*
Togo	476	..	21	..	2	..	26	..	40	..	11	..
Trinidad and Tobago	2,728	2,258	2	11	0	0	93	45	0	0	5	44
Tunisia	2,195	5,725	7	9	1	1	52	6	4	1	36	82
Turkey	2,910	31,220	51	17	14	1	1	1	7	2	27	77
Turkmenistan	..	..	..	..	..	..	..	..	..	..	..	..
Uganda	319	..	96	..	2	..	1	..	1	..	1	..
Ukraine	..	13,699	..	..	..	..	..	..	..	..	..	..
United Arab Emirates	..	..	..	..	..	..	..	..	..	..	..	..
United Kingdom	109,620	271,845	7	6	1	1	13	4	5	2	71	85
United States	224,250	672,207	18	8	5	2	4	2	5	2	66	82
Uruguay	1,059	2,832	39	51	22	9	0	1	1	1	38	39
Uzbekistan	..	..	..	..	..	..	..	..	..	..	..	..
Venezuela, RB	19,275	17,564	0	4	0	0	94	72	4	6	2	19
Vietnam	..	..	..	..	..	..	..	..	..	..	..	..
West Bank and Gaza	..	..	..	..	..	..	..	..	..	..	..	..
Yemen, Rep.	..	1,501	..	..	..	..	..	..	..	..	..	..
Yugoslavia, FR (Serb./Mont.)	..	..	..	..	..	..	..	..	..	..	..	..
Zambia	1,457	..	1	..	0	..	0	..	82	..	16	..
Zimbabwe	1,441	..	40	..	3	..	3	..	17	..	36	..
World	**1,900,797 t**	**5,397,430 t**	**12 w**	**8 w**	**4 w**	**2 w**	**11 w**	**4 w**	**5 w**	**3 w**	**66 w**	**80 w**
Low income	89,218	344,253	..	9	..	2	..	6	..	2	..	77
Excl. China & India	80,493	126,650	20	..	14	..	50	..	5	..	11	..
Middle income	443,065	978,169	21	12	7	3	28	12	8	6	33	65
Lower middle income	175,395	339,759	..	*13*	..	*3*	..	*23*	..	*7*	..	*46*
Upper middle income	267,670	638,410	17	12	7	2	30	7	7	4	39	74
Low & middle income	532,283	1,322,422	21	11	8	2	30	10	8	5	32	68
East Asia & Pacific	69,163	533,638	18	6	12	2	16	5	7	2	45	82
Europe & Central Asia	105,745	256,604	..	7	..	3	..	19	..	9	..	57
Latin America & Carib.	97,994	289,318	32	25	4	3	31	13	12	9	20	49
Middle East & N. Africa	167,875	108,409	3	*4*	1	*1*	87	*76*	3	*2*	6	*17*
South Asia	13,606	53,681	28	*16*	10	*2*	3	*1*	5	*2*	54	*78*
Sub-Saharan Africa	77,900	80,772	22	..	6	..	27	..	9	..	12	..
High income	1,368,514	4,075,008	11	7	4	2	7	3	4	2	73	82
Europe EMU	574,503	1,715,780	11	9	3	1	6	2	3	2	75	83

Note: Components may not sum to 100 percent due to unclassified trade.

a. Includes Luxembourg. b. Includes reexports. c. Data prior to 1990 refer to the Federal Republic of Germany before unification. d. Data on export commodity shares refer to the South African Customs Union, which comprises Botswana, Lesotho, Namibia, and South Africa.

Structure of merchandise exports 4.5

About the data

Data on merchandise trade come from customs reports of goods entering an economy or from reports of the financial transactions related to merchandise trade recorded in the balance of payments. Because of differences in timing and definitions, estimates of trade flows from customs reports are likely to differ from those based on the balance of payments. Furthermore, several international agencies process trade data, each making estimates to correct for unreported or misreported data, and this leads to other differences in the available data.

The most detailed source of data on international trade in goods is the Commodity Trade (COMTRADE) database maintained by the United Nations Statistics Division. The International Monetary Fund (IMF) also collects customs-based data on exports and imports of goods. The value of exports is recorded as the cost of the goods delivered to the frontier of the exporting country for shipment—the f.o.b. (free on board) value. Many countries report trade data in U.S. dollars. When countries report in local currency, the United Nations Statistics Division applies the average official exchange rate for the period shown.

Countries may report trade according to the general or special system of trade (see *Primary data documentation*). Under the general system exports comprise outward-moving goods that are (a) goods wholly or partly produced in the country; (b) foreign goods, neither transformed nor declared for domestic consumption in the country, that move outward from customs storage; and (c) goods previously included as imports for domestic consumption but subsequently exported without transformation. Under the special system exports comprise categories a and c. In some compilations categories b and c are classified as reexports. Because of differences in reporting practices, data on exports may not be fully comparable across economies.

The data on total exports of goods (merchandise) in this table come from the World Trade Organization (WTO). The WTO uses two main sources, national statistical offices and the IMF's *International Financial Statistics*. It supplements these with the COMTRADE database and publications or databases of regional organizations, specialized agencies, and economic groups (such as the Economic Commission for Latin America and the Caribbean, Eurostat, the Food and Agriculture Organization, the Organisation for Economic Co-operation and Development, the Commonwealth of Independent States, and the Organization of Petroleum Exporting Countries). It also consults private sources, such as country reports of the Economist Intelligence Unit and press clippings. In recent years country websites and direct contacts through email have helped significantly improve the collection of up-to-date statistics for many countries, reducing the proportion of estimated figures. The WTO database now covers most of the major traders in Africa, Asia, and Latin America, which together with the high-income countries account for nearly 90 percent of total world trade. There has also been a remarkable improvement in the availability of recent, reliable, and standardized figures for countries in Europe and Central Asia.

The shares of exports by major commodity group were estimated by World Bank staff from the COMTRADE database. The values of total exports reported here have not been fully reconciled with the estimates of exports of goods and services from the national accounts (shown in table 4.9) or those from the balance of payments (table 4.17). The classification of commodity groups is based on the Standard International Trade Classification (SITC) revision 1. Most countries now report using later revisions of the SITC or the Harmonized System. Concordance tables are used to convert data reported in one system of nomenclature to another. The conversion process may introduce some errors of classification, but conversions from later to early systems are generally reliable. Shares may not sum to 100 percent because of unclassified trade.

Definitions

• **Merchandise exports** show the f.o.b. value of goods provided to the rest of the world valued in U.S. dollars. • **Food** comprises the commodities in SITC sections 0 (food and live animals), 1 (beverages and tobacco), and 4 (animal and vegetable oils and fats) and SITC division 22 (oil seeds, oil nuts, and oil kernels). • **Agricultural raw materials** comprise SITC section 2 (crude materials except fuels) excluding divisions 22, 27 (crude fertilizers and minerals excluding coal, petroleum, and precious stones), and 28 (metalliferous ores and scrap). • **Fuels** comprise SITC section 3 (mineral fuels). • **Ores and metals** comprise the commodities in SITC divisions 27, 28, and 68 (nonferrous metals). • **Manufactures** comprise the commodities in SITC sections 5 (chemicals), 6 (basic manufactures), 7 (machinery and transport equipment), and 8 (miscellaneous manufactured goods), excluding division 68.

Data sources

The WTO publishes data on world trade in its *Annual Report*. Estimates of total exports of goods are also published in the IMF's *International Financial Statistics* and *Direction of Trade Statistics* and in the United Nations Statistics Division's *Monthly Bulletin of Statistics*. The United Nations Conference on Trade and Development (UNCTAD) publishes data on the structure of exports and imports in its *Handbook of International Trade and Development Statistics*. Tariff line records of exports and imports are compiled in the United Nations' COMTRADE database.

Global financial flows

	Net private capital flows		Foreign direct investment		Portfolio investment flows				Bank and trade-related lending	
					Bonds		Equity			
	$ millions		$ millions		$ millions		$ millions		$ millions	
	1990	1998	1990	1998	1990	1998	1990	1998	1990	1998
Albania	31	42	0	45	0	0	0	0	31	–3
Algeria	–424	–1,321	0	5	–16	0	0	2	–409	–1,328
Angola	235	40	–335	360	0	0	0	0	570	–320
Argentina	–203	18,899	1,836	6,150	–857	9,037	13	50	–1,196	3,662
Armenia	0	232	0	232	0	0	0	0	0	0
Australia	..	..	7,465	6,165	..	..	..	..	..	..
Austria	..	..	653	6,034	..	..	..	..	..	..
Azerbaijan	..	1,081	..	1,023	..	0	..	0	..	58
Bangladesh	70	288	3	308	0	0	0	3	67	–23
Belarus	..	122	..	149	..	0	..	0	..	–27
Belgium	..	..	..	..	..	..	..	..	..	..
Benin	1	34	1	34	0	0	0	0	0	0
Bolivia	3	860	27	872	0	0	0	0	–24	–12
Bosnia and Herzegovina	..	..	..	..	..	..	..	..	..	..
Botswana	77	91	95	95	0	0	0	0	–19	–4
Brazil	562	54,385	989	31,913	129	1,409	0	542	–556	20,521
Bulgaria	–42	498	4	401	65	–57	0	66	–111	88
Burkina Faso	0	0	0	0	0	0	0	0	0	0
Burundi	–5	2	1	1	0	0	0	0	–6	1
Cambodia	0	118	0	121	0	0	0	0	0	–3
Cameroon	–125	1	–113	50	0	0	0	0	–12	–49
Canada	..	..	7,581	16,514	..	..	..	..	..	..
Central African Republic	0	5	1	5	0	0	0	0	–1	0
Chad	–1	16	0	16	0	0	0	0	–1	0
Chile	2,098	9,252	590	4,638	–7	702	320	87	1,194	3,825
China	8,107	42,676	3,487	43,751	–48	1,587	0	1,273	4,668	–3,936
Hong Kong, China	..	..	..	..	..	..	..	..	..	..
Colombia	345	3,629	500	3,038	–4	1,752	0	26	–151	–1,187
Congo, Dem. Rep.	–24	1	–12	1	0	0	0	0	–12	0
Congo, Rep.	–100	4	0	4	0	0	0	0	–100	0
Costa Rica	23	800	163	559	–42	184	0	0	–99	57
Côte d'Ivoire	57	181	48	435	–1	–23	0	6	10	–237
Croatia	..	1,666	..	873	..	89	..	205	..	499
Cuba	..	..	..	..	..	..	..	..	..	..
Czech Republic	876	3,331	207	2,554	0	837	0	129	669	–188
Denmark	..	..	1,132	6,373	..	..	..	..	..	..
Dominican Republic	130	771	133	691	0	–4	0	74	–3	10
Ecuador	183	584	126	831	0	–10	0	0	57	–238
Egypt, Arab Rep.	698	1,385	734	1,076	–1	0	0	494	–35	–186
El Salvador	8	242	2	12	0	0	0	0	6	230
Eritrea	..	0	..	0	..	0	..	0	..	0
Estonia	..	714	..	581	..	17	..	53	..	63
Ethiopia	–45	6	12	4	0	0	0	0	–57	2
Finland	..	..	812	12,029	..	..	..	..	..	..
France	..	..	13,183	27,998	..	..	..	..	..	..
Gabon	103	–57	74	–50	0	0	0	0	29	–7
Gambia, The	–8	13	0	13	0	0	0	0	–8	0
Georgia	..	57	..	50	..	0	..	0	..	7
Germany	..	..	2,532	18,712	..	..	..	..	..	..
Ghana	–5	42	15	56	0	0	0	15	–20	–29
Greece	..	..	1,005	..	..	..	..	..	..	..
Guatemala	44	621	48	673	–11	–31	0	0	7	–21
Guinea	–1	–9	18	1	0	0	0	0	–19	–10
Guinea-Bissau	2	1	2	1	0	0	0	0	0	0
Haiti	8	11	8	11	0	0	0	0	0	0
Honduras	77	193	44	84	0	–32	0	0	33	141

Global financial flows 6.7

	Net private capital flows $ millions		Foreign direct investment $ millions		Portfolio investment flows: Bonds $ millions		Portfolio investment flows: Equity $ millions		Bank and trade-related lending $ millions	
	1990	1998	1990	1998	1990	1998	1990	1998	1990	1998
Hungary	–308	4,683	0	1,936	921	688	150	259	–1,379	1,800
India	1,872	6,151	162	2,635	147	4,120	105	342	1,458	–946
Indonesia	3,235	–3,759	1,093	–356	26	–141	312	250	1,804	–3,512
Iran, Islamic Rep.	–392	588	–362	24	0	0	0	0	–30	564
Iraq	..	..	..	..	..	..	..	..	..	..
Ireland	..	..	627	2,920	..	..	..	..	..	..
Israel	..	..	129	1,850	..	..	..	..	..	..
Italy	..	..	6,411	2,635	..	..	..	..	..	..
Jamaica	92	586	138	369	0	250	0	0	–46	–33
Japan	..	..	1,777	3,268	..	..	..	..	..	..
Jordan	254	207	38	310	0	–10	0	11	216	–104
Kazakhstan	..	1,983	..	1,158	..	100	..	0	..	725
Kenya	122	–57	57	11	0	0	0	4	65	–72
Korea, Dem. Rep.	..	..	..	..	..	..	..	..	..	..
Korea, Rep.	1,056	7,644	788	5,415	168	1,220	518	4,096	–418	–3,087
Kuwait	..	..	..	59	..	..	..	..	..	..
Kyrgyz Republic	..	108	..	109	..	0	..	0	..	–2
Lao PDR	6	46	6	46	0	0	0	0	0	0
Latvia	..	366	..	357	..	0	..	4	..	5
Lebanon	12	1,740	6	200	0	1,350	0	147	6	43
Lesotho	17	281	17	265	0	0	0	0	0	16
Libya	..	..	..	..	..	..	..	..	..	..
Lithuania	..	982	..	926	..	0	..	0	..	57
Macedonia, FYR	..	190	..	118	..	0	..	0	..	72
Madagascar	7	15	22	16	0	0	0	0	–15	–1
Malawi	2	24	0	1	0	0	0	24	2	–1
Malaysia	769	8,295	2,333	5,000	–1,239	–314	293	592	–617	3,017
Mali	–8	17	–7	17	0	0	0	0	–1	0
Mauritania	6	3	7	5	0	0	0	0	–1	–2
Mauritius	86	–79	41	12	0	0	0	8	45	–99
Mexico	8,253	23,188	2,634	10,238	661	2,428	563	730	4,396	9,792
Moldova	..	62	..	85	..	0	..	0	..	–23
Mongolia	..	7	..	19	..	0	..	0	..	–12
Morocco	341	965	165	322	0	0	0	174	176	470
Mozambique	35	209	9	213	0	0	0	0	26	–4
Myanmar	153	153	161	70	0	0	0	0	–8	83
Namibia	..	..	..	..	..	..	..	..	..	..
Nepal	–8	–1	6	12	0	0	0	0	–14	–13
Netherlands	..	..	12,352	33,346	..	..	..	..	..	..
New Zealand	..	..	1,735	..	..	..	..	..	..	..
Nicaragua	21	171	0	184	0	0	0	0	21	–13
Niger	9	–23	–1	1	0	0	0	0	10	–24
Nigeria	467	1,028	588	1,051	0	0	0	2	–121	–25
Norway	..	..	1,003	3,597	..	..	..	..	..	..
Oman	–259	–214	141	106	0	0	0	10	–400	–330
Pakistan	182	806	244	500	0	0	0	0	–63	306
Panama	127	1,459	132	1,206	–2	218	0	0	–4	34
Papua New Guinea	204	230	155	110	0	0	0	0	49	120
Paraguay	67	236	76	256	0	0	0	0	–9	–20
Peru	59	2,724	41	1,930	0	0	0	174	18	620
Philippines	639	2,587	530	1,713	395	151	0	454	–286	269
Poland	71	9,653	89	6,365	0	1,202	0	969	–18	1,117
Portugal	..	..	2,610	1,783	..	..	..	..	..	..
Puerto Rico	..	..	..	..	..	..	..	..	..	..
Romania	4	1,826	0	2,031	0	0	0	42	4	–247
Russian Federation	5,562	19,346	0	2,764	310	11,538	0	296	5,252	4,748

	Net private capital flows $ millions		Foreign direct investment $ millions		Portfolio investment flows Bonds $ millions		Portfolio investment flows Equity $ millions		Bank and trade-related lending $ millions	
	1990	1998	1990	1998	1990	1998	1990	1998	1990	1998
Rwanda	6	7	8	7	0	0	0	0	–2	0
Saudi Arabia	..	..	..	..	..	..	..	..	..	..
Senegal	42	24	57	40	0	0	0	0	–15	–16
Sierra Leone	36	5	32	5	0	0	0	0	4	0
Singapore	..	..	5,575	7,218	..	..	..	..	..	..
Slovak Republic	278	1,480	0	562	0	–570	0	0	278	1,488
Slovenia	..	..	..	165	..	..	..	..	..	..
South Africa	..	783	..	550	..	303	..	619	..	–689
Spain	..	..	13,984	11,392	..	..	..	..	..	..
Sri Lanka	54	325	43	193	0	65	0	6	11	61
Sudan	0	371	0	371	0	0	0	0	0	0
Sweden	..	..	1,982	19,413	..	..	..	..	..	..
Switzerland	..	..	4,961	5,488	..	..	..	..	..	..
Syrian Arab Republic	18	76	71	80	0	0	0	0	–53	–4
Tajikistan	..	–3	..	18	..	0	..	0	..	–21
Tanzania	4	157	0	172	0	0	0	0	4	–16
Thailand	4,399	7,825	2,444	6,941	–87	–632	449	2,341	1,593	–826
Togo	0	0	0	0	0	0	0	0	0	0
Trinidad and Tobago	–69	761	109	730	–52	0	0	0	–126	31
Tunisia	–122	694	76	650	–60	0	0	40	–138	4
Turkey	1,782	1,641	684	940	597	–535	35	880	466	357
Turkmenistan	..	473	..	130	..	0	..	0	..	343
Uganda	16	198	0	200	0	0	0	0	16	–2
Ukraine	..	2,087	..	743	..	1,076	..	0	..	267
United Arab Emirates	..	..	..	..	..	..	..	..	..	..
United Kingdom	..	..	32,518	67,481	..	..	..	..	..	..
United States	..	..	48,954	193,373	..	..	..	..	..	..
Uruguay	–192	496	0	164	–16	336	0	0	–176	–5
Uzbekistan	..	592	..	200	..	0	..	0	..	392
Venezuela, RB	–126	6,866	451	4,435	345	1,408	0	64	–922	959
Vietnam	16	832	16	1,200	0	0	0	0	0	–368
West Bank and Gaza	..	..	..	..	..	..	..	..	..	..
Yemen, Rep.	30	–210	–131	–210	0	0	0	0	161	0
Yugoslavia, FR (Serb./Mont.)	..	0	..	0	..	0	..	0	..	0
Zambia	194	40	203	72	0	0	0	0	–9	–32
Zimbabwe	85	–217	–12	76	–30	–30	0	3	127	–266
World	.. s	.. s	198,382 s	619,258 s	.. s	.. s	.. s	.. s	.. s	.. s
Low income	14,831	52,365	5,732	53,517	95	5,482	417	1,921	8,588	–8,556
Excl. China & India	..	..	..	..	..	..	..	..	..	..
Middle income	27,775	215,336	18,398	117,425	1,083	34,175	2,340	13,646	5,953	50,090
Lower middle income	..	..	..	..	..	..	..	..	..	..
Upper middle income	..	..	..	..	..	..	..	..	..	..
Low & middle income	42,606	267,700	24,130	170,942	1,178	39,658	2,757	15,567	14,541	41,534
East Asia & Pacific	18,720	67,249	11,135	64,162	–784	1,870	1,571	9,007	6,798	–7,790
Europe & Central Asia	7,649	53,342	1,051	24,350	1,893	14,385	185	2,904	4,520	11,704
Latin America & Carib.	12,411	126,854	8,188	69,323	101	17,627	896	1,748	3,226	38,156
Middle East & N. Africa	369	9,223	2,458	5,054	–148	1,340	0	878	–1,941	1,950
South Asia	2,174	7,580	464	3,659	147	4,185	105	351	1,458	–615
Sub-Saharan Africa	1,283	3,452	834	4,394	–31	250	0	679	480	–1,872
High income	..	..	169,252	448,316	..	..	..	..	..	..
Europe EMU	..	..	53,165	116,849	..	..	..	..	..	..

About the data

The data on foreign direct investment are based on balance of payments data reported by the International Monetary Fund (IMF), supplemented by data on net foreign direct investment reported by the Organisation for Economic Co-operation and Development (OECD) and official national sources. The internationally accepted definition of foreign direct investment is that provided in the fifth edition of the IMF's *Balance of Payments Manual* (1993).

Under this definition foreign direct investment has three components: equity investment, reinvested earnings, and short- and long-term intercompany loans between parent firms and foreign affiliates. However, many countries fail to report reinvested earnings, and the definition of long-term loans differs among countries. Foreign direct investment, as distinguished from other kinds of international investment, is made to establish a lasting interest in or effective management control over an enterprise in another country. As a guideline, the IMF suggests that investments should account for at least 10 percent of voting stock to be counted as foreign direct investment. In practice many countries set a higher threshold.

The OECD has also published a definition, in consultation with the IMF, Eurostat, and the United Nations. Because of the multiplicity of sources and differences in definitions and reporting methods, there may be more than one estimate of foreign direct investment for a country and data may not be comparable across countries.

Foreign direct investment data do not give a complete picture of international investment in an economy. Balance of payments data on foreign direct investment do not include capital raised locally, which has become an important source of financing for investment projects in some developing countries. In addition, foreign direct investment data capture only cross-border investment flows involving equity participation and thus omit nonequity cross-border transactions such as intrafirm flows of goods and services. For a detailed discussion of the data issues see the World Bank's *World Debt Tables 1993–94* (volume 1, chapter 3).

Portfolio flow data are compiled from several official and market sources, including Euromoney databases and publications, Micropal, Lipper Analytical Services, published reports of private investment houses, central banks, national securities and exchange commissions, national stock exchanges, and the World Bank's Debtor Reporting System.

Gross statistics on international bond and equity issues are produced by aggregating individual transactions reported by market sources. Transactions of public and publicly guaranteed bonds are reported through the Debtor Reporting System by World Bank member economies that have received either International Bank for Reconstruction and Development loans or International Development Association credits. Information on private nonguaranteed bonds is collected from market sources, because official national sources reporting to the Debtor Reporting System are not asked to report the breakdown between private nonguaranteed bonds and private nonguaranteed loans. Information on transactions by nonresidents in local equity markets is gathered from national authorities, investment positions of mutual funds, and market sources.

The volume of portfolio investment reported by the World Bank generally differs from that reported by other sources because of differences in the classification of economies, in the sources, and in the method used to adjust and disaggregate reported information. Differences in reporting arise particularly for foreign investments in local equity markets because clarity, adequate disaggregation, and comprehensive and periodic reporting are lacking in many developing economies. By contrast, capital flows through international debt and equity instruments are well recorded, and for these the differences in reporting lie primarily in the classification of economies, the exchange rates used, whether particular tranches of the transactions are included, and the treatment of certain offshore issuances.

Definitions

• **Net private capital flows** consist of private debt and nondebt flows. Private debt flows include commercial bank lending, bonds, and other private credits; nondebt private flows are foreign direct investment and portfolio equity investment. • **Foreign direct investment** is net inflows of investment to acquire a lasting management interest (10 percent or more of voting stock) in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital, as shown in the balance of payments. • **Portfolio investment flows** are net and include non-debt-creating portfolio equity flows (the sum of country funds, depository receipts, and direct purchases of shares by foreign investors) and portfolio debt flows (bond issues purchased by foreign investors). • **Bank and trade-related lending** covers commercial bank lending and other private credits.

Data sources

The data in this table are compiled from a variety of public and private sources, including the World Bank's Debtor Reporting System, the IMF's International Financial Statistics and Balance of Payments databases, and other sources mentioned in *About the data*. These data are also published in the World Bank's *Global Development Finance 2000*.

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