PRODUCTIVITY BIAS HYPOTHESIS IN PURCHASING POWER PARITY:

A SWISS - SOUTH AFRICAN CASE

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BY

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ABSTRACT

Professors Bela Balassa and Paul Samuelson (1964) have made a significant contribution to the theories of exchange rate by bringing a new thinking to the most popular exchange rate model, Purchasing Power Parity (PPP). They have elucidated the contribution of productivity in the determination of PPP. Accordingly, the emphasis of this thesis is Balassa and Samuelson's Productivity Bias Hypothesis (PBH) in Purchasing Power Parity (PPP) and the application thereof to South Africa and Switzerland for the period 1994Q1 -2003Q4.

The productivity bias hypothesis that explains real exchange rate movements in terms of sectoral productivities rests on two components: firstly, it implies that the relative price of non-traded goods in each country should reflect the relative productivity of labour in the traded and non-traded goods sectors. Secondly, it assumes that purchasing power parity holds for traded goods. The deviation of PPP from the equilibrium exchange rate or the real exchange rate is directly related to the ratio of productivity in a counter country over that of the base country. With inter-country productivity differences believed to be smaller in the service sector than in the sectors producing goods and with the prices of traded goods equalised through arbitrage, the relative prices of non-traded goods (services) would be directly correlated with productivity levels in individual countries. The thesis employs stationarity and cointegration tests in order to determine the presence of long-term, equilibrium, relationship between PPP and productivity variables of the above-mentioned two countries.

The overall finding of this thesis is supportive of the productivity bias hypothesis in purchasing power parity concerning the two countries, South Africa and Switzerland. Accordingly, it has been found out that the deviation from equilibrium exchange rate can be explained by differences in productivity. Though currently being challenged by the service sector, South Africa's manufacturing sector is assuming an important place in the economy. Given the need for improved competitiveness in the manufacturing sector, it is imperative that policy analysis and formulation render increased emphasis on efficiency and cost-effectiveness. Such an integrated approach may aid not only in raising productivity but also in managing the intertwined socio-economic challenges of unemployment, poverty and inequality.

CHAPTER 1
INTRODUCTION

Pioneered by Gustav Cassel in the 1920's as a theory of exchange rate determination, PPP (Officer, 1982:247-8) posits that the rate of exchange between two currencies is determined by the differences in the price levels of their respective countries. Put differently, when similar goods are produced in different countries and traded internationally, arbitrage tends to equalize the price of these goods. However, most economists are divided along the lines of monetary and real factors as to the causes of divergences from PPP.

Some economists consider changes on the real side of the economy as driving the real exchange rate. According to Lippert and Breuer (1994), economists who fall into this category include Balassa (1964), Samuelson (1964), Hooper and Morton (1982), Jones and Puvis (1983), Davuytan and Pippenger (1985), Edison (1985), Daniel (1986), and Stockman (1987). Another group of economists, whose belief is based on asset theory foundation, attributes departures from PPP to monetary shocks in the presence of nominal rigidities. Lippert and Breuer (1994) cite Fleming (1962), Mundel (1964) and Dornbusch (1976) as those economists that fall into this category.

Various studies have attempted to verify whether exchange rates follow the path outlined by the PPP equation. Nevertheless, the empirical results, at best, are inconclusive or mixed. Reasons associated with monetary and real variables have been given in the literature for the departure of PPP-based exchange rates from equilibrium exchange rates. Among the real variables, the productivity differential between two countries has received most of the attention in the literature (Bahmani-Oskooee and Niroomand, 1996).

The previous reasoning of PPP, thus, might fail when one applies it to a real economy that produces not only traded goods but non-traded goods as well, the latter not being subject to the possibility of arbitrage. Against the background of these non-traded goods, the Productivity Bias Hypothesis (PBH) or the Balassa–Samuelson (BS) thesis argues that a price index that embraces both traded and non-traded goods can impart bias into the purchasing power calculations, and this is particularly marked when there are significant productivity differences between countries (Balassa, 1964, and Samuelson, 1974 cited in Buckely, 2000).

Thus, taking this hypothesis into account, the proposed model of the Balassa-Samuelson (BS) thesis drops the PPP assumption for broad price indices, and allows the real exchange rate to depend on the relative price of non-tradeables, itself a function of productivity differentials. Likewise, it appears likely that findings that are more useful can be achieved if, instead of attempting to rely on aggregate indexes, more attention is paid to the behaviour of sectoral indexes with appropriate disaggregation. The introduction of non-traded goods can enhance the realism of these [international trade] models and may offer new theoretical insights (Balassa, 1964). In perspective, the hypothesis argues that rapid economic growth is accompanied by real exchange rate appreciation because of differential productivity growth between tradable and non-tradable sectors (Drine and Rault, 2003). This is particularly vivid in view of the prevalence of sharp differences in productivity between countries.

The aim of the proposed thesis is, therefore, to test empirically the validity of Productivity Bias Hypothesis (PBH) for the South African Rand (ZAR), against the Swiss Franc (CHF) in view of a possible deviation or departure from the theorem of Purchasing Power Parity (PPP). It endeavours to examine the contribution of productivity towards the determination of PPP. In parallel, it assesses the establishment of long term, equilibrium, relationships between these variables, i.e. prices and nominal exchange rates. It investigates whether and, if so, to what extent of the systematic divergence between PPP and the equilibrium rate is attributable to the existence of productivity differences between South Africa and Switzerland. The prospective finding of the thesis is expected to reflect the nature of the exchange rate relationship between a highly developed economy of Switzerland and an emerging economy of South Africa, where both economies at least moderately have relied on tertiary and primary products respectively.

The reason behind studying the case of South Africa and Switzerland rests on the magnitude of their economic links i.e. trade and investment. As indicated in chapter four, South Africa is the most important trading partner of Switzerland on the African continent. During the period covered by this study, the trade between the two countries has grown fast. The Swiss Embassy (2005:1) indicates that South African exports to Switzerland have tripled since 1994 and that Swiss exports to South Africa are more stable, but still account for more than CHF 500 Million per year. Since 2001, South Africa enjoys a surplus in the trade balance with Switzerland. This fact is mainly due to a 50% increase of South African exports to Switzerland since 1999. As indicated in chapter 4, the trade balance in 2004 was R

4,174,874,000 in favour of South Africa. There has been an increasing trend of trade between the two countries during the period under study.

Regarding the field of investment, Switzerland is an important investment partner of South Africa. "Switzerland is the fifth largest foreign direct investor in South Africa with a stock of CHF 1.25 Billion…The more than 250 Swiss companies active in South Africa represent more than 80% of the value of the Swiss stock exchange" (ibid:3). Many of these companies not only sell their products but also use South Africa as a platform to produce and export to markets in the region and beyond. South Africa is an important hub for Swiss companies for expanding their activities in the whole Southern African region.

Likewise, the importance of the bilateral links is more vivid in view of the new trade and investment opportunities offered by Trade and Investment Network of Switzerland – Southern Africa, TINSSA. TINSSA is a network of Swiss and Southern African partner institutions in the economic and trade field that include the Botswana Export Development and Investment Authority (BEDIA), Business Unity South Africa (BUSA), the Durban Chamber of Commerce and Industry (DCCI), the Industrial Development Corporation (IDC), the Johannesburg Chamber of Commerce and Industry (NAFCOC-JCCI), The Swiss Business Council (SBC), Swisscham Southern Africa and the Trade and Investment Promotion Agency for the Western Cape (WESGRO).

The ever-rising trade and capital inflow between South Africa and Switzerland makes the economies of both countries more intertwined. Such an economic interaction appears to impinge on inflation, unemployment and economic growth considerably. As the magnitude of these economic links grows, it tends to have a greater impact on the exchange rate. This situation is particularly likely in view of a small open economy such as South Africa. Thus, the significance of the exchange rate and its movements and the factor behind them calls for, inter alia, an econometric investigation within the framework of productivity.

The choice of the sample period, 1994Q1-2003Q4 has also been duly made in order to indicate the performance of the exchange rate in the ten years into the new dispensation in South Africa. Given a well-established representation of the Swiss economy in South Africa characterised by substantial and broad-based Swiss investment, it is useful and practical to look into the impact of competitiveness, inflation and labour productivity on the exchange

rate of their currencies. Overall, this empirical study can serve as a basis for designing a more effective industrial, trade and monetary policies.

Furthermore, it can provide an insight into developing a fuller picture of PPP relationship either as a short cut or as a substitute for a complete econometric model of exchange rate determination. In so doing, the research will look into PPP and its extended version, one that takes into account real variables, whether it has policy usefulness in furnishing a guide to the general trend of exchange rates. It is against this background that the policy relevance of the postulates of the PPP and Productivity Bias Hypothesis can be analysed.

In its approach of examining the real shock in the form of productivity growth in South Africa and Switzerland, this research plans to make use of the single-measure productivity measure, labour productivity, of both countries as an explanatory variable. Labour productivity is taken, rather than capital productivity, in view of the former's nature of relatively immobile factor of production. To put it in a bivariate model,

$[PPP/ER] = \alpha + \beta \, Prod + \epsilon$ where

- $[PPP/ER_{ZACH}]$ = the purchasing power ratio (PPP) for South Africa relative to a base country, Switzerland, P_{ZA} / P_{CH} , divided by $ER_{ZACH,}$ the number of units of South African currency (ZAR) per unit of a Swiss currency (CHF);
- P_{ZA} / P_{CH} = ratio of the average market price of goods in South Africa to the average market price of goods in Switzerland; and
- Prod is the ratio of labour productivity for South Africa relative to labour productivity for Switzerland, in which the variable, labour productivity is taken as a measure of the level of productivity within a country.

Accordingly, the research will employ time series techniques of cointegration for the sample period 1994Q1- 2003Q4 in 40 observations in order to observe the inter-temporal dynamics. To be specific, the research will carry out graphical analysis, sample correlogram test for autocorrelation, as well as Dickey Fuller (DF) and Augmented Dickey Fuller tests (ADF) in order to test the (non) stationarity of the above-mentioned macroeconomic variables. As informal methods of identifying the (non) stationarity, the graphical analysis will depict the level and differenced forms; whereas, the sample correlogram test will illustrate the lag-length that extends to a roughly one-third of the length of time series. In unit root testing, the

pure random, drift and trend scenarios will be applied using the DF test. Likewise, the drift, trend and lagged differences scenario will be dealt with using the ADF test.

In order to estimate the cointegrating regression and test for cointegration between the PPP and labour productivity, the above model ($[PPP/ER_{ZACH}] = \alpha + \beta \text{ Prod} + \epsilon$), will initially be estimated by Ordinary Least Squares (OLS). Following this, a test for stationarity of the residuals in this regression will be made in order to test for the existence of a cointegrating relationship. Besides, a unit root test in the residuals will be done by means of the Cointegrating Regression Durbin-Watson (CRDW) test, based on the Durbin-Watson statistic. In so doing, it will undertake tests of (non) cointegration to assess whether purchasing power parity and labour productivity differentials in both countries have a long-term, equilibrium, relationship for the period covered in the time series analysis using the Engle –Granger (EG) or Augmented Engle-Granger (AEG) test.

To summarise the thesis organisation, following on from this introductory chapter, chapter two discusses the theoretical and conceptual framework of various exchange rate models and their empiricism. This leads the discussion to chapter three in which a detailed exposition of the Productivity Bias Hypothesis (PBH) in purchasing power parity (PPP) is presented. PBH's economic underpinnings, arguments and counter-arguments accompanied with corresponding empirical evidence as well as PBH's linkage with the real exchange rate are dealt with. Chapter 4 explores the economic profiles of both countries, i.e. South Africa and Switzerland and it focuses on major macroeconomic variables and labour productivity of each country.

Chapter 5 covers empirical methodology in which data description, model specification and estimation and inference procedures to be employed in chapter six. In light of the relevant literature cited, chapter six employs econometric techniques in order to examine the presence of long-term or equilibrium relationship between the PPP and the productivity variable. Finally, chapter seven, based on the findings in the preceding chapter, draws conclusions and outlines recommendation deemed relevant in policy analysis and formulation on the area of productivity and exchange rate in South Africa. It also sketches possible extension and limitation of the study.

CHAPTER 2
THEORETICAL FRAMEWORK: EXCHANGE RATE MODELS AND EMPRICISM

2.1 Introduction

The determination and predictability of exchange rates has received greater research attention in recent years by economists, corporate leaders, governments and international financial institutions. This research attention is the result of greater economic globalisation characterised by greater mobility of goods, capital and, to a certain extent, labour. Globalisation requires elaborate models that can explain the exchange rate behaviour more fully.

To this effect, various models or approaches of differential importance have found their way into the international economics' literature. Virtually all theories or models rely on two basic concepts, namely purchasing power parity (PPP) and interest rate parity (IRP). The theoretical framework in this chapter will, therefore, visit the PPP, IRP, balance of payments (using mainly the Mundell-Fleming model), Dornbusch (Sticky Prices), Rational Expectations (RE) and 'News' models or approaches.

This chapter will provide an insight into the conceptual background of the above models. It also attempts to cite the assumptions under which these models are likely to apply. In addition, it discusses some of the commonalities as well as the distinctions of these models. In so doing, it looks into the strengths and weaknesses of these models. In parallel, it reviews the empirical evidence that either supports or weakens the validity of the theoretical justification of the above models, without setting aside the mixed evidence. Likewise, it examines the models' significance on their theoretical validity. Concurrently, it brings to the fore the wide array of variables involved and the methodology employed.

The latest models have enjoyed the privilege of making fuller and better use of the economic underpinnings applied by their predecessors. These models are built on the merits of the older models while simultaneously learning from their demerits. In so doing, they endeavour to explain and predict exchange rate movements. The above mentioned theories, with the exception of the 'News' model, represent macroeconomic forecasting models and can be a useful source of guidance to national authorities in the process of economic policy formulation in general, and that of exchange rate policy in particular. Recognising the PPP as

the oldest theory of exchange rate, this chapter emphasises its contribution to exchange rate movements and prediction about the future.

2.2 The Purchasing Power Parity and the Interest Rate Parity Models

2.2.1 The Purchasing Power Parity Model

As to the conceptual framework, purchasing power parity is the oldest but probably the most influential theory of exchange rate determination. "PPP states that the price of the same good in different countries with their own currencies should be the same when the domestic price of the good is converted to a common currency" (Patterson, 2000:590). Thus, the exchange rate between countries should equal the ratio of the two countries' price level of a fixed basket of goods and services. The above definition denotes that when a country's domestic price level is increasing (that country is experiencing inflation); the exchange rate of that country must depreciate in order for PPP to hold.

Gustav Cassel, a Swedish economist who coined the term purchasing power parity (1918 cited in Isard, 1995:58) maintains that there are two versions of PPP: absolute PPP and relative PPP. Absolute PPP refers to the equalisation of price levels across countries; whereas, relative PPP refers to rates of change of price levels, or more specifically, inflation rates. Probably the simplest way to compute PPP between two countries is to compare the price of a commodity believed to be standardized (homogenous) or identical in both countries. Thus, according to the highly restrictive notion of (absolute) PPP, the exchange rate between currencies should be determined by the price levels of comparable bundles of goods in two different countries:

$S = P/P^*$,

-where S is the exchange rate defined as units of domestic currency per unit of foreign currency (direct quotation method), P is the price of a bundle of goods expressed in domestic currency, and P* is the price of an identical bundle of goods in the foreign country, expressed in terms of the foreign currency. In relative PPP, the percentage change in the exchange rate reflects the inflation rate differential between the two countries:

$\%\Delta S = \%\Delta P - \%\Delta P^*$

Relative PPP can also be expressed, by taking logarithms of $S=kP/P^*$, in the following way:

$s = \alpha + p - p^*$,

- where k is a constant parameter; s, p and p* are the logarithms of S, P and P* and $\alpha = 0$ under absolute PPP.

According to Isard (1995: 59), the PPP hypothesis is often restated in terms of the real exchange rate (Q). It denotes the nominal exchange rate corrected for price differentials and is formulated as $Q = S\ P^*/P$. Its formulation points to the proposition that countries with higher inflation have depreciating currencies. Conversely, countries with lower inflation have appreciating currencies. By implication, the relative PPP theory can be employed as a tool to predict long-run changes in nominal exchange rates. Thus, looking at the relative PPP theory of exchange rates, one can see that differences in inflation are offset by changes in the nominal exchange rate and, as a result, the real exchange rate stays constant.

Despite the prudence of PPP, various objectives have been raised that call into question the model's validity. The actual real exchange rate can depart from the theoretical real exchange rate because of various arguments put forward by economists. This divergence of the actual real exchange rate from the theoretical level of PPP divides economists into two groups: those that propose monetary reasons for divergence and those that advance real factors as the cause. According to Lippert and Breuer (1994), economists who favour the real factors include Balassa (1964), Samuelson (1964), Hooper and Morton (1982), Jones and Purvis (1983), Davuytan and Pippenger (1985), Edison (1985), Daniel (1986), and Stockman (1987). Another group of economists, whose beliefs are based on an asset theory foundation, attribute departures from PPP to monetary shocks in the presence of nominal rigidities. Lippert and Breuer (ibid) cite Fleming (1962), Mundell (1964) and Dornbusch (1976) as the economists that fall into this category.

Various studies examined whether exchange rates follow the path outlined by the PPP equation. The empirical results tend to be inconclusive or mixed. No economic model is immune from flaws and PPP is no exception. Bahmani-Oskooee and Niroomand (1996:195) outline theoretical limitations causing departures from PPP as follows:

> Several reasons have been given in the literature for the failure of the PPP or deviation of the PPP-based exchange rates from equilibrium exchange rates, including lack of free trade; existence of transaction costs; existence of non-tradables; simultaneity problems; different weights used in constructing different national price indexes; money and asset prices; and real factors or real variables.

2.2.1.1 Causes of divergence from PPP

Some of the problems raised by Bahmani-Oskooee and Niroomand will now be outlined. The assumption of free trade made by PPP is one factor that limits the empirical validity of PPP. The lack of free trade, which takes the form of, *inter alia*, import quotas, tariffs and high administrative costs weakens its empirical relevance. The existence of transaction costs is another source of divergence from PPP. PPP ignores or underrates the effect of transactions, which inhibits the PPP from holding. Similarly, the existence of non-tradeables is a flaw of PPP. It is possible that some goods may not be traded because of their intrinsic nature; they are simply not transportable. However, one must not rule out the possibility that some goods are transportable and hence tradeable but not actually traded because it is unprofitable to do so, due to costs of transportation or other expenses such as tariffs mentioned earlier.

In addition, this chapter shows that various exchange rate models, except the overshooting model, are not explicit about short-run dynamics. As the PPP model is a long-run model, any attempt to test the model with short-run data is inadequate. Differential weights applied in establishing different national price indices also affect PPP in that the weights applied in one country to traded goods may not be similar to the weights applied in another country. As monetary variables, money and asset prices also affect PPP. They influence the PPP via interest rate fluctuation. A change in money and asset prices, which is expressed in interest rates, is indicated by the appreciation or depreciation of the exchange rate.

Many of these factors mentioned are reflected in the various models as a possible cause of divergence in this chapter. Among real variables, the productivity differential between two countries has received a great deal of attention in exchange rate literature. However, given the importance of the productivity differential explanation, this issue will be discussed in chapter three.

2.2.1.2 Empirical Evidence on PPP

The above-stated theoretical limitations of PPP are seen in the model's empirical application. The empirical evidence is influenced by various factors such as the specific time-period covered by the sample size, whether the country is developed or not and the econometric techniques employed. From this perspective, Buckley (2004:117) notes:

> ...Prior to the 1980s, there were many and various tests of Cassel's medium-term model. Generally, these found that purchasing power parity held as a long-term phenomenon. Indeed, dynamic exchange rate models, as developed, for example, by Dornbusch (1976) and Mussa (1982), began to rely on purchasing power parity as a long-term condition for equilibrium of foreign exchange rates. In the 1980s, much research challenged this view. The orientation of tests moved towards whether the real effective exchange rate follows a random walk. The findings of these studies are by no means unanimous.

Treuherz (1969, cited in ibid) investigates the relationship between annual inflation rates and devaluation percentages against the US dollar for five South American countries - Argentina, Brazil, Chile, Colombia and Peru – for a fourteen-year period from 1954 to 1967. Though Treuherz's results revealed that the relationship between the two variables was weak for any individual year on its own, he found an almost perfect relationship between changes in internal purchasing power and the external value of the currency when using averages beyond four years.

In a panel study, Albert and Stickney (1975, cited in ibid) tracked inflation rates, as measured by consumer price indices and exchange rates for forty-eight countries over the period 1960 to 1971. In concordance with the findings produced by Treuherz, their results are that for individual years, there may be substantial deviations from PPP but, as a long-run phenomenon, PPP holds up well. Their investigation shows deviations from PPP to be far greater for developing countries than for industrialised countries. Surprisingly enough, the authors note that the use of different measures of inflation, such as WPI (Wholesale Price Index), Gross Domestic Product (GDP) Deflators and so on, would have little effect on their findings.

However, the conventional wisdom that takes the holding of PPP in the long run for granted might not hold good anymore. Put slightly differently, there have been some challenges even to the statement that PPP holds in the long run. Using various indices to account for inflation differentials, Kravis and Lipsey (1978, cited in ibid) found that PPP held more closely for

traded goods than for non-traded items, but departures from PPP were substantial, even over long periods and even for traded goods.

In tests of the floating periods of the inter-war years and the 1970s, Krugman (1978, cited in ibid) concludes that '…There is evidence that there is more to exchange rates than PPP. This evidence is that the deviations from PPP are larger, fairly persistent and seem to be larger in countries with unstable monetary policies.' Edison (1985 cited in ibid) also reinforces this lack of support for PPP. Using monthly changes in the US dollar/Sterling exchange rate over the period from 1973 to 1979, she tested how well three models fared in terms of predicting rates. First, a monetary model was used; then the Dornbusch overshooting model was used; and finally a combined monetary/portfolio balance model was tested. Edison concluded that exchange rate behaviour over the period concerned was inconsistent with PPP.

Not all recent studies have rejected PPP, though. Using average quarterly data for the US dollar/Swiss franc exchange rate from 1973 to 1977, Driskill (1981, cited in Buckley, 2004:119) found evidence of overshooting in the face of monetary shocks. Such monetary disturbances during a particular quarter caused an overshoot by a factor of two. Defining the long run as a period of two to three years, he found some evidence to support PPP holding over this time span. Ironically, this, in a way, signifies whether there is indeed a need to set a time limit for equilibrium, and if so, how long the time span for long-term equilibrium should be.

The PPP relationship can be considered as a good example of exchange rate determination theory under which certain variables should not diverge from one another without limit. There has been some time series analysis that employed the co-integration methodology. Taylor (1988 cited in ibid) tested nominal exchange rates and relative manufacturing prices for five major countries - the United Kingdom, West Germany, France, Canada and Japan. The PPP hypothesis was tested over the floating exchange rate period since the demise of the Bretton Woods system. The results found little evidence of PPP holding. Taylor was unable to reject the hypothesis that the nominal exchange rates and prices for the different countries tended to drift apart without bound. But Taylor and McMahon (1988 cited in ibid:120), using co-integration techniques, found that, in general, long-run PPP held among the US dollar, the UK pound, the German mark and the French franc during the 1920s.

Some of the empirical evidence put a question mark over the holding of PPP, while other studies began to examine whether the random walk was behind the divergence of the real exchange rate. In parallel, the tendency for stocks to follow the pattern of a random walk sparked the carrying out of various time series analyses to examine whether exchange rates themselves, as financial assets, followed suit. In a related development, Buckley (ibid) maintains that important investigations by Roll (1979), Pigott and Sweeney (1985), Adler and Lehmann (1983) and Hakkio (1986) have not been able to reject the hypothesis that real exchange rates do follow a random walk.

By contrast, if PPP were to hold, we would experience a mean-reverting process. Put another way, a random walk real exchange would not revert to a constant mean. Therefore, a random walk real exchange rate indicates that currency appreciation or, as the case may be, currency depreciation does not offset an inflation differential in two countries. The perturbation of either the nominal exchange rate or relative prices is reflected in or carried through into the real exchange rate with a lasting effect.

In retrospect, not all random walk tests have come out against PPP. Buckley (ibid) cites the empirical results arrived at by the following authors. Work undertaken by Cumby and Obstfeld (1984) and Cumby and Huizinga (1988) on expected exchange rate changes and relative inflation rates found that real exchange rate changes were somewhat predictable. Investigating the behaviour of long-run real exchange rates, Huisinga (1987) found a tendency – albeit statistically insignificant – towards reversion to the mean. However, Abuaf and Jorion (1990 cited in ibid), studying exchange rate data for six European Union countries plus Canada, Japan, Norway and Switzerland for the period 1973 to 1987, applied more sophisticated statistical techniques than heretofore and concluded that 'empirical results… cast doubt on the hypothesis that the real exchange rate follows a random walk'. Hence, given the tendency for a real exchange rate (RER) not to revert to its mean, it follows a random walk pattern. This shows an example of a non-stationary time series, because of the fact that it holds no inclination to return to its starting or any other value.

Usually, the long-run path of the real exchange rate is assumed, for the sake of convenience, to be constant. One might plausibly justify the constant nature of RER on the premise that while real disturbances occur, they affect all nations reasonably equally, as a result of which long-run real exchange rates remain unchanged. The question remains as to what the impact

would be if the real shock affected specific countries only. To be specific, if one country enjoys the discovery of new oil or other strategic minerals, it is likely that there would be a change in long run real exchange rates.

Likewise, the concepts of long run and the nature of the disturbance term deserve further elaboration. Given the admission by Cassel, that price-exchange relationships are not instantaneous, the existing relationship is considered a long run one. However, long run equilibrium does not necessarily require a long period for the fulfilment of the relationship. Nor does this fulfilment require the employment of low-frequency observations, as opposed to high frequency ones. Maeso-Fernandez (1998:1444) clarifies:

> 'Long run' does mean that the variable or the relationship under study has an equilibrium value towards its trends, but from which it can deviate due to the presence of multifarious disturbances. Therefore, 'long run' implies the existence of an equilibrium value, but not that such value is reached necessarily. In fact, the variable may remain in permanent disequilibrium and still keep having a stable reference point. Implicitly, two key concepts are being assumed: first, the disturbances have to be of no permanent nature, i.e. they must tend to disappear once they have been produced; second, and the equilibrium value is stable. Both concepts are closely related.

Therefore, the presence of short-term divergences has stimulated a continuous quest for a better-formulated explanatory model. Having gone through the theoretical background of PPP, its limitations and the empirical evidence involved, the next section will discuss the other parity i.e. interest rate parity.

2.2.2 Interest Rate Parity (IRP) Model

The previous section on PPP involved relative prices of commodities. In this section, we will consider a more conventional asset in the open economy, namely foreign assets. Thus, we shall look at the markets for financial assets rather than for commodities and at the linkage between domestic and foreign asset prices. This approach reflects some of the afore-mentioned monetary factors that cause divergence from PPP.

The theoretical underpinning of IRP is mainly attributable to the 'Fisher effect' or Fisher's closed hypothesis, coined after the US economist Irving Fisher who considered interest rates in a country as a reflection of anticipated real returns adjusted for domestic inflation expectations. Assuming international mobility of capital, expected real returns should lead to

convergence. Hence, arbitrageurs' buying and selling assets in search of higher returns will tend to force these returns towards convergence.

The financial markets in the open economy assume that there are no barriers to international transfers of funds, an assumption that is reasonably realistic given economic globalisation, in general, and currency markets, in particular. Moreover, the financial markets assume that investors are exempt from all taxes that might otherwise influence the choice of where to deposit funds. The prevalence of risk neutrality on the part of agents or investors is another assumption. Nevertheless, this applies only to Covered Interest Rate Parity and not to Uncovered Interest Rate Parity, as we will see later. In this regard, risk neutrality implies that agents are concerned only with average returns in that they are indifferent to an investment that generates a completely secure return, on the one hand, and one that offers the prospect of an identical return on average, but with the possibility of a much higher or lower return, on the other.

Placing the Fisher effect within the perspective of exchange rate expectations, the international Fisher effect or Fisher's open hypothesis maintains that differences in interest rates should underpin the expected movement in the spot exchange rate. Thus, if PPP is to hold, the difference between the interest rates offered by domestic and foreign currency deposits should equal the difference between the inflation rates expected over the relevant time span in both countries. Therefore, a rise in a country's expected inflation rate would, *ceteris paribus*, ultimately result in an equal rise in the interest rate those deposits of its currency offer. Likewise, a fall in the expected inflation rate will result in a fall in the interest rate at the end of the day.

The interest rate parity model has two variants; namely, Covered Interest Rate Parity (CIRP) and Uncovered Interest Rate Parity (UIRP). According to Moosa (2000:393):

> CIRP is an equilibrium condition that precludes covered interest arbitrage. It is obtained when the return on a currency position is equal to the covered return on a position in another currency, or when the interest rate differential is equal to the forward spread.

Thus, it can be formulated as follows:

$\Rightarrow r = r^* + f$ where r = domestic interest rate; r* = foreign interest rate and

> f = *forward* premium (discount) i.e. the proportion by which a country's forward exchange rate exceeds (falls below) its spot rate.

In contradistinction with CIRP, UIRP is designed bearing the risks involved in expected future exchange rates in mind. According to Moosa (2000:407):

> UIRP is an equilibrium condition that precludes uncovered interest arbitrage. It is obtained when the return on a currency position is equal to the uncovered return on a position in another currency, or when the interest rate differential is equal to the expected change in the exchange rate.

Likewise, UIRP can be formulated as follows:

$\Rightarrow r = r^* + \Delta s^e$ where Δs^e = the domestic currency's expected rate of depreciation.

One can see here that the Δs^e in UIRP replaces the f in CIRP. In UIRP, rational investors would use all available information and make reasonable estimates of future spot rates of exchange. In justifying their expectation of profit (in excess of the level of risk involved), their action in buying one currency spot and selling another would influence exchange rates, which eventually leads to the elimination of excess returns from the uncovered speculation.

It is worth noting here that under UIRP, the agent speculates on the future spot rate, in which any potential earning is associated with a risky profit; whereas, under covered interest arbitrage, the agent is not speculating but making a risk-free profit based on divergences in interest rate differentials as well as forward and spot rates. The nature of the formulation in UIRP makes it virtually impossible to test in isolation, which is attributable to the limited availability and quality of data taken on exchange rate expectations. Highlighting this limitation, Isard (1995:74) argues:

> For the most part, uncovered interest parity has therefore been assessed jointly with the hypothesis that exchange rate expectations are rational and unbiased. The joint hypothesis - often called the efficient market hypothesis – implies that interest rate differentials should be unbiased predictors of changes in exchange rates, which can be tested empirically.

Hence, the crucial question arises as to whether or not interest rate differentials act as predictors of exchange rate changes. In evaluating the interest rate differential in UIP as a predictor of the change in the spot exchange rate, or by the same token, the forward rate as a predictor of the level of the spot rate, it is important that the overall size of the prediction errors be computed. In this respect, Isard (ibid: 81) observes the data (1980-94) on bilateral

exchange rates between three key currencies and three selected European currencies and concludes the following:

> … It has become widely acknowledged that interest differentials explain only a small proportion of subsequent changes in exchange rates… Not only were the predicted changes much smaller on average than the actual changes, but for three of the four exchange rates shown the 'unpredicted changes' – that is, the actual changes minus the predicted changes – exceeded the actual changes in average absolute value. Roughly speaking, for these three exchange rates, the sum of the absolute values of those predicted changes that were not even in the same direction as the changes that actually occurred outweighed the corresponding sum for predicted changes that proved correct in direction.

Given the above scenario, the lack of a significant relationship between interest differentials and changes in exchange rates stimulates a more systematic search for other relevant variables. In this regard, Isard (ibid: 82) argues:

> The widespread evidence that interest differentials tend to predict only a small component of the changes in exchange rates that actually occur (and often mispredict the direction of change) has been generally interpreted as implying that the predominant part of the observed changes in exchange rates is triggered by unexpected information – or 'news' – about economic statistics, policies, or other relevant developments.

With the assumption of smooth capital mobility not hampered by exchange restrictions, prohibitions on profit remittances or capital repatriations, government controls on capital flows and related market imperfections, some empirical studies have confirmed that the covered interest differential is not significantly different from zero. In support of the covered interest differential being zero, Roll and Solnik (1975, cited in Buckley, 2004:125) found that 'dealers in the Eurocurrency markets actually used the interest rate parity theorem to establish their prices'.

Another issue worth stressing is the empirical evidence available on the emergence of long-term forwards. More recently, Popper (1993, cited in Buckley, 2004:125) analysed long-term IRP using five-year and seven-year securities and the interest differential implied by currency swaps of matching maturities. For her sample, covered interest parity was only slightly higher (about 0.1 per cent) than deviations from the short-term covered interest parity. However, in a similar study, Fletcher and Taylor (1994 cited in ibid) examined five-, seven- and ten-year securities for deviations from long-term IRP. They reported that in every market studied, there were significant deviations from IRP. They suggested that these deviations represented profit opportunities even after allowing for transaction costs. Deviations of this sort create a

window of opportunity for firms and may partly be responsible for the rapid growth in long-term currency swaps.

In addition, there has been some empirical evidence that applied cointegration tests to explore the factor behind the time series behaviour of real exchange rates and long-term real interest rate differentials. A study carried out by Meese and Rogoff (1988, cited in Isard, 1995:171) found that little of the variance in real exchange rate changes can be accounted for by real interest rate differentials, and other econometric studies have not been able to reject this finding. These results suggest that additional intensive and extensive research in this direction may indeed be warranted.

2.3 The Balance of Payments Approach

While recognizing the linkage between the exchange rates behaviour on the one hand and national price levels and interest rates on the other, researchers have underscored the close interdependence between the former and balance of payments. Early models of exchange rates and the balance of payments treated the current account as the only endogenous component of the overall balance of payments. The exchange rate was regarded as either exogenously given or a choice parameter to be determined by the monetary authorities concerned. Isard (1995:92) elucidates:

> The earliest models relating the current account to the exchange rate followed an 'elasticities approach' in the Marshallian tradition or treating the exchange rate as a relative price that cleared a market with well-defined flow demand and supply curves. In efforts to address the deficiencies of early models, subsequent contributions to the literature sought to integrate the elasticities approach with an analysis of the national income accounts in the Keynesian tradition. These latter contributions emphasized that an exchange rate could only affect the current account balance if it induced a change in domestic absorption relative to domestic production.

This new body of analysis known as 'absorption approach' builds on merits of the elasticities approach that indicates the sensitivity of volumes of imports and exports to real exchange rates. This approach is convincing in that the devaluation of the home currency (by lowering the relative price of the home goods and thereby inducing a shift in the composition of demand) would likely lead to a rise in domestic output and a decline in foreign output. "It was also recognised that the effects on home output and income would have feedback effects on trade flows, and accordingly, that a devaluation that improved the trade balance would do so by less than the amount suggested by a simple elasticities approach in which these feedback effects were ignored" (Kenen, 1985 cited in Isard, 1995:95). However, the

absorption approach has an important drawback in that it assumes a static approach to national income analysis. It does not possess a dynamic framework that captures the inter-temporal aspects of aggregate savings and investment variables.

Similarly, it is also imperative to demonstrate the effect of a J-curve on balance of payments, particularly on current-account balance. Following a devaluation of domestic currency, a country's current account balance (measured in domestic-currency units) could be expected to worsen initially and only to improve subsequently. This effect revolves around the short run impact of currency devaluation on import and export prices. In the short run, import prices in domestic-currency terms would increase more rapidly than export prices. In contrast, trade in volume terms would respond not instantaneously, but with a time lag.

In the early 1960s, the evolution of the increasingly interconnected global economy developed in such a way that the balance of payments incorporates not only merchandise transactions but endogenous private capital flows as well. This ignorance or underrating of capital mobility and, by implication, of interest rates could be attributable, at least partly, to the then non-convertibility of most major currencies that resulted in minimal private capital flows. Isard (1995: 98) notes:

> The Mundell-Fleming framework combined a simple Keynesian model of goods and money markets for an open economy with the assumption that net international capital flows into the economy depended positively on the home rate of interest. The analysis took foreign prices and interest rates as exogenous, focusing on either the home interest rate or the home money supply as the instrument of monetary policy, and often on the budget balance as the instrument of fiscal policy.

In order to illustrate the workings of the Mundell-Fleming (M-F) model, an increase in national income with an accompanying deterioration in the current account balance can be assumed. If overall balance of payments equilibrium is to be maintained at zero as national income grows, the domestic rate of interest must necessarily also increase. This results in an initial deterioration on the current account, as the gap between imports and exports widens. The effect of a rise in national income is such that it improves capital flows to compensate for the initial deterioration on the current account. Consequently, this increase in the rate of interest depresses demand, which, in turn, has the effect of cutting down imports. The reduction of imports subsequently leads to the narrowing of the gap between imports and exports in the current account. Ultimately, the knock on effect of an increase in national income is reflected in the improvement of the current account balance. "The mechanism of

this version of the balance of payments model involves the interest rate increase as a means of avoiding a weakening in the domestic currency" (Buckley, 2004:101).

However, Isard (1995:102) notes that the Mundell-Fleming model faces critics who argue that the capital account balance should be conceptualised not as an ongoing flow, but rather as a reflection of efforts to adjust asset stocks to the levels that economic participants' desire. This new conceptualisation of the capital account crystallizes in two different categories of asset equilibrium models: the monetary approach to the balance of payments, and the portfolio-balance approach. While clarifying the monetary approach, the next section discusses how the balance of payments responds to changes in the menu of assets.

2.4 The Portfolio - Balance Model

The portfolio-balance model is an extension of the monetary approach of balance of payments. The monetary approach provides a framework in which the balance of payments could be analysed in a linkage between the balance of payments behaviour and the change in the stock of base money, a liability of a central bank formed of currency and reserve deposits. In parallel, changes in the stock of base money were, in turn, perceived as responses to excess demands or supplies in the money market. According to Johnson (1977, cited in Isard, 1995:103), this implied that as a fundamental proposition, balance-of-payments deficits and surpluses … are monetary symptoms of monetary disequilibria that will cure themselves in time without any inherent need for a government balance-of-payments policy.

On the other side of the coin, the portfolio balance model capitalizes on the proposition of the monetary model in which the exchange rates are determined by the relative supply of and demand for money at home. It further introduces two variables i.e. foreign money and foreign bonds as potential substitutes for money and bonds at home respectively. Assuming foreign and domestic bonds as such substitutes and the holding of interest arbitrage conditions, the portfolio-balance model would be no different from the monetary model. This is because exchange rates would be left to be determined by money markets alone. In differentiating the monetary approach from the portfolio balance approach, Isard (1995) notes that the former regards home-currency securities (which represent assets rather than money) as perfect substitutes for foreign-currency securities. In contrast, the latter regards them as imperfect substitutes.

Thus, the very holding of international portfolios of assets denominated in different currencies makes the demand for money a more complex function than its predecessor, the monetary model. Likewise, the portfolio balance approach indicates the presence of wealth effect, as changes in exchange rates affect the wealth (savings) of holders of assets denominated in foreign currency. In so doing, it allows the private sector saving to take the form of accumulation of foreign currency assets via the capital account of the balance of payments. In parallel, saving is to be considered as a flow of foreign currency assets via a current account surplus. By implication, assuming a floating exchange rate, the capital account deficit of a domestic economy must be the counterpart of an equal amount of surplus on the current account of the rest of the world. By the reverse token, the current account deficit of a domestic economy must be the net import of capital, i.e. dissaving in the form of a reduction in domestic economy's net foreign currency claims on the rest of the world. This reflects the central feature of the portfolio balance model, the interaction between the real sector and the financial markets, which ultimately determines the long-run equilibrium rate.

It is highly likely that uninsurable background risk can affect portfolio allocations, despite its disproportionate magnitude. This is because of the rationale that it can change people's tolerance for stock market risk. Hence, the impact of background risks from various sources on stock holdings ultimately depends on the correlation between the returns on stocks and the returns on the other assets exercising an inverse relationship. Heaton and Lucas, in effect, share a similar view with Copeland on asset risk diversification. Using the Survey of Consumer Finances (SCF), Heaton and Lucas (2000:5) suggest that potentially important sources of background risk arise from labour income (which can be thought of as the income from human capital), owner-occupied and commercial real estate, and proprietary income from privately held businesses. Besides this, they maintain that the relative shares of these assets in financial wealth vary across various age and net worth brackets.

Though the portfolio balance model has been influential in shaping the asset markets literature, it suffers from serious drawbacks: empirical and fundamental. In clarifying these limitations, Copeland (1994:257) outlines:

> The first problem that confronts researchers in this field is finding data. It is virtually impossible to find reliable data on holdings of assets denominated in the different currencies - at least at a frequency high enough to be of any use for research purposes…The second problem is more fundamental. As has already been made

> clear, the portfolio balance approach relies on an analysis of the determination of the risk premium…This analysis implies stable asset demand functions only under fairly restrictive conditions, which are probably inconsistent, even in principle, with the content to which they are being applied here.

To emphasise the fundamental problem, the approach requires that the expected returns be stationary i.e. constant over time. On the flipside, the reality in the financial world is far from this, since interest rates fluctuate quite often. Thus, it becomes difficult to reconcile this restriction with the situation unlikely to follow the path of mean reverting process. As to the empirical issue, however, one may need to await the collection of more accurate data. In an endeavour to explain the exchange rate determination better, a hybrid model was formulated in the mid-70s, as we shall see in the following section.

2.5 The Dornbusch (Sticky Prices) Model

The Dornbusch model, named after Professor Rudiger Dornbusch of the MIT in 1976, builds on identifying and justifiably rectifying the drawbacks of both the monetary and M-F models and responding to them accordingly. The monetary model had difficulty explaining the facts in exchange rate determination not only because of its reliance on the assumption of PPP but also because of its tendency to ignore the element of expectations in determining the international interest rate differentials. Nor does the M-F model take the factor of expectations into account. Besides, the M-F model assumes a fixed price level, which limits its importance to the very shortest horizons. In expounding the Dornbusch model, Copeland maintains, "in its short-run features, it fits into the established Keynesian tradition, with its emphasis on the stickiness of prices in product (and labour) markets. On the other hand, it displays the long-run characteristics of the monetary model" (1994:209).

It has been accepted as conventional wisdom that financial markets adjust far more rapidly – virtually instantaneously – to an exogenous shock. However, commodity markets adjust slowly over time. This sluggish adjustment of national price levels can help to illustrate the phenomenon of overshooting exchange rate. In response to the slowly adjusting national price levels, overshooting exchange rates pinpoints a tendency for the exchange rate to jump in one direction in response to news and subsequently to go at least part of the way back to its original position. It is upon this observation on both commodity and financial market responses that the originality of Dornbush's work depends. He introduced the sticky-price

monetary model of exchange to explain how exchange rates respond to new information or news about the money supply.

The presence of sticky nominal prices can be attributable to a couple of factors. One could be revolving around the idea of menu costs such as the actual costs of printing new price lists and catalogues. Besides, business firms may perceive a different type of menu costs because of their customers' imperfect information about competitor's prices. In an endeavour to examine the stickiness of prices, Swedish economists Marcus Asplund and Richard Frieberg studied pricing behaviour in the duty-free stores of two Scandinavian ferry lines and the airline SAS (Scandinavian Airlines system) all of whose catalogues quote the prices of each good in various currencies for the convenience of customers from different countries. Asplund and Frieberg (2001, cited in Krugman and Obstfeld, 2003:412) elaborate:

> …Swedish passengers, who held relatively large quantities of their own national currency, tended to buy at the kronor prices, whereas Finnish customers tended to buy at markka prices… One big impediment to taking advantage of the arbitrage opportunities was the cost of changing currencies at the onboard foreign exchange booth- roughly 7.5 per cent.

In emphasising the linkage between the afore-mentioned sticky prices and exchange rates, the overshooting of exchange rate analysis indicates the process of adjustment to an unanticipated change in the money supply. This situation demonstrates exchange rate behaviour under which the initial jump in the exchange rate exceeded the adjustment in the long-run equilibrium exchange rate. The issue at stake here is the likely impact in the long run and the stickiness of prices affects the domestic interest rate in the long term. The divergence of domestic interest rates from that of the rest of the world appears to be quite transient. Copeland (1994:210) further observes:

> Ultimately, as product prices begin their delayed response, the change in the real money stock starts to reverse itself, and with it, the whole process goes into reverse, driving interest rates, aggregate demand and the real exchange rate back towards their original values. The process ends with all the real variables back where they started, as in the monetary model, and the nominal exchange rate at a new long-term level, which reflects the proportionate change in the money supply.

Another important element in the Dornbusch model is that market participants are assumed to know the model and that they form their expectations in a manner consistent with the model. In so doing, the model has abstracted completely from the sources of inaccuracy in rationally formed expectation. It does so by effectively assuming that the model-consistent expected path of the exchange rate parallels to the perfect foresight. "The basic motivation of the

Dornbusch model was to develop a theory that is suggestive of the observed large fluctuations in exchange rates while at the same time establishing that such exchange rate movements are consistent with rational expectations formation" (Isard, 1995:122).

Despite its analytical merit, practicality and its superiority over the classical assumption of perfectly flexible prices, the Dornbusch model does suffer from a couple of drawbacks. Isard (ibid: 124) outlines the limitations:

> …Its ad hoc specification of the price determination process and its failure to provide an explicit role for the current account in exchange rate determination – may have contributed to its poor empirical performance, and have greatly limited its relevance in policy-oriented discussions of exchange rate dynamics. In this connection, recent models based on an inter temporal optimisation approach have made progress in overcoming the two major handicaps and may ultimately be regarded as a major conceptual advance.

In contrast to the flexible price monetary approach, where prices are continuously flexible and the exchange rate is always at a PPP-defined equilibrium, the sticky price variant of the monetary approach makes a distinction between long and short run equilibrium. While it defines long-run equilibrium as in the flexible price monetary approach, it assumes commodity prices as sticky, taking time to adjust to their equilibrium values. However, asset prices such as bond or security prices as well as exchange rates constantly change and this very asymmetry between goods and asset price adjustment brings about the renowned phenomenon of Overshooting.

2.6 The Rational Expectations (RE) Model

The models covered hitherto have enjoyed a limited success in strongly explaining the observed exchange rates behaviour, prompting the need for the formulation of better – equipped models. With the exception of the Dornbusch model, these models have not taken into account expectations of market participants. In contrast, the Rational Expectations (RE) model, applies efficient market hypothesis, to explain how agents form their expectations. One needs to make use of whatever relevant information is available in order to take a view about the future value of the exchange rate.

According to Moosa (2000), the exchange rate literature has seen three levels of efficiency; namely, weak, semi-strong and strong efficiency. In a weakly efficient market, the current exchange rate reflects all the information embodied in the past behaviour, obviously excluding other relevant variables that affect exchange rates. In semi-strong efficiency, the

information set comprises the past behaviour as well as all publicly available information. In strong efficiency markets, exchange rates reflect all the available information including private and insider information.

In a weakly efficient foreign exchange market, the future behaviour of the exchange rate cannot reliably be forecast from its past behaviour. Likewise, in a semi-strong efficiency case, there are no unexpected opportunities for profit because the economic and statistical analysis related to the variables that impinge on exchange rates are reported by the media as soon as it is released. The strong efficiency case does not help to forecast exchange rates either. In elaborating the drawbacks of strong efficiency, Moosa (2000:147) argues:

> Insider information can also be transmitted by Treasury officials who are aware of hitherto unreleased information pertaining to changes in economic policy that are bound to affect the exchange rate. Private information may arise when, for example, an analyst develops a profitable trading rule that is not revealed as public information. If the foreign exchange market is efficient in this sense, then not even insider and private information can help us forecast the future behaviour of the exchange rate or to make abnormal profit.

Against the background of efficient markets, Copeland (ibid: 319) notes:

> An economic agent is said to hold a (fully) rational expectation with respect to a variable if his subjective expectation is the same as the variable's (mathematical) expected value, conditional on an information set containing all publicly information. The Rational Expectations (RE) hypothesis states that the market's (subjective) expectations are in fact the same as the expected value, conditional on the set of all available information.

Viewed from an exchange rate perspective, the forward market efficiency holds if the forward rate ruling at any time is equal to the rational expectation of the future (spot) rate upon the maturity of the contract signed including the risk premium. The risk premium is required in order to convince speculators that the risk they bear is compensated for. Thus, when expectations are established rationally, the market will not escape the wrong forecast, but the errors will be random.

Given the failure of several models in predicting the behaviour of exchange rates, new directions for conceptual models of flexible rates are appearing in the exchange rate literature. Bringing efficient market and weakly efficient market into perspective, rational expectations models can be formed in two major ways. The first refers to the maintained hypothesis that market participants enjoy complete information and form rational

expectations. The second refers to models in which market behaviour is assumed to reflect either a substantial irrational component or a process in which rational but, as opposed to the former models, incompletely informed market participants extract relevant information from the past history of trading exchange rate.

The hypothesis that treats models with irrationality or limited information tends to challenge the (fully) rational expectations model in some respects. This is attributable to the growing awareness of the shortfalls of rational expectations and complete information model in explaining what new information about the relevant economic fundamentals could prompt the required revision in either expectations or risk premiums. This very development has incited some economists to consider building models that accommodate the features of feedback trading. Feedback trading, also known as technical analysis or Chartism, takes into account past price movements to search for potential future trends. By assuming that price patterns provide a guide to future movements, feedback trading expects that exchange rate patterns will be repeated.

In retrospect, though feedback trading lacks real economic (theoretical) underpinnings for its methodology, there has been survey evidence that shows that many market participants or agents condition their behaviour largely on the technical analysis or chart techniques. Consequently, the frequency of employing feedback trading of recent trends by the market participants in establishing their expectation of exchange rates makes it almost irresistible for economists to put it aside altogether. Cognizant of this situation, one of the surveys (Engle *et al*. 1990 cited in Isard, 1995:179) argues:

> …Consistent with this survey evidence, simulation experiments have confirmed that various types of trading strategies based on technical analysis generate statistically significant profits, and studies of the intra-day behaviour of exchange rates have found that volatility spills over from one market to the next, like meteor showers, as trading days open and close around the globe.

Besides, it sounds as if foreign investors in different categories have different trading partners owing to information asymmetry. Their heterogeneity seems to affect their decisions on positive feedback trading in which they buy past winners and sell past losers. Conversely, their heterogeneity also influences their decisions on negative trading strategy or herding in which they buy past losers and sell past winners. A case study was carried out on the trading behaviour of foreign portfolio investors of Korea Stock Exchange (KSE) in South Korea before and after the Asian financial crisis in 1997, i.e. from December 1996 to June 1998. In

the case study of their paper that was engaged in investors' feedback trading, Kim and Wei (2002:83) measured the connection between their trading on particular stocks and the prior performance of the stocks and argue:

> An important finding of the paper is that heterogeneity among foreign investors matters. …For example, the Korean branches/ subsidies of foreign institutions or foreign individual investors living in Korea are less likely to engage in positive feedback trading and less likely to engage in herding than their non-resident counterparts… If one is to consider controls on foreign capital inflows, one area that has not received much attention is policies that may encourage foreign investors to acquire more information about the emerging markets (e.g., by setting up a subsidiary or a branch in the country).

These two expectation phenomena have prompted some economists to consider building models that provide not only for economic fundamentals but also for the features of feedback. Isard (1995:180) observes:

> In these models, the first groups of traders, who behave on the basis of expectations about future fundamentals, have the predominant influence on exchange rates over the long run. But the risk aversion and subsequent uncertainties can make the fundamentalists less influential than feedback traders during period in which there are no major revisions in expectations about future fundamentals.

In this regard, the exchange rate policy can breed a degree of uncertainty, thereby influencing the impact of economic fundamentals. To cite an example, the moderate, if not dramatic depreciation of the US dollar against most major currencies in 2004 and early 2005 may have been fuelled, at least partially, by the 'benign neglect' shown over the dollar exchange rates in an attempt to reduce the twin deficits, i.e. the budget deficit and the trade deficit in the US economy. In elaborating the interface between fundamentals and feedback trading, Krugman and Miller (1993, cited in ibid) comment:

> Accordingly, in the presence of feedback traders, the reluctance of fundamentalists to take large risks allows exchange rates to vary much more widely than is warranted by changes in fundamentals, thereby providing a rationale for the authorities to try to limit exchange rate fluctuations by establishing a target zone.

It is quite certain that the choice of bandwidth involves an inevitable trade-off between the flexibility to react to unanticipated exchange rate misalignments (i.e. differences between desired and actual real exchange rates) and the minimisation of nominal variability. The concern of the authorities would be to preserve and improve the competitiveness of their exports and the current account position, while concurrently avoiding the inflationary consequences of nominal exchange rate depreciation. Cukierman *et al*. (2004:382) focus on the case in which expectations, and, by implication prices, are determined after shocks

realisation, so that price formation is subject to political, but not to economic uncertainty. He further cautions:

> ... In that case a peg (a zero bandwidth) is, inter alia, optimal only if the policymaker's reputation is perfect in the sense that once a peg is announced, the public expects the policymaker to keep the exchange rate fixed *under all circumstances*. However, if the policymaker's reputation is not perfect so that the public expects him to exit the band with some positive probability, then the optimal regime is either a band of a finite width or a free float (a band of infinite width). The latter is optimal only in the (unlikely) case where large exchange rate misalignments… are more likely than small ones. Otherwise, it is optimal for the policymaker to set up a two-sided band. Unless the distribution of misalignments is symmetric, the optimal band is not necessarily symmetric…

Under the first view, feedback trading can be viewed as irrational in the context of complete information. On the other hand, it can also be considered as rational in the context of incomplete information. Each one has its guess as to how far or close the band would be and how often it would diverge. In underscoring the proposition that changes in asset prices over short periods are not necessarily related closely to outside news about economic fundamentals, Isard (1995:181) argues:

> Under the first view - that feedback trading is irrational - the scope for asset prices to diverge from values that rational "fundamentals" regard as appropriate essentially depends on the widths of the confidence bands that fundamentalists place around their assessments of appropriate prices. If fundamentalists had reason to be highly confident of their point estimates of appropriate asset prices, their pursuit of low-risk expected returns would presumably keep asset prices within a relatively small neighbourhood of those point estimates. Under the second view – that feedback trading is rational in the context of limited information – the scope for asset prices to diverge from appropriate level depends on how quickly market participants can correctly assess the implications of outside news about economic fundamentals.

Viewed from an interest rate parity angle, the important questions would be whether or not one can find; firstly, whether the coefficient of the regressions of exchange rate change on the interest rate differential are not significantly different from one; secondly, whether it is a truly random error term. Despite theoretical foreign exchange efficiency, feedback traders find unexploited-profit condition which they enjoy by applying their trading rules such as filter rules that allow the would be speculator to profit by maintaining a long and short position in trough and peak respectively. In elaborating the traders' success, MacDonald and March (1999:157) maintain:

> While many economists are convinced that the foreign exchange market is at least weak form efficient, which would preclude such methods from returning excess profits, the empirical evidence is largely in chartists' favour. Their advice is widely used (Allen and Taylor, 1990), is frequently more accurate than that of economists

> (Goodman, 1979), and is significantly profitable to follow (Levich and Thomas, 1993)…

Therefore, it is highly unlikely that rational market participants or agents will trade currencies based on expectations formed only from assessments of macroeconomic fundamentals. This conjecture can be another research area in exchange rate modelling that warrantees further investigative research and analysis in view of the challenge it faces from feedback trading. In parallel, feedback trading appears to have an implication on the stabilization policy in that it has an effect on exchange rate variability that requires monetary authorities to follow prudent measures in managing their flexible exchange rate arrangements. Moreover, in recognition of its potential capacity to influence, if not to dictate exchange rate regimes choice, feedback trading may deserve further policy and research attention.

To return to the RE theory that suggests that forward rate today tends, on the average, to be equal to the future spot rate and, by implication, that forward rate will be an unbiased predictor of the future spot rate, empirical evidence poses a question mark. In this regard, Buckley (2004:125) notes the mixed and probably inconclusive evidence:

> Work undertaken by Kohlhagen (1978) Giddy and Duffy (1975), Cornell (1977) Levich (1978), Frenkel (1979, 1980) and MacDonald (1983) all indicate that the forward rate is an unbiased predictor of the future spot rate. According to an investigation by Kettel (1979) of US dollar, Deutschmark and Swiss franc forward rates during the decade to 1976, the 30-day forward rate was an unbiased predictor but the 90-day rate was not.

Coverage of exchange rate models so far may prompt one to surmise that future spot exchange rate can be forecast reliably. In reality, however, a reliable prediction of future currency trend is a daunting task. The models and or/approaches that we have visited are, to a varying degree, relevant in explaining systematic patterns of exchange rate behaviour. These models, nonetheless, are by no means adequate in predicting exchange rate trend. The theoretical contribution of these models for predicting exchange rates is inhibited by the propensity for the unexpected to occur. This tendency refers to the role of the news, an approach that we shall see in the following section.

2.7 The 'News' Model

The world has seen various unexpected political and economic events occurring in the 1970's, 1980's, and the early years of the 1990's and the new millennium s, such as oil price shock, international debt problems, the demise of the Eastern bloc, the Asian Financial Crises, the September 11th attack on the US and the War in Iraq. During these events, economies were affected disproportionately and large unexpected exchange rate movements crystallised in substantial divergence from purchasing power parity. It seems that exchange rates will remain volatile as long as world political events remain unpredictable and unstable.

The news model takes us back to efficient market equilibrium in which the forward rate reflects both the publicly available information summarised in the rational expectation, $E_t s_{t+1,}$ and the market's attitude to risk that is embodied in the risk premium. Copeland (1994:323) writes the equilibrium as:

$$\Rightarrow f_t^{t+1} = E_t s_{t+1} + \rho_t \qquad \textbf{(1.1)}$$

where the left-hand side is the (log of the) forward price foreign currency at time t for delivery one period later (at $t + 1$), ρ_t is the market's risk premium and Et s_{t+1} is the publicly available information summarised in the rational expectations. In other words, Et s_{t+1} indicates the expected value of the period t+1 spot rate, conditional on information available to the market at t. Re-writing Equation 1.1 by subtracting s_{t+1} from both sides, to give

$$\Rightarrow f_t^{t+1} - s_{t+1} = [E_t s_{t+1} - s_{t+1}] + \rho_t \qquad \textbf{(1.2)}$$

$$= u_{t+1} + \rho_t$$

The term u_{t+1} has been substituted for the expression in the square brackets on the RHS, the percentage gap between what the market expected the exchange rate to be at t+1 and the actual outcome. Since, by assumption, the market expectation is said to be rational, that error will have very peculiar characteristics. It will be strictly random that shows no systematic pattern. Thus, this error, often known as pure white noise error, surprises or innovations, will have a value of zero as its mean. This implies that it has a zero autocorrelation function and zero cross correlations with other variables whose values are known at time *t.* Put differently, it will be correlated with neither contemporaneous nor past spot nor forward rates.

One can think about news headlines that are considered relevant to exchange rate: accession to economic union, major bank failure, announcements of current economic data and forecasts, political changes, international monetary agreements, debt relief and so on.

Exchange rates, as financial assets, tend to respond quite rapidly to the arrival of new information. As a result, news on price levels will have an instantaneous impact upon exchange rates. Put simply, in response to the frequent arrival of news, exchange rates appear to vary a great deal relative to commodity prices, which, in turn, are manifested in large divergences from PPP. According to Copeland, (1994:342), "…Apart from the (often insurmountable) problem of how to quantify the news, there remains the difficulty of actually isolating the element of surprise."

For instance, it is not the gross estimate of, say, the South African trade current account balance that influences the exchange rate of the South African Rand. Rather, it is the magnitude that this very current account balance is anticipated by the market before the fact. Thus, if one is to trace out and gauge the size of the net 'news' component in any 'gross' information, one needs to have an estimate of the market's *ex ante* expectations with regard to the variable under consideration. Therefore, the news model involves a more detailed discussion of the technical, or to be specific, econometric issues than the other models visited so far in this chapter.

In articulating the importance of the 'news' model, Copeland (ibid) contends:

> As [it] will become clear, the 'news' model is, by its very nature, less of a self-contained theory of exchange rate determination than an approach to estimating a variety of (possibly competing) theories…The simplest and most general example of a news model would take the following form:

He took the (log of the) spot exchange rate as given by the relationship:

$$\Rightarrow s_t = \gamma z_t \qquad \textbf{(1.3)}$$

where γ is a slope coefficient and z_t is the variable or variables determining the exchange rate i.e. the 'fundamentals' or 'fundamental variables'.

Assuming RE, agents will form their expectations of next period's spot rate using Equation 1.3. Specifically, at time $_{t-1}$, they will make use of the available information in the set I_{t-1} in order to form the conditional expectation of s_t, which, given in Equation 1.3, means:

$$E_{t-1}\, s_t = \gamma\, E_{t-1}\, z_t \qquad \textbf{(1.4)}$$

Put another way, forming a rational expectation of the exchange rate, requires forecasting of the fundamental variables or fundamentals. In terms of the forecast errors, we obviously subtract Equation 1.4 from Equation 1.3:

$$\Rightarrow s_t - E_{t-1}\, s_t = \gamma\,(z_t - E_{t-1}\, z_t) \qquad \textbf{(1.5)}$$

The LHS of this equation is the unexpected component of the spot exchange rate. The term in the brackets on the right is the 'news': the surprise component of the fundamental variables in $z_{t.}$ It shows the deviation of the actual outcome of the fundamental or structural variable(s) from its (or their) mathematical expected value. As we saw in earlier discussion, this deviation is random in the sense that it has a mean value of zero and displays no systematic pattern over time. To this effect, Equation 1.5 indicates that the relationship between the unexpected exchange rate and the 'news' about the fundamental variables that drive it is identical to the one between the level of the exchange rate and the level of the fundamentals (ibid).

It is important to notice here that RE assumption is critical for two reasons. Firstly, it is tantamount to assuming that economic agents are knowledgeable about the true structural model that links the endogenous variable, s_t , to the fundamentals. This permits us to conclude that the same structure will link expectations of those variables. Therefore, if, for instance, the spot rate under consideration is simply a multiple, γ, of the fundamental variable or variables, in $z_{t,}$ the expected spot rate will likewise be the same multiple of $z_{t.}$ Secondly, RE allows us to deduce that the 'news' will be that part of the fundamental variable which is not unforeseen. More emphatically, the 'news' is not only unforeseen but also unforeseeable, particularly when using the data set $I_{t-1.}$ In contrast to the weak rationality, in pure RE, the information set, I_{t-1}, includes all publicly available information. The former embodies just the past history of all the fundamental variables.

However, some economists have argued that the forward rate is not a good forecast of the future spot rate. This position enjoys support from some studies made on the British pound and the US dollar from January 1971 to January 1986. Though the graph superimposes those two observations (spot for February, forward for January), it does not reflect the un-biasedness. Copeland (ibid: 331), however, cautions:

> Certainly, the forward rate does appear to track the spot rate very closely. However, the match is more apparent than real… In virtually every case, it is the spot rate that leads the change of direction, up or down. Only at the next observation does the (lagged) forward rate follow. In other words, February's change of direction was completely missed by January's forward rate, and is only reflected in February's forward rate. The interpretation has to be that when market sentiment changes it results in a change of direction in both spot and forward rates simultaneously.

The poor forecasting performance of the forward rate is likely to be found in the predominance of news. In the face of major announcements or items of news arriving with high frequency, for instance, on a monthly basis, markets have no choice but to make a substantial revision in their assessment of future fundamental variables. Any movements in the spot rate, which are predictable in advance, as reflected in the forward premium, will be overwhelmed by the impact of new information.

In order to test how well the 'news' model fits the facts, one needs to be able to measure market expectations of the exchange rate itself, identify the fundamental variables and then design the methodology one has to follow in measuring the market expectations of the level of fundamental variables.

There has been some empirical evidence that indicates that there is a systematic link between public information arrival, quotes frequency and volatility. More specifically, public information has been seen to be a determinant of exchange rate volatility and quote frequency in a continuous, high frequency setting that captured the 24-hour nature of the market. Melvin and Yin examined the exchange rate data based on tick-by-tick observations on the Japanese yen and German mark price of the U.S. dollar as displayed on the Reuters FXFX screen from December 1, 1993 to April 26, 1995. For this period, the number of news headlines related to the United States, Germany or Japan reported on the Reuters Money Market Headline News screen, measured the arrival of information. Upon employing a simple mixture of the distributions model that links price revisions to information arrival, Melvin and Yin (2000:660) conclude that:

> Without identifying the nature of the information flow in terms of specific fundamentals, we examine the arrival of information over the business week for the 1993-5 period and document that the number of price revisions (quotes) and the conditional volatility of returns for the yen and mark are functions of the rate of information arrival. Our findings do not support the hypothesis that foreign exchange market activity is largely self-generating and unrelated to new information. This suggests that trading is providing the functions it is mean to provide – adjusting prices and quantities to achieve an efficient allocation of resources…

Though these empirical results may not hold elsewhere on similar proportions, they can serve as an input in consolidating the debate around the need for foreign exchange market regulation. This situation shows that it is difficult to insulate the foreign exchange market from the impact of unexpected news or to smoothen it when it happens.

2.8 SUMMARY

The exchange rate literature has gained substantially from the contribution imparted by approaches or models such as the purchasing power and interest rate parities, the balance of payments, the portfolio balance, the sticky prices, the RE and the 'news' models. PPP, which states that exchange rates between different currencies are in equilibrium when their purchasing power is the same in each of the two countries, owes its credibility to the role of arbitrageurs. However, monetary and real variables such as the existence of transaction cost and non-tradeables, variants of indices, the pattern of money and asset prices, simultaneity problem and productivity differentials weaken its validity and, hence, its empirical evidence. As to IRP, which takes the interest rate differential as a predictor of exchange rate, states that interest rate differential driven speculators and arbitrageurs engagement in buying and selling assets higher for real returns force these returns to convergence for risky and risk-free profit respectively. The UIRP, unlike its variant, CIRP, is virtually impossible to test in isolation, given limited availability and questionable data quality. The consistency evidence on CIRP has been mixed and sometimes classified along the long and short-term currency swaps.

In the floating exchange rate BOP version that prohibits capital flow, an increase in the national income appears to dampen the current account and weaken the exchange rate. Consequently, the lower currency rate ameliorates exports while depressing imports, thereby making current account improvement and currency strength imminent. In contrast, the version that permits capital flows worsens the current account in response to national income increases. In order to avoid official reserve movements, capital account improvement may be achieved via higher interest rates that dampens demand and, by implication, imports.

The Portfolio Balance Model that treats exchange rate as a function of the relative supply of domestic and foreign bonds considers home-currency securities or bonds, unlike the monetary approach of BOP, as imperfect substitutes, and considers the risk aversion as the overwhelming rationale for investment choice between domestic and foreign currency securities. Its wealth effect that regards saving as a flow of foreign currency via current account surplus assumes that, in floating exchange rate, the capital account surplus of a domestic economy must equate with the deficit on the current account of the rest of the world, and vice versa.

Table 2.1 Summary: Some Aspects of Exchange Rate (ER) Models

Exchange Rate Model	Variables Involved		Merit	Demerit	Focus	Remark
	Dependent	Independent				
The PPP Model (Absolute and Relative)	ER	commodity prices in respective countries	largely explains ER in the long-run	failure to address non-tradeables, transaction cost, money & asset prices, indexes' variants, simultaneity & productivity differentials	role of arbitrageurs	most influential and popular, results sometimes tend to vary along sample size, cross-section vs. time series, & level of economic development lines
The IRP (Interest Rate Parity) Model	ER	Interest rate differential in domestic & foreign assets	plausible given mobile international capital & convertibility	heavily influenced by 'news'	International capital mobility	The need for distinction b/n Covered Interest Rate & Uncovered Interest Rate Parities
The Balance of Payments (BOP) Model	ER	Current & capital accounts	Covers inter-action of capital & current a/c with the ROW	applies static rather than dynamic approach to national income analysis	sensitivity to imports and exports	-assumes domestic & foreign bonds as perfect substitutes
The Portfolio-Balance Model	ER	Domestic and foreign bonds	Extends monetary approach by adding foreign money & bonds	Foreign denominated assets make demand for money more complex than in monetary approach	risk aversion as rationale for investment choice	-assumes foreign money bonds as perfect substitutes for domestic money and bonds
The Dornbusch (Sticky Prices) Model	ER	Commodity price in respective countries	Realistically reflects sluggish adjustment to price levels	-failure to account for current a/c role & its ad hoc specification of price determination process	menu costs and customer imperfect information on price	- sticky as opposed to flexible prices - affected by news on money supply
The RE (Rational Expectation) Model	ER (Future spot rate)	forward rate	Enjoys fair empirical evidence	Lacks solid economic underpinnings	significance of expectation	prompts economists to consider feedback features in model building
The News 'Model' or Approach	ER	News regarding fundamentals	Often affects ER greatly & unpredictably	Difficulty in quantifying the news & isolating the white noise error	revising future fundamentals	unforeseen & unforeseeable nature of news

The Dornbusch model, as opposed to previous models that presume either floating or fixed exchange rates, opts for sticky prices. The sticky prices act in response to new information about money supply. Thus, in response to slowly adjusting price levels, exchange rate overshoots – its tendency to jump in one direction precipitated by news, to be subsequently followed by its retreat to its original position. In parallel, the model has established the notion that such exchange rate movements are consistent with rational expectation formation. Regarding expectations based on efficient and weakly efficient markets, the RE model refers to market participants enjoying complete information, form rational expectations, and to those incompletely informed who extract relevant information from the past exchange rate trading history per se respectively. Though the former lack economic underpinnings, its application by agents makes it difficult for economists to sideline it. The latter, fundamentals, highlights the importance of different structural models of exchange rates.

Finally, the ‘news’ model, more of an approach to estimating various theories, points to a random error that, in addition to forward rates and risk premium (discount) determines the spot rate. It indicates the unpredictable and unexpectational error written out explicitly in terms of ‘news’ regarding the fundamentals. Assuming RE and relying on the bootstrap feature; the information set incorporates all the previously available information including the latest news that arrives during the period. The next chapter looks into the productivity bias hypothesis that reflects the real variable in PPP determination. It discusses the importance of PPP in the context of productivity that falls under the category of real variables.

CHAPTER 3
PRODUCTIVITY BIAS HYPOTHESIS (PBH) IN PURCHASING POWER PARITY

3.1 Introduction

As we have seen in the previous chapter, monetary as well as real variables are sources of divergence from purchasing power parity (PPP). In this chapter, we will examine one of the most important real variables, i.e. productivity. The Productivity Bias Hypothesis (PBH), sometimes known as Balassa-Samuelson Hypothesis or Productivity Differential Theory, refers to the productivity differential affecting the PPP. Balassa and Samuelson introduced a new variable in their model in which sectoral classification along tradable and non-tradable lines is structured. This chapter visits the conceptual framework of PBH, its rationale, supporting and opposing empirical evidence and its linkage with the real exchange rate.

3.2 Productivity Bias Hypothesis : Conceptual Framework

The validity of the purchasing power parity ratio between countries to measure or predict the exchange rate between them has been increasingly challenged by some economists. Generally, a basket of goods in any country is not composed of goods involved in international trade, or as we shall use the term throughout the thesis, tradable goods alone. However, it is difficult to draw a line between tradable and non-tradable goods. Generally, tradable goods can be associated with manufactured commodities, agricultural products and raw materials. In contrast, non-tradables are mainly related to tertiary activities such as services and the output of the construction sector. The quintessence of hairdressing, housing, routine medical treatment and gymnastic instruction may also fall under the category of non-tradables.

Understandably, tradable and non-tradables are sometimes subject to overlapping. Financial services provided by banks, insurers and mutual funds could also be traded internationally. Conversely, trade barriers can also turn tradeables (non-tradeable goods) into nontradeables (non-tradeable goods). Another point that deserves attention in the desegregation of the two sectors is that some costs of non-traded goods may be imputed in the prices of tradable products. The prices of tradable goods may incorporate the costs of nontraded retail, marketing, promotion, and distribution costs in the process of delivery from producer to consumer. Hence, it is, important that due attention is accorded to a commodity being non-traded and non-tradable and subsequently, to the profitability factor.

Besides, there are goods which are not involved in international trade, and hence, non-tradable for multitude grounds. The very presence of non-tradable goods suggests that international variations in the prices of non-tradables may contribute to price level discrepancies between rich and poor countries. Two of the economists who maintain such a proposition are Bela Balassa and Paul Samuelson. Balassa (1964: 593) elaborates:

> In a more general model, the impact on the general price level of productivity improvements in sectors producing traded goods can be examined under alternative assumptions with regard to changes in money wages. Should money wages remain unchanged and productivity improvements be translated into lower prices, the prices of traded goods will fall but service prices will not decline proportionately, restricting thereby the decrease in the general price level.

Largely, differences in the relative price of non-tradables tend to be attributable to differences in overall productivity, labour productivity being an important input. It appears that there is a lower relative price of non-tradables in poor countries. Kravis and Lipsey (1983 cited in Krugman and Obstfeld, 2003:411) argue that the labour productivity in the tradable sector of developing countries is less than that of the developed countries. Assuming that the labour market is competitive in each country, the wage rate in each sector remains the same. Assuming further that the prices of traded goods are roughly equal in all countries, lower productivity in the tradable industries of developing countries entails lower wages than it does in developed countries. This low labour cost also leads to lower production costs in nontradables and, by implication, lower prices for nontradables.

Developed countries, which are characterised by higher labour productivity in the tradable sector, also tend to face higher nontradables prices and hence, higher price levels. This is largely because of the high price of skilled labour in the developed world relative to that of the developing world. On the other hand, taking the classic example of nontradables like hairdressing, which does not enjoy cross-border trade due to a disproportionate transaction cost, a barber can give several haircuts in a given period. However, there may be significant scope for cross-border productivity differences in the manufacture of tradable commodities such as mega computers and other electronic goods i.e. technology use.

It is also important to note here that the price of a nontradable is determined entirely by its domestic demand and supply factors and not by foreign factors. Thus, changes in the domestic factors may cause the domestic price of a broad commodity basket to change relative to the foreign price of the same market. Similarly, a rise in the price of a country's

nontradables, *ceteris paribus*, will raise its price level relative to foreign price levels i.e. when all countries' price levels are measured in terms of a single currency. Put differently, the purchasing power of any given currency will weaken in countries, where the price of nontradables rises.

3.3 Productivity Bias Hypothesis: Rationale

As mentioned in the previous section, though high-income countries generally enjoy more productive technology than low-income countries, this very advantage of the former countries is not symmetric over all sectors of the economy. The efficiency advantage is higher for traded goods such as manufactured and agricultural products than for non-traded goods, which encompasses more of the service sector. This is because arbitrage tends to equalise the price of traded goods across countries, but this does not or is highly unlikely to apply to non-traded ones. With the wage rate much greater in the more productive countries and wages equalised domestically across all countries, the internal price ratio [ratio of the price level of nontraded commodities to the price level of traded commodities] should be greater than in the more productive (higher-income) countries.

For this reason, the prices of non-traded goods (relatively higher in the high-income countries) are not directly relevant for the balance of payments' equilibrium. Therefore, a price parity computed from the aggregate price levels comes up with an exchange value of the high-income country's currency that is less than its true long-run equilibrium value. This implies that the systematic bias increases with the overall productivity difference, proxied by the per capita income difference between the economies involved. In addition, viewed from a national economic accounts perspective, merchandise trade data are relatively reliable, but those data on services are not. To cite an example, purchases and sales of professional financial consultancy and software programming assistance may not be traced out. Precise measurement of international interest income and dividend receipts from overseas is not an easy task either.

In underscoring the differences in two sectors, Balassa (1964: 586) observes:

> In other words, assuming that international productivity differences are greater in the production of traded goods than in the production of non-traded goods, the currency of the country with the higher productivity levels will appear to be overvalued in terms of purchasing power parity. If per capita incomes are taken as representatives of levels of productivity, the ratio of purchasing power parity to the exchange rate

> [number of units of domestic currency per unit of the standard currency] will thus be an increasing function of income levels.

From the above proposition made by Balassa, it appears that the higher level of service prices at higher income levels leads to systematic differences between purchasing power parities and equilibrium exchange rates. Probably, equally importantly, increased productive technology in the traded sector of the high-income country may not be the sole reason for higher productivity. It is also possible that, owing to the ever widening and deepening presence of economic globalisation, exposure to international competition in the traded sector spurs to increased efficiency.

An alternative theory propounded by Bhagwati-Kravis-Lipsey shares similar views with Balassa-Samuelson's theory on the prevalence of lower price levels in poor countries. This theory is based on differences in endowments of capital and labour rather than productivity differences, as explicated by the PBH. Relatively speaking, developed countries have high capital-labour ratios, while the developing countries have the reverse. In parallel, non-tradables, which consist mainly of services, are labour-intensive relative to their counterparts, tradables. In elaborating their view, (Kravis and Lipsey, 1983 cited in Krugman and Obstfeld, 2003:411) argue:

> Because rich countries have higher capital-labour ratios, the marginal productivity of labour is greater in rich countries than in poor countries, and the former will therefore have a higher wage level than the latter…Because labour is cheaper in poor countries and is used intensively in producing non-tradables, nontradables also will be cheaper there than in the rich, high-wage countries. Once again, this international difference in the relative price of nontradables suggests that overall price levels, when measured in a single currency, should be higher in rich countries than in poor.

Correspondingly, Samuelson himself visited the Balassa-Samuelson hypothesis 30 years later. He emphasised Penn effect or the Kravis, Alan Heston and Robert Summers (K-H-S) effect, in which real per capita income ratios between the developing and the developed world are systematically exaggerated by conventional exchange-rate conversions. According to Samuelson (1994:201), K-H-S effect – or Penn effect – states that:

> A rich country, in comparison with a poor one, will be estimated to be richer than it really is if you pretend that the simplified Cassel version of purchasing power parity (PPP) is correct and if you use crude exchange-rate conversions to deflate the nominal total per capita incomes of the two countries. The greater their per capita real-income differentials truly are, the greater tends to be the resulting coefficient of bias…

The above quotation implies that Casselian exchange rate conversions would be valid for real income comparisons if all goods were perfect tradables and they enjoyed the least bias. Thus,

underrating the value of the non-tradable sector where the high-income countries are inherently least strong influences the conventional exchange rate conversions to overestimate their wealth. Kravis, Heston and Summers (1978, cited in Samuelson, 1994:205-6) rationalise the Penn effect by the following economic theory:

> …The ratio of real GDP per capita to exchange rate converted GDP per capita $[(y^*/y)/(y^*_e)]$… falls as per capita GDP [or y^*/y] rises. This phenomenon can be explained in terms of what may be referred to as a 'productivity-differential' model, which has been offered at various times by Ricardo, Viner, Harrod, and Balassa. The model turns on the impact of differences in the productivity gap between high- and low-income countries for traded and non-traded goods. International trade tends to drive the prices of traded goods, mainly commodities (but occasionally services), towards equality in different countries. With equal or nearly equal prices, wages in traded goods industries in each country will depend on productivity…

The economic justification of the Kravis, Heston and Summers [K-H-S] effect suggests that in a relatively higher productivity country high wages entail high prices of services and related non-traded goods. In contrast, in a relatively lower productivity country, the prevalence of low wages is manifested in low prices. Thus, the lower a country's income, the lower will be the price of its (domestic) goods which are non-tradable and the higher will be the trend or likelihood for conventional exchange rate conversions to underrate its real income in relation to that of wealthier countries.

3.4 Productivity and Real Exchange Rate

In contexualising the real exchange rate and PPP, the former can be described as the nominal exchange rate adjusted for the relative prices of both countries that measures deviations from PPP in terms of alternative price indices. Real exchange rate can also be defined in a more detailed form. According to Hinkle and Nsengiyumva (1999:41):

> the real exchange rate is generally defined in the economic literature in two principal ways: either (a) in *external* terms as the nominal exchange rate adjusted for price level differences *between countries* (that is, as the ratio of the aggregate foreign price level or cost level to the home country's aggregate price level or cost level measured in a common currency) or (b) in *internal* terms as the ratio of the domestic price of tradable to nontradable goods *within a single country*.

The former, which is derived originally from the purchasing power parity, compares the relative value of currencies by measuring the relative prices of foreign and domestic consumption or production baskets. In contrast, the latter compares the internal relative price incentive in a particular economy for producing or consuming tradable as opposed to nontradable goods. This approach magnifies the influence of the real exchange rate as an

indicator of domestic resource allocation incentives in the domestic economy. By implication, this real exchange rate indicates the *internal* RER.

Generally, RER determination is linked with the level of competitiveness in price. The nature of price competitiveness and the extent of its equalisation by arbitrageurs in the international economy are determined by the nature of substitutes. This proposition points to the nature of traded goods, as they could be either homogeneous perfect substitutes such as agricultural products or differentiated imperfect substitutes such as manufactured goods. This difference, in turn, has an influence on the internal and external competitiveness of products.

For homogeneous goods, external competitiveness involves a dichotomous choice of 'yes' or 'no'. With prices set by international markets based on the LOOP (Law of One Price), homogenous products either change hands at this price, or they are not sold at all. From an economic development perspective, most developing countries whose homogenous commodities' exports in the terms of trade forms a greater percentage than their imports, are likely to witness the LOOP applying to their exports rather than to their imports. In elaborating the internal competitiveness, Hinkle and Nsengiyumva (1999: 130) maintain:

> For homogenous goods, whatever a small country produces can be sold at the international market place. Therefore, the question of market share becomes one of internal competitiveness – that is, of what quantity can profitably be produced in the home country – and hence is a question of domestic price incentives and profitability in the production of tradables. Such *internal* competitiveness is the internal profitability *in the home country* of producing tradable goods relative to producing nontradables. Internal competitiveness is what the internal RER is designed to measure.

In contrast, for differentiated products or imperfect substitutes, some differences in price prevail owing to the degree of substitutability as well as to the cross-price elasticities of demand in the case of close substitutes. This makes external competitiveness for differentiated products a matter of degree rather than a dichotomous choice as in homogenous products. Thus, the key indicator of competitiveness in the pricing of differentiated products tends to be changes in the market shares because of the propositions that competitive pricing is likely to lead to a stable or rising market share and that uncompetitive pricing is likely to be manifested in a falling market share. In emphasising the importance of internal and external measurement of competitiveness, Hinkle and Nsengiyumva (1999: 131) reiterate:

> Hence, *external* competitiveness is a question of the relative price *compared with those of competitor countries* at which the home country's *traded* goods are sold – that is, of the external RER for traded goods. Since the home country still needs internal incentives for producing an adequate volume of traded goods, in this situation measures of both internal and external competitiveness are usually relevant.

External competitiveness has not received a uniform definition in the economic literature, however. External competitiveness has been defined in two different ways i.e. in terms of macroeconomic balance on the one hand and in differentiated products and market shares for traded goods on the other. The macroeconomic balance approach to external competitiveness has been associated with external RER for all goods. In propounding this approach, Hinkle and Nsengiyumva (1999: 131) maintain:

> In the macroeconomic balance interpretation, a competitive external RER is synonymous with an equilibrium RER – it is an RER that achieves a sustainable internal and external balance for the home country…Economists following this macroeconomic balance approach generally set out the model that they consider relevant for determining macroeconomic balance in a given country and then try to find the closest empirical counterpart of the theoretical measure of the RER required by their model.

As cited earlier, an alternative way of viewing external competitiveness is in terms of market shares of international trade in imperfect substitutes or differentiated products. In this approach, competitiveness refers to the relative cost in foreign exchange terms of producing traded goods. Hinkle and Nsengiyumva (1999: 132) elaborate the effect of relative price rise:

> A rise in costs or prices, expressed in foreign currency, in the traded sector of the home country, relative to costs or prices of its competitors, will lead to loss of competitiveness and market share and, thus, to deterioration in the home countries trade balance. Relative PPP may be assumed to hold for the external RER for traded goods. Alternatively, it may be used as the relative price in empirical trade equations for import and export demand in industrial countries.

To put it into the context of the PBH, the relationship between internal and external RERs is affected by different rates of productivity growth in the tradable and nontradable sectors. The Balassa-Samuelson hypothesis that postulated that higher productivity growth in the tradable sector than in its nontradable counterpart leads to a declining relative price of tradables is worth mention in advance here. From the the B-S hypothesis perspective, Hinkle and Nsengiyumva (1999: 135) expound:

> …Hence, in all countries experiencing faster productivity growth in the tradables than in the non-tradables would, other things being equal, have *internal RERs that appreciate over time*. Furthermore, Balassa and Samuelson showed that, if productivity in the tradable sector relative to the productivity in the nontradable

> sector grew faster in a country than it did in its trading partners, the country's *external RERs* would also appreciate, although less rapidly than its internal RER.

This appreciation in the external RER is attributable to the comparatively higher productivity growth in the tradable sector than in the nontradable one, thereby causing a larger increase in the relative price of nontradables than its trading partners do. In parallel, arbitrageurs equalise the domestic and foreign prices of tradable goods, causing the external RER for traded goods to remain constant. Since the external RER is expressed in terms of relative aggregate price levels while the internal RER is expressed in terms of relative domestic prices of traded and non-traded goods, the extent of price volatility varies. To be more specific, the price of traded goods, particularly exports in homogenous products from developing countries, is likely to be more volatile than the prices of nontraded goods.

By analogy, the aggregate price level, owing to its composition of traded and nontraded goods, is likely to be somewhat more volatile than the price of nontraded goods alone. Consequently, the economy's internal RER is likely to be more volatile than its external RER since its numerator (the price of traded goods) is more volatile and its denominator (the price of nontraded goods) is less volatile than the aggregate price level.

Nonetheless, Balassa's productivity bias hypothesis, like any other hypothesis, is not immune to criticism. The strongest and probably the only criticism emanates from Lawrence Officer. Though Officer (1974) does not dispute Balassa's contention that inter-country comparison of the price statistics of consumer goods justifies his thesis across the board, i.e. including professional services of all kinds, he challenges Balassa's theoretical analysis on the grounds that it ignores quality differences in consumer services among countries. He (1974:874) cautions:

> My objection is that such a straightforward use of these price data neglects a tremendous problem of achieving international comparability in measurement of output. In a technologically inferior country, education and medical care might be superficially cheaper than in an advanced country, but actually would be more expensive when proper account is taken of the difference in the qualities of the services.

Officer (1976) draws an important distinction between consumer and professional services. In so doing, he allocates a differential value to both services and explains their corresponding differential impact on efficiency. In qualifying his criticism, Officer (1976a:19) admits:

> These differences [in consumer services' quality] are minimal for highly labour intensive consumer services; but they would appear significant for professional services, such as education and medical care. The labour involved in such higher-level services embodies human capital and/or works with physical capital, including advanced technology and that it is only logical to expect the more productive (higher income) country to have an efficiency advantage in these services.

In order to appraise the validity of Officer's assertion, one needs to measure the possible differences in the quality of services. To this effect, Balassa looks into the magnitude of quality differences in professional services to see whether it makes up for the observed price differences concerning consumer services. He made his calculation using the data for Western Europe and utilised it to indicate the relationship between relative productivity in industries producing traded goods and services. These calculations have been made for the two sectors, education and medical care, in order to address Officer's argument that the professional services exhibit international quality differences. In an investigative response to this criticism, Balassa (1974a:881) produces the following findings:

> The data show the following percentage ratios of national to US prices of consumer prices in the year 1950: Denmark, 62; United Kingdom, 61; Norway, 66; Belgium, 74; France, 59; Netherlands, 60; Germany, 56; and Italy, 42. For these price differences to be offset by differences in the quality of education and medical care, accounting for 28 to 33 percent of consumer services in the individual countries, the quality of education and medical care in the United States would have to be two-and-a-half to five times as high as in the European countries.

In parallel, in re-enforcing his proposition, Balassa (1974a:880-81) argues that, for Officer's criticism to hold, the asserted quality difference between a high-income and a low income country would have to be large enough to compensate for the observed price differences over *all* consumer services, not just those services subject to an international quality differential.

Officer also sees the application of absolute price parity on PBH in a broader way. He argues that even if Balassa's analysis is confirmed empirically, absolute price parity is not thereby destroyed. Officer (1976a:19) presents the following reasons for not setting aside the absolute parity:

> First, the theory would remain applicable as it stands for exchange rate analyses among countries at approximately the same level of technological advancement. Second, to consider countries at diverse levels of development, the theory could be amended by including the effect of international productivity differences on the internal price ratio, thus correcting the bias of the simply computed parity.

Looking at the analysis made by Balassa, one may need to examine further, whether the theoretical validity of PBH is substantiated by empirical evidence. Therefore, the following section will address the empirical evidence of productivity bias hypothesis in PPP.

3.5 Productivity Bias Hypothesis: Empiricism

Previous sections have visited productivity bias hypothesis from a conceptual and theoretical perspective. This section explores the empirical evidence supporting and rejecting the theoretical justification of PBH. The empirical evidence involves developing countries as well as developed countries. Besides, this covers inter-temporal and cross-sectional data in an attempt to analyse the association between productivity and the exchange rate. The studies or empirical evidence obtained is based on different types of econometric techniques that employ alternative variables.

With regard to some developed countries, the empirical evidence of Japan and the United States supports the impact of the differences in productivity growth. Productivity growth, in general, and sectoral productivity growth in the tradable and non-tradable sectors, enjoys due treatment in the study. Its impact was accentuated when the fixed exchange rate system that had been applied for about twenty years was abandoned and the dollar/yen exchange rate was allowed to float. Krugman (2003:419) recollects:

> Things changed with the coming of floating exchange rates in the early 1970s. After suffering through some very high inflation in 1973 and 1974, Japan's leaders began to show a preference for lower inflation than in the United States. Between 1979 and 1993, for example, American inflation averaged 4.7 percent per year while Japanese inflation averaged only 2.3 percent… Japan has had extremely high rates of productivity growth in its traded goods, but the productivity of factors employed in nontraded goods such as services has grown much more slowly.

This development can be explained by the Balassa-Samuelson effect. Though the rising productivity in the traded sector had an influence in raising wages in both sectors, productivity in nontradables lagged behind. Due to this lag, producers in the tradable sector could afford to raise wages only by raising the prices of their products. Consequently, the relative price of nontraded goods (in terms of traded goods) in Japan had risen over time. Though the productivity in Japan and the United States in the traded sector increased, the former has done so more quickly than that of the latter. In a study of industry-level data made by Marston (1993, cited in Krugman, 2003:420), it was found out that:

> Labour productivity growth in US tradables exceeded that in U.S. nontradables by 13.2 percent over the 1973-1983 periods. In Japan, however, productivity growth in tradables outstripped that in nontradables by a massive 73.2 per cent… Japanese workers were substantially more productive than their US counterparts in several key manufacturing industries, including autos, auto parts, steel, and consumer electronics. In contrast, Japanese workers appeared less productive than American workers in nontraded goods did. .. Over 1973-1983, the relative price of non-tradables rose by 12.4 percent in the United States but by 56.9 per cent in Japan.

As the above study shows, though the prices of Japanese-produced tradables did fall sharply relative to those of US tradables, this was not adequate to compensate for the real exchange effect of Japan's soaring nontradables prices. Thus, Japan's more rapidly rising prices for nontraded goods explains why the dollar's real exchange rate against the yen [$q_{\$/¥}$] has steadily increased i.e. indicating the appreciation of the dollar.

In parallel, one can also deduce from the above empirical evidence that the massive productivity growth in the traded sector, as opposed to the non-traded sector, requires a continuous adjustment of real exchange rates between the two currencies in order to keep U.S. goods competitive with their Japanese counterparts. In a related development, Marston (1986:28) notes:

> Since the adjustment of these real exchange rates has been minimal at best, U.S. traded goods have become much more expensive relative to Japanese goods. To maintain the competitiveness of the U.S. traded sector, the real exchange rate based on the GDP deflator would have had to fall by almost 40% relative to unit labour costs in the traded sector during the 1973-83 period. Similar adjustments would have had to occur in the real exchange rate based on the CPI and in relative nominal and real wages in the two countries…

Likewise, the overall difference in productivity also rests on the real per capita income of countries. It appears that price levels of countries are directly related to the level of real income per capita. For instance, a Swiss Franc, when converted to a local currency at the market exchange rate, will stretch further in a developing or emerging economy like South Africa, than in a developed one like Switzerland. Some research on differences in international price levels has provided empirical evidence to support this.

In a study covering more than 60 countries with the U.S. dollar as a base currency, Krugman (2003) examined the relation between price level and real per capita income in 1992 dollars. Krugman (2003:410) indicated that countries' price levels tended to rise as their real incomes rose. This finding is consistent with the argument of Balassa. It also concurs with Balassa's argument that posits that the difference in the relative price of nontrables is due to the relative

difference in productivity in the two sectors in each country and that not only are the developed countries more productive, but the advantage is greater in tradable products than in nontradeable products.

Balassa also argues that this distortion of PPP from the exchange rate becomes clearer as the productivity gap between the countries widens. In order to test the hypothesis mentioned above, Balassa and Salazar-Carrillo (1982 cited in Lott and Ray, 1992: 210) utilised the following simple model:

$$[PPP_i/ER_i] = \alpha + \beta GP_i + \epsilon_i$$

> ….where $[PPP_i/ER_i]$ = the purchasing power ratio (PPP_i) for country *i* relative to some base country divided by ER_i, the exchange rate for the base country's currency in terms of country *i*'s currency. GP_i is the ratio of GDP (gross domestic product) per capita for country *i* relative to GDP per capita for the base country. GDP per capita is used as a measure of the level of productivity within a country.

In this equation, it is imperative that β be positive and significantly different from zero if Balassa's theory is to be correct. Accordingly, Salazar-Carrillo tested Balassa's hypothesis using two data sets: the first, covering 22 developed and less-developed countries in 1970 and the second, covering sixteen Latin American countries in 1973. In the first data set in which Mexico was used as the base country, while the estimates of β tested significantly greater than zero when GP was measured as a ratio of nominal GDP's per capita, it was not significant when GP was measured as the ratio of real GDP's per capita. In the second test, the estimates of β tested significantly greater than zero for both measures of GDP. Based on regression results and other analysis, Salazar-Carrilo (1982 cited in Lott and Ray, 1992:211) concludes:

> All elements considered, the productivity bias does not appear to affect the use of purchasing-power-parity rates for the estimation of equilibrium exchange rates within homogenous groups of countries (although other problems may make this unwise). For heterogeneous country groupings, the productivity bias hypothesis cannot be rejected, and the purchasing-power-parities are to be avoided as a means of estimating exchange rates.

Likewise, studies made by Asea and Mendoza's empirical findings appear to share a common conclusion with that of Salazar-Carrillo. They examined the cross-sectional rather than the time series implications of the Balassa-Samuelson hypothesis. Their results indicate a close relationship between productivity differentials and the relative price of non-tradables, but not between productivity differentials and real exchange rates. On the findings of Asea and Mendoza, Froot and Rogoff (1996, cited in Strauss,1999:386) concur and elaborate, 'but the

empirical evidence found in favour of the 'Balassa-Samuelson' effect is weaker than commonly believed, especially when comparing real exchange rates across industrialised countries over the post-Bretton Woods period'.

There has also been another study that applied panel unit root tests, rather than standard unit tests, that revealed that the relative prices of non-tradables, productivity differentials, government spending as a percentage of GDP and real exchange rates follow a stationary process. The study classified the economy into tradable and non-tradable sectors and, by implication, traded and non-traded price and labour productivity indices. The data covered the floating period 1973.3 -1995.1 for fourteen European countries (for a counter currency) and the UK (for a base currency). In this study, Strauss (1999:391-2) observes:

> In all economies, ADF [Augmented Dickey Fuller] tests fail to reject at the 5% level [in] the null hypothesis of a unit root process for the real exchange rate. For most economies, ADF tests also fail to reject unit root processes for productivity differentials, the relative price of non-tradables and government spending… Using four lags and a deterministic drift panel unit tests significantly reject at the 1% level the null hypothesis of a unit root for the real exchange rate … Panel unit root tests also significantly reject at the 1% level unit root processes for productivity differentials, the relative price of non-tradables and government spending.

The above statement also shows how (standard) unit root tests are weak relative to panel unit tests in that the former suffer from low power. Standard ADF tests may not reject the null hypothesis of a unit root in the real exchange rate. In contrast, it is possible that panel unit roots tests have sufficient power to reject the null hypothesis of an integrated process. Thus, it is likely that the panel unit root tests reject the null hypothesis that the standard unit root tests fail to do.

The above study also explored the relationship between the domestic and foreign relative price of non-tradables and real exchange rates. It applied Johansen, DOLS (Dynamic Ordinary Least Squares) and FMOLS (Fully Modified Ordinary Least Squares) econometric methods in which the data revealed a strong significant relationship. In this study, Strauss (1999:393) maintains:

> As predicted, increases in the domestic relative price of non-tradables are related to significant appreciations of the real exchange rate (a fall in q). Similarly, increases in the foreign relative price of non-tradables were linked with significant depreciations of the real exchange rate. This significant relationship is robust to econometric method, and hence presents strong evidence for a non-tradable relative price and real exchange rate link.

The results of all econometric methods applied in the above study were not, however, uniform. This was depicted in the coefficient estimates and standard errors, which where higher for the Johansen method. This could be attributed to the variation in the techniques employed in the three methods. It is possible that multicolinearity exists in many VAR (Vector Auto-regression) techniques in that they use past levels of highly correlated variables; whereas, DOLS and FMOLS techniques use levels and differences which are not highly correlated (Strauss, 1999).

The above study also examined the long-run relationship between the domestic (p_{NT}-p_T) and foreign (p^*_{NT}-p^*_T) relative prices of non-tradables, the relative aggregate price level and the nominal exchange rate. It depicts that the relative price, p*-p, is significant and close to one. This indicates that a one-for-one relationship between nominal exchange rates cannot be rejected. Strauss (1999:395) has obtained a robust result:

> (1) increases in the relative price of domestic non-tradables are associated with a significant appreciation of the nominal exchange rate; and
> (2) increases in the relative price of foreign non-tradables are associated with a significant depreciation of the nominal exchange rate.

This study has also examined the possible long-run relationship between the relative price of non-tradables and productivity differentials. In all 14 economies, all three econometric techniques (Johansen, DOLS and FMOLS) provide parameter estimates that are significant, but the coefficient magnitudes are less than one. Drawing on the significant parameter estimates provided by FMOLS procedures on most economies for which a deterministic time trend and four lags are assumed, Strauss (1999:395) contends:

> Productivity differentials are also significantly related to the relative price of non-tradables. Results posses the correct sign, albeit the coefficients, similar to (*sic*) before, are also significantly less than one-for-one. These weak but often significant relationships are also robust to Johansen and DOLS econometric methodologies and suggest other factors may influence the relative price of non-tradables.

An important aspect of causality on the part of the productivity differential has also been part of the study that examines possible Granger causality between the productivity differential and the relative price of non-tradables. The productivity bias hypothesis predicts one-way causality i.e. $a_{NT} - a_T \rightarrow p_{NT} - p_{NT.}$ In other words, it refers to productivity differential Granger-causing relative price differential. In contrast, simultaneity predicts a two-way causation i.e. ($a_{NT} - a_T \leftrightarrow p_{NT} - p_{NT}$) i.e. productivity and relative price differentials Granger-causing each other.

As we have seen in the second chapter, the presence of sticky prices leads to nominal and real exchange rate co-movements in the short-run. The Dornbusch model brings the feedback effects into play in that asset market determination of exchange rates and sluggish adjustment of traded (commodity) prices implies a feedback from exchange rates to productivity via traded prices. The real exchange rate disequilibrium, due to short-run co-movements with nominal exchange rates, over time may lead to simultaneous movements in both traded prices and the relative prices of non-tradables, because of arbitrage in commodities. Consequently, the feedback effect $a_{NT} - a_T \leftarrow p_{NT} - p_{NT}$ comes into effect. Relying on his empirical evidence, Strauss (1999:399) comments on the links:

> For seven economies using four or eight lags, the null hypothesis that productivity differences do not cause (or explain) movements in the relative price of non-tradables [$a_{NT} - a_T \rightarrow\neq p_{NT} - p_{NT}$] can be rejected. Similarly, in seven economies, the null hypothesis that $a_{NT} - a_T \rightarrow\neq p_{NT} - p_{NT}$ can be rejected. Although this is not strong evidence for either simultaneity or the feedback effect, it is suggestive because a strong feedback and/or simultaneity effect exists in half the economies.

Thus, Granger-causality tests carried out by the study indicate the presence of a strong feedback effect from the relative price of non-tradables to the real variable (as opposed to a nominal variable), productivity differentials. In so doing, it reinforces the hypothesis that international competitiveness encourages productivity adjustments.

It is worth mentioning here that even if studies indicate that there is a statistically significant relationship between changes in labour productivity and changes in the real exchange rate, the results may differ by model specification, sample size and data type. Besides, it is not clear how good proxy labour productivity is for total factor productivity (TFP), the theoretically implied or recommended variable of interest. Strauss (1996, cited in Chinn, 1999:167) examines the relationship in levels for six bilateral exchange rates against the Deutschemark (Belgian franc, Canadian dollar, Finnish markka, French franc, pound and US dollar). Using the Johansen (1988) multivariate approach, he detects evidence of cointegration between real exchange rates and sectoral *labor* productivity. However, his estimates for β_1 (β_2) range from -1.21 (-8.72) to -10.53 (13.97)! In all cases the β_1 coefficient rejects the null hypothesis of $\beta_1 = 0$, but also rejects the null of $\beta_1 = 0.5$, which is what would be expected if about half of the CPI was accounted for by nontraded goods.

Strauss (1995, cited in Chinn, 1999:167) addresses both the TFP and cointegration issues. Again using the Johansen procedure, he tests for a cointegrating relationship between the bilateral real exchange rate (versus Deutschemark) and relative productivity variables, where

total factor productivity (TFP) instead of labour productivity is now used. While TFP is the appropriate variable, it also limits the span of the data series for five of 14 countries to 21 years. Using the conventional asymptotic critical values from Osterwald-Lenum (1992), he finds that eight cases are cointegrated at the 10% marginal significance level. However, if one adjusts for small sample effects, then the number of cases of cointegration drops to a mere two: UK and possibly France.

Balassa (1964) stated explicitly the hypothesis of a systematic bias in PPP as a measure of the equilibrium exchange rate, this bias arising from productivity differentials. Balassa (1964:589) maintains, 'The higher level of service prices at higher income levels leads to systematic differences between purchasing-power parities and equilibrium exchange rates.' He furnishes two kinds of empirical evidence for his hypothesis. Firstly, He (1964:588) employs sectoral PPP computations in order to show that 'services [i.e., nontraded goods] are by and large cheaper in countries with relatively low incomes'. Secondly, he regresses PPP/R on per capita GNP (converted into dollars using R) for 12 member countries of the Organisation for Economic Cooperation and Development (OECD) for the year 1960. He (1964:585) suggests that the high correlation coefficient (0.92), obtained by regressing the ratio of purchasing power parities to exchange rates on per capita GNP, provides evidence in support of this hypothesis.

In unpacking his theoretical justification for the observed relationship between PPP and exchange rates, Balassa assumes that there are no international quality differences in services. He (1973: 1258) further explains:

> … Now, since service prices enter into purchasing power parities without directly affecting exchange rates, it is expected that the ratio of purchasing power parities to exchange rates (expressed as units of national currency per the U.S. dollar) will rise with levels of productivity. Correspondingly, in using official exchange rates to covert national income data into U.S. dollars, one will underestimate real incomes in countries other than the United States, and the degree of understatement will be positively correlated with differences in levels of productivity.

Officer (1974, cited in Officer, 1982:165) also questioned Balassa's econometric test of PPP. One criticism concerns the choice of an independent variable. According to him, the ratio of GDP to employment would appear to be a better measure of a country's level of productivity than GNP divided by total population. He also noted the need for the disproportionate effects of measurement of GDP and GNP and he suggests that Balassa made use of GDP rather than GNP. In response to Officer's criticism, Balassa (1974a:882) underscores, "…The case of

GNP rather than GDP and that of per capita GNP rather than the ratio of GNP to employment in the regressions are trivial as the differences are too small to affect the results."

Not many studies have tested the applicability of Balassa's result to less developed countries. Grunwald and Salazar-Carrillo (1972 cited in Officer, 1982:166-7) present PPP's for 11 Latin American countries in 1968, based on specially collected data. Letting Venezuela replace the United States as the standard country, they found that the rank correlation between PPP/R and per capita GDP had the wrong sign, irrespective of whether official exchange rates or free rates were used. This result led the authors to conclude that the Balassa hypothesis was not applicable to Latin America.

In a related study, Clague and Tanzi (1972, cited in Officer, 1982:166) performed Balassa's regression (PPP/R on per capita output) for a sample of 19 Latin American countries, with the Unites States as the standard country, for the year 1960. The explanatory variable, per capita, was converted from domestic currency to dollars using, alternatively, R and PPP. The PPP measures are absolute parities with a GDP price concept. The authors reported R^2 to be .24 in the first case and -.05 in the second. These results did not enjoy the arguments of productivity bias hypothesis, either. In this regard, Officer (1982:166) maintained that challenges to the hypothesis are confined to samples of LDCs. However, it is also possible that the above study could produce different results when time series econometrics such as the cointegration techniques employed.

Kravis and Lipsey (1978a cited in Officer, 1982:168) perform a double-logarithmic regression of the GDP price level on PPP-based GDP (both relative to the United States) for a cross-section of 16 countries(12 DCs and 4 LDCs), with the data taken from Kravis and others in 1975. They show that, as a cross-sectional relationship over the 16 countries, the relative price of services, or of services and construction that represent the non-tradable sector, increases with per capita income. A positive relationship predicted by the PBH is obtained. Substituting the price level of non-tradables for the GDP price level also provides a positive slope coefficient, thereby supporting the PBH.

3.5 Summary

Economists such as Bela Balassa and Paul Samuelson challenge the PPP model that states that, in the long run, the difference between inflation rates in two countries tends to equal the rate of change of the exchange rate between the currencies of the countries concerned. By analogy, both challenge the validity of PPP ratio to measure or predict the exchange rate between the countries involved. Likewise, PBH argues that the deviation of PPP from the equilibrium rate or the real exchange rate is positively related to the ratio of productivity in a counter country over that of the base country. Thus, this difference in productivity is largely presumed to be attributable to the productivity differences in their tradable and non-tradable sectors.

According to PBH, with inter-country productivity differences being smaller in the service sector than in the sectors producing traded goods and the prices of traded goods equalised through arbitrage, the relative prices of non-traded goods (services) will be positively correlated with productivity levels in individual countries. As far as service (non-traded) prices enter into purchasing power parities without directly affecting exchange rates, it is surmised that the ratio of purchasing power parities to exchange rates tends to be positively correlated with levels of productivity. In parallel, in using official exchange rates in order to convert national income data into a base currency, one underrates real incomes in counter rather than base countries. Likewise, the degree of understatement will be directly related to differences in levels of productivity.

Lawrence Officer raised probably the only challenge to Balassa's theoretical argument in 1974 that was subsequently rejected by Balassa in the same year. The PBH faces criticism from Officer who claims that the PBH ignores or underestimates the differences in quality of services (i.e. education and medical care) in the countries concerned. Balassa, taking the data on US and Western Europe, defends his proposition by depicting that the quality of education and medical care would have to be 2.5 to 5 times as high as in the European countries if price differences are to be offset by differences in the quality of these services.

The empirical evidence visited in this chapter does not provide unequivocal support to the validity of PBH. Results tend to vary along model specification, sample size, data type, and level of economic development or other factors. Besides, a time-series comparison of the exchange rate and PPP may differ from a comparative-static or cross-sectional comparison of

the variables at two points in time. Though Balassa's argument that PPP calculated from price level would understate the true equilibrium value of the currency of the technologically advanced country appears logical, it is imperative that his hypothesis is further tested empirically for countries at different stages of economic development. Further empirical investigation could help to examine whether or not the PBH proves so in most, if not all, cases. Accordingly, the following chapter will look at the profiles of economies of South Africa and Switzerland. It will provide the overall picture of these economies and the link with each other.

CHAPTER 4
ECONOMIC PROFILES: SOUTH AFRICA AND SWITZERLAND

4.1 Introduction

This chapter explores the economic profiles of both countries, i.e. South Africa and Switzerland. The discussion focuses on major macroeconomic variables and the labour productivity of each country. In the first section, it highlights the growth rate, the exchange rate and the inflation rate of each economy. In addition, it discusses labour productivity and the factors behind the changes in it. In so doing, it endeavours to present empirical evidence in support of the factors mentioned. In parallel, it also elaborates the simultaneity effect of exchange rate as an endogenous explanatory variable for the productivity variable. In the second section, it visits the economic links between the two countries that take the form of trade, investment and bilateral agreements. It also looks at the inflation rate differential in the two countries and its associated consequences on the exchange rate and on the terms of trade.

4.2 Economic Profile: South Africa

South Africa is one of the sophisticated and promising emerging markets in the world economy that enjoys a highly developed first world economic infrastructure. It is one of the most advanced and productive countries in Africa and has have a great potential for economic growth and development. After years of international isolation and economic rejection by most countries, South Africa was welcomed back into the world as a full member of the international community from the late 1980s and early 1990s. Positive socio-political developments and the 1994 democratic election have largely changed South Africa's image in the world community.

In an endeavour to improve economic growth significantly and to bring about development for all South Africans and a meaningful decline in unemployment, the government designed and implemented its Growth, Employment and Redistribution strategy (GEAR). Following the successful transition to democracy in 1994, the country witnessed significant capital inflows relative to those that existed during the Apartheid era. This development combined with a much more positive image of the country in the international community motivated the abolishing of the *financial Rand* early in 1995. The *financial* (blocked) Rand was mainly introduced to curb the outflow of foreign investments from South Africa by making it cheaper for foreigners than the *commercial Rand*. Mohr (2004:110) maintains that between

the middle of 1994 and the end of 2003, South Africa attracted net capital inflows of over R150, 000 million – inflows that, if used productively, may provide the capacity future economic growth. However, the caveat here is that a greater proportion of this inflow of foreign capital is of a portfolio nature. Thus, it has the potential to become an outflow rapidly.

From the fiscus point of view, the country has enjoyed an impressive performance over the last ten years. The country's budget deficit has been heavily reduced. According to *South African Embassy* (2005:1), "the budge deficit fell from 8.6% of GDP in 1992/93 to 1.4% in 2002/03. Public debt decreased from 48.1% of GDP in 1996/97 to 42% of GDP in 2002/03. Foreign currency reserves are on the rise and inflation is on the fall." The decline in the budget deficit is also expected to contribute in moderating inflation rates further.

Despite the prevalence of difficult environment for developing countries, South Africa has been capable of scoring a positive annual growth rate record throughout the last ten years in the aftermath of the new dispensation. *Annual Economic Report* (1998:5) highlights this very situation:

> The South African economy entered its sixth year of positive economic growth in1998, albeit at a considerably slower pace than earlier in the upturn. In the early stages of the recovery, growth in real gross domestic product accelerated robustly to 3 ½ per cent in 1995 and 3 percent in 1996, but later tapered off to about 1 ½ per cent in 1997. Growth diminished even further in the second half of 1997 and in the first two quarters of 1998 – on average, an annualised economic growth rate of only ½ per cent was realised over this period.

According to Mohr (2004:47), the economic growth rate since 1994 has averaged 2.6%, which is a welcome improvement on the growth of performance during the previous 13 years. In figuring out the sectoral contribution to the economy, Mohr (2004:41) contends:

> Agriculture (including forestry and fishing) is still an important sector of the South African economy, although its contribution to total GDP has declined over time - from 8.1% in 1950 to 3.7% in 2003. Collectively, the agricultural and mining sectors contribute towards approximately 9.3% of our total GDP, as compared with about 28% in 1950 and 30% in 1960.

The South African economy, as almost any other economy in the world, has been influenced by developments in the Asian crisis in 1997 and 1998, albeit at different proportion. The contagion effects of the Asian crisis were exacerbated by the worsening economic situation in Russia. As the international financial crisis ended by the end of 1998, output growth in Asia

started to solidify. Concurrently, as the economic conditions in Asia began to improve, the demand for commodities and manufactured goods from South Africa rose. "As a result, real gross domestic production recovered somewhat in the fourth quarter of 1998 and increased further during the first half of 1999" (*Annual Economic Report*, 1999:1).

In response to the recovery from the setbacks suffered, the outlook for export-oriented developing countries became brighter. For the same reason, this development has positively affected South African trade with the rest of the world. "The outlook for demand, especially in the Euro area, South Africa's most important export market, has improved substantially since 1998. The pace of economic activity in Southeast Asia, another prominent destination for South African exports, is also accelerating" (*Annual Economic Report*, 2000:5).

In a separate development, the depreciation of the Rand, though precipitated largely by factors beyond the control of the South African economy, has brought forth a congenial situation for the export sector. Since the European Union is South Africa's most important trading partner, the Rand tends to take its cue largely from the euro (€). As the depreciation of the rand exceeded the inflation differential between South Africa and its trading partners by a substantial margin, the competitiveness of domestic producers in the export sector rose considerably. According to *Annual Economic Report* (2001:9):

> From the beginning of the 1990s [until 2001], boosted by the real depreciation of the rand, *export-oriented industries* (defined here as those industries producing chemicals and chemical products, basic metals and transport equipment) increased their share of total manufacturing output from about 45 ½ per cent to 51 per cent. This increase in relative importance came mainly at the expense of the shrinking shares of food, beverages and tobacco producers and of the clothing, textile and leather product industries.

External factors such as the September 2001 attack on the United States and the long-running political tension in the Middle East exacerbated by uncertainty about the future of the global economy has done harm to the South African economy. These developments have manifested themselves, inter alia, by major fluctuations in the exchange rates. The South African economy could not benefit in full from the global economic expansion in the second half of the 1990s because of the Southeast Asian financial crisis of 1997 and 1998. However, the adjustment made to relative prices during those years, particularly the depreciation of the rand has helped to mitigate the effect of the global slowdown on economic activity in South

Africa during 2001. In highlighting the exchange rate swings in the early 2000s, *Annual Economic Report* (2002: 4) elaborates:

> The exchange rate of the rand declined against almost all foreign currencies during 2001, but recovered quite strongly in the first half of 2002 when the surpluses on the overall balance of payments added to the supply of foreign currency in the domestic foreign exchange market. In the last quarter of 2001, the opposite situation had prevailed: a deficit on the current account of the balance of payments then had coincided with an outflow of capital from the economy. Under such circumstances where there is a greater demand for than supply of foreign exchange, depreciation in the exchange rate of the rand could be expected as a normal market reaction, but the extent of the depreciation would be largely unpredictable. Ultimately, the weighted average value of the rand lost more than a third of its value in 2001…

Pushed by market forces and perhaps by market sentiment, the exchange rate of the rand has gone through upswings and downswings from 2001 until 2003. It weakened significantly towards the end of the 2001, strengthened somewhat at the beginning of 2002, but recovered more significantly towards the end of the year and in the first half of 2003. *Annual Economic Report* (2003:3) indicates the volatility of the Rand:

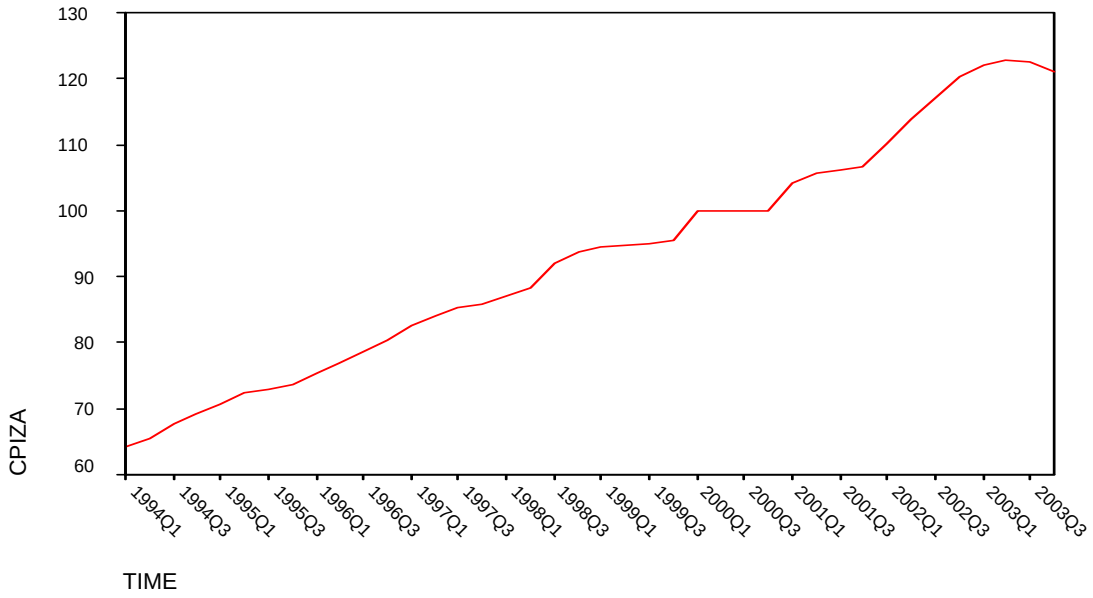
> Having depreciated by 34 ½ per cent in 2001, nominal effective exchange rate of the rand recovered by 24 per cent during 2002 and by a further 12 per cent during the first half of 2003. A preliminary comparison of the volatility of the exchange value of the rand with other currencies reveals that, over the past six years, the rand has been more volatile than the average emerging-market currency, and far more volatile than the average developed-market currency.

The simultaneity effect that the exchange rate has had on the export sector in the 1990s appears to have continued in the early years of 2000s. The export sector shot up, not because of possible increase in productivity gained per se, but also because of a decline in the exchange rate of the rand. In elaborating this simultaneity bias, *Annual Economic Report* (2004:5) argues:

> Following a firm increase of 3 ½ per cent in 2002, South Africa's *real gross domestic product* increased at a more moderate pace of 2 per cent in 2003. These developments broadly reflected the performance of the primary and secondary sectors of the economy. The secondary sector of the economy, of which the manufacturing sector is the largest, performed exceptionally well in 2002, partly as a result of the surge in manufactured exports which benefited to a large extent from the weaker exchange rate of the rand. The recovery of the exchange rate, which started in the second half of 2002 and continued throughout 2003, contributed to a contraction in the real value added by the manufacturing sector, thus leading to virtually no change in the real output of the secondary sector for 2003 as a whole.

Since the early 2000, the framework of the South African monetary policy has been that of inflation rate targeting (3%-6%). In coherence with this monetary policy, the South African Reserve Bank (SARB) pursues a floating exchange rate policy. However, it has options of intervening in the forex market through buying and selling of forex, use interest rates or allowing market forces (including the actions of currency speculators) to determine the exchange rate.

Fig. 4.1 Consumer Price Index (CPI): South Africa, 1994Q1-2003Q4



Source: *Plotted based on IMF (IFS) data, August, 2005*

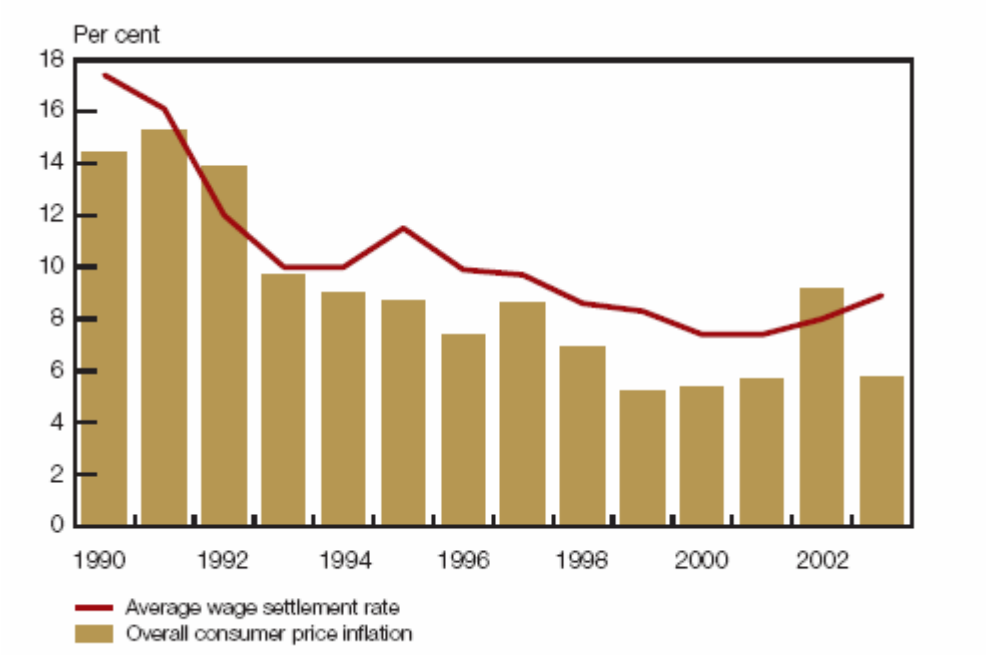
South Africa, a country with a remarkable history of relative price stability during the 1960s, was transformed into a country where inflation was generally expected to be around 15 per cent per year. This has happened in the aftermath of the breakdown of the international monetary system of fixed exchange rates and of the oil price shock of 1973. The high and growing inflation that the country had gone through for more than two decades, however, subsided significantly in the early 1990s. The CPI depicted in Figure 4.1 hints that inflation rate has remained within the inflation rate targeting (3%-6%) set by SARB, as we shall see later in the analysis component.

4.3 Labour Productivity: South Africa

Labour productivity in South Africa from 1994-2003 has gone through various swings. However, the reason for the changes in productivity is neither a uniform nor a consistent one. For instance, prior to this period i.e. 1989 - 1992, the stronger growth in labour productivity was achieved not so much through a stronger commitment to work, but more by retrenching workers at a quicker rate than the decrease in output volumes. In substantiating this argument, *Annual Economic Report* (1993: 18) maintains:

> During the recession of 1989-93, the growth in labour productivity was nevertheless considerably higher than its longer-term trend: labour productivity in the non-agricultural sectors of the economy rose at an average annual rate of 0,9 per cent from 1988 to 1992. … In 1991 and 1992 the real output per worker in the formal non-agricultural sectors even increased at an average annual rate of 1,3 per cent.

Fig 4.2 Wage Settlement rate and overall consumer price inflation



Source: *South African Reserve Bank (SARB), Annual Economic Report, 2004*

In a related development, the other important element is the level of the pay structure of workers who retained their jobs. As labour productivity growth fails to cope up with nominal remuneration growth, inflationary pressures in the labour market tend to feed in to a rise in unit labour cost. Conversely, if there is a meaningful increase in labour productivity or a decline in unit labour cost in the years to come, the inflationary pressure is expected to subside. As the above figure, Figure 4.2 illustrates, the overall labour cost has gone beyond the CPI level during the period under study i.e. 1994Q1-2003Q4.

Thus, a unique feature of South Africa's labour market during the first half of the 1990s was that the increase in nominal remuneration per worker exceeded the rise in output prices, not withstanding the high and rising unemployment in the country. *Annual Economic Report* (1996: 13) reveals the discrepancy:

> *Real remuneration per worker* (i.e. nominal remuneration per worker deflated by the price Deflator for the non-agricultural gross domestic product) increased in every calendar year since 1987, except in 1993 when it declined fractionally by 0,3 per cent. The average annual rate of increase in the real remuneration per worker was equal to 1,3 per cent between 1989 and 1995. Unlike real wage growth in the public sector, the growth in real remuneration per worker in the private sector increased steadily over this period.

Given the extent of the above mentioned productivity growth and changes in the manufacturing labour costs, South Africa remained behind its main trading partners. The lower labour productivity growth accompanied with a higher rate of increase in unit labour costs in the manufacturing sector in relation to South Africa's trading partners reveals a depressing of the competitiveness of the South African manufacturing industry. It has not been all doom and gloom in that competitiveness began to improve since 1995. *Annual Economic Report* (1997:1) indicates the improvement in productivity:

> Partly in response to the repeal of trade sanctions, but more importantly because of the increased competitiveness of South African manufacturers in world markets, export volumes have expanded and contributed materially to the narrowing of the deficit on the current account since 1995. Total export earnings have unfortunately been adversely affected by a decline in the price of gold since the beginning of 1997.

According to the Global Competitiveness Report published by the World Economic Forum (2003:1), Switzerland and South Africa are ranked 6th and 32nd among 80 countries during the period 2002/2003. This indicates the extent that South Africa has lagged behind in the area of productivity. Likewise, the Swiss Embassy (nd: 1) maintains that Switzerland is one of the top ten in international competitiveness.

Despite these improvements in productivity and the slowdown in nominal wage growth, the competitive capacity of the South African economy has a long way to go to reach the competitive position of its trading partners. This is evident in view of changes in nominal unit labour costs and productivity of South Africa compared with that of its main trading partner countries. In explaining the productivity differential, *Annual Economic Report* (1997:15) indicates:

> Unit labour costs in South Africa increased approximately 7 ½ times as fast as the arithmetic average of the rates of increase in unit labour costs in the main trading partner countries during the first half of the 1990s. Over the same period, the growth in labour productivity in South Africa was only about 60% of the arithmetic average of productivity growth in the trading partner countries.

By and large, the productivity improvement in 1999 probably reflected the contraction in employment numbers more than anything else. However, this does not follow that there were no efficiency gains throughout the economy. *Annual Economic Report* (1999:15) points out:

> As a consequence of the slowdown in output growth and the increase in industrial action, the growth in *output per worker* in the formal non-agricultural sectors of the economy receded from 4.2 per cent in 1997 to 0,9 per cent in the year to March 1999. Of particular significance was that growth in aggregate output in the first quarter of 1999 was accompanied by an increase in the level of employment in the formal private non-agricultural sectors of the economy.

As the South Africa's economy moves from a predominantly goods-producing industry to the service-delivery industries, the pattern for and the level of the skill of labour also has changed. These structural changes in the economy place greater importance and, hence, a higher value, on the demand for skilled labour. Conversely, they put a reduced importance and, hence, a lower value on the demand for the unskilled or semi-skilled labour. Besides, some sub-sectors that fall under the tertiary sector are more skills-intensive than others are. This situation has led to a more intense competition to satisfy the demand for highly skilled employees, even within the tertiary sector.

With the economy characterised by an increasingly more diversified and export-oriented structure, labour productivity appears to have begun to make a significant improvement. Labour productivity growth was exceptionally buoyant during the second half of the 1990s. As *Annual Economic Report* (2001:27) indicates:

> For the period 1994-2000, the average annual rate of increase in labour productivity in the formal non-agricultural sectors amounted to 4,5 per cent, which was, 1,4 percentage points higher than the growth in real remuneration per worker. The growth in output per worker in the formal non-agricultural sectors of the economy amounted to 6,0 per cent in 2000 – the highest rate of increase in the past thirty years. This compares with rates of increase of 4,0 per cent in 1999 and 4,8 per cent in 1998. The rise in labour productivity since the early 1990s, however, been accompanied by declining employment levels in the regularly surveyed formal non-agricultural sectors of the economy.

The relationship that existed between CPIX and the level of general staff annual salary increases in the early and mid-1990s has also crystallised during the period 2000-2004.

Annual salary increases have largely followed the CPIX trend. As Table 4.1 depicts, salary raises have averaged around 7.7% while CPIX has averaged 7.0% for the past five years. This situation has been influenced by a backward looking process in that CPIX increase in the previous year precipitate salary increases higher than the current CPIX in order to 'make up the gap'.

Table 4.1 CPIX[1] [%age change] versus Annual Salary Increases, 2000-2004

Year	CPIX	General Staff [Salary] Increases	Differential
2000	7.8	8.0	+0.2
2001	6.6	8.0	+1.4
2002	9.3	8.0	-1.3
2003	6.8	8.5	+1.7
2004	4.3	6.3	2.0
2005	4.5*	4-6#	0.5 to +1.5#

*=Forecast by Economists
#=Forecast by Hay Group
[1] CPIX excludes mortgage rates

Source: Hay Group, Economic Outlook, June 2005

The upswings and downswings of the exchange rate of the rand in 2001, 2002 and 2003 have obviously also affected the competitiveness of South African exporters in the opposite direction. However, an increase in international competitiveness should preferably not be as a result of a downward trend in the exchange value of a country's national currency alone, but should also emanate from higher efficiency and cost-effectiveness in the process of production. Strong growth in output per worker reflects the ability of domestic producers to meet or exceed the efficiency standards of other countries. Depending on the extent of the depreciation of the exchange rate, the decline in productivity might not have a significant effect on exports. For instance, the following empirical evidence shows the decline in the output per worker. According to A*nnual Economic Report* (2002:25):

> Mainly due to the slowdown in economy-wide output growth, growth in *output per worker* in the formal non-agricultural sectors of the economy receded from 6,1 per cent in 2000 to 4,1 per cent in 2001 and to 3,0 per cent in the year to March 2002. Productivity growth in the manufacturing sector nevertheless remained solid at around the 6 per cent level in 2000 and 2001.

As the exchange rate of the rand appreciated in 2003, it had a perverse impact on business confidence in general, and the export-oriented mining industry and sections of manufacturing and agriculture, in particular. Consequently, the recovery of the rand eroded part of the competitiveness, which these industries had enjoyed in the previous year. The highly unpredictable volatility of the exchange rate appeared to be more of a liability than an asset for business confidence in many industries, as it complicated long-term planning and increased the perceived risk of exchange rate losses. Overall, growth in nominal remuneration per worker in the formal non-agricultural sectors of the economy slowed down substantially over the period 1994-2003. According to *Annual Economic Report* (2004:21),

> The year-to-year increase in nominal remuneration per worker in the formal non-agricultural sectors of the economy amounted to 8,7 per cent in 2003, substantially down from 13,1 per cent in 1994.[1] … When allowance is made for the statistical break in the time series in the third quarter of 2002, following the publication of a new expanded Survey of Employment and Earnings by Statistics South Africa, nominal remuneration growth in the private sector amounted to 8,1 per cent in 2003 – the lowest rate of increase in more than thirty years.

4.4 Economic Profile: Switzerland

Switzerland has none of the raw materials that served as a traditional locomotive of industrial development. With a per capita gross national product ranking among the highest four countries in the world, Switzerland has remained to be an important force to be reckoned with in the global economy. Its assets comprise highly skilled and educated human resources equipped with superior technological expertise. The Swiss industrial sector concentrates on highly developed specialised products that require substantial manufacturing skills.

The Swiss industrial sector has made a technological advancement in areas of machine-tool, electrical engineering, electronics, optics, watch making, pharmaceutical, chemical, textile, and food industries. The country has developed into a service centre par excellence since World War II. According to the Swiss embassy (2005:1):

> With a share of 99.7%, small and medium-sized enterprises (SME) with workforce up to 250 employees are the backbone of the Swiss industry. They provide work for over 70% of the approximate total of 3,5 million employees. Around 12% of the over 300,000 SME also export products and almost 10,000 of them generate more than two thirds of their net sales abroad. Over two-thirds of the country's work forces are currently employed in the service sector. In this sector, banking and insurance have set standards of quality for the whole world.

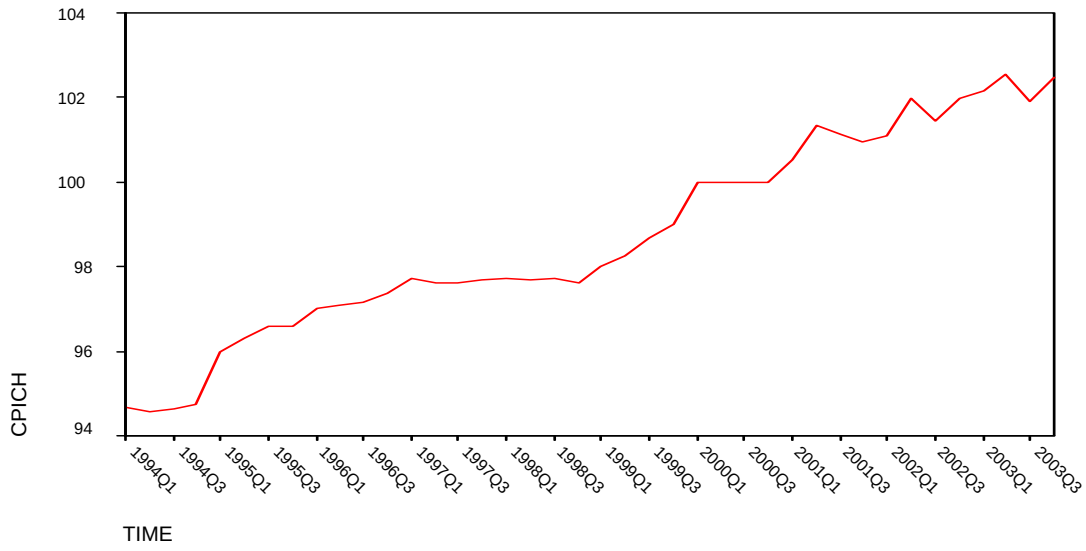
As to the interaction in the global economy, Switzerland is one of the most liberal and highly competitive economies. The agricultural sector is, however, not competitive, since it is subsidised by state funds. "Critics say there is not just one Swiss economy but at least two: the efficient export sector, dominated by large, internationally competitive companies, and the inefficient domestic sector that survives only because it is highly protected" *The Economist*, 2004:11). The agricultural sector is said to be the last market-oriented sector in the Swiss economy. In contrast, a think-tank financed by Swiss multinationals, Thomas Held (ibid), outlines the classification of the Swiss economy as follows:

> …the global companies based in Switzerland that create much of the country's wealth; the competitive and innovative small and medium-sized outfits that live on exports; the state-owned or semi-privatised sectors, such as the post office, the telecommunications operator (Swiss-com) and the electricity industry; and the plethora of small domestic enterprises with lowish productivity in retailing, construction, tourism, farming and so on.

Thus, the strength of the Swiss economy is largely attributable to its international outreach and strong interweaving with the economies of other countries. Switzerland is one of the countries that enjoy high export rates as a percentage of gross domestic product. *The*

Economist (2004: 11) indicates that one Swiss franc in two is earned abroad (from exports of goods and services, income from direct investment and so on)… Low inflation, low long-term capital costs, a good investment climate, sound public finances and smooth labour relations have also contributed to the prosperity and stability of the Swiss economy. In parallel, The *Economist* (2004: 13) acclaims that the Swiss central bank's inflation target, defined as a range of 0-2%, has been met every year since the mid-1990s, after a scary period in the early 1990s when inflation topped 6 ½ %. Likewise, the CPI depicted in Figure 4.3 hints that inflation rate has remained within the inflation rate targeting (0-2%) set by Swiss National Bank (SNB), as we shall see later in the analysis component.

Fig. 4.3 Consumer Price Index (CPI): Switzerland, 1994Q1-2003Q4



Source: *Plotted based on IMF (IFS) data, August, 2005*

After more than half a century as the richest country in the world, Switzerland appears not to be enjoying this position anymore. However, this does not imply that the Swiss are getting poorer. Rather other countries such as Luxembourg, Norway and the United States are growing faster. The huge advantage that the Switzerland has had in possessing its entire infrastructure in one piece after the World War II is gradually diminishing. According to figures calculated by an economic historian, Angus Maddison (n.d., cited in *The Economist*, 2004:10):

> Switzerland's income per head in 1950 was 80% above the European average. But by 1998, its GDP per head at purchasing-power parity was only 14% above the European average. … Certainly, Switzerland's recent growth rate seems to have been exceptionally slow. Average annual growth in GDP for the past two decades has been

> 1 ¼ %, less than half the OECD average. During the 1990s, real GDP per head remained absolutely flat, whereas in Britain and America it grew by around 2%.

The structure of the Swiss economy has gone through a considerable change at the end of the 20th century. This significant change of the share in the economy has been largely in favour of the service sector accompanied with a decline in agriculture, construction and engineering. In illustrating this shift, Swissworld (2002:1) states that:

> The number of farming jobs fell by 25% between 1985 and 1995. Traditionally important industries such as construction and engineering also declined, while most branches in the service sector continued to grow. In 2003, the service sector accounted for 72% of those in employment. Nearly 24% were employed in industry and craft, and only just over four per cent were working in agriculture and forestry.

Further breakdown of the contribution of the service sector to the economy depicts its level of significance more deeply. This is reflected not only in its contribution to the gross domestic product but also in the nature and level of employment that it creates or retains. In this regard, *The Economist* (2004:13) indicates:

> In the country as a whole, the financial-services industry makes up about 11% of GDP (and more than twice that in Zurich and Geneva). Draw the definition a little wider to include insurance and pension funds, and you get to a 16% share of GDP, ahead of commerce and tourism at 15% and engineering at 9%. The financial sector employs about 220,000 people in Switzerland itself and a further 190,000 in other countries, mostly in high-quality, well-paid jobs.

Switzerland has contemplated joining the European Union (EU). After all, the European Union is its most important trade partner. "Some 60% of Swiss exports go to members of the EU…" (The Economist, 2004:11). However, this decision can have a serious implication on its economy and particularly on its financial sector, a sector on which the economy relies heavily. Joining the EU would mean the end of the Swiss franc, which offers an alternative to investors who would like to diversify their investment portfolio and reduce the risk of putting their eggs in one euro basket. In addressing the possible implications, The *Economist* (2004:14-15) argues:

> Swiss banks look after about a third of all private financial assets invested across borders, much more than any other financial centre anywhere. This generates large tax revenues, which helps to keep down taxation elsewhere in the economy. It also contributes about a third of Switzerland's consistently huge current-account surplus...The Swiss franc is now the world's fifth strongest currency for international loan issues, after the dollar, the euro, the yen and sterling. Equally important, the ultra-low Swiss interest rates (three-month LIBOR, the rate at which banks lend to each other, is currently 0.25) would have to rise to European levels, increasing the cost of capital.

4.5 Labour Productivity: Switzerland

In spite of high level of economic and technological development, the country's economic performance has been weak for several years. It has been suffering from a growth deficit for a long period. Its economic performance was particularly weak in the period between 1991 and 1996, when GDP more or less stagnated. Things were similarly bad between 2001 and 2003. The reasons behind this weak growth rate are two-fold: the low utilisation of potential output across the economy as a whole and the dwindling growth of potential output itself. According to Credit Suisse Economic Research (2005:4):

> The increase in 2004 was only about 1.2 per cent, compared with more than 2 percent in the 1980s. The main cause of this reduction in the potential economic expansion rate is the low growth of labour productivity. Over the last 15 years, this has continually fallen behind that of most other industrial countries.

Table 4.2 Growth of potential output and its components (all information in %), 1992-2004

YEAR	Hours per Worker (Δs^*)	Employ-ment Rate (Δb^*)	Economic Activity rate (Δe^*)	Working-age popu-lation (Δn^*)	Volume of Work (Δh^*)	Labour Productivity (Δp^*)	Potential Output (Δy^*)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
1992	-0.28	-0.15	-.031	0.44	-0.29	1.64	**1.35**
1993	-0.29	-0.14	-0.29	0.44	-0.28	1.53	**1.25**
1994	-0.31	-0.12	-0.26	0.44	-0.25	1.46	**1.21**
1995	-0.34	-0.09	-0.21	0.44	-0.20	1.41	**1.21**
1996	-0.36	-0.06	-0.15	0.44	-0.13	1.37	**1.24**
1997	-0.38	-0.03	-0.08	0.45	-0.04	1.33	**1.29**
1998	-0.38	-0.01	-0.03	0.48	0.05	1.28	**1.33**
1999	-0.40	-0.01	0.01	0.50	0.11	1.24	**1.35**
2000	-0.42	-0.02	0.05	0.53	0.14	1.20	**1.34**
2001	-0.44	-0.03	0.06	0.55	0.15	1.16	**1.31**
2002	-0.43	-0.06	0.07	0.57	0.15	1.12	**1.27**
2003	-0.42	-0.07	0.07	0.57	0.14	1.10	**1.24**
2004	-0.42	-0.08	0.07	0.58	0.14	1.09	**1.23**
.p/a.	-0.37	-0.07	-0.08	0.49	-0.02	1.30	**1.28**

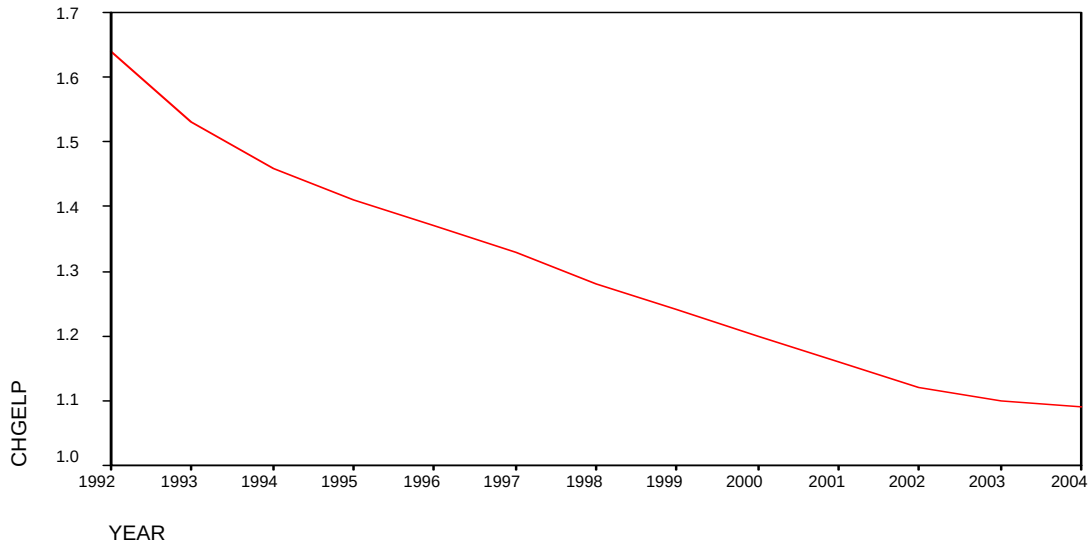
The relationship between the individual columns is as follows:

(5) = (1) + (2) + (3) + (4) (7) = (5) + (6)

Sources: Swiss Federal Statistical Office, Credit Suisse Economic Research

Table 4.2 demonstrates the performance of the individual components of potential output over the last 13 years i.e. 1992-2004. According to the estimates made by Credit Suisse Economic Research (2005:14), the growth in potential output has fallen by 0.12 percentage points to since 1992, though there was a small interim peak at the end of 1990s. Table 2 divides real-term GDP by the volume of work in order to obtain the figure for labour productivity in hours. It shows that the trend growth for this variable (Δp) has been slowing since the early 1990s.

Fig. 4.4 Growth Rates for Labour Productivity: 1992-2004



Sources: Swiss Federal Statistical Office, Credit Suisse Economic Research

Figure 4.4 depicts that labour productivity has changed very slightly since 2000. The year-on-year change in labour productivity has not made any meaningful increase since then. This low growth of labour productivity over the past 15 years (1992-2004) has been reflected in the weak economic performance of Switzerland.

It is evident that there have been changes in the Swiss economy since early 1990s. As the above figure depicts, these very changes largely dictated the country's growth trajectory. Such a weak economic performance for 15 years places a question mark over grounds for optimism in the future. In an endeavour to single out the factor behind the crises, Credit Suisse Economic Research (2005:8) explains:

> There are always lots of different explanations for a growth crisis, but it seems that the Swiss voters' 'no' to the EEA [European Economic Area] and the consequences of this rejection played a major role, as did the country's (excessive) delay in committing to a more competitive approach. The resulting disadvantages suffered by Switzerland as a business location have not yet been offset by the policy changes made in the last few years, such as the bilateral agreements with the EU [European Union] and the strengthening of competition through the revision [of] the cartel law. Clearly, Switzerland has to press ahead with further reforms if it is to overcome its persistent growth crisis.

Credit Suisse Economic Research (2005:20) has estimated Switzerland's potential growth for 2004 at 1.2 per cent, which compares with about 2 per cent in the early 1980s. They maintain that the reason for the reduction in growth potential is the fall in the growth rate for labour productivity per hour, which, according to their study, has fallen from an annual 1.6 per cent in 1992 to 1.1 per cent. They further argue that this downward trend began at the start of the 1970s and was evident in other major industrial nations such as the USA, Japan, Canada and Germany at least until the mid-1990s.

There may be several reasons as to why the downward trend in labour productivity occurred. There are three possible hypotheses for this trend change. According to the Credit Suisse Economic Research (2005:20),

> The first hypothesis assumes that there wasn't actually any slowdown in labour productivity but that mistakes in the collation of statistics merely gave this impression. In many sectors, it is extremely difficult to measure productivity; the second hypothesis focuses on the changing structure of the market. In many major industrial nations, the proportion of workers in the secondary sector has fallen while the proportion working in the tertiary sector has risen. The argument posited by the second hypothesis is that productivity gains in the services sector are generally more difficult to achieve than in the industrial sector… The final hypothesis concentrates on the importance of research and development. Many sectors have specialised heavily in terms of technology. As a result, fewer new inventions than before actually deliver a benefit across the whole economy.

According to calculations by Brunetti and Zurcher (2002, cited in Credit Suisse Economic Research, 2005:20), the average annual growth in labour productivity per hour for the [Swiss] economy as a whole between 1991 and 2000 was around 1.1 per cent. During this period, Switzerland's largest neighbours, as well as the world's major economies, recorded higher, and in some cases much higher, labour productivity growth.

4.6 Economic links between South Africa and Switzerland

South Africa is an emerging economy while Switzerland is a highly developed economy. However, both have at least two common denominators. Firstly, their economies are moving, albeit at a different pace, from goods producing to the service-providing sector. Secondly, their main trading partner is the European Union. It is, thus, possible that their individual exchange rate would take, though at different magnitudes, their cue largely from the currency of the European Union member countries, the euro. According to the Swiss Embassy (2005:1), "The South African market, by international standards, is rather small. With a population six times bigger than Switzerland, South Africa's Gross Domestic Product (GDP) is only half of the Swiss GDP."

Economic links between South Africa and Switzerland goes back to at least as early as the 1950s. According to the Swiss Embassy (2005:1):

> South Africa and Switzerland have signed a set of bilateral agreements to promote trade and investment between the two countries: air services (in force since 1959), avoidance of double taxation (in force since 1968) and investment of protection (in force since 1997)… Switzerland (as a member of the European Free Trade Association) and South Africa (as a member of the Southern African Customs Union) are busy to negotiate a Free trade Agreement.

The Agreement, which aims to promote trade in the areas of goods, services, investment, government procurement and related topics, was launched in 2002. The negotiation launched formally in 2002 between EFTA (European Free Trade Area) and SACU (Southern African Customs Union) includes areas such as intellectual property, complementation or market access for agricultural goods, which are the other topics that are dealt with in the Agreement.

In South Africa, tariffs have been reduced, and non-tariff barriers are in the process of being phased out. Moreover, foreign trade seizes an important share of the South African economy. In parallel, South African-European Trade relations are of highest importance to the South African economy. According to South African Embassy (2005: 1):

> …The comparatively high ratio of merchandise exports (25.8% in 2002) and imports (25.5%) to Gross Domestic Product (GDP)…. Of SA's [South Africa's] Total Trade in 2002 (value), 37.3% was generated with Europe. Of South Africa's Exports, 31.1% went to Europe, while European Imports to SA accounted for 44.4%.

South Africa has become the most important partner for Switzerland in the fields of trade, investment and economic cooperation on the African continent. The term of trade between the two countries is unfolding in favour of South Africa. This trade pattern between the two countries tends to push up the demand for the Rand (ZAR), the currency of the net exporter country. Thus, the increased demand for the Rand, *ceteris paribus*, also tends to strengthen the Rand, while weakening the Swiss Franc (CH). This trade phenomenon has become more vivid in the aftermath of the new dispensation. Swiss Embassy (2005:1) indicates:

> Since 2001, Switzerland faces a deficit in its trade balance with South Africa. This fact is mainly due to a 50% increase of South African exports to Switzerland since 1999. In fact, since 1994 South African exports to Switzerland have tripled. Swiss exports to South Africa are more stable, but still account for more than CHF 500 mio [million] per year. The bulk of Swiss exports are machinery (26.7%), chemical (21.6%) and pharmaceutical products (22.6%) as well as instruments (8.3%). Our bilateral trade volume is roughly equivalent to the cumulative trade-exchanges of Switzerland with the rest of Sub-Saharan Africa. First figures for 2003 show a promising picture: Despite a sluggish international economic environment, trade in both directions is increasing at a solid pace.

Table 4.3 Bilateral Trade (R' 000): South Africa and Switzerland, 2002-2004

Year	Exports	Imports	Balance
2004	7,270,604	3,095,730	4,174,874
2003	5,743,533	3,483,799	2,259,734
2002	5,567,727	4,765,871	801,856
Switzerland ranked in 2004, as one of the South Africa's largest trading partners	8	24	5

Source: Adapted from the Department of Trade and Industry, August, 2005

Table 4.3 depicts that trade between the two countries is expanding over time. It further illustrates that the terms of trade over the three years (2002-2004) has been in favour of South Africa. This favourable term of trade on the part of South Africa has been moving in both trade directions. Exports to Switzerland have increased while imports from that country have decreased in the past three years. When the overall trade sector is taken into account, Switzerland has become the fifth main trading partner of South Africa.

The ever-increasing share of the tourism sector in South African economy also coincides with the above pattern. Likewise, the above trend shows that South Africa is becoming an important hub for Swiss companies that aim at expanding their activities in the whole

Southern African region. The volume of trade is also expected to rise considerably in the near future. According to the South African Embassy (2005:3),

> Switzerland is the fifth largest foreign direct investor in South Africa with a stock of CHF 1.25 bln securing more than 25,000 workplace in the country. Since 1994, the value of Swiss direct investments in South Africa has grown by 60%. Trade volume between Switzerland and South Africa stands at CHF 1.4 bln (2003) with a trade surplus of CHF 340 mio [million] in favour of South Africa. Trade volume has grown since 1999 by more than 50%. Major South African exports to Switzerland are focussed on precious metals (i.e. platinum) and agricultural products. Major Swiss exports to South Africa include machinery, chemical and pharmaceutical products as well as technical instruments.

Looking at their economic links within the framework of investment, Swiss investments in South Africa are deemed substantial and diversified. This indicates the underlying premise that the Swiss economy is well represented in South Africa. Furthermore, the Swiss Embassy (2005:1) points out:

> The more than 250 Swiss companies active in South Africa represent more than 80% of the value of the Swiss stock exchange. Many of these companies are not just selling products but are using South Africa as platform to produce and export to markets in the region and beyond. As a result, Swiss companies offer more than 21,000 workplaces in this country. … At the same time, prominent South African owned companies, such as Richmond and De Beers are managing a number of their business activities out of Switzerland… As a tourist destination, Switzerland is the 6th most important European destination for South African tourists and business people.

As cited earlier, South African export products are not confined to primary products. In addition to the traditional export commodities, such platinum**,** manufactured or value-added goods make a growing contribution to South Africa's exports to Switzerland. These export items include prepared foodstuffs and beverages, animal products as well as machinery and electrical equipment.

As Table 4.2 and Fig. 4.3 both illustrate, the growth rate and, by implication, the labour productivity growth, of Switzerland has not been substantial. The corresponding figures for the South African economy are not significantly different from that of Switzerland either. Given the historically different levels of playing fields in the areas of economic growth and labour productivity, however, the labour productivity difference between the two economies remains wide. Notwithstanding the progress made towards greater efficiency in the South African economy, the Growth Competitiveness Index 2003-2004 (World Economic Forum, 2004:1) ranked South African competitiveness 42nd out of a total of 102 international countries in terms of its competitiveness. In sharp contrast to this, the same report places

Switzerland in the 7th position. This, in turn, reflects the wide gap prevalent between the two countries' productivity levels.

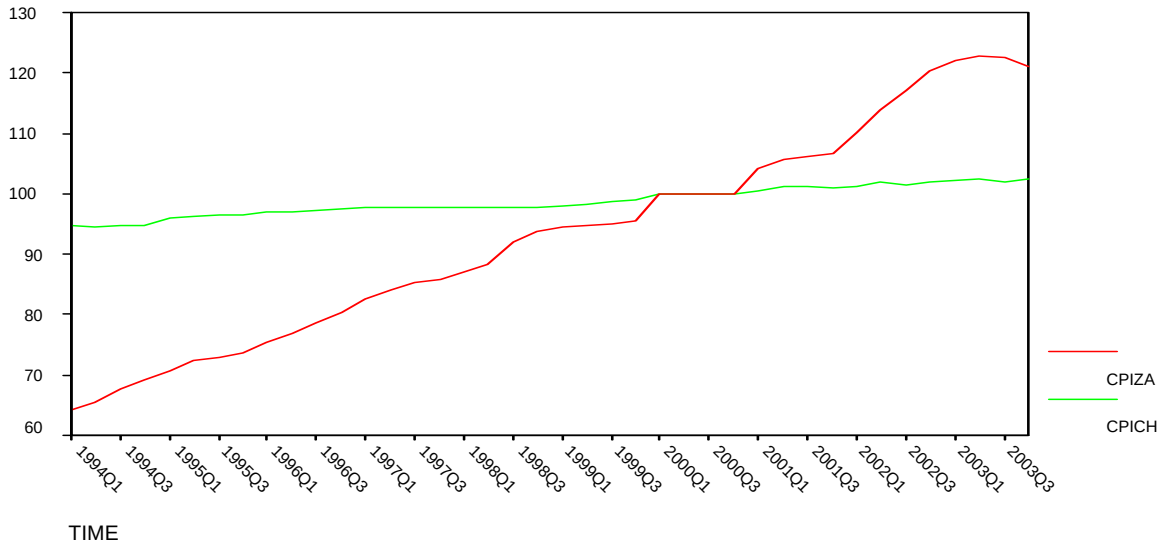
It is also important to note here that the working hours in both countries vary significantly. An average working hour per week in South Africa is less than 37. Moreover, the frequency of strikes in South Africa is not quite low. The corresponding figure for Switzerland is significantly different from that of South Africa. According to Swissworld (2002:1):

> The Swiss work a lot, an average of 42 hours a week. Full-time employees are entitled to leave of only 20 working days per year. This is less than in many other European countries. Public holidays vary from canton to canton, but there are generally 8 or 9. In 1985, the Swiss rejected a general increase in vacation entitlement from four to five weeks and in 2002, they voted against the introduction of the 36-hour week. Strikes are rare and workplace absenteeism is low.

Owing to the consistent adherence to a counter-inflationary monetary policy, the rate of increase in the consumer and production price indices has declined to considerably lower levels since the early 1990s. According to *Annual Economic Report* (1997:15):

> The consistent application of a counter-inflationary monetary policy, together with other policy developments such as improved fiscal discipline, trade liberalisation and growing competition in the domestic goods markets, improved industrial relations and some moderation of nominal wage growth have jointly and separately contributed to a decline in price inflation since the beginning of the 1990s.

Fig. 4.5 Consumer Price Indexes (CPI), South Africa and Switzerland, 1994Q1-2003Q4



Source: *Plotted based on IMF (IFS) data, August, 2005*

As Fig. 4.5 indicates, the Consumer Price Indexes of South Africa (CPIZA) and Switzerland (CPICH) have quite substantial differences between them. The CPI of Switzerland has hardly increased over the period 1994Q1 – 2003Q4. This is particularly vivid when compared to the CPI of South Africa. As it will be illustrated further in the following chapter, the inflation rate of Switzerland has been maintained at less than 2 per cent, whereas, that of South Africa has gone far beyond that. There has been virtually no rise in the inflation rate of Switzerland since the early 1990s. This inflation rate differential in between these countries plays itself into the theoretical underpinnings of PPP as well as into the study under consideration.

Though the inflation rate has been brought down to single-digit levels that last prevailed in the early 1970s, relative to South Africa's main trading partners, the current inflation rate in South Africa is still high. Furthermore, past inflation tends to feed into the subsequent wage negotiations that, in turn, contribute to quite high settlements. The recent case in point here is the acceleration in price inflation during 2002 that was precipitated by the sharp depreciation in the external value of the rand in the second half of 2001. As cited earlier, this is in sharp contrast to the inflation rate in Switzerland. The Swiss National Bank's inflation target (0-2%) has been achieved since the mid-1990s, in the aftermath of the early 1990s when inflation topped 6 ½ %.

4.7 Summary

Overall, the economies of both countries grew slightly during the period 1994-2003, despite this happening at different rates associated with infrequent interim peaks. Like all other countries, their economies have been affected by both their capacity to achieve economic growth and by the windfall and vagaries of the global economy. It is important to note here that changes in inflation rates and in exchange rates have influenced the terms of trade. During the period under study, the terms of trade have turned out to be in favour of South Africa. Given the current situation, this trend of terms of trade appears to continue in the near future.

Besides, the fact that the main trading partner of both countries is the European Union has been reflected in the swings of the external value of their currencies, as both currencies track the euro. Consequently, the actual exchange rate has affected the productivity and, hence, the competitiveness of South African exports. An important exogenous variable, labour unit cost, reflects the wage settlements, which over the study period (1994Q1-2003Q4) have often gone beyond the overall consumer price inflation. Investment has been another promising field of economic ties between the two countries. Investment as well as economic cooperation has been stable and can serve as another instrument for a wider and deeper economic links. The following chapter deals with the empirical analysis of Productivity Bias Hypothesis in PPP for South Africa and Switzerland. Accordingly, it covers the methodological aspect of the thesis and serves to identify and elaborate the type of variables, the sample size and the type of econometric techniques to be employed in such an analysis.

CHAPTER 5
EMPIRICAL METHODOLOGY AND MODEL SPECIFICATION

5.1 Introduction

Chapters 2 and 3 have visited some aspects of the literature on exchange rate determination models and Productivity Bias Hypothesis in PPP respectively. This chapter deals with the empirical methodology and model specification to be employed in the next chapter, the analysis component. Therefore, the main purpose of this chapter is, in concordance with that of the overall thesis, to outline the research methodology to be applied in empirically testing the validity of Productivity Bias Hypothesis (PBH) for South African Rand (ZAR) against the Swiss Franc (CHF).

It focuses on econometric testing of the existence and magnitude of the bias. In so doing, it carries out a test in order to explore the theoretical underpinning of the bias, determining whether disparate productivity advances between South Africa and Switzerland does lead to divergent movements in their internal price ratios. The internal price ratio is defined as the ratio of the price level of non-traded commodities to that of traded commodities (Officer, 1982: 236). In addition, it looks at a model pertaining to the establishment of long term, equilibrium, relationship between exchange rate and productivity in the two countries. Thus, the prospective finding of the thesis is expected to reflect the nature of the exchange rate relationship between the highly developed economy of Switzerland and the emerging economy of South Africa.

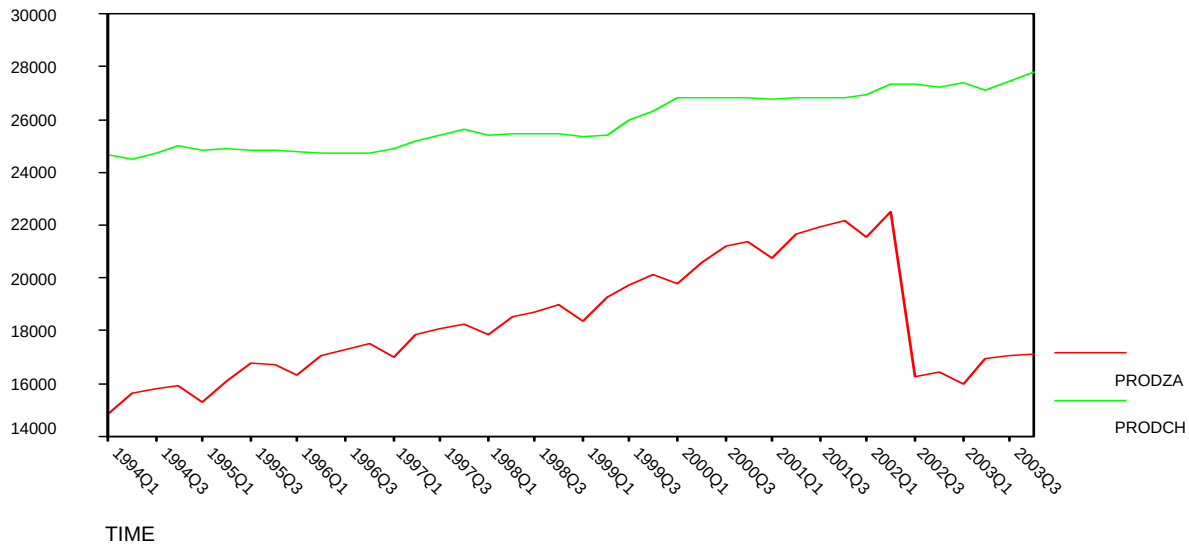
5.2 Data Description

The ideal variables to take into account in formulating the economic model are, in compliance with the literature, tradables and nontradables in both countries. This requires the classification of sectors of both economies into tradable and nontradable sectors. In other words, the traded sector should include (1) agriculture, hunting, forestry and fishing, (2) mining and quarrying, and (3) manufacturing (Officer, 1982: 219-20). The nontraded sector should encompass (1) electricity, gas and water (2) construction, (3) wholesale and retail trade, restaurants, and hotels, (4) transport, storage and communications, (5) finance, insurance, real estate, and business services, (6) community, social, and personal services, (7) government, (8) private nonprofit services to households, and (9) domestic services of households in which GDP originates (Officer, 1982:245, fn).

Though such a measure of productivity is closest to the productivity concept involved in the theoretical argument for the productivity bias, it is difficult to classify the economy of both countries in such a uniform way. This is so because, *inter alia,* the above-mentioned sectors of both countries do not fall neatly into the same category of economic classification. Furthermore, it is also difficult to determine the traded value in proportion to the overall tradable goods.

Another possible proxy for productivity is the level of per capita income of a country. It is surmised that the higher the per capita income of a country, the higher the level of productivity that it enjoys relative to other countries. Overall, countries with higher per capita income are presumed to possess higher productive capacity, productivity and better cost effectiveness in relation to other countries. However, per capita income may not reflect the magnitude of productivity fully, owing to the inclusion of part of the population that is not directly involved in productive activities. Where per-capita GDP is an acceptable concept of productivity, a better measure would be the ratio of GDP to total employment in the economy rather than to population of the country (Officer, 1982:218). Thus, the next best alternative variable, Gross Domestic Product to employment (GDP/employment) ratio, is taken in level as well as in index form to proxy the productivity variable for the analysis.

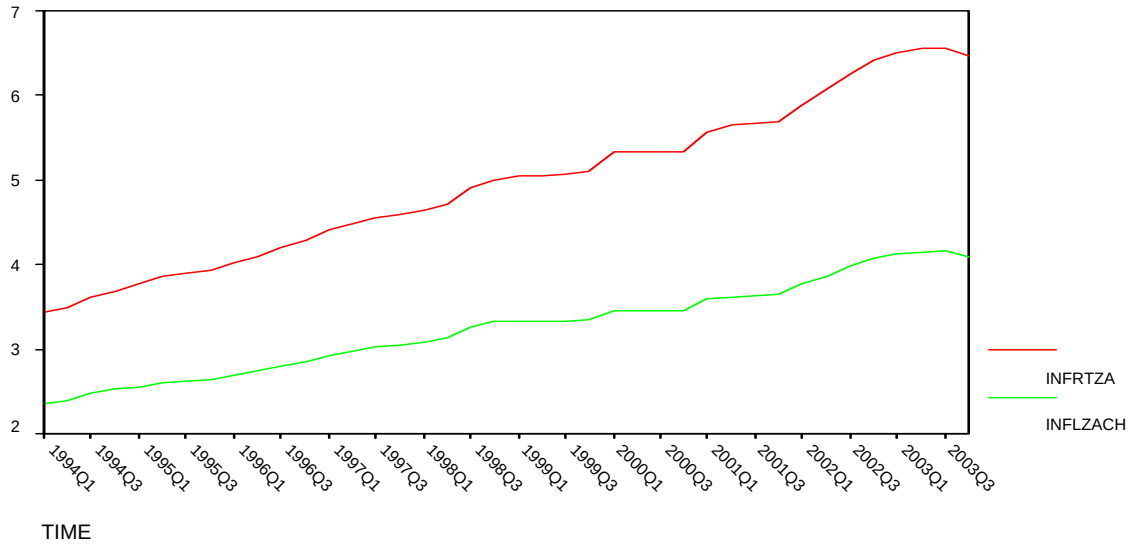
Fig 5.1 Productivity in level form: South Africa and Switzerland, 1994Q1-2003Q4



Source: *Plotted based on IMF (IFS) data, August, 2005 and on SARB website*

As Fig. 5.1 indicates productivity in level form for both countries South Africa and Switzerland. Productivity of each country is computed as a ratio of gross domestic product to employment in the respective country. One can see the wide difference of productivity between the two countries.

Fig. 5.2 Inflation rates (CPI% change): South Africa and Switzerland, 1994Q1-2003Q4



Source: *Plotted based on IMF (IFS) data, August, 2005*

Fig. 5.2 indicates the inflation rates of both countries. The Consumer Price Index of each country has been taken as a proxy for inflation rate. Likewise, one can also see the wide difference in the inflation rates of the two countries.

Regarding the data collection, the monthly data on exchange rate for the period 1994:1-2003:12 (to be extrapolated into quarterly data) is available from the South African Reserve Bank (SARB) Quarterly bulletin. The data on South African GDP is available on quarterly bases in the International Financial Statistics (IFS) Yearbook of International Monetary Fund (IMF). However, it has not been employed here because of some inconsistency between the quarterly and yearly data. Hence, the GDP for South Africa has been captured from South African Reserve Bank (SARB). The inflation rates of both countries i.e. CPI% changes have been collected from the IFS website. Accordingly, the employment level has been obtained from the same IFS website. The data on GDP and employment indexes for Switzerland as well as the data on employment index for South Africa have been collected from the same source in IFS.

5.3 Model Specification

The model employed will apply a time-series approach rather than a cross-section one. In the time series approach, the model relates current values of the regressand (dependent variable), for instance, the ratio of price to exchange rate to its past values as well as past values of the regressor (independent variable) i.e. productivity to be forecast as well as the values of current and past random errors. Thus, models that relate the current values of two variables to their past values and current and past errors are called bivariate models. In this time series analysis, cointegration test will be carried out. Economically speaking, two variables are said to be cointegrated if they have a long-term, or equilibrium, relationship between them (Gujarati, 2003:822).

As cited earlier, the second variable, GDP/employment in level and indices form is a finer measure as compared to the real GDP variable taken alone. Thus, the thesis will interchangeably apply alternative variables i.e. GDP/employment ratio and GDP/employment indices to proxy productivity. In its approach of examining the real shock in the form of productivity growth in South Africa and Switzerland, this chapter makes use of GDP/employment ratio in level and indices forms for the independent variable to measure for the single-measure productivity, labour productivity.

In computing the PPP, it will employ inflation rate (Consumer Price Index percentage change) of the respective country in dealing with the equilibrium exchange rate in level form. In contrast, it will take the GDP Deflator of respective country in computing the PPP in index form. Besides, labour productivity, rather than capital productivity, is taken in view of examining the impact of relatively immobile factor of production.

In order to examine the impact of the productivity bias on PPP, the method of testing employed will fit the following regression equation by Ordinary Least Squares (OLS):

$PPP_t/R_t = \alpha + \beta\ Prod_t + \varepsilon_t$

The following chapter treats the variables in level and indices forms separately. The variables in level form will be dealt with at first, subsequently followed by the variables in indices form. In so doing, the model tests whether the estimate of β is significantly different from zero. Upon performing the analysis, the research will also compare the results obtained from

both methods: levels and indices. Accordingly, the following model is formulated for the variables in level form:

$PPP_t/R_t = \alpha + \beta\ Prod_t + \varepsilon_t$

- where

PPP_t = purchasing power parity defined as a number of units of domestic currency (ZAR) per unit of a standard currency (CHF). PPP is computed as the ratio of inflation rates of both countries ($Infrat_{ZA}/Infrat_{CH}$). Consumer Price Index (CPI) percentage change is taken as a proxy for inflation rate.

R_t = actual exchange rate, number of units of domestic currency (ZAR) per unit of standard currency (CHF)

$Prod_t$ = ratio of productivity in South Africa (ZA) to productivity in Switzerland (CH).

ε_t = an error (residual) term

Thus, $PPP_t = \dfrac{(Infrat_{ZA}/Infrat_{CH})}{R_{ZA,CH}}$

$= \dfrac{\text{CPI\% change of South Africa/CPI\% change of Switzerland}}{R_{ZA,CH}}$

- where $Infrat_{ZA}$ = inflation rate in South Africa and

$Infrat_{CH}$ = inflation rate in Switzerland

Accordingly, the foreign exchange rate of monthly middle rates, aggregated into quarterly data, will be used as a proxy for the exchange rate. GDP/ Employment ratio will be used as a proxy for productivity in the level form. Inflation rate (CPI% change) of both countries will be used to proxy price changes in respective countries.

On the type of exchange rate to be applied, Officer (1976a:36) argues that the exchange rate (R) used in the dependent variable should be the equilibrium value of the exchange rate, as the productivity bias refers to the relationship between PPP and the *equilibrium* exchange rate. In compliance with the caveat underscoring the need for use of the equilibrium exchange rate, the South African GDP/employment in ZAR has been divided by its equilibrium exchange rate against ZAR, rather than the exchange rate, R, in comparing it with the Swiss GDP/employment. Hence, the figure **2.349** has been taken as an equilibrium exchange rate ($EQLR_{ZA,CH}$) in computing the PPP. This figure is singled out for the reason that it is the rate that brings the PPP very close to one.

In parallel, a relatively distinct model is formulated for variables in indices form. There is controversy concerning the use of PPP versus R in converting the income of an individual country (to be used in the productivity variable) from domestic currency to the standard currency. In a time series analysis, such as the case in point, this issue can be resolved by relying upon the productivity indices that are said to be unit free. According to Bahmani-Oskooee (1992:229-30):

> Using productivity indices rather than the productivity levels only change the *size* of the estimated coefficient with which the cointegration techniques is not concerned. Neither the *sign* nor the *statistical properties* of the estimated coefficient such as t-ratio, D.W statistics etc., are affected by indexing.

The following model is formulated for the variables in indexes form:

$PPP_t/R_t = \alpha + \beta\ Prod_t + \varepsilon_t$

- where

PPP_t = purchasing power parity defined as the ratio of South African GDP Deflator to the GDP Deflator of Switzerland. The GDP Deflators refer to constant prices (2000 = 100).

R_{ZACH} = actual exchange rate, number of units of domestic currency (ZAR) per unit of Standard currency (CHF) in indexes (2000=100)

$Prod_t$ = ratio of productivity index in South Africa (ZA) to productivity index in Switzerland (CH), both indexes in constant prices (2000=100)

- where productivity index in South Africa = GDP index/employment index and productivity index in Switzerland = GDP index/employment index

ε_t = an error (residual) term

As in the case of level form, foreign exchange of monthly middle rates that are the foreign exchange rate of monthly middle rates aggregated into quarterly data will proxy the variable exchange rate, but in index form. Likewise, GDP/ Employment ratio in index form will be used to compute productivity proxy. PPP will also be computed based on GDP Deflator and exchange rate indexes.

The methodology under consideration will employ time series techniques of cointegration for the sample period 1994Q1 – 2003Q4 in 40 observations in order to observe the inter-temporal dynamics. To be specific, it will carry out graphical analysis, sample correlogram test for

autocorrelation, as well as Dickey Fuller (DF) in order to test the unit root or (non) stationarity of the above-mentioned macroeconomic variables. The following chapter will also establish whether the PBH is a long-run phenomenon using the techniques of cointegration.

5.4 Estimation and Inference Procedures for levels and indices

For all the dependent and independent variables in levels and indices, informal methods of identifying the (non) stationarity such as the graphical analysis will depict the level and differenced forms; whereas, the sample correlogram test will illustrate the sample correlation function using the lag-length that extends to a roughly one-third of the length of time series. In unit root testing, the pure random, drift and trend scenarios will be applied using the DF test, prior to carrying out cointegration test.

Engle and Granger developed the cointegration approach or technique in 1987. The widely used version of the Dickey-Fuller test for (non) cointegration, due to Engle and Granger (1987), is the first stage of what is known as the two-stage Engle-Granger procedure. Engle and Granger (1987, cited in Bahmani-Oskooee, 1992:230) define a non-stationary time series X_t to be integrated of order *d* if it takes *d* times to difference X_t in order to achieve stationarity in it. This notion is usually denoted by $X_t \sim I(d)$. As one considers two series X_t and Y_t that are both integrated of the same order *d*, i.e. $X_t \sim I(d)$ and $Y_t \sim I(d)$, X_t and Y_t are said to be contegrated if in the simple regression of X_t on Y_t , the residuals are I (*d*-*b*) where $b > 0$. Put differently, *d* stands for the order of integration of the variables and *b,* for the reduction in order of integration produced by the linear combination, which then has order of integration $d - b$.

Therefore, testing for cointegration is basically reduced to taking three simple steps. First step is to test and make sure that both series are integrated of the same order, i.e., $X_t \sim I(d)$ and $Y_t \sim I(d)$. Second step is to estimate the following regression equation (known as cointegration equation) by OLSQ:

$X_t = \alpha_1 + \beta_1 Y + \nu_t$

The third step is to test for stationarity of the residuals from the equation to make sure that $\nu_t \sim I(d\text{-}b)$. Thus, if, for instance, X_t and Y_t are both I (1), then ν_t must be I (0) to conclude that the two time series are cointegrated.

It is also important to note here that testing for cointegration is only one part of a strategy for model building. The presence of cointegration justifies the need for going further in order to estimate not only the cointegrating - or equilibrium – relationship but also the dynamic relationship that incorporates both the equilibrium and the short-run adjustments process. This is the second stage of the Engle-Granger two-stage procedure, in which an error, or more precisely, equilibrium correction model is estimated. Estimating the equilibrium relationship is one, but by no means the only part of the aim of empirical model building. Typically, in a changing environment, adjustment takes time and it has to be modelled. The Error Correction Mechanism (ECM) first used by Sargan and later popularised by Engle and Granger corrects for disequibrium (Gujarati, 2003: 824-5). According to Patterson (2000:341), ECM [Error Correction Models], incorporates two key elements:

1) Adjustment to lagged disequilbirum so that, given no other change, equilibrium is gradually achieved.
2) Adjustment to contemporaneous changes in the variables that determine equilibrium.

Through ECM, Granger's representation theorem shows that the important link between the existence of cointegration and an error correction specification.

Besides, as a prelude to the discussion of the estimated regression results pertaining to Productivity-Bias Hypothesis, it is imperative that the econometric testing procedures are identified for autocorrelation. These tests will be performed with the aim of validating the results found. The major test that will be accomplished in this regard is the Durbin and Watson *d* test for autocorrelation. One of the assumptions of the Classical Linear Regression Model (CLRM) states that there is no autocorrelation between the disturbances. According to Gujarati (2003:442):

> Correlation may be defined as the correlation between members of series of observations ordered in time [as in time series data] or space [as in cross-sectional data]. Put simply, the classical model assumes that the disturbance term relating to any observation is not influenced by the disturbance term relating to any other observation.

As in the case of heteroscedasticity, in the presence of autocorrelation, OLS estimators are still linear unbiased as well as consistent and asymptotically normally distributed, but they are no longer efficient i.e. minimum variance (Gujarati, 2003: 454). In the presence of first-order serial correlation or autocorrelation, the method of Generalised Least-Squares (GLS) will be applied in order to obtain a more efficient estimator. Thus, if an estimated regression is flawed with autocorrelation, the method of GLS will be employed as a remedial measure in order to cater or correct for autocorrelation and provide estimated results that are now BLUE.

Finally, a unit root test in the residuals that are computed based on the index form will be carried out by means of the Cointegrating Regression Durbin-Watson (CRDW) test, based on the Durbin-Watson statistic. In parallel, this test of (non) cointegration assesses whether PPP and labour productivity differentials in both countries have a long term, equilibrium, relationship for the period covered in the time series analysis. In the chapter forthcoming, comparison will be made between the results obtained from the variables in level and index forms based on equilibrium exchange rate and GDP Deflator indexes. The analysis and interpretation to be carried out will be based upon results obtained from one of the most common statistical programmes, *The Statistical Package for the Social Sciences* or SPSS.

CHAPTER 6
ANALYSIS AND FINDINGS

6.1 Introduction

Based on the empirical methodology and model specification formulated on the previous chapter, this chapter performs the analysis component of productivity bias hypothesis in PPP for South Africa and Switzerland. It undertakes econometric investigation into whether there is a cointegration, long-term or equilibrium, relationship between the PPP and the productivity variables. In order to determine the existence of cointegrating relationship between these two variables, the analysis makes use of cointegration test based on Engle-Granger method. Prior to that, however, the analysis carries out both methods of testing stationarity. In its informal methods, it plots both time series on level and differenced forms as well as it displays sample correlogram for observing the autocorrelation. In its formal methods, it performs the unit root test (Dickey-Fuller) test of stationarity.

More importantly, it follows a similar procedure for time series in level forms and in index forms. The first section of this chapter examines the time series in level form; whereas, in its second section it examines the time series in index form. Firstly, in dealing with the level form, it computes the dependent variable, PPP, by taking the ratio of CPI% change of South Africa to CPI% change of Switzerland and divides it by the actual exchange rate (number of units of South Africa rand (ZAR) per unit of Swiss franc (CHF).

In parallel, in calculating the independent variable, it takes the ratio of productivity in South Africa to the productivity in Switzerland. However, it picks the equilibrium exchange rate in converting the productivity of South Africa measured in Rand to its corresponding value in Swiss franc. In other words, it takes the ratio (CPI% change of South Africa to CPI% change of Switzerland) and divides it by the exchange rate that makes the PPP equal or very close to 1 and uses this rate (**2.349**) to compute the productivity in South Africa in terms of the standard currency. It is worthwhile to note here that the productivity variable of each country, in itself, is computed as the ratio of GDP to employment levels in the respective country.

Secondly, this chapter makes use of the index form in computing the PPP and productivity. In dealing with the dependent variable, the PPP, it takes the ratio of South African GDP Deflator to the GDP Deflator of Switzerland. The GDP Deflator of each country refers to constant prices (2000:100). Likewise, the exchange rate and productivity variables are taken in their index form. It may also be important to indicate here that the productivity index, in itself, is the ratio of GDP index/employment index of the respective country. Thus, this (second) model computes its dependent variable (PPP/R) as the ratio of PPP to the exchange rate with both the numerator and denominator in index form. The model computes its independent variable, productivity, as the ratio of productivity index in South Africa (ZA) to productivity index in Switzerland (CH), both indexes in constant prices (2000=100). Obviously, the constant and error terms are also included.

6.2 Tests for Stationarity: Based on Equilibrium Exchange Rate in level form

Prior to engaging on tests for stationarity, it may be useful to explain the need for stationary time series using data generating process. Given $y = \rho y_{t-1} + u_t$, current values of the variable, y_t, depend on last period's value, y_{t-1}, plus a disturbance term, u_t. The latter variable incorporates all other random or stochastic influences. It is expected that this disturbance term comprises *n* random numbers drawn from a normal distribution with mean equal to 0 and variance σ^2. As we shall see later, y_t will be stationary if $|\rho| < 1$. However, if $|\rho| = 1$, y_t will be non-stationary. There is a tendency in stationary time series to revert to its mean value and move around it within a more-or-less a constant range, an indication that it has a finite variance. In contrast, a non-stationary time series has a different mean at different points in time, indicating variance rise in tandem with the sample size. By implication, the concept of mean value becomes not applicable here.

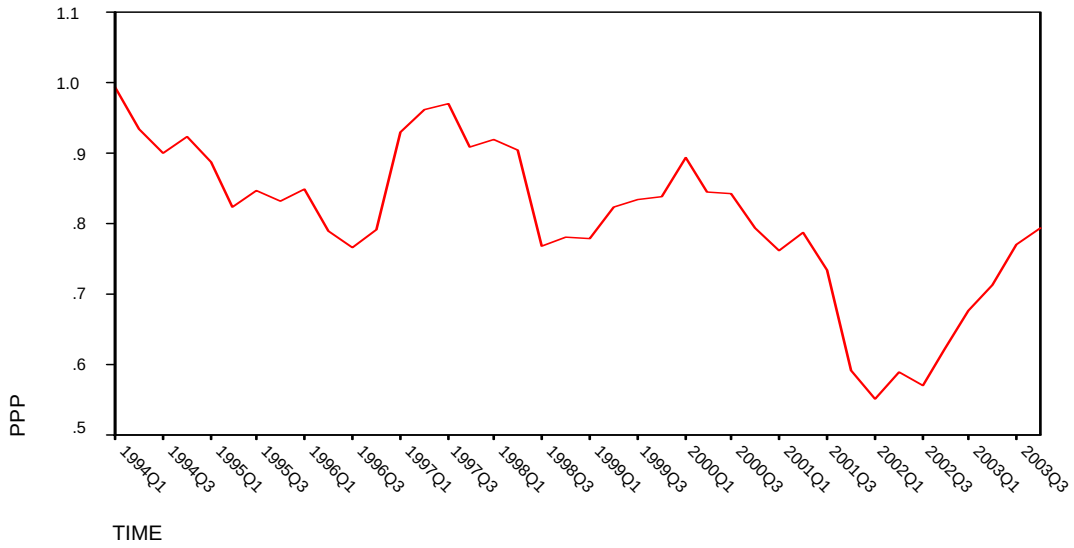
Many of the results obtained from estimation based on the conventional T and F statistics are misleading. To be specific, the existence of high R^2 may result in spurious or meaningless regression. Thus, estimation of such a process requires that economic variables be a stationary time series. In expounding the need for classifying time series as stationary or non-stationary, Gujarati (2003:798) argues:

> This is because if a time series is non-stationary, we can study its behaviour only for the period under consideration. Each set of time series data will, therefore, be for a particular episode. As a consequence, it is not possible to generalise it to other time periods. Therefore, for the purpose of forecasting, such (non-stationary) time series may be of little practical value.

6.2.1 Visual Inspection

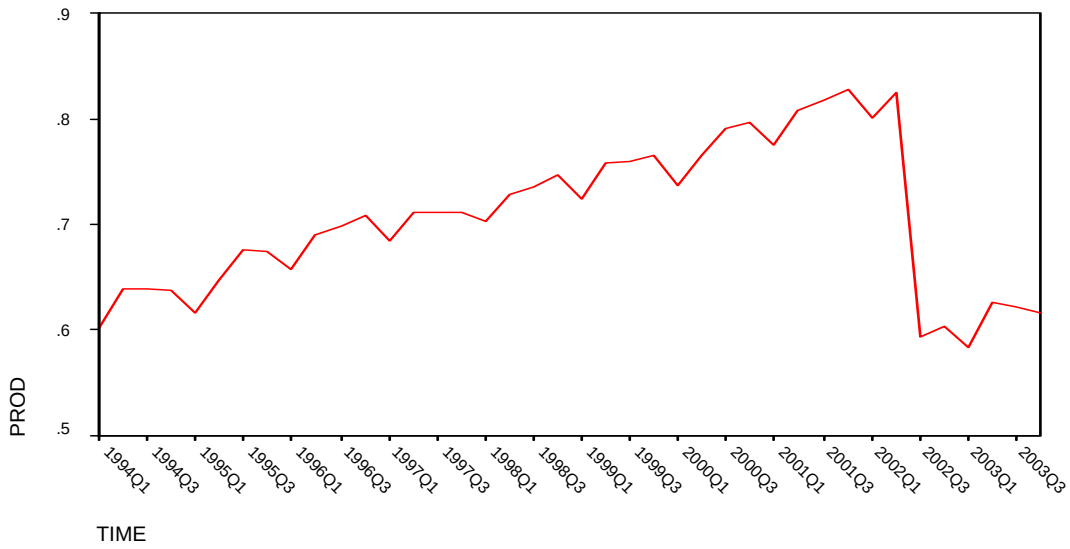
A visual inspection of the above data, illustrated in Fig. 6.1 and Fig. 6.2 on PPP and productivity respectively provide a general picture of time series analysis. There is an indication from the plotting of these series that there is a general tendency for the productivity and PPP to trend upwards and downwards respectively over time. They slowly wander upwards or downwards, but they have no real or definite pattern. A possible explanation of the upward and downward trend in Productivity and PPP respectively is that the realisations are outcomes from a stochastic process where the mean is increasing or decreasing over time. Fig. 6.1 and Fig 6.2 indicate that the realisation observed do not support the idea that the mean of both series productivity and PPP are constant for **t** = 1994Q1 to 2003Q4.

Fig. 6.1 PPP in level form, 1994Q1-2003Q4



These time series appear to be pure random walk. The productivity variable (ratio of productivity of South Africa to the productivity of Switzerland) plunged around mid 2002. This may be explained by, *ceteris paribus*, the volatility of the external value of the rand and, thus, its simultaneity effect on productivity. The exchange rate of the rand declined precipitously against almost all currencies during 2001, but recovered quite strongly in the first quarter of 2002. Consequently, the recovery in the exchange value of the Rand reduced the international competitiveness of South African exports. On the other hand, the growth rate in productivity was low during this period. The visual inspection of these time series can be presumed as a first indicator of non-stationarity, though not a conclusive one. This graphical analysis provides us with at least a hint that both variables may be non-stationary, a motivation to undergo another technique in search of better accuracy.

Fig. 6.2 Productivity in level form, 1994Q1-2003Q4



Pure random walk or Random Walk Model (RWM) without a drift or constant is non-stationary. Mostly, however, it turns stationary when differenced once or twice. The mean of the differenced PPP series is now about constant, even though the variance indicates unusually high outliers in the 13th (1997Q1) observation and unusually low in the 19th (1998Q3) and 33rd (2002Q1) observations. Likewise, the mean of the differenced productivity is now almost constant, in spite of the fact that the variance turned unusually low in the 35th (2002Q3) and 37th (2003Q1) observations.

Fig. 6. 3 PPP in differenced form, 1994Q1-2003Q4

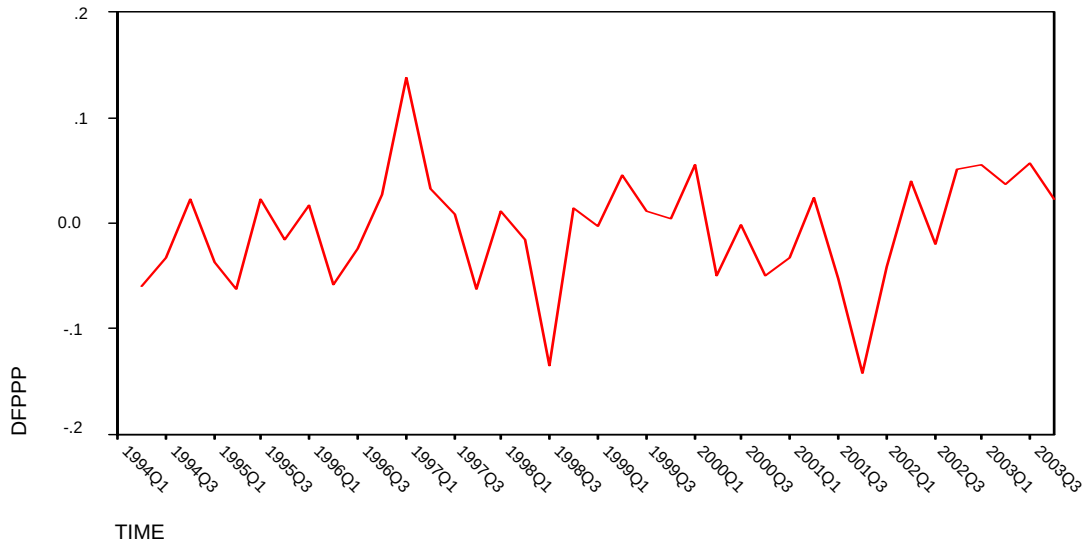
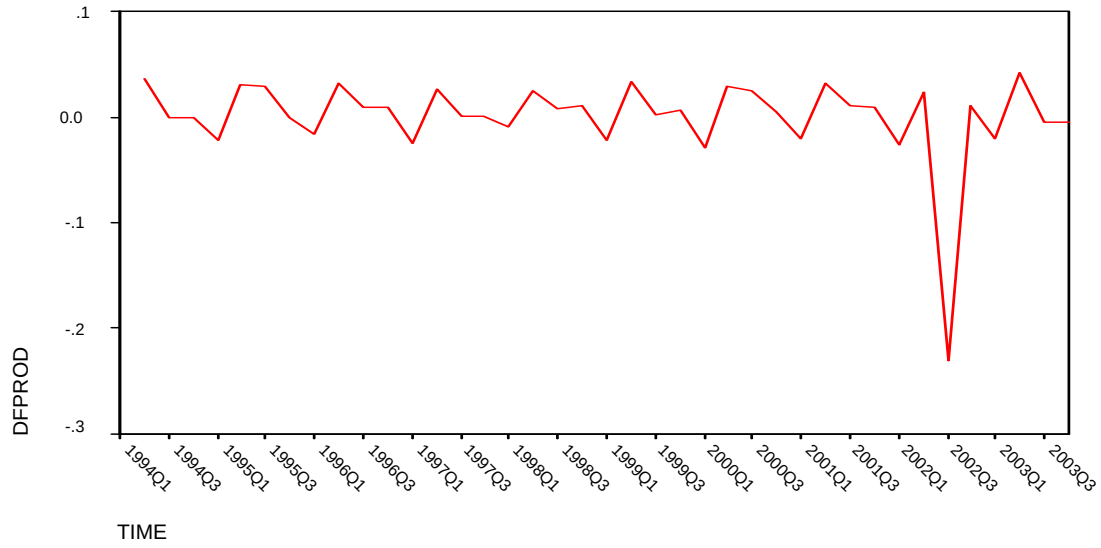


Fig. 6.3 and Fig. 6.4 depict the first differences of Swiss-South African PPP and Productivity. Considering these figures, there is now not a tendency, as it was the case in the *level* form, for the series to increase or decrease over time. When differenced, each series does have a zero mean and a constant variance. In both cases, the amplitude of the movement does not go far away from, rather hovers around, the mean. The realisations may deviate for a while, but they tend to bounce back to the mean i.e. I (0) series.

Fig. 6. 4 Productivity in differenced form, 1994Q1-2003Q4



6.2.2 Sample Correlogram

Another less formal test of stationarity is based on a sample correlogram, which is a plot of estimated ρ_k ($\hat{\rho}$), an autocorrelation of order *k*, against *k*. Autocorrelation (ρ_k), with limits $-1 \leq \rho_k \leq +1$, is a simple extension of the ordinary correlation coefficient applied to a single time series and its lags. By telling how much correlation exists, the autocorrelation function, through its estimate of autocorrelation known as sample autocorrelation function, implicitly can help in detecting the interdependence between neighbouring data points in both series, the PPP and Productivity. A plot of the autocorrelation of a series is a useful descriptive device in assessing whether a particular time series is consistent with random walk. This plot illustrates whether or not the effect of a shock, say, period 1 is persistent.

As to the choice of lag length, the rule of thumb that extends the limit up to one third of the length of the length of time series is taken (Gujarat, 812:2003). The estimated

autocorrelation coefficient for the PPP_t starts at a high level (.852), shrinks gradually, and approaches close to zero at PPP_{t-7} (.027), PPP_{t-8} (.028) and PPP_{t-9} (.042). At these levels, the current values have little or no link with their lagged values. If $\hat{\rho}$ does not fall off quickly as *k* increases, this is an indication of non-stationarity (Pindyck, 1991:449). This tapering of the autocorrelation indicates that the values further in the past are less correlated with the current value.

Likewise, the estimated autocorrelation coefficient for the productivity variable starts at a fairly high level (.777), but less than that of the PPP (.852), and shrinks slowly and approaches close to zero at $Prod_{t-7}$ (-0.030), $Prod_{t-8}$ (-.051) and $Prod_{t-8}$(.096). The dying out of the autocorrelation in productivity hints that the values further in the past are less linked with the current value that the values of PPP are. (See Appendix A: 1) Though the ρ_k has not died out in the same magnitude, as it was the case in PPP, it appears from the sample correlogram that both the PPP and productivity are non-stationary time series. It is important to note here that each process mentioned above has an infinite memory. The current values of the process for PPP and Productivity depend on all past values, although the magnitude of this dependence declines with time. Both time series may be nonstationary in mean or variance or both.

6.2.3 Dickey Fuller (DF) Test for stationarity : Based on Equilibrium Exchange rate

So far, the graphical analysis and sample correlogram test signal the nature of (non) stationarity of the time series of variables involved. Both time series variables in level form have found to be non-stationary; however, their differenced forms have turned stationary. However, another test has gained widespread popularity – unit root test, also known as the Dickey-Fuller (DF) test. The DF test caters for the three different forms of a random walk processes; namely, pure random walk (without a drift or a constant), random walk with a drift (a constant) and random walk with drift around deterministic trend. Generalised Least Square (GLS) method is applied on the unit root stochastic processes that can serve as a starting point.

$PPP_t = \rho\, PPP_{t-1} + \varepsilon_t$

$Prod_t = \rho\, Prod_{t-1} + \varepsilon_t$

-where $\varepsilon_t \sim$ iid $(0,\delta^2)$ referring to white noise error term. If $\rho = 1$, it indicates the presence of a unit root or a random walk model without a drift, which indicates non-stationary stochastic process. By subtracting PPP_{t-1} from both sides of the equation, the following is obtained:

$PPP_t - PPP_{t-1} = (\rho - 1)\, PPP_{t-1} + \varepsilon_t$

$\Delta PPP_t = \delta\, PPP_{t-1} + \varepsilon_t$

Where $\delta = (\rho - 1)$ and Δ is the first-difference lag operator.

Since the data have 40 quarterly observations, the critical value of 50 observations in the Dickey-Fuller table is taken, as this figure is the closest one to the sample size. With the relationship between ρ and δ i.e. $\delta = (\rho - 1)$ in mind, the null and alternative hypothesis for the three scenarios (a pure random, random walk with drift, and a random walk with deterministic trend) can be designed as follows:

H_0: $\delta = 0 \rightarrow \rho = 1 \rightarrow$ unit root $\rightarrow$ non-stationarity

H_1: $\delta < 0 \rightarrow \rho < 1 \rightarrow$ no unit root $\rightarrow$ stationarity

6.2.3.1 Dickey Fuller (DF) Test for PPP

In order to see whether the estimated ρ is statistically equal to one, differenced PPP (ΔPPP_t) is regressed on its (one period) lagged value (δPPP_{t-1}). If it is so, then PPP_t is non-stationary. Accordingly, the three forms will have the following equations:

A pure random walk: $\Delta PPP_t = \delta\, PPP_{t-1} + \varepsilon_t$

A random walk with drift: $\Delta PPP_t = \alpha_1 + \delta\, PPP_{t-1} + \varepsilon_t$

A random walk with deterministic trend: $\Delta PPP_t = \alpha_1 + \alpha_2 t + \delta\, PPP_{t-1} + \varepsilon_t$

- where $\delta = (\rho - 1)$ and Δ is the first-difference lag operator.

Thus, following similar procedure, equations for the productivity variable can be established for the above-mentioned three different forms. To proceed to estimation and interpretation, the first difference of PPP_t (DIFFPPP) is regressed on its lagged value (LGPPP) and it has provided the following result:

$\Delta PPP_t = -.009 PPP_{t-1}$

In this no constant, no trend scenario, the 1, 5 and 10 per cent critical values (-2.6, -1.95 and -1.61) respectively, in absolute terms, exceed the computed tau (τ) value -.861. The estimated coefficient of PPP_{t-1} (lagged value of PPP), which in this case is δ, is not statistically

significantly different from zero. Thus, we fail to reject the null hypothesis that $\delta = 0$ implying that the process is rather non-stationary.

In the second scenario, in which there is a constant but no trend, the 1, 5 and 10 percent critical values (-3.58, -2.93 and -2.60) respectively, in absolute terms, exceed the computed tau (τ) value -.2.002.

$\Delta PPP_t = .114 \; -.147PPP_{t-1} + \varepsilon_t$

The estimated coefficient of PPP_{t-1} (lagged value of PPP), which in this case is δ, is not statistically significantly different from zero. Thus, the null hypothesis is not rejected because of the indication of the presence of non-stationarity.

In order to explore the presence of a differenced stationary, the equation in the level form has been differenced twice. In the same scenario, the 1, 5 and 10 percent critical values, in absolute terms, exceed the computed tau (τ) value -1.954.

$\Delta^2 PPP_t = .112 \; -.145PPP_{t-2} \; + \varepsilon_t$

The estimated coefficient of PPP_{t-1} (lagged value of PPP), δ, is not statistically significantly different from 0. Thus, the null hypothesis is not rejected because of the indication of the presence of non-stationarity.

In the third scenario, in which there is a constant and trend, the 1, 5 and 10 percent critical values (-4.15, -3.50 and -3.18) respectively, in absolute terms, exceed the computed tau (τ) value -1.876.

$\Delta PPP_t = .172 \; - .692t \; -.201PPP_{t-1} + \varepsilon_t$

The estimated coefficient of PPP_{t-1} (lagged value of PPP), δ, is not statistically significantly different from zero, as a result of which the null hypothesis is not rejected.

Comparing the informal and formal tests for stationarity of the PPP, the realisations or outcomes are similar. In level form of variables, the non-stationarity nature of the PPP has been depicted by graphical method as well as by its residual values in sample correlogram. The unit root test has shown that PPP is not a difference stationary, either. Put slightly differently, the non-stationary PPP could not turn stationary when differenced. This is in

contrast to the inherent behaviour in most macroeconomic variables that turn stationary when differenced.

It is possible that PPP is a trend stationary process (TSP) rather than difference stationary process (DSP). In order to avoid over differencing i.e. treating a trend-stationary process (TSP) as difference-stationary process, there is a simple way of detecting the nature of stationarity in transforming nonstationary time series (Gujarati, 2003: 820-1). Regressing the time series on time enables to examine whether the residuals from this regression are stationary i.e. trend stationary. Accordingly, the regression runs as follows:

$PPP_t = \alpha + \alpha_2 \mathbf{t} + \varepsilon_t$

- where PPP_t is the time series under study and where t is the trend variable measured chronologically.
- $\hat{\varepsilon}_t = (PPP_t - \hat{\beta}_1 - \hat{\beta}_2 \mathbf{t})$

$\Delta \hat{\varepsilon}_t = \delta \hat{\varepsilon}_{t-1}$

$= -.207 \hat{\varepsilon}_{t-1}$

In the above regression, the computed tau (τ) value -1.977 exceeds, in absolute terms, the 5 and 10 per cent critical values (-1.95 and -1.61) respectively. The estimated coefficient of PPP_{t-1} (lagged value of PPP), δ, is statistically significantly different from zero. Thus, the null hypothesis δ = zero, implying that process is non-stationary is rejected. The regression result has shown that PPP_t is a trend stationary and not a difference stationary. Thus, $\hat{\varepsilon}_t$ is a (linearly) detrended time series. It can be concluded that the informal and formal tests for stationarity of the PPP have similar outcome realisations.

6.2.3.2 Dickey Fuller (DF) Test for Productivity

Following similar procedure, equations for the productivity variable are formulated for the three versions. To proceed to estimation and interpretation, the first difference of productivity (DIFFPROD) is regressed on its lagged value (LGPROD), providing the following result:

$\Delta Prod_t = .001 Prod_{t-1}$

The null and alternative hypotheses applied earlier on the PPP are also used in treating the productivity variable in the three scenarios (a pure random, random walk with drift, and a random walk with deterministic trend) as follows:

H_0: $\delta = 0 \rightarrow \rho = 1 \rightarrow$ unit root $\rightarrow$ non-stationarity
H_1: $\delta < 0 \rightarrow \rho < 1 \rightarrow$ no unit root $\rightarrow$ stationarity

Thus, in this no constant, no trend scenario, the 1, 5 and 10 per cent critical values, in absolute terms, exceed the computed tau (τ) value -.140. The estimated coefficient of $Prod_{t-1}$ (lagged value of productivity), δ, is not statistically significantly different from 0. Thus, the null hypothesis is not rejected, implying that the process is rather non-stationary.

In the second scenario in which there is a constant but no trend, the 1, 5 and 10 percent critical values, in absolute terms, exceed the computed tau (τ) value -.2.016.
$\Delta\ Prod_t = .114 - .191\ Prod_{t-1}$

The estimated coefficient of $Prod_{t-1}$ (lagged value of productivity), δ, is not statistically significantly different from 0. Thus, the null hypothesis is not rejected because of the indication of the presence of non-stationarity.

In order to explore the presence of a differenced stationary, the equation in the level form has been differenced twice. In the same scenario, in which there is a constant but no trend, the 1, 5 and 10 percent critical values, in absolute terms, exceed the computed tau (τ) value -2.066.
$\Delta^2 Prod_t = .112 - .201 Prod_{t-2} + \varepsilon_t$

The estimated coefficient of $Prod_{t-1}$ (lagged value of productivity), δ, is not statistically significantly different from 0. Thus, the null hypothesis is not rejected because of the indication of the presence of non-stationarity.

In the third scenario in which there is a constant and trend, the 1, 5 and 10 percent critical values, in absolute terms, exceed the computed tau (τ) value -1.657.
$\Delta\ Prod_t = .128 - .692t - .167 Prod_{t-1} + \varepsilon_t$

The estimated coefficient of $Prod_{t-1}$ (lagged value of Productivity), δ, is not statistically significantly different from zero, as a result of which the null hypothesis is not rejected.

Comparing the informal and formal tests for stationarity of the productivity, the realisations or outcomes are similar. In level form of variables, the non-stationarity nature of the productivity variable has been depicted by graphical method and by the residual values in the sample correlogram. The unit root test has shown that productivity is not a difference stationary either. In other words, the non-stationary productivity could not turn stationary when differenced, as it was the case in the PPP.

However, it is possible that productivity, like its dependent variable, PPP, is a trend stationary rather than difference stationary. In order to avoid over-differencing i.e. treating a trend-stationary process (TSP) as difference-stationary process, the procedure applied on PPP has also been used. The time series was regressed on time series; the residuals were saved and tested whether they were stationary. Accordingly, the regression runs as follows:

$Prod_t = \alpha + \alpha_2 \mathbf{t} + \varepsilon_t$

- where $Prod_t$ is the time series under study and where *t* is the trend variable measured chronologically.
- $\hat{\varepsilon}_t = (Prod_t - \hat{\beta}_1 - \hat{\beta}_2 \mathbf{t})$.

$\Delta \hat{\varepsilon}_t = \delta \hat{\varepsilon}_{t-1}$

$= -.178 \hat{\varepsilon}_{t-1}$

In the above regression, the computed tau (τ) value -1.782 exceeds, in absolute terms, the 10 per cent critical value (-1.61). The estimated coefficient of $Prod_{t-1}$ (lagged value of Productivity), δ, is statistically significantly different from 0, implying that the process is rather stationary. The regression result has shown that $Prod_t$ is a trend stationary. Thus , the null hypothesis $\delta = 0$ is rejected. Thus, $\hat{\varepsilon}_t$ is a (linearly) detrended time series. It can be concluded that, in the same manner applied on PPP, the informal and formal tests for stationarity of the productivity variable have similar outcome realisations.

6.2.4 Engle Granger (EG) Test for Cointegration : Based on Equilibrium Exchange rate in level form

Economic theory contends that time series of economic variables should move jointly, characterised by a long run, equilibrium relationship. In highlighting this theory, Harris (1995:22) maintains:

> The economic interpretation of cointegration is that if two (or more) series are linked to form an equilibrium relationship spanning the long-run, then even though the series themselves may contain stochastic trends (i.e. be non-stationary) they will nevertheless move closely together over time and the difference between them will be stable (i.e. stationary).

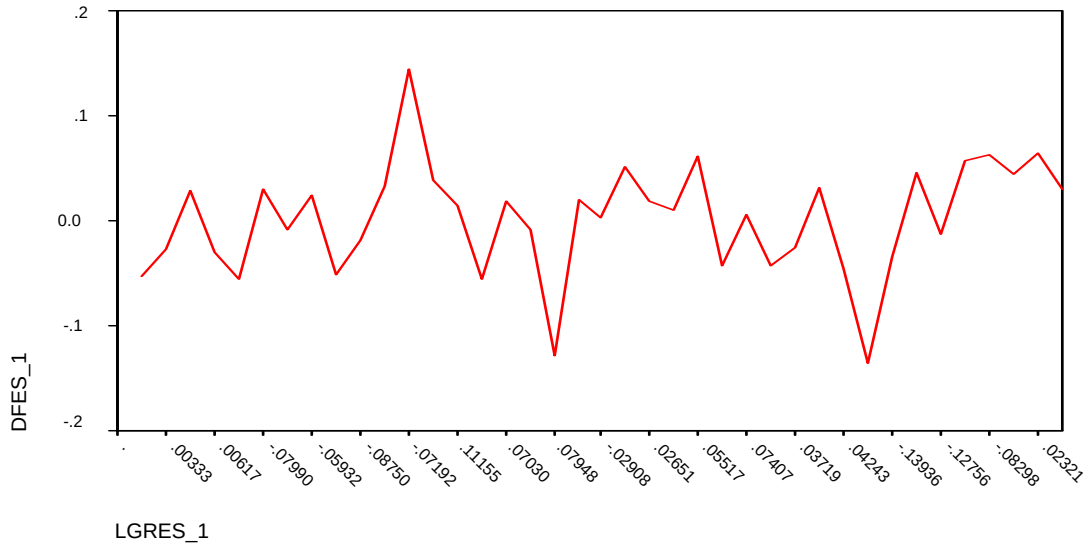
The above definition indicates that the concept of cointegration presumes the existence of a long-run equilibrium to which an economic system converges over time and the distance that the system is away from equilibrium at time **t** can be interpreted as the disequilbrium error. Likewise, Banerjee (1993:4) elaborates the stationarity and equilibrium relationships as follows:

> …We can say that an equilibrium relationship $f(x_1, x_2) = 0$ holds between two variables x_1 and x_2 if the amount $\varepsilon_t \equiv f(x_{1t}, x_{2t})$ by which actual observations deviate from this equilibrium is a median zero stationary process. That is, the 'error' or discrepancy between outcome and postulated equilibrium has a fixed distribution, centered on zero, that does not change over time. This error cannot therefore grow indefinitely; if it did, the relationship could not have been an equilibrium one since the system is free to move ever further away from it.

The above explanation underscores the presumption that an equilibrium relationship holds automatically when applied to series that are themselves stationary. In an endeavour to examine the presence of such an equilibrium relationship between the two economic variables i.e. PPP and productivity of South Africa and Switzerland, a cointegration test has been carried out. In the previous sub-section 6.2.3, subjecting PPP and productivity time series individually to unit root analysis has indicated that both are I (1); that is, they contain a unit root. Prior to engaging on cointegration, it may also be important to look at the plotting of the residuals.

The plotting in Fig. 6.5 resembles that of stationary time series obtained while differencing the PPP and productivity variables earlier. Regressing the differenced residual on the residual lag has indicated a stationary process, as the values have not moved far away from the mean, zero. This reflects the maintenance of more or less the constant variance.

Fig. 6.5 Plot of residuals based on level form



To proceed with the testing procedure of cointegration, regressing PPP on productivity has provided the following results.

$$PPP_t = \alpha_1 + \alpha_2 \ Prod_t + \varepsilon_t$$

$$\hat{PPP}_t = 1.023 + -.306 \ Prod_t + \varepsilon_t$$

It may be important here to touch on the point illustrated by Granger and Newbold who present examples with artificially generated data where the errors u_t and v_t were generated independently so that there was no relationship between y_t and x_t, but the correlations between y_t and y_{t-1} and x_t and x_{t-1} were high. Granger and Newbold (1974, cited in Maddala and Kim, 1998:28) found out:

> The regression of y on x gave a high R^2 but a low Durbin-Watson (DW) statistic. When the regression was run in first differences, the R^2 was close to zero and the DW statistic was close to 2, thus demonstrating that there was no relationship between y and x and that the R^2 obtained was spurious.

The above stated cointegrating regression estimated by the above equation can be re-written as:

$$\varepsilon_t = PPP_t - \alpha_1 - \alpha_2 \ Prod_t$$

As a unit root test is performed on the residuals from the above regression, the following results are obtained.

$$\Delta \hat{\varepsilon}_t = -.145 \ \hat{\varepsilon}_{t-1}$$

The above equation running the differenced residuals on their lagged values does not include a constant term. The constant term is suppressed because, by construction, the OLS residuals are centred around zero.

Since the estimated ε_t are based on the *estimated* cointegrating parameter α_2 , the Dickey Fuller (DF) critical significance values are not quite appropriate. Therefore, the DF test in the present context known as Engle-Granger (EG) test is applied. It is, however, important to note here that the critical values for the Engle Granger (EG) Cointegration test and for the Dickey Fuller (DF) test are the same for the sample size under consideration i.e. 40. Accordingly, the null hypothesis run as follows:

H_0: $\delta = 0 \rightarrow \rho = 1 \rightarrow$ unit root in residuals$\rightarrow$ non-stationarity$\rightarrow$ no-cointegration

H_1: $\delta < 0 \rightarrow \rho < 1 \rightarrow$ no unit root in residuals $\rightarrow$ stationarity$\rightarrow$ cointegration

In the above regression, the computed tau (τ) value -1.902 exceeds, in absolute terms, the 10 per cent critical value (-1.61). The estimated coefficient of the residuals, δ, is statistically significantly different from 0. Thus , the null hypothesis $\delta = 0$, i.e. there is no cointegration is rejected.

When ε_t is subjected to unit root analysis, it has become stationary i.e. I(0). Although PPP_t and $Prod_t$ are individually I(1), that is, they have stochastic trends, their linear combination is I(0) in that the linear combination cancels out the stochastic trends in the two series. Had PPP and productivity not been cointegrated any linear combination of them i.e. ε_t would also have remained non-stationary. In this case, it can be concluded that the two variables move jointly and they are cointegrated because they have a long-term or equilibrium relationship between them.

6.2.5 Error Correction Mechanism (ECM): Based on Equilibrium Exchange rate in level form

Although the ARIMA (Auto Regressive Integrated Moving Average) models were introduced largely for forecasting purposes, they may also prove helpful to understand the mechanisms ruling the dynamics of a macro-econometric model or to derive its specification. According to Gourieroux and Monfort (1997:426), the presence of trending variables and the properties of cointegration can be examined in the perspective of explanatory model building using the following two steps:

(i) economic theory or some intuitive line of reasoning is used to obtain some equations linking the variables of interest; the resulting system is basically static;
(ii) this system is augmented by considering the dynamic aspect, in order to capture a number of phenomena which should be modelled in a specific way: technological progress, expectations by the economic agents, behavioural changes, adjustment costs, learning, and so on.

The dual classification of the model building process is linked to the need for the separation of the short term and long-term relationships. While the basic static model allows for an interpretation of long-run equilibrium relationship, the additional dynamics can be interpreted as the result of the adjustment surrounding this very equilibrium. There could be multiple of reasons behind this adjustment. Harris (1995:23) underscores:

> The major reason why relationships are not always in equilibrium centres on the inability of economic agents to adjust to new information instantaneously. There are often substantial costs of adjustment (both pecuniary and non-pecuniary) which result in the current value of the dependent variable, y, being determined not only by the current value of some explanatory variable, X, but also by past values of X. In addition, as Y evolves through time in reaction to current and previous values of X, past (i.e. lagged) values of itself will also enter the short-run (dynamic) model.

Most of the variables in a dynamic model are likely to be non-stationary, since they enter in levels. As mentioned earlier, this leads to the potential problem of spurious regression, while *t*- and F-statistics do not have standard distribution and the usual statistical inference is invalid. In a search for a way out of this problem, Harris (1995:24) steps back to the concept of stationarity and looks forward as follows:

> A solution might be to respecify the dynamic model in (first) differences. However, this then removes any information about the long-term from the model and consequently is unlikely to be useful for forecasting purposes. A more suitable approach is to adopt the error-correction (ECM) formulation of the dynamic model…

The fact that two variables are cointegrated does not imply that there was no disequilibrium. In the short run, there may be disequilibrium and this error term can be treated as an equilibrium error. The equilibrium error is important in linking the short-run behaviour of the PPP to its long run value, a situation where the importance of Error Correction mechanism comes to into play. The Error Correction Mechanism (ECM) first used by Sargan and later popularised by Engle and Granger corrects for disequilibrium. An important theorem, known as the Granger representation theorem, states that if two variables Y and X are cointegrated, then the relationship between the two can be expressed as ECM. According to Harris (1995:24), ECM has several distinct advantages:

> First, and assuming that X and Y are cointegrated, the ECM incorporates both short-run and long-run effects… will provide information on the speed of adjustment, that is, how the variable y_t changes in response to disequibrium… A second feature of the ECM is that all the terms in the model are stationary so standard regression techniques are valid, assuming cointegration and that we have estimates of β_0 and β_1. Third, … the practical implication of Granger's representation theorem for dynamic modelling is that it provides the ECM with immunity from the spurious regression problem, provided that the terms in levels cointegrate.

In the present context, the model that treats the error correction mechanism runs as follows:

$\Delta PPP_t = \alpha + \Delta Prod_t - \delta \hat{\varepsilon}_{t-1}$

- where $\hat{\varepsilon}_{t-1}$ is the lagged value of the error correction term from the preceding term

  $= -.005 + .081\ \Delta Prod_t - .186\ \hat{\varepsilon}_{t-1}$

The fact that the estimated coefficient of residual lag variable has a negative sign indicates its compliance with the requirement of Error Correction Mechanism (ECM). ECM equation states that ΔPPP_t depends on $\Delta Prod_t$ and on the equilibrium error term. If the latter is non-zero, then the model is away from equibrium. If $\Delta Prod_t$ is zero and ε_{t-1} is positive, PPP_{t-1} is too high to be in equilibrium, i.e. PPP_{t-1} is above its equilibrium value $\alpha_0 + \alpha_1 Prod_{t-1}$. Since α_2 (the coefficient of ε_{t-1} is expected to be negative), the term $\alpha_2\ \varepsilon_{t-1}$ is negative and, therefore, ΔPPP_t will be negative to restore the equilibrium. That is, if ΔPPP_t is above its equilibrium value, it will start falling in the next observation period, which is quarterly in the study under consideration..

Conversely, if ε_{t-1} is negative, PPP is below the equilibrium value. Thus $\alpha_2\ \varepsilon_{t-1}$, will be positive, which will cause ΔPPP_t to be positive, leading PPP_t to rise in period **t**. This shows

that the absolute value of α_2 determines how quickly the equilibrium is restored. For the model under consideration, the estimated coefficient of $\hat{\varepsilon}_{t-1}$ (residual lag) is statistically significantly different from zero at 5 % level of significance. As these results show, 0.186 of the discrepancy between the PPP and the productivity variables in the previous quarter is eliminated this quarter. By analogy, the proportion of disequilbrium in the previous quarter corrected or eliminated in the current quarter is 0.186. The coefficient of the lagged value of the error correction term helps to reconcile the short-run behaviour of PPP with its long-run behaviour.

6.3 Tests for Stationarity: Based on GDP Deflator Index

The previous section has employed informal and formal methods of determining the (non) stationary nature of PPP and productivity variables in level form. In its computation of productivity, it has taken the equilibrium exchange rate (R**2.349**) in converting the rand value of South African GDP in terms of the base or standard currency, i.e. the Swiss franc. This section, however, will take the index, rather than the level, form in its computation. As it has been cited earlier in the Empirical methodology and Model Specification chapter, the PPP, in turn, is computed as a ratio of South African GDP Deflator to the GDP Deflator of Switzerland.

6.3.1 Visual Inspection

A visual inspection of the above data, illustrated in Fig. 6.6 and Fig 6.7 on PPP and productivity based on indexes provide similar preliminary view of time series analysis with that of time series based on equilibrium exchange rate in level form depicted in Fig. 6.1 and Fig.6.2. There is an indication from the plotting of these series that there is a general tendency for the productivity and PPP to trend upwards and downwards respectively over time, with no real or definite pattern. Like Fig. 6.1 and Fig. 6.2, Fig 6.6 and Fig. 6.7 also indicate that the realisation observed do not support the idea that the mean of both series productivity and PPP are constant for **t** = 1994Q1 to 2003Q4.

The productivity variable (ratio of productivity of South Africa to the productivity of Switzerland) plummeted in mid-2002. As in the case of equilibrium exchange rate in level form indicated in sub-section 6.2**,** the factor behind such a dramatic fall may be, *ceteris paribus*, explained by the volatility of the external value of the Rand. To be specific, the fall

in the external value of the Rand, followed by a quick recovery in the first half of 2002 may be the factor behind the decline of productivity and, hence, that of competitiveness.

Fig. 6.6 PPP in level form based on GDP Deflator, 1994Q1-2003Q4

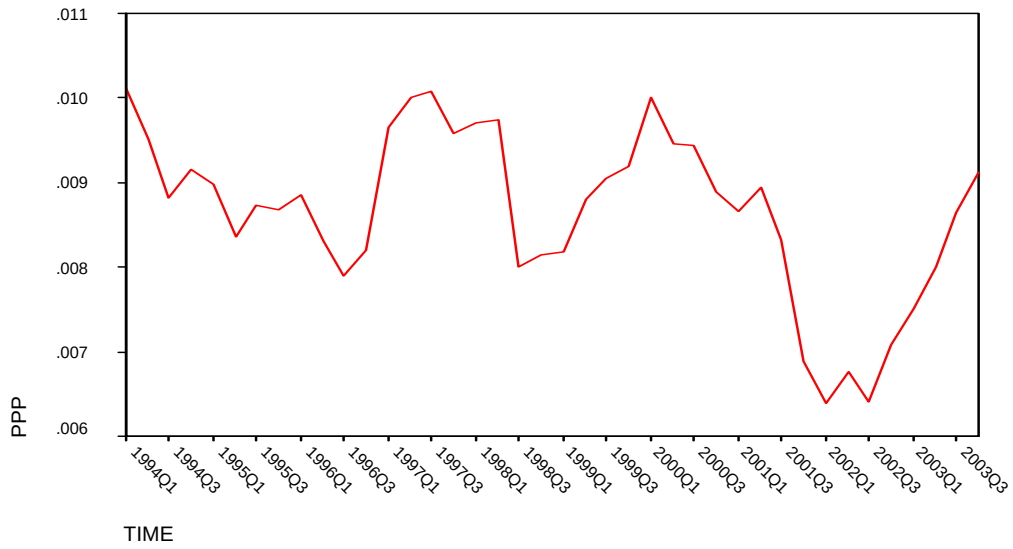
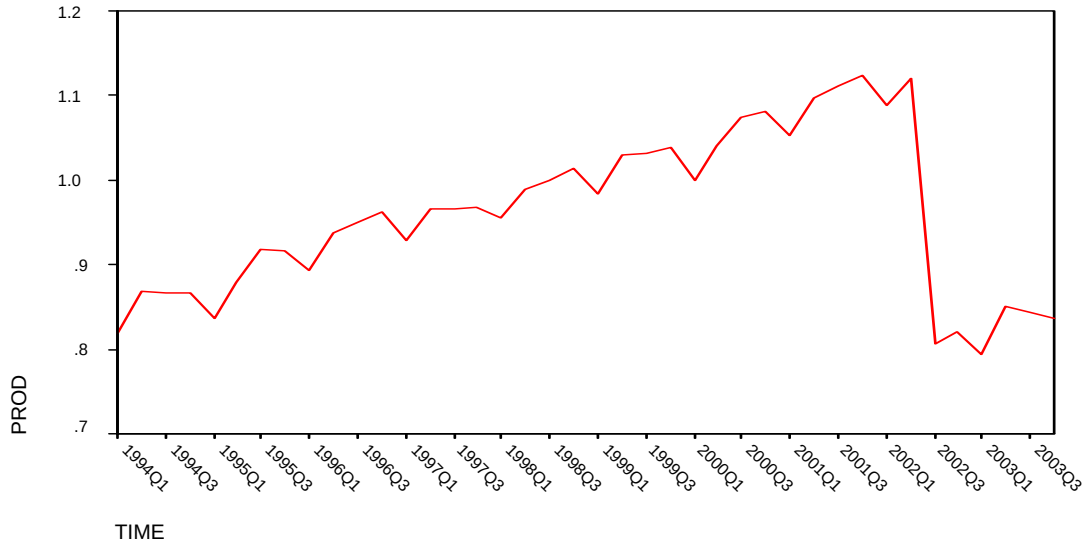
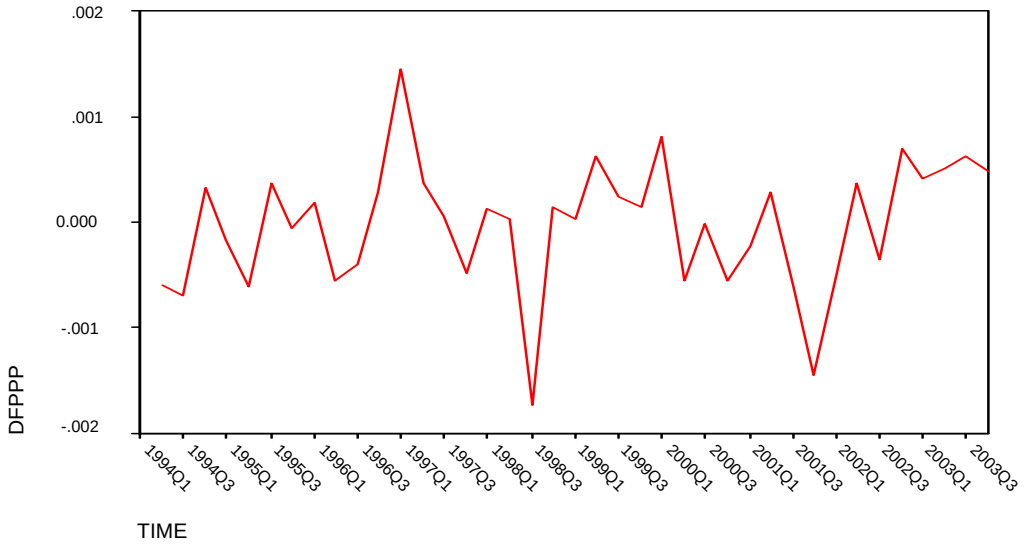


Fig. 6.7 Productivity in level form based on GDP Deflator, 1994Q1-2003Q4



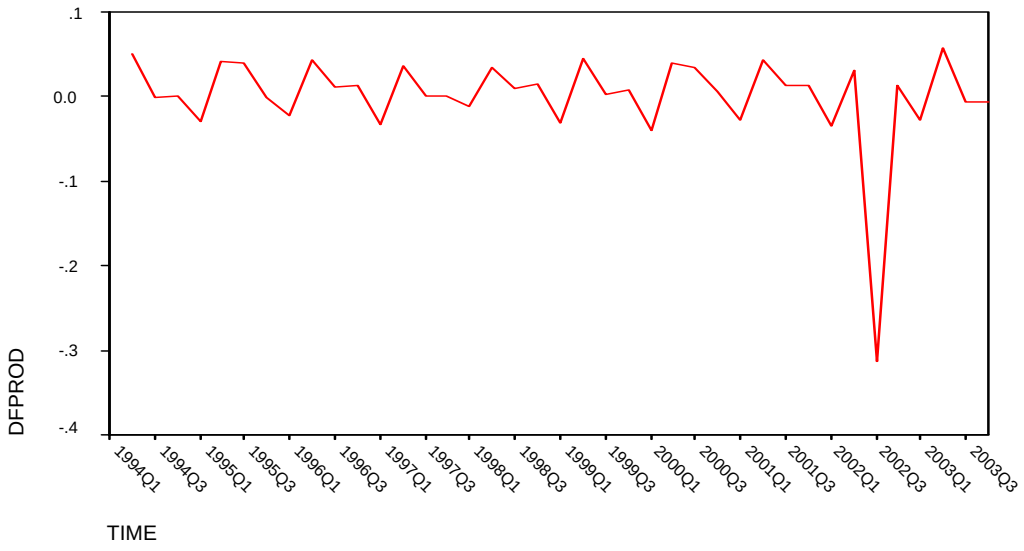
Pure random walk or Random Walk Model (RWM) without a drift or constant is non-stationary. Mostly, however, it turns stationary when differenced once or twice.

Fig. 6.8 PPP in differenced form based on GDP Deflator, 1994Q1-2003Q4



Like its counterpart in the equilibrium exchange rate in level form depicted in Fig.6.3, Fig. 6.8 shows that the mean of the differenced PPP series is also constant. This has occurred despite the presence of unusually high variance in the 13th observation and unusually low in the 19th and 32nd observations.

Fig. 6.9 Productivity in differenced form based on GDP Deflator, 1994Q1-2003Q4



In coherence with the case in equilibrium exchange rate in level form illustrated in Fig. 6.4, Fig. 6.9 also shows the mean of the differenced productivity in the indexes form is more or less constant. This has been the case in spite of the unusually low variance in the 35th observation period.

6.3.2 Sample Correlogram

In examining sample corelogram, the lag length applied in the previous section for equilibrium exchange rate in level form is also used for the index form here. Accordingly, when one third of the lag length is taken, the estimated autocorrelation coefficient for the PPP_t starts at a high level (.787) and shrinks gradually and approaches close to zero at PPP_{t-5} (-.068). Prior to this period, it had a negative value. The tapering of the autocorrelation indicates that the values further in the past are less correlated with the current value. The estimated autocorrelation coefficient appears to decline more quickly than that in the previous section, which was based on equilibrium exchange rate in level form.

Likewise, the estimated autocorrelation coefficient for the Productivity variable starts at a high level (.777), but less than that of the PPP, and shrinks slowly and approaches close to zero at $Prod_{t-6}$ (0.003). The dying out of the autocorrelation hints that the values further in the past are less correlated with the current value. (See Appendix A: 2) Though the ρ_k has not died out in the same pattern, as it was the case in PPP, it appears from the sample correlogram that both the PPP and productivity are non-stationary time series. Similar to the case of time series based on equilibrium exchange rate in level form, each process mentioned above has an infinite memory.

6.3.3 Dickey Fuller (DF) Test for stationarity : Based on GDP Deflator

The graphical analysis and sample correlogram test based on GDP Deflator index signal the nature of (non) stationarity of the time series of variables involved. To explore their (non) stationarity, the Dickey Fuller (DF) test has also been carried out. In order to get rid of autocorrelation and to restore the minimum variance, Generalised Least Square (GLS) method is applied on the unit root stochastic processes. The transformation procedure is skipped here, as it has already been indicated in the previous section.

6.3.3.1 Dickey Fuller (DF) Test for Purchasing Power Parity (PPP)

Similar estimation and inference procedure have been employed throughout the whole section. Thus, equations for the PPP that is computed based on index values can be established for the three different forms mentioned earlier. To proceed to estimation and interpretation, the first difference of PPP_t (DIFFPPP) is regressed on its lagged value (LGPPP) and it has provided the following result:

$\Delta PPP_t = -.006PPP_{t-1} + \varepsilon_t$

Thus, in this no constant, no trend scenario, the 1, 5 and 10 per cent critical values, in absolute terms, exceed the computed tau (τ) value -.502. The estimated coefficient of PPP_{t-1} (lagged value of PPP), δ, is not statistically significantly different from zero. Thus, we fail to reject the null hypothesis that δ = 0 that implies that the process is rather non-stationary.

In the second scenario, in which there is a constant but no trend, the 1, 5 and 10 percent critical values, in absolute terms, exceed the computed tau (τ) value -.2.236.

$\Delta PPP_t = .002 - .209PPP_{t-1} + \varepsilon_t$

The estimated coefficient of PPP_{t-1} (lagged value of PPP), which in this case is δ, is not statistically significantly different from 0.Thus, the null hypothesis is not rejected because of the indication of the presence of non-stationarity.

The equation in the index form has been differenced twice, in order to explore the presence of a differenced stationary. In the same scenario, in which there is a constant but no trend, the 1, 5 and 10 percent critical values, in absolute terms, exceed the computed tau (τ) value -2,229.

$\Delta PPP_t = .002 - .209PPP_{t-1} + \varepsilon_t$

The estimated coefficient of PPP_{t-1} (lagged value of PPP), δ, is not statistically significantly different from 0. Thus, the null hypothesis, once again, is not rejected because of the indication of the presence of non-stationarity.

In the third scenario in which there is a constant and trend, the 1, 5 and 10 percent critical values, in absolute terms, exceed the computed tau (τ) value -2.011.

$\Delta PPP_t = .002 - 2.10E\text{-}06\mathbf{t} - .221PPP_{t-1} + \varepsilon_t$

The estimated coefficient of PPP_{t-1} (lagged value of PPP), δ, is not statistically significantly different from zero, as a result of which the null hypothesis is not rejected.

Comparing the informal and formal tests for stationarity of the PPP, the realisations or outcomes are similar. In the index form of variables, the non-stationarity nature of the PPP has been depicted by graphical method as well as by the residual values in the sample

correlogram. However, the unit root test has shown that PPP is not a difference stationary. Similar results were obtained in the earlier section when the calculation was based on equilibrium exchange rates.

PPP, as it has been the case in level form, may be a trend stationary rather than difference stationary. In order to avoid over differencing i.e. treating a trend-stationary process (TSP) as difference-stationary process, it is imperative that the time series in regressed on time. The time series is regressed on time in order to examine whether the residuals from this regression are stationary i.e. trend stationary. Accordingly, the regression runs as follows:

$PPP_t = \alpha + \alpha_2 \mathbf{t} + \varepsilon_t$

- where PPP_t is the time series under study and where *t* is the trend variable measured chronologically.
- $\hat{\varepsilon}_t = (PPP_t - \hat{\beta}_1 - \hat{\beta}_2 \mathbf{t})$

$\Delta \hat{\varepsilon}_t = \delta \hat{\varepsilon}_{t-1}$

$= -.227 \hat{\varepsilon}_{t-1}$

In the above regression, the computed tau (τ) value -2.111 exceeds, in absolute terms, the 5 and 10 per cent critical values (-1.95 and -1.61) respectively . The estimated coefficient of PPP_{t-1} (lagged value of PPP), δ, is statistically significantly different from zero. Thus, the null hypothesis that implies that the process is rather not stationary ($\delta = 0$) is rejected. The regression result has shown that PPP_t is a trend stationary. Thus, $\hat{\varepsilon}_t$ is a (linearly) detrended time series. It can be concluded that the informal and formal tests for stationarity of the PPP have similar outcome realisations.

6.3.3.2 Dickey Fuller (DF) Test for Productivity

Following similar procedure, equations for the productivity variable are formulated for the three versions. To proceed to estimation and interpretation, the first difference of Productivity, (DIFPROD) is regressed on its lagged value (LGPROD) and it has provided the following result:

$\Delta Prod_t = -.001 Prod_{t-1} + \varepsilon_t$

The null and alternative hypotheses applied earlier on the PPP are also used in treating the productivity variable in the three scenarios i.e. a pure random, random walk with drift, and a random walk with deterministic trend. Thus, in this no constant, no trend scenario, the 1, 5 and 10 per cent critical values, in absolute terms, exceed the computed tau (τ) value -.140. The estimated coefficient of PPP_{t-1} (lagged value of PPP), δ, is not statistically significantly different from zero. Thus, the null hypothesis that implies that the process is rather non-stationary is rejected.

In the second scenario, in which there is a constant but no trend, the 1, 5 and 10 percent critical values, in absolute terms, exceed the computed tau (τ) value -.2.016.

$\Delta Prod_t = .184 \; -.191 \; Prod_{t-1} + \varepsilon_t$

The estimated coefficient of $Prod_{t-1}$ (lagged value of Productivity), δ, is not statistically significantly different from 0. Thus, the null hypothesis is not rejected because of the indication of the presence of non-stationarity.

In order to explore the presence of a differenced stationary, the equation in the index form, as it was the case in the equilibrium exchange rate in level form, has been differenced twice. The 1, 5 and 10 percent critical values, in absolute terms, exceed the computed tau (τ) value -2.066.

$\Delta^2 Prod_t = .0195 \; -.201 Prod_{t-2} + \varepsilon_t$

The estimated coefficient of $Prod_{t-1}$ (lagged value of Productivity), δ, is not statistically significantly different from 0. Thus, the null hypothesis is not rejected because of the indication of the presence of non-stationarity.

In the third scenario, in which there is a constant and trend, the 1, 5 and 10 percent critical values, in absolute terms, exceed the computed tau (τ) value -1.657.

$\Delta Prod_t = .174 - .001t - .167 Prod_{t-1} + \varepsilon_t$

The estimated coefficient of PPP_{t-1} (lagged value of Productivity), δ, is not statistically significantly different from zero, as a result of which the null hypothesis is not rejected.

When comparing the informal and formal tests for stationarity of the productivity variable in the index form, it can be seen that the realisations or outcomes are similar to that of the level form. In the index form of variables, the non-stationarity nature of the productivity variable has been depicted graphically and by sample correlogram. However, the unit root test has shown that productivity is not a difference stationary.

Nevertheless, it is possible that productivity is a trend stationary rather than difference stationary. In order to avoid over-differencing i.e. treating a trend-stationary process (TSP) as difference-stationary process, the procedure applied earlier on PPP has been employed here as well. The time series has been regressed on time, and the residuals saved from this regression have been tested to determine their (non) stationarity. Accordingly, the regression runs as follows:

$Prod_t = \alpha + \alpha_2 \mathbf{t} + \varepsilon_t$

- where $Prod_t$ is the time series under study and where *t* is the trend variable measured chronologically.
- $\hat{\varepsilon}_t = (Prod_t - \hat{\beta}_1 - \hat{\beta}_2 \mathbf{t})$.

$\Delta \hat{\varepsilon}_t = \delta \hat{\varepsilon}_{t-1}$

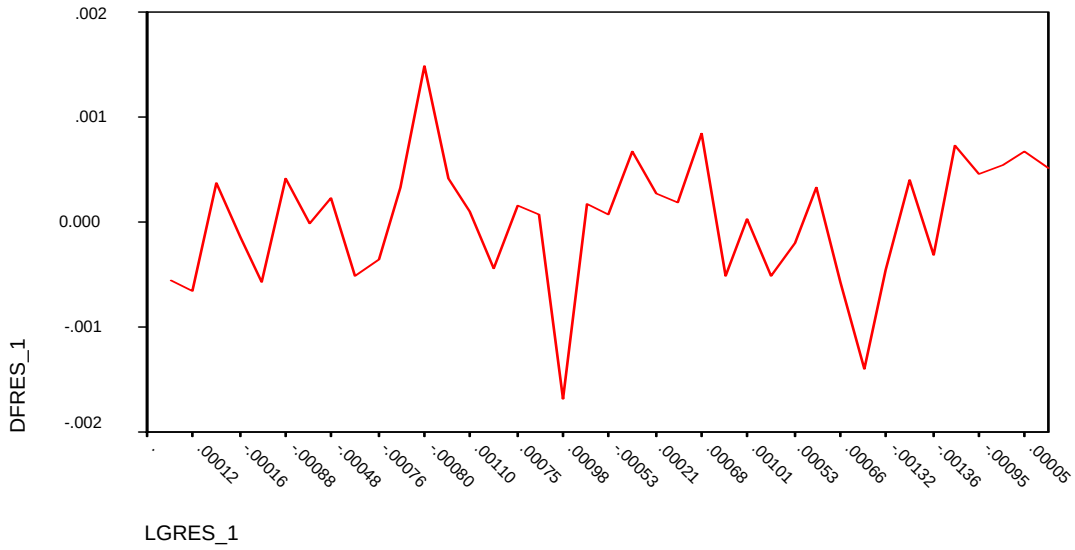
$= -.178\ \hat{\varepsilon}_{t-1}$

In the above regression, the computed tau (τ) value -1.782 exceeds, in absolute terms, the 10 per cent critical value (-1.61). The estimated coefficient of $Prod_{t-1}$ (lagged value of productivity), δ, is statistically significantly different from zero, implying that the process is rather stationary. Thus, the null hypothesis $\delta = 0$ is rejected. Thus, $\hat{\varepsilon}_t$ is a (linearly) detrended time series. It can be concluded that, similar to the circumstances in PPP, the informal and formal tests for stationarity of the productivity have similar outcome realisations.

6.3.4 Engle Granger (EG) Test for Cointegration : Based on GDP Deflator index

In order to examine whether PPP and Productivity variables in index form move jointly, the test applied earlier on equilibrium exchange rate in level form is also applied in index form here. Before carrying out cointegration test, however, it may be relevant to see whether the plot of the residuals based on index form resembles that of level form.

Fig. 6.10 Plot of Residuals based on index form



As expected, the above plot shares similar trends with that of the stationary time series obtained while differencing the PPP and productivity variables earlier. Regressing the differenced residual on the residual lag has provided a stationary process, as the values have not moved far away from the mean, with more or less the constant variance.

To proceed with the testing procedure of cointegration, regressing PPP on productivity has provided the following results:

$PPP_t = \alpha_1 + \alpha_2 \ Prod_t + \varepsilon_t$

$\hat{PPP}_t = .009 + -.001 \ Prod_t + \varepsilon_t$

The above cointegrating regression estimated by the above equation can be re-written as:

$\varepsilon_t = PPP_t - \alpha_1 - \alpha_2 \ Prod_t$

As a unit root test is performed on the residuals from the cointegrating regression, the following results are obtained.

$\Delta \hat{\varepsilon}_t = \delta \hat{\varepsilon}_{t-1}$

$\Delta \hat{\varepsilon}_t = -.207 \ \hat{\varepsilon}_{t-1}$

H_0: $\delta = 0 \rightarrow \rho = 1 \rightarrow$ unit root in residuals$\rightarrow$ non-stationarity$\rightarrow$ no-cointegration

H_1: $\delta < 0 \rightarrow \rho < 1 \rightarrow$ no unit root in residuals $\rightarrow$ stationarity$\rightarrow$ cointegration

Given the above regression and the null and alternative hypothesis, the computed tau (τ) value -2.238 exceeds, in absolute terms, the 5 per cent critical value (-1.95). The estimated coefficient of the residuals, δ, is statistically significantly different from zero. Thus, the null hypothesis $\delta = 0$, which claims that there is no cointegration is rejected. Thus, it can once again be concluded that, as it was the case for the variables in level forms, the two variables computed on the index form move jointly and they are cointegrated because they have a long-term, or equilibrium, relationship between them.

6.3.5 Error Correction Mechanism: Based on GDP Deflator Index

It is also imperative that the value of the equilibrium error is determined, given the presence of cointegration between the two variables. In the present context, the model that treats the Error Correction Mechanism (ECM) runs as follows:

$\Delta PPP_t = \alpha + \Delta Prod_t - \hat{\varepsilon}_{t-1}$

- where $\hat{\varepsilon}_{t-1}$ is the lagged value of the error correction term from the preceding term.
- $= -2.85E\text{-}05 + .001\ \Delta Prod_t - .243\ \hat{\varepsilon}_{t-1}$

Similar to the empirical results and conclusion drawn in the previous section, the estimated coefficient of residual lag variable has had a negative sign. The estimated coefficient of $\hat{\varepsilon}_{t-1}$ (residual lag) is statistically significantly different from zero at 5 % level of significance. This negativity is in coherence with the requirement and expectation of the ECM. As the above results show, 0.243 of the discrepancy between the PPP and the productivity variables in the previous quarter is eliminated in the current quarter. By implication, the proportion of disequilbrium in the previous quarter corrected or eliminated in the current quarter is 0.243. The coefficient of the lagged value of the error correction term helps to reconcile the short-run behaviour of PPP with its long-run behaviour. The corresponding figure for ECM in the level form indicated similar result, i.e. 0.186.

6.3.6 Cointegration Regression Durbin-Watson Test : Based on GDP Deflator

There is also another, quicker, method of finding out whether or not PPP and productivity variables are cointegrated. "A technique known as Cointegrating Regression Durbin-Watson (CRDW) test makes use of Durbin-Watson *d* retained from the cointegrating regression (Gujarati, 2003:824). This technique uses $d = 0$ for its null hypothesis, instead of $d = 2$, as it was the case in testing for autocorrelation. The cointegrating regression that run PPP on productivity variable showed that $d = .368$. Given $d \approx 2(1-\hat{\rho})$, estimated ρ will be about 1, if there is to be a unit root. Thus, the null and alternative hypothesis runs as follows:

H_0: $d = 0 \rightarrow \rho = 1 \rightarrow$ unit root in residuals→ non-stationarity→ no-cointegration

H_1: $d < 0 \rightarrow \rho < 1 \rightarrow$ no unit root in residuals → stationarity→ cointegration

The critical values of CRDW are .511, .386 and .322 for 1, 5 and 10 per cent level of significance respectively. Since the computed *d* value (.368) is greater than the 10 per cent critical value (.322), the null hypothesis can be rejected at this level. This method indicates the existence of cointegration between the two variables.

Table 6.1 Summary: Stationarity and Cointegration Tests based on Equilibrium Exchange Rate on level form, 1994Q1-2003Q4

I/N	Equation	R^2	*d*	t	Sig. value	Coeff.	1%	5%	10%	Remark / Outcome
1	2	3	4	5	6	7	8	9	10	11
1	$\Delta PPP_t = \delta PPP_{t-1} + \varepsilon$	**.**019	1.546	-.861	.395	-.009	-2.62	-1.95	-1.61	Not Difference SP
	$\Delta Prod_t = \delta Prod_{t-1} + \varepsilon$	.001	2.324	-.140	.889	-.001	‘’	‘’	‘’	‘’
	$\Delta PPP_t = \delta PPP_{t-1} + \beta + \varepsilon$	.098	1.480	-2.002	.053	-.147	-3.58	-2.93	-2.60	‘’
	$\Delta Prod_t = \delta Prod_{t-1} + \beta + \varepsilon$	.099	2.126	-2.016	.051	-.191	‘’	‘’	‘’	‘’
	$\Delta^2 PPP_t = \delta PPP_{t-2} + \beta + \varepsilon$	.096	1.484	-1.954	.059	-.145	‘’	‘’	‘’	‘’
	$\Delta^2 Prod_t = \delta Prod_{t-2} + \beta + \varepsilon$	.106	2.120	-2.066	.046	-.201	‘’	‘’	‘’	‘’
2	$PPPt = \beta + \beta_2 \boldsymbol{t} + \varepsilon$	.489	.434	-6.032	.000	-.007				
	$\Delta\varepsilon_t = \delta\varepsilon_{t-1}$	.093	1.393	-1.977	**.055**	-.207	-2.62	-1.95	-1.61	Trend SP 10% sig.
	$Prod_t = \beta + \beta_2 \boldsymbol{t} + \varepsilon$	.067	.378	1.657	.106	.002				
	$\Delta\varepsilon_t = \delta\varepsilon_{t-1}$	.077	2.101	-1.782	**.083**	-.178	-2.62	-1.95	-1.61	Trend SP 10% sig
3	$\Delta PPP_t = \delta PPP_{t-1} + \beta + \beta_2 \boldsymbol{t} + \varepsilon$	.110	1.427	-1.876	.069	-.201	-4.15	-3.50	-3.18	
	$\Delta Prod_t = \delta Prod_{t-1} + \beta + \beta_2 \boldsymbol{t} + \varepsilon$	.111	2.205	-1.657	.106	-.167	‘’	‘’	‘’	
4	$PPP_t = \beta + \delta\ Prod_t + \varepsilon$	.038	.242	-1.227	.227	-.306				For E.G Cointegration Test
	$\Delta\varepsilon_t = \delta\varepsilon_{t-1}$	.087	1.622	-1.902	**.065**	-.145	-2.62	-1.95	-1.61	Cointegrated at 10% sig. level
5	$\Delta PPP_t = \beta + \delta\ Prod_t - \varepsilon_{t-1}$	.140	1.468	-2.402	**.022**	**-.186**				For Error Correction Mechanism (ECM)

6.4 Summary

This chapter has performed an empirical investigation on the determination of cointegration between two variables, PPP and productivity. In so doing, it has used two settings where the first setting has been based on equilibrium exchange rate in level form, and the second setting has been based on GDP Deflator index. In both cases, informal and formal methods of test of stationarity have been carried out. Moreover, Engle-Granger test of cointegration have also been applied to determine the cointegration relationship between PPP and productivity.

Table 6.2 Summary: Stationarity and Cointegration Tests based on GDP Deflator Index, 1994Q1-2003Q4

I/No.	Equation	R^2	*d*	t	Sig. value	Coeff.	1%	5%	10%	Remark
1	2	3	4	5	6	7	8	9	10	11
1	$\Delta PPP_t = \delta PPP_{t-1} + \varepsilon$	.007	1.599	-.502	.618	-.006	-2.62	-1.95	-1.61	Not Difference SP
	$\Delta Prod_t = \delta Prod_{t-1} + \varepsilon$	.001	2.324	-.140	.889	-.001				‘’
	$\Delta PPP_t = \delta PPP_{t-1} + \beta + \varepsilon$	.119	1.484	-2.236	.031	-.209	-3.58	-2.93	-2.60	‘’
	$\Delta Prod_t = \delta Prod_{t-1} + \beta + \varepsilon$	.099	2.126	-2.016	.051	-.191				‘’
	$\Delta^2 PPP_t = \delta PPP_{t-2} + \beta + \varepsilon$	.121	1.516	-2.229	.032	-.209				‘’
	$\Delta^2 Prod_t = \delta Prod_{t-2} + \beta + \varepsilon$	.106	2.120	-2.066	.046	-.201				‘’
2	$PPP_t = \beta + \beta_2 \boldsymbol{t} + \varepsilon$	.219	.467	-3.265	.002	-3.96E-05				
	$\Delta\varepsilon_t = \delta\varepsilon_{t-1}$	.105	1.437	-2.111	**.041**	-.227	-2.62	-1.95	-1.61	Trend SP 5% sig.
	$Prod_t = \beta + \beta_2 \boldsymbol{t} + \varepsilon$	.067	.378	1.657	.106	.002				
	$\Delta\varepsilon_t = \delta\varepsilon_{t-1}$	.077	2.101	-1.782	**.083**	-.178	-2.62	-1.95	-1.61	Trend SP 10%sig
3	$\Delta PPP_t = \delta PPP_{t-1} + \beta + \beta_2 \boldsymbol{t} + \varepsilon$	.120	1.470	-2.011	.052	-.221	-4.15	-3.50	-3.18	
	$\Delta Prod_t = \delta Prod_{t-1} + \beta + \beta_2 \boldsymbol{t} + \varepsilon$	.111	2.205	-1.657	.106	-.167	‘’	‘’	‘’	
4	$PPP_t = \beta + \delta\ Prod_t + \varepsilon$	.003	.368	-.353	.726	-.001				For E.G Cointegration Test
	$\Delta\varepsilon_t = \delta\varepsilon_{t-1}$	.116	1.516	-2.238	**.031**	-.207	-2.62	-1.95	-1.61	Cointegrated at 5% sig. level
5	$\Delta PPP_t = \beta + \delta\ Prod_t - \varepsilon_{t-1}$	.145	1.424	-2.472	**.018**	**-.243**				For Error Correction Mechanism (ECM)
6	$PPP_t = \beta + \delta\ Prod_t + \varepsilon_t$		**.368**				.511	.386	.322	For CRDW Test cointegrated at 10%

The empirical results performed by informal and formal methods have shown that both time series i.e. PPP and productivity are trend stationary, and not difference stationary. Likewise, the cointegration tests undertaken on level as well as index form have indicated that PPP and productivity of South Africa and Switzerland have a long-term, equilibrium economic relationship. In parallel, the ECM that has been based on equilibrium exchange rate level form and on GDP Deflator index form has respectively indicated that .186 and .243 of the discrepancy in the calculation between the PPP and the productivity variables in the previous

quarter is eliminated in the following quarter. Likewise, the estimated coefficient of $\hat{\varepsilon}_{t-1}$ (residual lag) has been statistically significantly different from zero for both the level and index forms at .022 and .018 levels of significance respectively. In addition , the CRDW test based on the GDP Deflator index has confirmed the results provided by Eagle-Granger test, which previously revealed that both variables, PPP and productivity, move jointly in the long-run.

CHAPTER 7
CONCLUSION AND RECOMMENDATION

7.1 Conclusion

From the study carried out and the empirical results obtained thereof, there is ground for the application of the productivity-bias hypothesis (PBH) in purchasing power parity (PPP). The real exchange rate or the deviation of PPP from the equilibrium is related to the ratio of productivity in South Africa to the productivity of Switzerland. Thus, this productivity-differential between these two countries is presumed to be linked with the productivity differences in their tradable and non-tradeable sectors.

Even though empirical results in some countries tend to differ along model specification, sample size, data type or level of economic development, the PBH test for South Africa and Switzerland has moderately enjoyed empirical support. The real exchange rate and productivity variables in South Africa and Switzerland have moved jointly indicating their long-term, or equilibrium, relationship during the study under consideration.

7.2 Recommendation

From the conclusion drawn above, the following recommendations can be considered for further policy analysis and formulation from the perspective of South Africa. South Africa is moving from a primary sector oriented economy to a manufacturing and service sector economy. Firstly, given the tendency of productivity differentials to be smaller in the service sector than in the sectors producing traded goods, and the increasing significance of the manufacturing sector to the economy in the future, the latter deserves increased attention. Improved productivity in the manufacturing sector helps to sustain the competition as an export-oriented growing sector. It may be advisable not to anticipate windfall gains from a weaker rand for export promotion and to intervene in the forex market to serve such anticipation. International competitiveness should preferably stem from higher efficiency as well as cost-effectiveness in the process of production, but not through the weakening of endogenous explanatory variable.

Secondly, given current high unemployment rates and the associated jobless growth in South Africa, it is imperative that all stakeholders (government, business community, trade unions and civic society) design and coordinate strategies that address the productivity deficiency

and rampant unemployment simultaneously. In coherence with the consistent application of skill development programme that can address the structural unemployment more effectively, the relaxation of labour legislation may be instrumental in raising productivity and in creating jobs. With inflation expectation subsiding and the threat of competition rising, it may not be feasible in the long run to accommodate wage settlements that persistently go beyond the inflation. Should the higher prevailing wage settlement trend continue unabated, it may raise the unit labour cost unnecessarily, weaken productivity and create higher inflation expectation, which, in turn, may feed to higher inflation. Consequently, this may create a vicious circle rather than long-lasting solutions.

Finally, it may be worthwhile to gauge more carefully the extent of the damage done to the economy in general, and on productivity in particular, the negative consequences of frequent strikes, protests and stoppages. This appears to be essential as unstable labour relations may discourage current and potential, local and foreign investors to invest or to expand their current capacity. Consequently, the entrepreneurial motivation for job creation and current job retention may be dented. If this trend is reversed, the productivity of the economy in general and that of the manufacturing sector, in particular improves. As a result, this situation develops the potential, *ceteris paribus,* to narrow the productivity gap between South Africa and Switzerland. South African products become less expensive or more affordable for consumers in the ROW. From the South African perspective, this improved competitiveness has the potential of pushing the export volumes up.

These issues tend to be particularly significant in view of the increasing trade with old and new trading partners. Thus, it may be helpful to consider the above recommendations as part of a development strategy, not only in raising productivity but also in accommodating the socio-economic challenges of unemployment, poverty and inequality.

7.3 Possible Extension and Limitation of the Study

This comparative study has raised an important question about the nature of data used in the analysis. It is surmised that the study has one major limitation, as briefly cited in Chapter 5 - Empirical Methodology and Model Specification. In formulating the econometric model and in computing labour productivity, the Gross Domestic Product to Employment ratio has been employed. The GDP/Employment ratio is a better measure than the per-capita GDP, as the

former partly rectifies the limitation of the latter by excluding the population not directly involved in productive activities.

Whilst enjoying such a merit, the GDP/ Employment ratio suffers from the demerits associated with its incapacity to gauge fully the labour productivity of both the tradeable and non-tradeable sectors. It does not indicate the breakdown of productivity in the largely tradable sector such as agriculture, manufacturing, mining and the largely non-tradable sector such as financial services and the output of the construction sector. It may be reasonably argued that the productivity of each sector of the economy varies, albeit at different proportion.

The other problem linked with the above limitation is the index-number problem. Not all the items that possibly fall under the category of the tradables in the economy of South Africa may do so in the Swiss economy. It is difficult to outline a definite group of commodities that can be imported or exported. Tradeables and non-tradables are not immune to overlapping on each other, either. All these problems raise a challenge to the successful disegregation of the sectors further.

Though the GDP/Employment ratio is an acceptable concept of productivity, there is still a better measure of productivity that can be employed to construct explanatory variable for further studies. "This measure is the ratio of productivity in the traded sector of the economy to productivity in the non-traded sector, where productivity in each sector is defined as the ratio of GDP (at constant prices) originating in the sector to total employment in the sector" (Officer, 1982:218). Were it not for the paucity of data, such a methodology would provide a more dependable analysis. The methodology applied here has not gone through such a recommended method of disaggregating, though.

Hence, this study may serve as a basis for further detailed study that can accommodate and treat the afore-mentioned inherent drawbacks. It appears likely that results that are more useful can be realized if further studies accord more emphasis to the behaviour of sectoral indexes with appropriate disintegration rather than relying on aggregate indexes alone. Disaggregating the productivity of sectors or sub-sectors may be a daunting task. It is, however, worth it in view of obtaining data that are more reliable and of the ensuing capacity achieved in explaining and predicting the variables involved.

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APPENDICES

Appendix A:

Sample Correlogram on PPP and Productivity, 1994Q1-2003Q4

Appendix A: 1 Sample Correlogram, based on equilibrium exchange rate in level form

```
MODEL:  MOD_5.
_

Autocorrelations:   PPP

     Auto- Stand.
Lag  Corr.   Err. -1  -.75  -.5 -.25   0   .25  .5   .75   1   Box-Ljung  Prob.
                   ▫⇩⇩⇩⇩⇳⇩⇩⇩⇩⇳⇩⇩⇩⇩⇳⇩⇩⇩⇩⇳⇩⇩⇩⇩⇳⇩⇩⇩⇩⇳⇩⇩⇩⇩⇳⇩⇩⇩⇩⇳⇩⇩⇩⇩▫
  1   .852   .152                .     ⇔*****.***********          31.299   .000
  2   .678   .150                .     ⇔*****.********             51.651   .000
  3   .518   .148                .     ⇔*****.****                 63.818   .000
  4   .345   .146                .     ⇔*****.*                    69.388   .000
  5   .192   .144                .     ⇔**** .                     71.159   .000
  6   .079   .142                .     ⇔**   .                     71.471   .000
  7   .027   .140                .     ⇔*    .                     71.508   .000
  8   .028   .138                .     ⇔*    .                     71.550   .000
  9   .042   .136                 .    ⇔*   .                      71.644   .000
 10   .057   .134                 .    ⇔*   .                      71.827   .000
 11   .095   .131                 .    ⇔**  .                      72.354   .000
 12   .149   .129                 .    ⇔*** .                      73.687   .000
 13   .138   .127                 .    ⇔*** .                      74.874   .000

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .

Total cases:  40     Computable first lags:  39
```

```
MODEL:  MOD_6.
_

Autocorrelations:   PROD

     Auto- Stand.
Lag  Corr.   Err. -1  -.75  -.5 -.25   0   .25  .5   .75   1   Box-Ljung  Prob.
                   ▫⇩⇩⇩⇩⇳⇩⇩⇩⇩⇳⇩⇩⇩⇩⇳⇩⇩⇩⇩⇳⇩⇩⇩⇩⇳⇩⇩⇩⇩⇳⇩⇩⇩⇩⇳⇩⇩⇩⇩⇳⇩⇩⇩⇩▫
  1   .777   .152                .     ⇔*****.**********           26.018   .000
  2   .636   .150                .     ⇔*****.*******              43.926   .000
  3   .448   .148                .     ⇔*****.***                  53.027   .000
  4   .320   .146                .     ⇔******                     57.802   .000
  5   .133   .144                .     ⇔***  .                     58.649   .000
  6   .003   .142                .      *     .                   58.649   .000
  7  -.030   .140                .    *⇔     .                     58.696   .000
  8  -.051   .138                .    *⇔     .                     58.831   .000
  9  -.096   .136                 .  **⇔    .                      59.329   .000
 10  -.078   .134                 .  **⇔    .                      59.665   .000
 11  -.097   .131                 .  **⇔    .                      60.207   .000
 12  -.104   .129                 .  **⇔    .                      60.854   .000
 13  -.161   .127                 . ***⇔    .                      62.463   .000

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .

Total cases:  40     Computable first lags:  39
```

Appendix A: 2 Sample Correlogram, based on GDP Deflator index

```
Autocorrelations:   PPP

     Auto- Stand.
Lag  Corr.   Err. -1  -.75  -.5 -.25   0   .25  .5   .75   1   Box-Ljung  Prob.
                   ▫⇩⇩⇩⇩⇧⇩⇩⇩⇩⇧⇩⇩⇩⇩⇧⇩⇩⇩⇩⇧⇩⇩⇩⇩⇧⇩⇩⇩⇩⇧⇩⇩⇩⇩⇧⇩⇩⇩⇩⇧⇩⇩⇩⇩▫
  1   .787   .152              .     ⇔*****.**********          26.677   .000
  2   .537   .150              .     ⇔*****.*****               39.422   .000
  3   .327   .148              .     ⇔*****.*                   44.268   .000
  4   .116   .146              .     ⇔**   .                    44.892   .000
  5  -.068   .144              .    *⇔     .                    45.111   .000
  6  -.196   .142              . ****⇔     .                    47.009   .000
  7  -.214   .140              . ****⇔     .                    49.346   .000
  8  -.158   .138              .  ***⇔     .                    50.656   .000
  9  -.090   .136               .  **⇔    .                     51.098   .000
 10  -.068   .134               .   *⇔    .                     51.355   .000
 11   .009   .131               .    *   .                     51.360   .000
 12   .126   .129               .    ⇔*** .                     52.305   .000
 13   .169   .127               .    ⇔*** .                     54.073   .000

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .

Total cases:  40     Computable first lags:  39
```

```
MODEL:  MOD_6.
_
```

```
Autocorrelations:   PROD

     Auto- Stand.
Lag  Corr.   Err. -1  -.75  -.5 -.25   0   .25  .5   .75   1   Box-Ljung  Prob.
                   ▫⇩⇩⇩⇩⇧⇩⇩⇩⇩⇧⇩⇩⇩⇩⇧⇩⇩⇩⇩⇧⇩⇩⇩⇩⇧⇩⇩⇩⇩⇧⇩⇩⇩⇩⇧⇩⇩⇩⇩⇧⇩⇩⇩⇩▫
  1   .777   .152              .     ⇔*****.**********          26.018   .000
  2   .636   .150              .     ⇔*****.*******             43.926   .000
  3   .448   .148              .     ⇔*****.***                 53.027   .000
  4   .320   .146              .     ⇔******                    57.802   .000
  5   .133   .144              .     ⇔***  .                    58.649   .000
  6   .003   .142              .     *    .                    58.649   .000
  7  -.030   .140              .    *⇔     .                    58.696   .000
  8  -.051   .138              .    *⇔     .                    58.831   .000
  9  -.096   .136               .  **⇔    .                     59.329   .000
 10  -.078   .134               .  **⇔    .                     59.665   .000
 11  -.097   .131               .  **⇔    .                     60.207   .000
 12  -.104   .129               .  **⇔    .                     60.854   .000
 13  -.161   .127               . ***⇔    .                     62.463   .000

Plot Symbols:      Autocorrelations *     Two Standard Error Limits .

Total cases:  40     Computable first lags:  39
```

APPENDIX B:

Data

Appendix B: 1

Variables used in plotting, stationarity and cointegration tests: based on equilibrium exchange rate in level form, 1994Q1-2003Q4*

Time	Infrtza	Infrtch	Inflzach	Rzach	PPP	infdfrtl	empsaimf	gdpza	gdpempza
1994Q1	3.43	1.46	2.35	2.3654	.9931	1.97	5311620	185428910000	34910.0
1994Q2	3.49	1.46	2.39	2.5634	.9340	2.03	5318870	195810750000	36814.4
1994Q3	3.62	1.46	2.48	2.7501	.9008	2.16	5337670	198026440000	37099.8
1994Q4	3.69	1.46	2.52	2.7332	.9234	2.23	5343370	200162920000	37460.1
1995Q1	3.77	1.48	2.55	2.8726	.8871	2.29	5374240	193086250000	35928.1
1995Q2	3.87	1.49	2.60	3.1564	.8240	2.38	5230160	197800610000	37819.2
1995Q3	3.90	1.49	2.62	3.0872	.8472	2.41	5209620	205532730000	39452.5
1995Q4	3.93	1.49	2.64	3.1754	.8313	2.44	5268920	207293840000	39342.8
1996Q1	4.02	1.50	2.69	3.1659	.8482	2.52	5236890	200508980000	38287.8
1996Q2	4.10	1.50	2.74	3.4657	.7897	2.60	5238570	209848250000	40058.3
1996Q3	4.19	1.50	2.80	3.6569	.7651	2.70	5241850	213052250000	40644.5
1996Q4	4.29	1.50	2.86	3.6057	.7920	2.79	5224990	214917470000	41132.6
1997Q1	4.41	1.51	2.92	3.1422	.9298	2.90	5189180	207431690000	39973.9
1997Q2	4.48	1.51	2.98	3.0948	.9621	2.98	5161280	216738690000	41993.2
1997Q3	4.56	1.51	3.03	3.1182	.9702	3.05	5139320	218043750000	42426.6
1997Q4	4.59	1.51	3.04	3.3548	.9075	3.08	5090550	218301830000	42883.7
1998Q1	4.65	1.51	3.08	3.3545	.9188	3.14	5005100	210091000000	41975.4
1998Q2	4.71	1.51	3.13	3.4629	.9033	3.21	4978200	217037000000	43597.5
1998Q3	4.91	1.51	3.25	4.2384	.7679	3.40	4962950	218372000000	44000.4
1998Q4	5.00	1.51	3.32	4.2522	.7814	3.50	4918930	219468000000	44617.0
1999Q1	5.04	1.51	3.33	4.2848	.7783	3.53	4927550	212290000000	43082.3
1999Q2	5.06	1.52	3.34	4.0507	.8237	3.54	4886030	221099000000	45251.3
1999Q3	5.07	1.52	3.33	3.9910	.8350	3.55	4842190	224441000000	46351.1
1999Q4	5.10	1.53	3.34	3.9799	.8390	3.57	4811200	227535000000	47292.8
2000Q1	5.34	1.54	3.46	3.8717	.8937	3.80	4734160	219828000000	46434.4
2000Q2	5.34	1.54	3.46	4.0972	.8445	3.80	4734160	228568000000	48280.6
2000Q3	5.34	1.54	3.46	4.1017	.8436	3.80	4734160	236118000000	49875.4
2000Q4	5.34	1.54	3.46	4.3563	.7943	3.80	4734160	237634000000	50195.6
2001Q1	5.57	1.55	3.59	4.7130	.7616	4.02	4673770	228116000000	48807.7
2001Q2	5.65	1.56	3.61	4.5926	.7862	4.08	4659750	237077000000	50877.6
2001Q3	5.67	1.56	3.63	4.9509	.7335	4.11	4649210	239764000000	51570.9
2001Q4	5.70	1.56	3.66	6.1846	.5910	4.14	4649170	242416000000	52141.8
2002Q1	5.88	1.56	3.77	6.8571	.5501	4.32	4632340	234735000000	50673.1
2002Q2	6.08	1.57	3.86	6.5560	.5895	4.51	4646020	245968000000	52941.7
2002Q3	6.25	1.57	3.99	7.0119	.5695	4.69	6508590	248457000000	38173.7
2002Q4	6.42	1.57	4.08	6.5720	.6207	4.85	6515860	251942000000	38666.0
2003Q1	6.51	1.58	4.13	6.1086	.6764	4.94	6456380	242491000000	37558.4
2003Q2	6.56	1.58	4.14	5.8085	.7136	4.98	6335650	252638000000	39875.6
2003Q3	6.55	1.57	4.17	5.4030	.7709	4.98	6369680	255096000000	40048.5
2003Q4	6.47	1.58	4.09	5.1516	.7943	4.89	6424800	258424000000	40222.9

*Namely, inflation rate in ZA (Infrtza), inflation rate in CH (Infrtch), (ratio of inflation rate in ZA to inflation rate in CH (Inflzach), no. of units of South African currency for a unit of Swiss currency (Rzach), purchasing power parity (PPP), inflation rate differential (infdfrtl), employment in ZA (empsaimf), gross domestic product in ZA (gdpza), ratio of gdp to employment in ZA (gdpempsa).

Appendix B: 1 (Cont'd)

Time	Eqlrzach	gdpch	empch	gdpempch	prodch	prodza
1994Q1	2.349	91674000000	3718500	24653.4893	24653.4893	14861.6638
1994Q2	2.349	91158300000	3718500	24514.8044	24514.8044	15672.3506
1994Q3	2.349	92004100000	3718500	24742.2617	24742.2617	15793.8658
1994Q4	2.349	92911300000	3718500	24986.2310	24986.2310	15947.2339
1995Q1	2.349	93017200000	3747200	24823.1213	24823.1213	15295.0631
1995Q2	2.349	93232700000	3747200	24880.6309	24880.6309	16100.1393
1995Q3	2.349	93062500000	3747200	24835.2103	24835.2103	16795.4610
1995Q4	2.349	92996600000	3747200	24817.6238	24817.6238	16748.7259
1996Q1	2.349	93671800000	3780600	24776.9666	24776.9666	16299.6155
1996Q2	2.349	93398200000	3780600	24704.5972	24704.5972	17053.3452
1996Q3	2.349	93567800000	3780600	24749.4578	24749.4578	17302.8849
1996Q4	2.349	93380700000	3780600	24699.9683	24699.9683	17510.6892
1997Q1	2.349	93680800000	3765600	24878.0540	24878.0540	17017.4057
1997Q2	2.349	94718100000	3765600	25153.5214	25153.5214	17877.0563
1997Q3	2.349	95565800000	3765600	25378.6382	25378.6382	18061.5478
1997Q4	2.349	96549500000	3765600	25639.8715	25639.8715	18256.1692
1998Q1	2.349	97427200000	3833000	25418.0016	25418.0016	17869.4700
1998Q2	2.349	97663200000	3833000	25479.5721	25479.5721	18560.0192
1998Q3	2.349	97565000000	3833000	25453.9525	25453.9525	18731.5638
1998Q4	2.349	97502300000	3833000	25437.5946	25437.5946	18994.0487
1999Q1	2.349	97784300000	3862000	25319.6012	25319.6012	18340.6820
1999Q2	2.349	98130600000	3862000	25409.2698	25409.2698	19264.0516
1999Q3	2.349	100303000000	3862000	25971.7763	25971.7763	19732.2837
1999Q4	2.349	101574000000	3862000	26300.8804	26300.8804	20133.1525
2000Q1	2.349	103882250000	3870000	26842.9587	26842.9587	19767.7418
2000Q2	2.349	103882250000	3870000	26842.9587	26842.9587	20553.6747
2000Q3	2.349	103882250000	3870000	26842.9587	26842.9587	21232.5985
2000Q4	2.349	103882250000	3870000	26842.9587	26842.9587	21368.9228
2001Q1	2.349	105507000000	3938000	26792.0264	26792.0264	20778.0791
2001Q2	2.349	105591000000	3938000	26813.3570	26813.3570	21659.2687
2001Q3	2.349	105701000000	3938000	26841.2900	26841.2900	21954.4113
2001Q4	2.349	105698000000	3938000	26840.5282	26840.5282	22197.4373
2002Q1	2.349	106601000000	3959000	26926.2440	26926.2440	21572.1984
2002Q2	2.349	108228000000	3959000	27337.2064	27337.2064	22537.9556
2002Q3	2.349	108303000000	3959000	27356.1505	27356.1505	16251.0455
2002Q4	2.349	107873000000	3959000	27247.5373	27247.5373	16460.6057
2003Q1	2.349	108147000000	3951000	27372.0577	27372.0577	15989.0818
2003Q2	2.349	107049000000	3951000	27094.1534	27094.1534	16975.5745
2003Q3	2.349	108372000000	3951000	27429.0053	27429.0053	17049.1612
2003Q4	2.349	109777000000	3951000	27784.6115	27784.6115	17123.4084

* Equilibrium exchange rate b/n ZA and CH (Eqlrzach), gross domestic product in CH (gdpch), employment in CH (empch), ratio of gdp to employment (gdpempch), productivity in CH(prodch) and productivity in ZA (prodsa). ZA refers to South Africa while CH refers to Switzerland.

Source: International Financial Statistics (IFS) of International Monetary Fund (IMF) and South African Reserve Bank (SARB), August, 2005

Appendix B: 2

Variables used in plotting, stationarity and cointegration tests: based on GDP Deflator index, 1994Q1-2003Q4*

Time	deflatza	deflatch	rzachidx	ppp	gdpza	gdpch
1994Q1	60.6830	98.2500	57.805	.010109634	84.352	88.248
1994Q2	61.6620	97.9550	62.439	.009507831	89.075	87.752
1994Q3	61.5780	98.3430	67.073	.008815342	90.082	88.566
1994Q4	63.4450	98.2450	66.585	.009147988	91.054	89.439
1995Q1	65.8460	98.9190	70.000	.008971636	87.835	89.541
1995Q2	67.6570	99.3340	77.073	.008354783	89.980	89.748
1995Q3	68.9540	99.0680	75.366	.008729083	93.497	89.585
1995Q4	70.2960	98.8080	77.561	.008674470	94.298	89.521
1996Q1	71.8550	99.1490	77.317	.008862843	91.212	90.171
1996Q2	73.4610	98.7740	84.634	.008308669	95.460	89.908
1996Q3	73.9340	99.0190	89.268	.007905195	96.918	90.071
1996Q4	75.5270	98.9560	88.049	.008195387	97.766	89.891
1997Q1	77.2980	98.7340	76.585	.009646485	94.361	90.180
1997Q2	79.1030	98.8170	75.366	.010014669	98.595	91.178
1997Q3	80.1150	98.7650	76.098	.010071857	99.188	91.994
1997Q4	82.2130	99.0000	81.707	.009583787	99.306	92.941
1998Q1	83.2580	99.0190	81.707	.009704947	95.571	93.786
1998Q2	85.8710	98.6100	84.390	.009736296	98.730	94.013
1998Q3	86.1520	98.2690	103.415	.008008589	99.338	93.919
1998Q4	88.0490	98.4010	103.659	.008147396	99.836	93.858
1999Q1	89.3790	98.7120	104.390	.008181683	96.571	94.130
1999Q2	90.7930	98.5200	98.780	.008808380	100.578	94.463
1999Q3	93.0250	99.7730	97.317	.009044972	102.098	96.555
1999Q4	94.3330	99.8250	97.073	.009192947	103.506	97.778
2000Q1	100.0000	100.0000	100.000	.010000000	100.000	100.000
2000Q2	100.0000	100.0000	100.000	.009449705	103.976	100.000
2000Q3	100.0000	100.0000	100.000	.009439261	107.410	100.000
2000Q4	100.0000	100.0000	100.000	.008887665	108.100	100.000
2001Q1	105.6310	100.2750	114.878	.008653736	103.770	101.564
2001Q2	106.3500	100.2810	111.951	.008940514	107.847	101.645
2001Q3	107.5200	100.9980	120.732	.008325259	109.069	101.751
2001Q4	111.1210	101.0510	150.732	.006884172	110.275	101.748
2002Q1	115.2490	101.7860	167.317	.006393107	106.781	102.617
2002Q2	117.7040	102.8580	160.000	.006758057	111.891	104.183
2002Q3	118.9290	102.6210	170.976	.006399104	113.023	104.256
2002Q4	122.9500	102.1650	160.244	.007089805	114.609	103.842
2003Q1	122.6390	103.5650	149.024	.007505495	110.309	104.105
2003Q2	123.1230	102.4370	141.707	.008011683	114.925	103.048
2003Q3	124.3670	103.1430	131.707	.008640440	116.043	104.322
2003Q4	126.1310	103.9350	125.610	.009120598	117.557	105.674

*Namely, GDP Deflator in ZA (deflatza), GDP Deflator in CH (deflatch), exchange rate index (rzachidx), purchasing power parity (PPP), GDP index in ZA (gdpza), GDP in CH (gdpch).

Appendix B: 2 (Cont'd)

Time	empldxza	empldxch	gdemdxza	gdemdxch	prod	cpiza	cpich
1994Q1	112.1980	96.0850	.75181	.91844	.818579740	64.288	94.684
1994Q2	112.3510	96.0850	.79283	.91327	.868115398	65.422	94.552
1994Q3	112.7480	96.0850	.79897	.92175	.866797673	67.756	94.651
1994Q4	112.8680	96.0850	.80673	.93083	.866676178	69.123	94.751
1995Q1	113.5200	96.8270	.77374	.92475	.836699981	70.690	95.980
1995Q2	110.4770	96.8270	.81447	.92689	.878710495	72.391	96.312
1995Q3	110.0430	96.8270	.84964	.92521	.918325053	72.991	96.578
1995Q4	111.2960	96.8270	.84727	.92455	.916419828	73.658	96.578
1996Q1	110.6190	97.6900	.82456	.92303	.893316743	75.292	97.010
1996Q2	110.6550	97.6900	.86268	.92034	.937350813	76.792	97.076
1996Q3	110.7240	97.6900	.87531	.92201	.949353164	78.560	97.143
1996Q4	110.3680	97.6900	.88582	.92017	.962672514	80.394	97.375
1997Q1	109.6110	97.3020	.86087	.92681	.928859294	82.528	97.741
1997Q2	109.0220	97.3020	.90436	.93706	.965100303	83.995	97.608
1997Q3	108.5580	97.3020	.91369	.94545	.966405881	85.328	97.608
1997Q4	107.5280	97.3020	.92354	.95518	.966870583	85.929	97.674
1998Q1	105.7230	99.0440	.90398	.94691	.954655788	87.062	97.708
1998Q2	105.1550	99.0440	.93890	.94920	.989143882	88.296	97.674
1998Q3	104.8330	99.0440	.94758	.94826	.999291307	91.931	97.708
1998Q4	103.9030	99.0440	.96086	.94764	1.013948649	93.731	97.608
1999Q1	104.0850	99.7930	.92781	.94325	.983627364	94.432	98.007
1999Q2	103.2080	99.7930	.97452	.94659	1.029503857	94.732	98.239
1999Q3	102.2820	99.7930	.99820	.96755	1.031676015	94.998	98.671
1999Q4	101.6270	99.7930	1.01849	.97981	1.039478112	95.565	99.003
2000Q1	100.0000	100.0000	1.00000	1.00000	1.000000000	100.000	100.000
2000Q2	100.0000	100.0000	1.03976	1.00000	1.039760000	100.000	100.000
2000Q3	100.0000	100.0000	1.07410	1.00000	1.074100000	100.000	100.000
2000Q4	100.0000	100.0000	1.08100	1.00000	1.081000000	100.000	100.000
2001Q1	98.7240	101.7570	1.05111	.99810	1.053109599	104.268	100.532
2001Q2	98.4280	101.7570	1.09569	.99890	1.096901632	105.769	101.329
2001Q3	98.2060	101.7570	1.11061	.99994	1.110679913	106.102	101.130
2001Q4	98.2050	101.7570	1.12291	.99991	1.123005491	106.669	100.963
2002Q1	97.8490	102.3000	1.09128	1.00310	1.087912362	110.203	101.096
2002Q2	98.1380	102.3000	1.14014	1.01841	1.119532555	113.938	101.993
2002Q3	137.4810	102.3000	.82210	1.01912	.806675234	117.139	101.462
2002Q4	137.6350	102.3000	.83270	1.01507	.820337237	120.273	101.993
2003Q1	136.3790	102.0930	.80884	1.01971	.793209347	121.974	102.159
2003Q2	133.8280	102.0930	.85875	1.00935	.850793030	122.808	102.558
2003Q3	134.5470	102.0930	.86247	1.02183	.844043812	122.641	101.894
2003Q4	135.7120	102.0930	.86622	1.03508	.836870122	121.174	102.492

***** Employment index in ZA (empldxza), Employment index in CH (empldxch), ratio of GDP to employment index in ZA (gdemdxza), ratio of GDP to employment index in CH (gdemdxch), ratio of productivity in SA to productivity in CH (prod), Consumer Price Index in ZA (cpiza), Consumer Price Index in CH (cpich),

Source: International Financial Statistics (IFS) of International Monetary Fund (IMF), August, 2005

APPENDIX C:
Critical Values for Stationarity and Cointegration Tests

APPENDIX C: 1

Critical Values for the Dickey-Fuller (DF or tau, τ) or Stationarity Test

Sample Size *n*	Significance Level							
	0.01	0.025	0.05	0.10	0.90	0.95	0.975	0.99
No Constant Included								
25	-2.66	-2.26	-1.95	-1.60	0.92	1.33	1.70	2.16
50	-2.62	-2.25	-1.95	-1.61	0.91	1.31	1.66	2.08
100	-2.60	-2.24	-1.95	-1.61	0.90	1.29	1.64	2.03
250	-2.58	-2.23	-1.95	-1.62	0.89	1.29	1.63	2.01
500	-2.58	-2.23	-1.95	-1.62	0.89	1.28	1.62	2.00
∞	-2.58	-2.23	-1.95	-1.62	0.89	1.28	1.62	2.00
Constant Included								
25	-3.75	-3.33	-3.00	-2.63	-0.37	0.00	0.34	0.72
50	-3.58	-3.22	-2.93	-2.60	-0.40	-0.03	0.29	0.66
100	-3.51	-3.17	-2.89	-2.58	-0.42	-0.05	0.26	0.63
250	-3.46	-3.14	-2.88	-2.57	-0.42	-0.06	0.24	0.62
500	-3.44	-3.13	-2.87	-2.57	-0.43	-0.07	0.24	0.61
∞	-3.43	-3.12	-2.86	-2.57	-0.44	-0.07	0.23	0.60
Constant and Linear Trend Included								
25	-4.38	-3.95	-3.60	-3.24	-1.14	-0.80	-0.50	-0.15
50	-4.15	-3.80	-3.50	-3.18	-1.19	-0.87	-0.58	-0.24
100	-4.04	-3.73	-3.45	-3.15	-1.22	-0.90	-0.62	-0.28
250	-3.99	-3.69	-3.43	-3.13	-1.23	-0.92	-0.64	-0.31
500	-3.98	-3.68	-3.42	-3.13	-1.24	-0.93	-0.65	-0.32
∞	-3.96	-3.66	-3.41	-3.12	-1.25	-0.94	-0.66	-0.33

Source: Adapted from Fuller, A.W. 1976:373

APPENDIX C: 2
Critical Values for the Engle-Granger (EG) Cointegration Test

Number of Variables	Sample Size	Significance Level		
		1%	5%	10%
1 (No Constant Included)	50	2.62	1.95	1.61
	100	2.60	1.95	1.61
	250	2.58	1.95	1.62
	500	2.58	1.95	1.62
	∞	2.58	1.95	1.62
2	50	4.32	3.67	3.28
	100	4.07	3.37	3.03
	200	4.00	3.37	3.02
3	50	4.84	4.11	3.73
	100	4.45	3.93	3.59
	200	4.35	3.78	3.47
4	50	4.94	4.35	4.02
	100	4.75	4.22	3.89
	200	4.70	4.18	3.89

Source: Adapted from Engle, F. R. and Yoo, S. B. 1987. 'Forecasting and Testing in Co-integrated Systems.' *Journal of Econometrics*. 35: 143-159.