AN ANALYSIS OF EXCHANGE RATE PASS-THROUGH TO PRICES IN SOUTH AFRICA

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Abstract

The fact that South Africa has a floating exchange rate policy as well as an open trade policy leaves the country's import, producer and consumer prices susceptible to the effects of exchange rate movements. Given the central role that inflation targeting occupies in South Africa's monetary policy, it becomes necessary to determine the nature of influence of exchange rate changes on domestic prices. To this end, this thesis examines the magnitude and speed of exchange rate pass-through (ERPT) to import, producer and consumer prices in South Africa. Furthermore, it explores whether the direction and size of changes in the exchange rate have different pass-through effects on import prices, that is, whether the exchange rate pass-through is symmetric or asymmetric. The paper uses monthly data covering the period January 1980 to December 2005. In investigating ERPT, two main stages are identified. The initial stage is the transmission of fluctuations in the exchange rate to import prices, while the second-stage entails the pass-through of changes in import prices to producer and consumer prices. The first stage is estimated using the Johansen (1991) and (1995) cointegration techniques and a vector error correction model (VECM). The second stage pass-through is determined by estimating impulse response and variance decomposition functions, as well as conducting block exogeneity Wald tests. The study follows Wickremasinghe and Silvapulle's (2004) approach in estimating pass-through asymmetry with respect to appreciations and depreciations. In addition, the thesis adapts the analytical framework of Wickremasinghe and Silvapulle (2004) to investigate the pass-through of large and small changes in the exchange rate to import prices. The results suggest that ERPT in South Africa is incomplete but relatively high. Furthermore, ERPT is found to be higher in periods of rand depreciation than appreciation which supports the binding quantity constraint theory. There is also some evidence that pass-through is higher in periods of small changes than large changes in the exchange rate, which supports the menu cost theory when invoices are denominated in the exporters' currency.

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I dedicate this thesis to my mother and father, Mrs G.R. Karoro and Col. A.S. Karoro. Words cannot express my gratitude for all you have done for me up to this point. May we continue to grow together in the fortitude, love and mercy of God, Almighty.

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CHAPTER 1: INTRODUCTION

1.1 Background, Context and Rationale for the Research

The common consensus among economists is that monetary policy should primarily be concerned with the establishment and maintenance of price stability (van der Merwe, 2004:1). However, there remains an unresolved debate as to how this objective can be achieved most effectively. As this debate ensues, an increasing number of countries have adopted inflation targeting as the core of their monetary policy framework. In February 2000, South Africa followed suit, by announcing that formal inflation targeting would be adopted in the country (van der Merwe, 2004: 1).

Consequently, it became imperative for the South African Reserve Bank (SARB) to monitor and, where possible, influence the determinants of inflation using monetary policy instruments. A major determinant of inflation is exchange rate movement (SARB, 2001). Thus, changes in exchange rates are important in the determination of monetary policy because they could have a major impact on inflation, especially when a country has a floating exchange rate policy as well as an open trade policy, allowing for significant levels of imports (SARB, 2001).

In the case of South Africa, the exchange rate regime has evolved from being fixed, to managed-floating, to free-floating. The degree of exchange rate management since the switch from a fixed to a floating rate policy in 1979 (De Kock Commission, 1984) has declined, and at present, the country has achieved its long-term objective of establishing a unitary exchange rate system, within which the rand is allowed to find its own level in a competitive environment (du Toit, 2005:26). Furthermore, imports to South Africa have increased by almost 800 percent over the last thirty years. In 1975, total imports amounted to US$8.8 billion and by 2005, had grown to US$62.3 billion in real terms (SARB, 2006).

The floating exchange rate regime, coupled with a more open trade policy and the growth in imports, leaves South Africa vulnerable to the effects of exchange rate behaviour on import, producer and consumer prices, which all contribute to inflation (SARB, 2001). The South African scenario suggests that any appreciation or

depreciation of the exchange rate will result in changes in the prices of imported finished goods, as well as the cost of imported inputs that also affect the price of locally produced finished goods and services. The transmission of exchange rate fluctuations to the above mentioned prices is referred to as exchange rate pass-through (ERPT).

Kiptui *et al*. (2005: 1) propose that an understanding of exchange rate pass-through is important for a number of reasons. Firstly, the level of ERPT is an approximation of international macroeconomic transmission and thus has implications for the timing of monetary policy intervention. Hence, the degree and speed of pass-through is important for forecasting inflation and formulating monetary policy responses to inflation shocks. Furthermore, the adoption of inflation targeting requires knowledge of the speed and magnitude of ERPT to inflation. Secondly, understanding ERPT at the macro and microeconomic levels gives insights into the strength of the international market power of domestic industries vis-à-vis their international counterparts. Thirdly, a low ERPT level would make it possible for trade flows to remain relatively unchanged by exchange rate fluctuations, even with highly elastic demand. If prices respond sluggishly to changes in the exchange rate and if trade flows respond slowly to the relative price change, then the overall balance of payments adjustment process could be severely held back (Kiptui *et al*., 2005: 1).

Numerous works have been conducted on ERPT. However, the scope of these studies has varied from analysing the first stage of ERPT, which involves the pass-through of exchange rate fluctuations to import prices, and has been the main focus of most studies on exchange rate pass-through (for example Menon (1995), Goldberg and Knetter (1997), Gust *et al.* (2006)), to analysing the second stage pass-through of exchange rate and import price changes to producer and consumer prices (for example Bhundia (2002), Devereux and Yetman (2003), Hyder and Shah (2004), Ito *et al*. (2005) and Kiptui *et al*. (2005)). Other ERPT studies have also investigated the asymmetry of ERPT to import prices (for example Feinberg (1989), Athukorala (1991), Webber (2000), Wickremasinghe and Silvapulle (2004) and Pollard and Coughlin (2004)).

Most of these studies have focused on developed countries such as the USA and the UK. The most cited of these is Menon (1995), who conducted a comprehensive survey of the literature on exchange rate pass-through, which summarised 43 empirical studies on industrialised countries, the majority of which were for the USA (Menon, 1995: 1). Fewer papers on ERPT in developing countries have been written, and in the case of South Africa, three country specific studies can be found, namely Nell (2000), Bhundia (2002), and SARB (2002), albeit focusing on different aspects of ERPT in South Africa[1] . Nonetheless a major gap remains unfilled by these South African studies as well as other studies from other developing countries, particularly the investigation of the asymmetric adjustment of domestic prices (import, producer and consumer prices) to fluctuations in the exchange rate.

Given the wealth of theoretical and empirical research on developed countries, and the shortage of such research in developing countries, including South Africa, this thesis investigates ERPT to import, producer and consumer prices and its impact on inflation levels in South Africa. Furthermore, the pass-through asymmetry of exchange rate changes to import prices is analysed. Thus, the scope of this study differs from the other ERPT studies on South Africa, as will be made clearer in Chapter 2.

1.2 Aim and Objectives of the Research

The aim of the study is to determine the extent of exchange rate pass-through to import, producer and consumer prices in South Africa. More specifically the study will endeavour to achieve the following goals:

1. To measure the magnitude and speed of exchange rate pass-through to import, producer and consumer prices in South Africa.
2. To determine whether appreciations and depreciations in the exchange rate, as well as the size of the change in the exchange rate, have different pass-through effects on import prices, that is, whether the estimates of exchange rate pass-through are symmetric or asymmetric.
3. To propose policy recommendations based on the findings of the study.

[1] A more detailed review of these papers is given in Chapter 2.

1.3 Methodology

The above stated goals will be achieved through empirical analysis, making use of monthly data spanning 26 years, from 1980 to 2005. 1980 is used as the starting year, due to the availability of data for all the series from that year onwards. The primary source of data is the IMF International Financial Statistics CD-ROM February 2006, unless stated otherwise.

In investigating the pass-through of exchange rate fluctuations to import, producer and consumer prices, two main stages are identified. The initial stage is the transmission of fluctuations in the exchange rate to the price of imported goods. Thereafter, the second stage of ERPT entails the pass-through of changes in the exchange rate and import prices to producer and consumer prices. The first stage is estimated using the Johansen (1991) and (1995) cointegration technique and a vector error correction model (VECM). The cointegration method will test for long-run cointegrating relationships between the variables. After ascertaining the existence of long-run relationships, the VECM is estimated to test for short-run dynamics in the relationships between the variables.

The second stage pass-through is determined by analysing impulse response and variance decomposition functions, as well as conducting block exogeneity Wald tests. The study follows Wickremasinghe and Silvapulle's (2004) approach to estimating pass-through asymmetry with respect to appreciations and depreciations. We also adapt the same approach (Wickremasinghe and Silvapulle, 2004) to investigate the pass-through of large and small changes in the exchange rate to import prices.

1.4 Organisation of the Study

The study is arranged as follows: Chapter 2 reviews the theoretical and empirical literature on exchange rate pass-through and the pass-through asymmetry of exchange rate changes to import prices. The chapter summarises the findings of different research papers on the subject matter and also highlights the main issues regarding the study of ERPT. Literature on ERPT in South Africa is also reviewed and this will set the tone for Chapter 3.

Chapter 3 discusses the South African macroeconomic environment - past and present - focusing specifically on the exchange rate and trade polices implemented in South Africa from the 1970s to the present, and their relevance to ERPT. In this regard, the chapter discusses the behaviour of the South African Rand over the years, as well as the structure and composition of South Africa's trade, and the implications of these for ERPT to domestic prices in the country.

The methodology and data are discussed in Chapter 4. The econometric models used for the empirical framework are laid out and the data used for analysis is described. Chapter 5 reports the findings of the empirical analysis, and Chapter 6 summarises the major findings of the study, and discusses the policy implications and recommendations, as well as the limitations of the study.

CHAPTER 2: A THEORETICAL AND EMPIRICAL REVIEW OF EXCHANGE RATE PASS-THROUGH

2.1 Introduction

This chapter reviews the theoretical and empirical literature on ERPT from global and South African perspectives. Issues pertaining to the magnitude and speed of pass-through are discussed, and in addition, literature on the pass-through asymmetry of exchange rate changes to import prices is reviewed.

2.2 Theoretical Literature

2.2.1 Exchange Rate Pass-Through Defined

The increased enthusiasm in investigating exchange rate pass-through (ERPT) emanated from the "adjustment puzzle" (Menon, 1995: 197). Friedman (1953) and Johnson (1969) (in Menon, 1995: 197) advocated the adoption of flexible exchange rate regimes across the world after the demise of the Bretton Woods system, and claimed that such a regime would provide a more efficient system of international adjustment. However, the initial enthusiasm about the expected equilibrating role of flexible exchange rates waned as the trade balances of major trading nations continued to show significant resilience to exchange rate changes (Menon, 1995: 197). Consequently, there was a frantic search to explain and account for this "adjustment puzzle".

A number of scholars have been motivated to examine more closely the underlying relationship between the exchange rate and prices of internationally traded commodities now popularly referred to as ERPT.

"Exchange rate pass-through" is an expression generally used to describe the effects of exchange rate fluctuations on one of the following: (1) import and export prices, (2) consumer prices, (3) investments and (4) trade volumes (Darvas, 2001: 12). Of these four topics, theoretical and empirical literature has focused on the effects of exchange rate changes on import and export prices because, firstly, this is the "natural ground" for investigating the pricing practices of firms and, secondly, a response by import-

export prices to exchange rate changes usually precedes any consequence for consumer prices, investment and trade volumes (Darvas, 2001: 12).

Kiptui *et al*. (2005: 1), and Gosh and Rajan (2006: 1) define ERPT as the percentage change in local currency import prices resulting from a one percent change in the exchange rate, that is, the change in domestic prices that can be attributed to a prior change in the nominal exchange rate. Other scholars such as Campa and Goldberg (2002: 5) and Mumtaz *et al*. (2006: 1) provide a similar definition of ERPT: as the percentage change in local currency import prices resulting from a one percent change in the exchange rate between the exporting and importing country.

ERPT refers to the transmission of exchange rate fluctuations to import (export) prices of specific commodities in the destination market currency (Menon, 1995: 197). It can be regarded as partial or incomplete if the import price rises by less than one percent, as exporters absorb a portion of the exchange rate changes (Gosh and Rajan, 2006: 1). The existence of incomplete pass-through forms the basis of the "adjustment puzzle" mentioned earlier. In an effort to understand this puzzle, the following sections discuss the channels of ERPT as well as the determinants and models of pass-through including its asymmetric properties.

2.2.2 The Channels of Exchange Rate Pass-Through

This section endeavours to identify the possible channels of ERPT to import, producer and consumer prices. Assuming that a free-floating exchange rate regime prevails, as is currently the case in South Africa, conventional economic theory stipulates that exchange rate movements do influence the price of tradables, that is, imports and exports. Hyder and Shah (2004: 2), in this regard, specify that a depreciation (an appreciation) in the exchange rate will result in a rise (fall) in the domestic price of imports and a decrease (increase) in the foreign price of exports.

The impact of exchange rate fluctuations on domestic prices can be transmitted through direct and/or indirect channels. As proposed by Hyder and Shah (2004: 1), the direct channel of transmission is when exchange rate movements affect domestic prices through changes in the price of imported finished goods and imported inputs. Thus when a currency depreciates, import prices will rise, while a currency

appreciation results in lower import prices. Consequently, in the case of a currency depreciation, higher costs of imported raw materials and capital goods emanating from the depreciation will increase marginal costs and lead to higher prices of domestically produced goods (Hyder and Shah 2004: 1). On the other hand, importing firms bringing in finished goods may simply increase the price in local currency in response to the increased purchasing cost of the imported commodity. Thus, two alternative channels can be identified under the direct transmission of ERPT. The first channel is the pass-through of exchange rate changes to import prices of production inputs, which affects the production price level, and finally influences the consumer price level. The second channel is where the changes in the exchange rate affect the import prices of finished goods, and thus impact on the level of domestic consumer prices.

Alternatively, in the case of the indirect transmission of ERPT, a currency depreciation, for example, would affect net exports as locally produced goods become cheaper in the export markets. The increase in foreign demand for local goods would result in the exertion of upward pressure on domestic prices (Hyder and Shah, 2004). Two alternative channels of pass-through begin to emerge. If the locally produced goods mentioned above are primarily inputs of production, then producer price levels are expected to rise and consequently consumer price levels will also increase. On the other hand, if the locally produced goods are finished products, local producers and retailers may increase their prices in response to foreign competitor price increases in order to maintain profit margins.

The direct and indirect transmission channels of ERPT as discussed above are illustrated in Figure 2.1 below. However, these transmission channels can be further broken down and simplified into the following schematics:

↓ ER → ↑ IMP → ↑ PP → ↑ CP

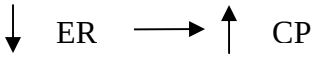
Schematic 2.1

↓ ER → ↑ IMP → ↑ CP

Schematic 2.2

↓ ER → ↑ PP → ↑ CP

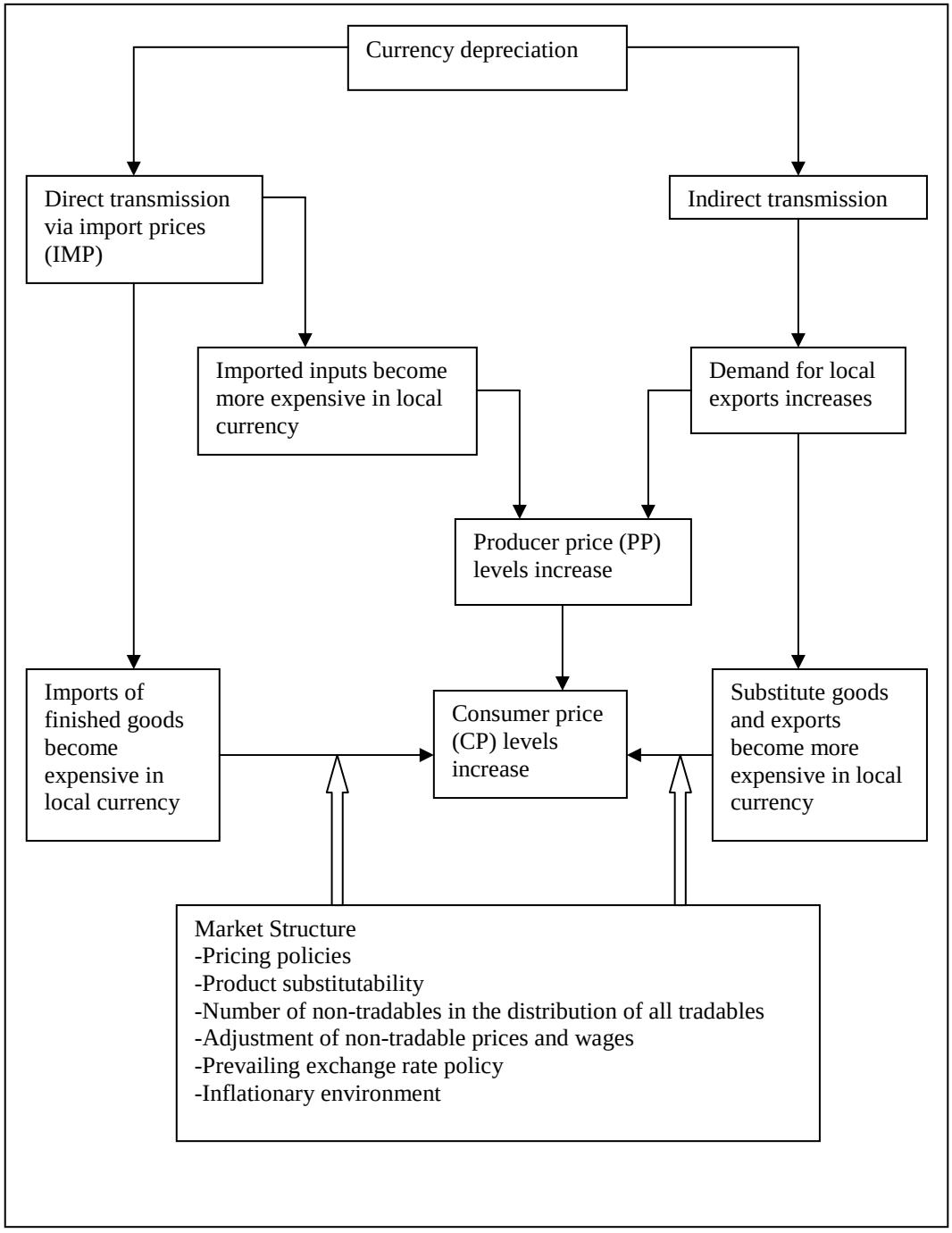
Schematic 2.3



Schematic 2.4

where ER is the exchange rate, IMP represents import prices, PP represents producer prices, and CP represents consumer prices. Schematics 2.1 and 2.2 represent the two alternative direct transmission channels, while schematics 2.3 and 2.4 show the two alternative indirect transmission channels. However, the magnitude, speed and asymmetry of ERPT through these channels will depend on several factors such as market structure, pricing policies, the inflationary environment, the share of non-tradables in the distribution of all goods and services, the relative share of imports in the wholesale price index (WPI) and consumer price index (CPI) basket, and the prevailing exchange rate policy, among other factors (Hyder and Shah, 2004: 1).

Figure 2.1: The Transmission of ERPT to Domestic Prices



Adapted from Hyder and Shah (2004)

2.2.3 The Determinants and Models of Exchange Rate Pass-Through

This section reviews the theoretical approaches used to model the channels of ERPT discussed above, and the determinants of ERPT. According to Gaulier *et al*. (2006: 1), partial exchange rate pass-through is a micro-based phenomenon that bears important macroeconomic consequences. The sensitivity and asymmetric adjustment of import

prices and other domestic prices to exchange rate movements are explained by a number of determining factors. In addition to those highlighted in Figure 2.1, other factors noted by Branson (1972), Dornbusch (1987), Menon (1996), Yang (1997), Hyder and Shah (2004), and Gaulier *et al*. (2006) include: the behaviour of exporting firms, which adopt pricing-to-market strategies; specific industry and market characteristics; and the perceived nature of exchange rate changes. On a macroeconomic level, the exchange rate regime adopted by an importing country and the openness of trade in or with that country also has a bearing on the size and speed of ERPT as well as the asymmetric response of domestic prices to exchange rate fluctuations.

Economists have considered that a low sensitivity of import prices to exchange rate changes is attributable to the possibility that exporting firms adjust their prices to exchange rate fluctuations in a manner that maintains their competitiveness in the destination market (Gaulier *et al*., 2006: 9). Krugman (1987) describes such behaviour as pricing-to-market. Theoretically, pricing-to-market is impractical in a perfectly competitive market as initially set export prices have to be above the marginal cost of production (Gaulier *et al*., 2006: 9). Conversely, when the exporting firms' margins are positive, pricing-to-market can become a sustainable strategy for the exporters, in which case the measured pass-through of exchange rate changes to import and other domestic prices, such as producer and consumer prices, will be less than one. Thus the size of the ERPT will be affected by the ability of exporters to absorb exchange rate shocks within their profit margins (Gaulier *et al*., 2006: 9).

According to Kara and Nelson (2003: 591) models of the 'pricing-to-market' phenomenon assume that import price-setters basically set prices equal to that prevailing for domestic goods, and do not adjust the prices with regard to world price or exchange rate variations. Imports are regarded simply as consumer goods in these models, implying that this approach would best model the channels represented by the schematics 2.2 and 2.4 above, as the intermediate-goods channels of transmission are not considered. Prices of imported consumer goods are set so that they equal prices of domestic goods, implying that there is no pass-through at all. At the extreme, such pricing-to-market models imply that channels through which exchange rate changes

are transmitted to costs and prices are 'shut off' by the failure of import prices to adjust to exchange rate movements (Devereux and Engel, 2002).

Another determining factor of ERPT that is closely linked to pricing-to-market is the specific industry or market characteristics. These characteristics include the degree of competition, relative domestic and foreign shares in the market (Dornbusch, 1987), the elasticity of import/export demand and supply, product substitutability and differentiation (Menon, 1995 and Yang, 1997), and the perceived reaction of incumbent industry competitors.

Dornbusch's (1987) findings suggest that industries that are imperfectly competitive and have a large share of imports in aggregate domestic sales, experience significant pass-through effects of exchange rate movements. Goldberg and Knetter (1996) and Hyder and Shah (2004: 3) also support Dornbusch's (1987) argument that markets which are not perfectly competitive may experience a range of pricing responses to exchange rate fluctuations resulting in greater pass-through effects. Gaulier *et al*. (2006: 12) note that the optimal markup as determined by firms' pricing-to-market still depends negatively on the price-elasticity of demand but also increases as the producer's market share in the destination market increases. Consequently, the optimal price reaction to exchange rate fluctuations is affected by the exporter's market share and the steadiness of the elasticity of demand with respect to the price of imports in local currency.

Feenstra *et al*. (1996: 188) state that under weak assumptions of the functional form of demand, the pass-through elasticity might initially fall as market share increases, but the elasticity will rise towards unity as market share approaches 100 percent. An exporter with low market share may have less room to manoeuvre to absorb exchange rate changes. However, as the exporter's market share and market power increases, the incentive to price-to-market decreases. In such a case the exporter is likely to pass on any increase in costs brought about by depreciation in the importer's currency, and thus, the ERPT is likely to be high.

Yang (1997: 98) shows that there is a negative relationship between the size of ERPT and the degree of substitution among different products in the industry. He (Yang,

1997) also found that foreign firms are more likely to keep prices in line with domestic prices and absorb exchange rate shocks rather than fully incorporating them into their prices when products in an industry have strong locally produced substitutes. According to Menon (1999: 4), a possible reason for this is that it may be less costly to absorb short-run movements in the exchange rate into profit margins than into price changes.

Wickremasinghe and Silvapulle (2004) propose that the extent of ERPT depends on market or industry specific factors such as product differentiation and the nature of competition. Wickremasinghe and Silvapulle (2004: 5) formulate a basic model of ERPT based on the principles of the monetary approach represented as:

$$PM = PX^{*} ER = (1 + \lambda) C^{*} ER \qquad (2.1)$$

The model describes the derivation of the import price (PM), where exporters set their price (PX^{*}) at a profit margin (λ) over the cost of production (C^{*}) and (ER) is the exchange rate. The model proceeds to set $(1 + \lambda) = \rho$, where ρ is the profit markup. According to Hooper and Mann (1989), it has been hypothesized that exporters base their pricing decisions on competitive pressures in the domestic market, which are a proxy for the gap between the prices of domestic import competing goods (PD) and exporters' cost in the local currency. The profit markup can thus be modelled as:

$$\rho = \{PD / (C^{*} ER)\}^{\alpha} \qquad (2.2)$$

Wickremasinghe and Silvapulle (2004: 5) proceed to substitute ρ in Equation (2.2) for $(1 + \lambda)$ in Equation (2.1) and take the logarithms of the variables (denoting them in lower case letters). The equation for the import price becomes:

$$pm = \alpha pd + (1 - \alpha)\, c^{*} + (1 - \alpha) er \qquad (2.3)$$

In Equation (2.3), $(1 - \alpha)$ represents the pass-through coefficient, which is expected to be between 0 and 1. If the foreign firm is a price taker in a domestic competitive market, then $\alpha = 1$ and therefore, pass-through is zero. This would imply that the domestic country's import price set by the foreign firm is equal to that country's

domestic price and changes in exchange rates and foreign costs have no effect on import prices. If the foreign firms do not face any competition in the domestic market, then both the changes in the exchange rate and foreign costs are fully passed on to import prices leaving the markup unchanged, in which case $\alpha = 0$ and ERPT = 1 (Wickremasinghe and Silvapulle, 2004: 5).

Campa and Goldberg (2002) formulated a model similar to Wickremasinghe and Silvapulle (2004: 5), based on relatively similar principles and theory. According to Campa and Goldberg (2002: 4), the analysis of exchange rates and price relationships have followed various paths, from the early macroeconomic debate on exchange rates and monetarism, to market integration or segmentation associated with the Law of One Price, to the role of market microstructure and the ability of firms to institute price discrimination. Campa and Goldberg's (2002) model starts off from Equation (2.4) below:

$$P_t = E_t P_t^* \qquad (2.4)$$

where P_t is the domestic price index, E_t is the nominal exchange rate defined as the domestic currency per unit of foreign currency, and P_t^* represents foreign prices. Campa and Goldberg (2002: 4) propose that the micro-foundations of the pricing behaviour of exporters are a better starting point for generating more economically meaningful specifications that are appropriate for hypothesis testing. The pricing equation of an exporter from a country (X) and its elasticity of response to an exchange rate movement depend on the make up of demand as well as the costs confronting the exporter. If the import price of a country (J), $P_t^{m,j}$, is the dependent variable, the pricing rule of the foreign exporters of Country (X) supplying Country (J) will be:

$$P_t^{m,j} = E_t P_t^{x,j} = E_t MKUP_t^{x,j} (P_t^{m,j} / P_t) C^{x,j} (W_t^j, Y_t, E_t) \qquad (2.5)$$

$$MKUP_t^{x,j} = P_t^{x,j} / C_t^{x,j}; \qquad (2.6)$$

where $C_w^{x,j} > 0$; $C_E^{x,j} < 0$; and $C_y^{x,j} > 0$. In Equation (2.6) $MKUP_t^{x,j}$ represents the markup rate of prices divided by the costs incurred by the exporter. Markup rates are

industry specific and depend on the demand curve facing exporters of Country (X) in Country (J). This demand depends on ($P_t^{m,j} / P_t$), that is, the prices of imports relative to prices of Country (J) producers. $C_t^{x,j}$ is the marginal cost function of the exporter in his/her own currency.

In a study of the relationship between the exchange rate and inflation in the United Kingdom, Kara and Nelson (2003) cite other approaches that have been used to determine ERPT and also follow some of the theory and assumptions used by the previously discussed models. The models include a New Keynesian open-economy specification, and the traditional backward-looking open economy Phillips curves. According to Kara and Nelson (2003: 593) the simplified versions of the New Keynesian Phillips curve (NKPC) model assume that the nominal prices of domestically produced goods are sticky; imports are flexible-price; and there are no imported intermediate goods, thus allowing for an exogenous disturbance term u_t. Thus the Phillips curve for domestic goods inflation is:

$$\Pi_t^D = \beta E_t \Pi_{t+1}^D + \alpha ulc_t + u_t \qquad (2.7)$$

where Π_t^D is interpreted as $\Delta \log P^D$ (the differenced log of P^D - the index of goods prices that are both produced and sold domestically); β is a discount factor near unity, $\alpha > 0$ and ulc is the log of real unit labour cost. Equation (2.8) below, makes use of the full pass-through assumption, and is then substituted into Equation (2.7) – the domestic inflation NKPC, resulting in the Phillips curve for CPI inflation – Equation (2.9) (Kara and Nelson, 2003: 594).

$$\Pi_t^D = \Pi_t - s_M \Delta q_t \qquad (2.8)$$

$$\Pi_t = \beta E_t \Pi_{t+1} + \alpha mc_t + \phi(\Delta q_t - \beta E_t \Delta q_{t+1}) + u_t, \; \alpha > 0, \; \phi > 0. \qquad (2.9)$$

In the above equations, Π_t is the annualized percentage change in CPI inflation; s_M is the share of imports; mc is the real marginal cost of domestic producers; while the term ($\Delta q_t - \beta E_t \Delta q_{t+1}$) describes the current real exchange rate depreciation relative to the subsequent period's expected depreciation; and α and ϕ are constants greater than zero.

Kara and Nelson (2003: 595) report that pure backward-looking Phillips curves studies that treat the model equations as structural assume that optimizing behaviour and rational expectations formation are unimportant in practice. Thus, aggregate inflation evolves as a function of lags of itself, domestic-demand variables, and changes in the real exchange rate.

2.2.4 The Models of Exchange Rate Pass-Through Asymmetry

Pollard and Coughlin (2003) investigate how asymmetry might arise in the case of ERPT and identify various circumstances (discussed below) that could generate asymmetry (see also Knetter, 1994 and Peltzman, 2000). Theory suggests that a currency appreciation can lead to either a higher or lower rate of pass-through than a depreciation (Pollard and Coughlin, 2003: 2). Thus, while prices may rise faster than they fall, as suggested by general economic theory, prices may also fall faster than they rise (Peltzman, 2000). An example of this phenomenon is given by Knetter (1994), who argues that if local and exporting firms that are trying to establish market-share are confronted with trade restrictions, then a currency appreciation of the importing country might cause pricing-to-market (in this case, lowering of prices) to be greater than the rise in prices during periods of depreciation. This would imply greater pass-through during episodes of appreciation than depreciation.

As discussed above, pricing-to-market can be used as a strategy to gain or increase market share, and it is often cited as one of the reasons for incomplete ERPT. The market share model of asymmetric pass-through, as discussed by Pollard and Coughlin (2003), supposes that if the goal of a firm[2] is to maintain its market share despite fluctuations in the exchange rate, the firm will try to keep its prices constant (Pollard and Coughlin, 2003: 6). Thus, when profits fall as a result of a decline in the exchange rate, the loss may be offset by rising profits during periods of exchange rate appreciation. In such a case, pricing-to-market implies symmetric pass-through (Pollard and Coughlin, 2003: 6). Marston (1990: 220) proposes a different outcome of the market share model of asymmetric pass-through. If a firm adjusts its markup to increase market share when the importing country's currency appreciates and

[2] A firm is assumed to be a domestic/importing or foreign/exporting firm unless stated otherwise.

maintains market share when the home country's currency depreciates, ERPT will be asymmetric as pass-through to the home country's domestic prices will be greater during episodes of currency appreciation than depreciation.

Other factors that can influence the asymmetry of ERPT at industry and firm level include production switching, binding quantity constraints and menu costs (Pollard and Coughlin, 2003: 7). Production switching describes a scenario where a price-taking firm that supplies both its home country and foreign importing countries can also purchase its production inputs from foreign or domestic markets. Thus, in the likelihood of changes in the exchange rate, the firm can switch its sources of inputs and the type of production technology it uses. Hence, if the firm's home currency appreciates, making imported inputs cheaper, the firm will switch to a production technology that maximizes the use of imported inputs; but if the home currency depreciates, making the imported inputs more expensive, the firm will switch to local input intensive production technologies (Ware and Winter, 1988).

Following from the above discussion, Webber (2000: 5) describes the production switching model of asymmetric pass-through by first defining $P^D(Q)$ as the inverse import demand curve denominated in the importing country's currency, Q as the quantity of export output, i^m as the quantity of the imported input, i as the quantity of the domestic input, P^{im} as the importers price of i^m and P^i as the domestic price of i, P^d as the price paid by the foreign importing country for the firm's product, and E as the exchange rate. Thus, assuming the extreme case in which the firm can switch entirely from one production technology to another without cost, the firm's 'dual' profit function can be denoted as:

$$\pi^D = P^D(Q)Q/E - P^{im}\, i^m/E \qquad \text{depreciation phase}$$

$$\pi^A = P^D\, Q/E - P^i\, i \qquad \text{appreciation phase}$$

Given the firm's 'dual' profit function, if for example, the exchange rate appreciates by 10 percent, the firm's marginal revenue will increase by 10 percent for a given P^d, but the marginal costs will not change. The firm will expand its output, resulting in a drop in P^D. Assuming that P^D decreases by 5 percent, this would imply partial pass-

through of 50 percent. On the other hand, if the exchange rate depreciates by 10 percent, then the firm's marginal revenue and costs will both fall by 10 percent. In this case the firm will not alter output and hence there is no change in P^D, implying that pass-through is zero. From this example, it would follow that according to the production switching model, ERPT is greater during periods of appreciation than depreciation.

The binding quantity constraints theory of asymmetric ERPT supposes that binding quantity constraints arise when the ability of the exporting firm to increase sales as the importing country's currency appreciates is limited. Quantity constraints faced by firms may arise because of trade restrictions such as quotas that limit imports, or voluntary export restraints. Constraints may also arise because of firm or industry specific factors such as limitations on a firm's ability to expand its production capacity (Pollard and Coughlin, 2003: 8). Under this scenario, when the exchange rate increases, the firm raises its markup to maintain its price in the importing country (Pollard and Coughlin, 2003: 8). Therefore, rather than increasing sales the firm may increase its profit margins. However, when the exchange rate decreases, the quantity constraint is not binding. The firm may reduce its markup but still allow its price in the importing country to rise (Pollard and Coughlin, 2003: 8). Pass-through is consequently higher when the importing country's currency depreciates than when it appreciates.

The menu costs theory of asymmetric pass-through proposes that a firm may respond asymmetrically to large and small changes in the exchange rate, that is, the size of the exchange rate change (Pollard and Coughlin, 2003: 8). According to Pollard and Coughlin (2003: 8), the asymmetry of ERPT, in this case, will depend on the currency of the invoice. On the one hand, if imports are invoiced in the importing country's currency, a small change in the exchange rate which is below a given "threshold" will result in the firm holding its price constant and absorbing the change in the exchange rate through the price it receives (Pollard and Coughlin, 2003: 9). In this case ERPT is zero. On the other hand, if the change in the exchange rate is large and above the "threshold", the firm will adjust its price, resulting in partial or complete pass-through depending on the size of the price adjustment. Consequently, invoicing in the

importing country's currency will result in greater ERPT when exchange rate changes are large than when they are small (Pollard and Coughlin, 2003: 9).

Alternatively, if imports are invoiced in an exporting firm's currency, then a small change in the exchange rate will have no effect on its invoice price, but the currency change will be fully reflected in the price charged to the importing country, implying complete ERPT. However, if the exchange rate change is large, the exporting firm will adjust its invoice price, thus reducing the amount of pass-through. In this case pass-through is greater when exchange rate changes are small (Pollard and Coughlin, 2003: 9).

In summary, both the market share and production switching models of asymmetric pass-through suggest that ERPT is larger when the importing country's currency is appreciating than when it is depreciating, although this may be debatable given that prices are generally sticky downwards. If a firm is subject to binding quantity constraints, ERPT will be higher when the importing country's currency is depreciating than when it is appreciating. Furthermore, the menu cost model suggests the asymmetry of ERPT depends on the size of change and currency denomination of the invoice. When the invoice is denominated in an importer's currency, ERPT is greater when the change in the exchange rate is above a threshold defined as large. However, if the invoice is denominated in the exporter's currency ERPT will be greater when the exchange rate change is below a threshold defined as small (see Table 2.1).

Interestingly, all the models show the pass-through of exchange rate changes to import prices. This shock is then transmitted to producer and then consumer prices. However, the same pricing strategies implemented by exporting firms regarding currency changes may also be implemented by domestic firms in the same industry, suggesting that these models of asymmetric pass-through also apply to the indirect transmission channels of ERPT as shown in Figure 2.1. However, these models remain largely theoretical, and can only be confirmed by empirical studies to prove their practical relevance. The next section discusses the empirical studies that have been conducted on ERPT, firstly in developed nations, followed by emerging and

developing markets, and then South Africa. Finally empirical studies on ERPT asymmetry are reviewed.

Table 2.1: Summary of the Direction of Asymmetry in ERPT

Asymmetric ERPT Factor	Pass-through
Market share	Appreciation > Depreciation
Production switching	Appreciation > Depreciation
Quantity constraints	Appreciation < Depreciation
Menu costs (invoicing in importer's currency)	ERPT is greater when ER changes are large
Menu costs (invoicing in exporter's currency)	ERPT is greater when ER changes are small

2.3 Empirical Literature

In order to examine and verify the theoretical propositions on the degree of exchange rate pass-through, there has been a plethora of empirical studies using various methodologies and data series across different countries. Hyder and Shah (2004: 1) categorise studies on ERPT into three groups. The first category consists of studies that examine ERPT to import prices for specific industries (for example, Feinberg, 1989, and Goldberg, 1995); the second category includes studies that look at pass-through to aggregate import prices (for example, Hooper and Mann, 1989, and Campa and Goldberg, 2002); and the third category examines ERPT to import prices, as well as wholesale/producer prices and consumer prices (for example, McCarthy, 2000, Papell, 1994, Heng, 1999, and Kim, 1998).

However, despite the above categorisation, most of these studies have focused on developed countries such as the USA and the UK. For example, Menon (1995) conducted a comprehensive survey of the literature on exchange rate pass-through. His (Menon, 1995) study reviews 43 empirical studies on ERPT in industrialised countries. The majority of the surveyed studies focus on the USA. Other studies such as those by Rabanal and Schwartz (2001), Leigh and Rossi (2002), Kiptui *et al.* (2005) investigate ERPT in emerging and developing countries, and in particular, Nell

(2000), Bhundia (2002), and SARB (2002) analyse ERPT in South Africa, albeit from different perspectives. This section will review empirical studies from developed, developing and emerging market economies, and specifically South Africa, in that order.

2.3.1 Empirical Literature on Developed Countries

A number of studies have been undertaken to investigate the size and speed of ERPT to import, producer and consumer prices, as well as the asymmetry of pass-through of changes in the exchange rate to import prices in the United States. Some of the popularly cited USA studies on ERPT include the works of Woo (1984) and Feinberg (1986, 1991).

Woo (1984) examines the relationship between exchange rate changes and USA price levels of non-food and non-fuel products from 1975:Q2 to 1984:Q1, using the ordinary least squares (OLS) estimation technique. The study finds that foreign manufacturers price their products according to USA demand and cost conditions with some adjustment for exchange rate fluctuations. Woo's (1984) estimate of exchange rate pass-through ranges from approximately 40 percent using an exchange rate index produced by the Board of Governors of the Federal Reserve System to 70 percent using an exchange rate index based on import shares. The range of exchange rate measures used by Woo (1984) are: the Federal Reserve exchange rate index, constructed from the USA bilateral exchange rates with ten industrialized countries and weighted according to their shares of global trade during 1972 to 1976; the Morgan Guaranty exchange rate index, based on fifteen currencies whose weights were the 1980 bilateral shares of those countries' trade in the USA manufacturing sector; and the import-share exchange rate index, constructed with the same group of countries as in the Federal Reserve index but using these countries' bilateral shares of total imports to the USA from 1972-1976 as weights. Woo (1984) argues that the choice of exchange rate measure depends on the model of price interactions and the research question under review. For example, if the research question is to investigate the influence of export prices on the domestic price level of overall trade through competition in every national sector, then the Federal Reserve exchange rate index, in the case of the USA, may be the best choice. However, if the main channel affecting

domestic inflation is the price of imports, then the import-share index would be the most suitable of the three exchange rate measures (Woo, 1984: 518).

Feinberg (1986) finds exchange rate pass-through to domestic producer prices in the United States to be greater in industries that are less concentrated and face greater import penetration. Feinberg (1991) also substantiates Woo's (1984) findings that different exchange rate measures yield different pass-through estimates. Feinberg (1991) examines ERPT to domestic producer prices in the USA, over the period 1973 to 1988, using different exchange rate indexes: the Federal Reserve exchange rate index compiled by the Board of Governors – as used by Woo (1984); a broad 101-country index produced by the Federal Reserve Bank of Dallas; and 81 industry specific exchange rate indexes, weighted according to the industries' import shares. The methodology of the study, which is based on the OLS estimation method, involves two procedures. The first stage is the estimation of a simple model to approximate the elasticity of response specific to each industry of relative producer prices to the real exchange rate, using pooled cross-section and time series data. The second procedure involves the estimation of a cross-sectional model to explain the differences in the estimated response elasticity across the industries. Feinberg's (1991) study finds that the industry-specific indexes generated the lowest estimate of pass-through, while the Dallas index generated the highest degree of pass-through. Feinberg (1991) also states that the Federal Reserve's 101-country exchange rate index approximation of the degree of real appreciation and depreciation in the external value of the United States' dollar since the late 1970s has been overestimated, and proposes that the Dallas index is a better proxy.

Prior to Menon's (1995) survey of the literature on exchange rate pass-through (mentioned earlier), Menon (1993) investigated the ERPT to import prices of motor vehicles in the USA, using Engle-Granger's two-step cointegration test and error correction model, and found that exchange rate pass-through to import prices of motor vehicles is incomplete even in the long-run. Menon (1993) suggests two possible explanations for the incomplete pass-through: the presence of quantitative restrictions, and pricing practices on intra-firm sales by multinational firms.

Of the studies surveyed in Menon (1995), 16 examine pass-through to import prices, 10 to export prices, 13 examine the pass-through to both import and export prices, and 3 examine the pass-through to domestic producer prices. The findings of the survey suggest that the USA has the most estimates of pass-through, while the majority of the countries in the top ten of the "estimates of pass-through by country" are European countries (Menon, 1995: 222). The pass-through estimates of 12 of the 19 small country studies are provided by a single study, authored by Khosla and Teranishi (1989 in Menon, 1995). The studies for both developed and developing countries show mixed results. According to Menon (1995), most of the studies prior to 1995 use OLS to estimate ERPT or, alternatively, employ polynomial distributed lags to model the response of traded goods to exchange rate fluctuations. Furthermore, Menon (1995) finds that, with the exception of 6 out of 46 studies, incomplete pass-through is a common feature. Secondly, the ERPT estimates across countries are significantly different and at times conflicting.

Another popularly cited study is Goldberg and Knetter (1997), who conclude that the median rate of pass-through in the United States is approximately 50 percent for shipments into the country. However, local USA price responses to exchange rate fluctuations vary from sector to sector and a considerable portion of the muted price responses seem to emanate from changes in markups on exports (Goldberg and Knetter, 1997: 1244). Gust *et al*. (2006) also find evidence consistent with Goldberg and Knetter (1997). Their estimate of pass-through for the 1980s is approximately 55 percent for the United States, implying that if there is a 10 percent depreciation of the dollar, a foreign exporter selling to the USA market will raise its price in the United States by 5.5 percent (Gust *et al*., 2006: 2). Furthermore, the findings also show that in the 1990s, there was a significant decline in ERPT, as fluctuations in import prices were moderated substantially, relative to exchange rate fluctuations.

Lutz and Reilly (1997) examine ERPT in the automobile markets of twelve European Union countries (Belgium, France, Germany, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, the UK, Austria and Sweden). The empirical model of the study is based on a hedonic pricing framework, which controls for model specific characteristics (Lutz and Reilly, 1997: 6). The results indicate that pass-through in all twelve countries is significantly below 50 percent. Furthermore, there is no evidence

that either the relative market share of domestic firms or the imposition of non-tariff barriers is associated with a lower degree of pass-through.

Contrary to Lutz and Reilly's (1997) findings, Adolfson's (1997) results indicate that the pricing-to-market behaviour in the majority of industries is the reason for limited pass-through. Adolfson's (1997) study examines Swedish import price determination using disaggregated monthly data from 1980 to 1995 for eight different industries. The methodological framework is based on a cointegration analysis, which indicates two cointegrating vectors in all industries, between import prices, the exchange rate, world market prices and domestic prices. Total pass-through estimates indicate a limited pass-through, and thus pricing-to-market behaviour in the majority of industries. The estimates range from 27 percent to 160 percent. Tests of linear restrictions on the cointegrating vectors indicate a complete long-run pass-through in most of the Swedish industries. Short-run pass-through is found to be limited to about 25 percent.

Kim (1998) uses a vector error correction model to estimate ERPT and finds that in the United States, the exchange rate has the expected negative long-run effect on the producer price index (PPI). However, Kim (1998) notes that one of the limitations of the study is that it does not address the relationship at shorter time horizons, which are more relevant for monetary policy.

McCarthy (2000) empirically examines the impact of exchange rates and import prices on domestic PPI and CPI in selected industrialised economies, which include the United States, Germany, Japan, France, the United Kingdom, Belgium, Netherlands, Switzerland and Sweden. The empirical framework of the study consists of a vector autoregressive (VAR) model incorporating a distribution chain of pricing. The findings of the study show that exchange rates and import prices have a modest effect on domestic price inflation over the post-Bretton Woods era. The pass-through is found to be stronger in countries with a larger import share.

Gagnon and Ihrig (2001) examine the relationship between the change in the rate of pass-through and monetary policy conditions in 20 industrialised countries between 1971 and 2000. The empirical framework is based on a macroeconomic model, which

is used to demonstrate that when a monetary authority increases its emphasis on combating inflation, particularly through changes in its policy reaction function, the rate of ERPT declines. The underlying assumption of the macroeconomic model is that when a central bank acts aggressively to stabilise domestic inflation, it will tighten its monetary policy in order to offset any inflationary impetus from a rise in import prices. The results of the study indicate that the estimated rates of ERPT vary across the 20 countries. The countries with low and stable inflation rates, most probably reflecting central bank policies, tend to have low estimated rates of pass-through from exchange rates to consumer prices. Gagnon and Ihrig (2001) also test if there is a direct relation between monetary policy and ERPT using Taylor-type monetary policy rules. The results of the test show that in a cross-country regression using the full sample, no statistically significant relationship is found.

Campa and Goldberg's (2002) study of 25 OECD countries from 1975 to 1999 provides extensive cross-country and time-series evidence on ERPT to import prices, as well as giving insights into the forces underlying cross country differences in pass-through rates and changes in pass-through elasticities over time, within countries. The methodology of the study is based on a log-linear regression model. The results of the study show that the average pass-through to import prices across the 25 OECD countries is 77 percent in the long run and 61 percent in the short run, implying that partial pass-through is the best description for import price responsiveness. Campa and Goldberg (2002) also find that macroeconomic variables play an important but limited role in explaining cross-country differences in levels of pass-through elasticities. The empirical evidence also suggests that ERPT rates have been declining over time in some of the countries. However, the pattern of pass-through decline is found not to be a common feature of all OECD countries. The study concludes that the decline in ERPT to import prices can be attributed to more widespread changes in the composition of industrial activity and trade than the types of changes in macroeconomic policy environments as observed in the OECD in recent decades.

Similar to Gagnon and Ihrig's (2001) argument that macroeconomic factors are pivotal in determining the extent of ERPT to domestic prices, Devereux and Yetman (2003) also argue that the rate of pass-through from exchange rates to prices is at least partly determined by macroeconomic factors, particularly sticky prices. Devereux and

Yetman (2003) also propose that the extent of ERPT is sensitive to the monetary policy regime, because the stickiness of prices is endogenous to the monetary regime. The results of the theoretical model used in the study illustrate how ERPT is determined by structural features of the economy, such as the persistence of shocks and the degree of price stickiness in a small open economy. The empirical results provide strong support for the presence of price stickiness in determining the degree of pass-through. More specifically, both mean inflation and mean exchange rate depreciation seem to increase pass-through, but in a non-linear manner, as suggested by the model. Overall, the evidence of the study strongly suggests the need to take into account ERPT in designing monetary policy.

Yang *et al*. (2004) investigate the international transmission of inflation among the G-7 countries using data-determined vector autoregression analysis. Over the period 1973 to 2003, the results show that unexpected changes in USA inflation have significant effects on inflation in the other countries. Similarly, shocks to the other G-7 countries have a statistically and economically significant influence on USA inflation. Furthermore, the findings indicate that USA inflation has become less susceptible to foreign shocks since the early 1990s, mainly because of the reduced influence from Germany and France.

Campa *et al*. (2005) present an empirical analysis of transmission rates from exchange rate fluctuations to import prices, across countries and product categories in the Euro-zone from 1990 to 2005. The results of the analysis show that although the transmission of exchange rate movements to import prices in the short run is high, it is however incomplete, and it differs across industries and countries. In the long run, ERPT is found to be higher and close to one. Another interesting result is that Campa *et al*. (2005) do not find strong statistical evidence that the introduction of the Euro caused a structural change in the ERPT. Though estimated point elasticities seem to have declined since the introduction of the Euro, there is little evidence of a structural break in the transmission of exchange rate changes except in the case of some manufacturing industries. It is also found that exchange rate changes continue to lead to large changes in import prices across Euro-area countries. Campa *et al*. (2005: 25) report that although ERPT in the Euro-area is clearly incomplete, it remains more than

60 percent one quarter after the exchange rate moves and 80 percent over the rest of the year.

Kardasz and Stollery (2005) examine direct and indirect ERPT elasticities for 37 Canadian manufacturing sectors and their determinants, based on annual data for the period 1971 to 1989. The methodology is made up of a two-stage procedure that is comprised of a VAR framework and estimations using the OLS method. The results of the study find that the direct and indirect elasticities are more or less equivalent in magnitude for domestic goods, though the direct effect is dominant for imports. Furthermore, for a small number of industries, the net result of the direct and indirect effects is that a depreciation of the domestic currency increases the competitiveness of imports. The important determinants of the direct and indirect elasticities, as indicated by the results, are the import share and non-tariff barriers.

2.3.2 Empirical literature on emerging and developing markets

Literature on ERPT in developing nations is scanty compared to that on developed nations. However, an attempt is made in this section to identify and review some of these studies. Webber (2000) investigates the relationship between exchange rates and import prices in nine Asian-Pacific countries, comprising developed, emerging and developing markets namely, Korea, Pakistan, the Philippines, Malaysia, Singapore, Japan, Australia and New Zealand. Specific attention is given to the latter markets; however, results from the developed markets are given for comparative purposes. Results from the Johansen cointegration methodology used by Webber (2000) indicate the existence of a stable, long run, linear relationship between import prices and exchange rates for seven of the nine countries from 1978 to 1994. The ERPT estimates are also found to vary across the countries, with the lowest income countries showing the highest ERPT estimates, for example, Pakistan (109 percent) and the Philippines (89.6 percent). ERPT in the other countries ranges from 25 percent to 50 percent, specifically, Australia (26.3 percent), New Zealand (35.9 percent), Korea (40.3 percent) and Japan (44.8 percent). Singapore is reported to have a far higher ERPT estimate in the latter group (77.1 percent).

In Darvas' (2001) analysis of ERPT in emerging European markets, the focus of the study centres on the choice of exchange rate regime by EU candidate countries (which

included the Czech Republic, Hungary, Poland and Slovenia) in the run-up to membership of the European Economic and Monetary Union (EMU). Darvas (2001: 1) notes that there was a wide range of different exchange rate regimes being employed by EU candidate countries; virtually every possible type could be found, including the two extreme systems, currency boards and freely floating exchange rates. The fact that these countries adopted various exchange rate systems indicated a divergence of opinion on the appropriate way to handle macroeconomics and, in particular, to control inflation.

Darvas (2001) looks at the relationship between changes in the exchange rate and inflation in relation to the different exchange rate systems from 1993 to 2000, in order to draw conclusions with regard to the possible role of exchange rate management in achieving and maintaining low inflation in these countries. The model used in the study is based on a state-space model and the Kalman filter to infer unobserved variables and time-varying parameters. Price and exchange rate changes are modelled simultaneously and the adjustment of price changes towards the equilibrium real exchange rate is incorporated. The study finds that the estimates of ERPT are higher in countries that have a fixed or managed exchange rate system – Hungary (40 percent) and Slovenia (40 percent), than in countries with a free-floating regime – Poland (10 percent) and the Czech Republic (zero pass-through).

Rabanal and Schwartz (2001) investigate ERPT in Brazil and find evidence suggesting that after 18 months, approximately two-thirds of an initial exchange rate shock is passed through to the wholesale price index (WPI) and two-ninths to the consumer price index (CPI). This implies that ERPT to the WPI is more pronounced compared to the pass-through to the CPI in the case of Brazil. Leigh and Rossi's (2002) study looks at ERPT in Turkey. The evidence produced by the investigation shows that the pass-through of exchange rate fluctuations to domestic prices in Turkey persists for a year but is more concentrated in the first four months. The results also show that pass-through to the WPI is more pronounced than the pass-through to the CPI, and the forecast of inflation based on estimates of the pass-through coefficient provides partial information about the underlying price pressures.

Hyder and Shah (2004) assess the extent of ERPT to domestic wholesale and consumer prices in Pakistan by analysing data from 1988 to 2003. The empirical model used in the study is a recursive VAR model incorporating a distribution chain of pricing. Results from the investigation suggest that the exchange rate movements have a moderate effect on domestic prices, that is, ERPT is low. Furthermore, ERPT is found to be stronger in the WPI relative to the CPI and the impact of pass-through on domestic prices is spread over 12 months. The results also suggest that ERPT to consumer prices weakened after the free float of Rupee/Dollar parity in July 2000, from an estimate of 8.25 percent prior to the free float policy to 4.73 percent. Hyder and Shah (2004) find that within the WPI commodity groups, the pass-through is stronger in Fuel and Lighting, and Manufactures groups while in the case of CPI, ERPT is more pronounced in the Transport and Communication, and Fuel and Lighting groups. Moreover, ERPT to domestic prices is reported to be significantly stronger in the higher inflationary environment during 1988 to 1997, relative to lower inflationary periods.

Korhonen and Wachtel (2005) analyse the size and speed of ERPT in the countries of the Commonwealth of Independent States (CIS). The countries included in the study are Armenia, Georgia, Kazakhstan, Kyrgyzstan, Moldova, Ukraine and Russia. The methodological framework consists of impulse response functions and variance decompositions based on a vector autoregressive regression framework, utilising monthly data from 1999 to 2004. Evidence from the study indicates that exchange rate movements have a clear impact on price developments in the CIS countries. The speed of ERPT is found to be moderately high, and in most of the countries, the full shock is transmitted to domestic prices in less than 12 months. Korhonen and Wachtel (2005) comment that, unlike in many other emerging market countries, an additional shock from USA prices to domestic prices is found not to be significant. The study also examines whether there are any asymmetries in the ERPT, that is, whether currency depreciations have a different effect on inflation than appreciations. The results show that there is evidence of asymmetry in Georgia, Kyrgyzstan and Moldova. In all of these countries exchange rate appreciations have a stronger effect on inflation than depreciations. In the remaining four countries, there seemed to be some evidence of asymmetry, but according to the authors (Korhonen and Wachtel, 2005: 16), the results across countries are far from robust.

Ito *et al*. (2005), like Webber (2000), focus their investigation of ERPT on 8 Asian countries consisting of a mixture of developed, emerging and developing markets, during the period 1986 to 2004. A first differenced model with a lag of the effective exchange rate up to 4 periods is used in the study. The results indicate that the ERPT estimates to import prices are high and significant for four of the eight countries – Hong Kong (49 percent), Japan (99 percent), Indonesia (100 percent) and Thailand (166 percent). The results of the other countries – Korea, Singapore, Taiwan and the Philippines – are found to be insignificant. However, the ERPT to consumer prices is found to be relatively lower than import prices, but, it is found to be higher for Indonesia (57 percent), Thailand (26 percent), Singapore (20 percent), the Philippines (15 percent) and Korea (13 percent).

Kiptui *et al*. (2005) investigate the two stages within the direct transmission of ERPT to domestic prices in Kenya using the Johansen cointegration method and impulse response and variance decomposition functions in stages one and two respectively. The results from the Granger causality tests show that world prices Granger-cause import prices, and import prices, exchange rates and world prices all Granger-cause manufacturing output prices. The study also shows that in the long-run, ERPT to import prices is 71 percent, suggesting incomplete pass-through. The short-run ERPT is also reported to be incomplete with exchange rate depreciations positively affecting import prices. In the short-run, ERPT is estimated to be 69 percent. This result is supported by variance decomposition estimates, which indicate that exchange rate shocks explain 76 percent of the variation of import prices during the first period.

Kiptui *et al*.'s (2005) error correction model passed all diagnostic tests. The Theil coefficient, the bias and variance proportions and the covariance proportion indicate that the estimated model is able to forecast import prices quite well. The impulse response functions show that an exchange rate shock leads to a sharp increase in consumer inflation but the increase is found to dissipate by the end of the fourth period. Shocks on import prices are found to have gradual positive effects on consumer prices which level at the end of the fifth period. The variance decompositions show that exchange rate shocks explained 46 percent of the variation in consumer inflation in the first period, increasing to 57 percent in the second period,

58 percent in the third period and decline thereafter. Import price shocks explained only 6 percent of the variation of consumer inflation in the first period, which increases to 7 percent and 9 percent in the second and third periods respectively.

2.3.3 Empirical literature on South Africa

In the case of South Africa, three noteworthy studies can be found, namely, Nell (2000), Bhundia (2002), and SARB (2002). Nell (2000) analyses the inflationary impact of exchange rate depreciation in South Africa from 1973 to 1998. This period is split into two, 1973 to 1983 and 1984 to 1998, in order to determine whether the underlying causes of inflation changed following significant structural, political and institutional changes, and when the monetary authorities adopted a more market-oriented exchange rate system. Nell (2000: 13) formulates price and wage equations which are estimated using Distributed Lag (DL) and Auto Regressive Distributed Lag (ARDL) models.

The findings of the study show that the long-run causes of inflation in South Africa have changed from demand-pull inflation over the period 1973-1983 to a cost-push cause of inflation since 1987, when a market determined exchange rate had finally stabilised. Nell (2000: 20) also reports that although there are various macroeconomic reasons to explain incomplete pass-through, low domestic demand seems to be particularly relevant in explaining the incomplete import pass-through in a small open economy like South Africa. The results showed that the long-run pass-through estimates were 72 percent and 82 percent in rates of change and levels respectively.

Bhundia's (2002) study, on the other hand, focuses on CPIX inflation, particularly the pass-through profile over the period 2000 to 2001, when monetary policy had the most impact on inflation[3]. Bhundia (2002: 5) defines exchange rate pass-through as the correlation between exchange rate fluctuations and quarterly CPIX inflation. The framework underpinning the analysis is based on the idea that prices are set along a distribution chain that comprises three stages: importation, production, and consumption. The distribution chain is modelled as a six-variable recursive vector autoregression (VAR) model. The results indicate that, while the average pass-

[3] See the SARB Monetary Policy Review for October 2001.

through is low, evidence from the structural vector autoregression model suggests that it is much higher for nominal (versus real) shocks. Exchange rate shocks result in a steady increase over time in the level of CPIX. The results also show that, on average, eight quarters after a 1 percent shock to the nominal effective exchange rate, the level of CPIX increases by 0.12 percent, giving a pass-through elasticity of 12 percent. The pass-through elasticity resulting from shocks to producer price inflation is approximately 72 percent after eight quarters, suggesting that favourable shocks to producer price inflation could possibly bring CPIX inflation back to target (Bhundia, 2002: 5).

Bhundia (2002) goes further to distinguish between real and nominal shocks, and analyses their impact on the exchange rate and prices. A bivariate VAR comprising of the real exchange rate and relative prices is estimated, and long-run restrictions are placed to identify structural nominal and real shocks. The impulse response tests for the nominal exchange rate and relative prices reveal the response of the variables to nominal versus real shocks. Results from the decomposition of the nominal effective exchange rate (NEER) indicate that up to November 2001, negative real shocks are the primary driver of the rand depreciation, and that positive nominal shocks contributed to the depreciation from December 2001 onward, when CPIX inflation also began to increase.

The third study, by the SARB (2002), investigates the first stage of exchange rate pass-through, that is, the relationship between changes in the exchange rate and the domestic currency price of imports in South Africa. The methodological approach adopted in the paper is based on Johansen-type vector error-correction models (VECM). The results suggest that approximately 78 percent of an exchange rate change passes through to import prices in South Africa in the long run, and that half of this adjustment occurs in just less than one year.

SARB's (2002) analysis reports the results for the cointegration tests, conducted on the basis of a VAR with 3 lags and an unrestricted constant term. Both the Johansen trace and maximum Eigenvalue tests select a single cointegrating relationship between the variables – domestic price for imported goods, the foreign currency price of the corresponding good and the exchange rate. The coefficient of the error-

correction term shows that the adjustment to exchange rate shocks is gradual. The value of the coefficient is -0.059, highly significant and correctly signed. This result suggests that import prices adjust to equilibrium by approximately 6 percent of any disequilibrium in the long-run relationship each month. Furthermore, a 10 percent depreciation in the exchange rate increases import prices by 0.46 percent within a month, and in each succeeding month the disequilibrium is reduced by gradually smaller increments until the long-run pass-through of 7.76 percent is achieved. The half-life of this process is found to be just over 11 months, in other words, half of the adjustment to the long run exchange rate pass-through takes place in 11 months.

2.3.4 Empirical Evidence on ERPT Asymmetry

Two kinds of ERPT asymmetry can be identified, namely pass-through asymmetry based on the direction of the change in the exchange rate, that is, appreciation versus depreciation; and pass-through asymmetry determined by the size of the change, that is, large versus small changes based on a given threshold. However, most of the studies on ERPT asymmetry have focused on testing for asymmetry in the direction of the change in the exchange rate, with the exception of Pollard and Coughlin's (2003) study, which analyses both approaches to ERPT asymmetry, and is one of the popularly cited pass-through asymmetry studies. Other popular papers on ERPT asymmetry include Mann (1986), Feinberg (1989), Athukorala (1991), Goldberg (1995), Kadiyali (1997) and Webber (2000). Mann's (1986) study on ERPT asymmetry uses aggregate trade data, and the findings of the study suggest that pass-through to USA import prices is larger in times of dollar appreciation than depreciation. However, Mann (1986) reports that the difference in pass-through estimates was not statistically significant.

Feinberg's (1989) study of USA import prices and Athukorala's (1991) study of Korean export prices, which analyse ERPT asymmetry in an array of industries in the USA and North Korea respectively, fail to find any evidence of asymmetry. In contrast, studies by Ohno (1989) and Marston (1990) that investigate pass-through asymmetry in Japanese machinery and equipment exports, find evidence of ERPT asymmetry, where Ohno's (1989) findings support the binding quantity constraint model of ERPT asymmetry, whereas Marston's (1990) findings support the market share and production switching models of ERPT asymmetry.

Goldberg (1995) and Kadiyali (1997) both investigate ERPT asymmetry in a single USA industry. Goldberg (1995) examines USA automobile imports from Germany and Japan while Kadiyali (1997) focuses on USA imports of photographic film from Japan. Both studies find that ERPT is higher when the dollar depreciates, a finding consistent with the binding quantity constraint theory. Webber's (2000) study, like Mann (1986), also uses aggregate trade data. Webber (2000) finds significant support for asymmetric ERPT into import prices in five of seven Asian countries. The findings also suggest that ERPT is larger when the importing country's currency depreciates than when it appreciates, also supporting the binding quantity constraint model of asymmetric pass-through.

Pollard and Coughlin (2003) examine the asymmetry of pass-through to USA import prices for 30 industries, from 1978 to 2000, using the OLS method. The findings of the study show that over 50 percent of the industries respond differently to appreciation and depreciation, suggesting that there is asymmetry in terms of the direction of currency change. Most of the 30 industries also respond asymmetrically to large and small currency changes, with pass-through being greater when the change is large. Pollard and Coughlin (2003) also examined both direction and size effects simultaneously and found that the size effect was the most dominant.

Wickremasinghe and Silvapulle (2004) investigate the ERPT to the yen based on manufactured import prices of Japan using asymmetric unit root and cointegration tests and asymmetric models that include the threshold autoregressive and momentum threshold autoregressive models. Wickremasinghe and Silvapulle (2004) suggest that due to sticky prices, there is reason to believe that the extent of ERPT depends on whether the exchange rate appreciates or depreciates. The sample used in the study covers the period from January 1975 to June 1997. The results of the study estimate the pass-through coefficients corresponding to appreciation and depreciation of the currency to be 98 percent and 83 percent respectively. These coefficients are shown to be significantly different, particularly in the post recession period. Moreover, it is also shown that the recession in Japan in the 1990s significantly affected the ERPT relationship particularly when the yen depreciated, and that the proposition that

exchange rate depreciation and appreciation had systematic asymmetric effects on the ERPT coefficient was indeed correct.

2.4 Concluding Remarks

As noted by Menon (1995), three major issues emerge from the review of literature on exchange rate pass-through. The issues are country coverage of the studies, the data and methodologies used and the findings of the studies.

In terms of country coverage, the USA has the most estimates of pass-through, followed by Japan and Australia. Most of the countries in the top ten of the "estimates of pass-through by country" are European countries (Menon, 1995: 222). The literature also shows that most of the ERPT estimates for small open economies are obtained from multi-country studies. The studies for both developed and developing countries have produced varied results, "leaving the issues very much unresolved" (Menon, 1995: 225).

Most of the studies use price proxies to represent transaction prices such as import, export, producer, and consumer prices. Menon (1995) makes a specific note of the commonly used import price proxy – import unit values. Import unit values are noted to have a number of limitations, one of which is the high likelihood of significant measurement errors. Shiells (1991: 378) highlights the bias in pass-through estimates brought about by measurement errors that are an innate characteristic of price proxies. In a comparison of pass-through results obtained using import prices versus import unit values, Alterman (1991) finds a significant discrepancy between the ERPT estimates, putting into question the reliability of ERPT estimates found using price proxies. As in Woo (1984) and Feinberg (1991), the measurement of the exchange rate in ERPT studies is also highlighted as a major factor in the over-or-underestimation of pass-through. Among the issues to consider when choosing or constructing an exchange rate measure is the number of currencies to be included and the weighting method to be used in constructing the index.

The literature also shows that most of the studies prior to 1995 use OLS to estimate ERPT or alternatively employ polynomial distributed lags to model the response of

traded goods to exchange rate fluctuations. Menon (1995) points out that these studies do not take into account the non-stationarity of macroeconomic series and asset price data. The use of OLS to estimate non-stationary time series data is likely to result in spurious regressions, making the previous estimates of pass-through biased (Menon, 1995: 223). According to Hendry (1986), a significant number of the studies that use OLS report high a R^2 and a low Durbin-Watson (DW) statistic, which may indicate non-stationary residuals. Furthermore when $R^2 >$ (DW), this may imply an extremely high chance of spurious results (Hendry, 1986). Menon (1995) finds that the general response of studies to the presence of serial correlation is to apply the Cochrane-Orcutt transformation or one of its derivatives. However, the application of such procedures in the presence of non-stationary variables can result in misleading findings.

The findings of the studies on ERPT can be summarised into five categories. Firstly, in terms of the degree and dynamics of ERPT, Menon (1995) finds that incomplete pass-through is a common phenomenon. Secondly, the ERPT estimates across countries are significantly different and at times conflicting. For example, Kreinin (1977 in Menon, 1995: 224) reports that ERPT estimates range from 50 percent for the USA to complete pass-through for Italy, while Khosla and Teranishi (1989) find pass-through to be almost complete in the USA and other larger economies, and incomplete for smaller open economies. Thirdly, ERPT estimates across studies for a particular country are also significantly different. Menon (1995: 224) cites the example of the USA which is the most studied country. The range of estimates of ERPT to import prices in seven USA studies (that cover approximately the same period: 1977 to 1986-88) is from 48.7 percent to 91 percent. Menon (1995: 224) attributes the diversity in results to differences in methodology, model specification and variable construction. As mentioned before, most of the studies employ the conventional OLS method but a few, such as Kim (1991) use the vector autoregressive (VAR) approach.

The fourth category is the pass-through across products, which is found to be significantly different. The literature shows that studies that investigate pricing-to-market vis-à-vis ERPT show incomplete pass-through, and the degree of pass-through varies across export markets. This may imply that exporting firms price-discriminate

across export markets by altering the degree of pass-through of exchange rate fluctuations to their customers.

The fifth category involves the stability of the pass-through relationship over time. Of the studies that investigate this relationship[4], only a few note that the ERPT relationship remains stable throughout the period under study. The majority of the studies recorded structural breaks in their analysis.

Therefore, given the conflicting findings of empirical literature on the size and speed of ERPT and the asymmetric properties of pass-through, it would be imprudent to generalise the estimates of ERPT in South Africa based on multi-country studies. Thus, this thesis aims to add to the existing literature on ERPT to developing and emerging markets, specifically, South Africa, and more so, to fill the gap in the literature on the asymmetric pass-through of exchange rate changes to import prices in South Africa and the developing nations. Table 2.2 below provides a brief summary of the data, methodology and findings of the reviewed literature.

[4] See Menon (1995: 226).

Table 2.2: The Empirical Literature on ERPT: Summary of Data, Methodology and Findings

Woo (1984) USA imports	Quarterly data from 1975:Q2 to 1984:Q4. The study uses three measures of the exchange rate: the Federal Reserve exchange rate index, the Morgan Guaranty index and the Import-share index.	The Instrumental variable technique, Almon polynomial lags and the Cochrane-Orcutt transformation method to correct for serial correlation.	Estimates of ERPT range from approximately 40 percent using the Federal Reserve index system to 70 percent using the Import-share index.
Feinberg (1986) German multi-industry study	Annual data from 1977 to 1983, sourced from the International Standard Industry Classification (ISIC) for 41, 3 and 4 digit industries.	OLS method	The study finds ERPT to be approximately 24 percent in real terms.
Mann (1986) USA imports and exports	Quarterly data from 1977:Q1 to 1985:Q2.	The methodology consists of an OLS estimator. Almon lags and the Cochrane-Orcutt transformation method are also used.	Findings suggest that the historical pass-through relationship in the USA changed significantly after the 1985 depreciation of the dollar. Furthermore ERPT in the USA is found to be asymmetric.
Athukorala (1991) Korean exports	Quarterly data from 1980 to 1989. Price data are true price indexes. ER proxied by a weighted average nominal rate.	OLS method	Korean exporters absorb 72 percent of a given exchange rate change within 4 to 5 quarters, and the major part of this adjustment occurs within 2 quarters.
Feinberg (1991) USA study	Annual data from 1974 to 1987. Three exchange rate measures are used: the Federal Reserve Board index, the Dallas Fed index and the Industry-specific indexes.	OLS method	The results show that ERPT is affected by the measure of exchange rate used. The reported ERPT estimates are; 24 percent for the Dallas Fed index and 13 percent for the Industry-specific indexes.

Menon (1993) Australian imports – passenger motor vehicles	Quarterly data from 1981:Q3 to 1990:Q4. All prices are true price indexes.	The methodology is based on the Engle-Granger (1987) two step procedure.	The findings show that long-run ERPT to vehicle import prices is 80 percent, while the short run pass-through is 70 percent. Furthermore, the pass-through of exchange rate changes and foreign costs is found to be symmetric.
Lutz and Reilly (1997) E.U. study	Data is based on retail prices for individual car models in 10 European markets for the period May 1993 to November 1996.	Methodology utilizes a hedonic regression framework.	ERPT is found to be significantly below fifty percent in all 10 markets. The researchers find no evidence that either the relative market share of domestic firms or the imposition of non-tariff barriers are associated with a lower degree of pass-through.
Adolfson and Malin (1997) Swedish imports	Monthly data from 1980:1 to 1995:5 for eight different industries. Exchange rate (ER) is proxied by the nominal effective rate (NEER). Price data are represented by price indexes.	Cointegration analysis	Total pass-through estimates range from 27 percent to 160 percent.
Kadiyali (1997) USA photographic print film industry	Quarterly data from 1980 to 1990. Variables include the WPI/PPI and seasonally adjusted CPI.	Methodology based on the New Empirical Industrial Organisation (NEIO) framework.	The results of the study show that market structure and the industry's marginal cost structure have a significant impact on the extent of ERPT.

Kim (1998) USA study	Seasonally adjusted monthly series from January 1973:M1 to 1995:M12. Variables include PPI, the index of trade-weighted exchange rate, M2, the aggregate personal income, and the 10-year US government bond yields.	Johansen (1998) cointegration method and a five system VECM framework. The Granger causality test is also used.	Results show variables have a long-run equilibrium relation. Furthermore, the cointegration tests show that there is a negative relationship between inflation and the exchange rate, while a positive relationship exits between inflation and the rest of the other variables. The exchange rate is also found to Granger-cause inflation.
McCarthy (2000) Multi-country study: USA, Japan, Germany, France, the UK, Belgium, the Netherlands, Sweden, and Switzerland.	Estimation period spans from 1976:Q1 to 1998:Q4.	Empirical model is a VAR framework that also incorporates impulse response and variance decomposition functions.	The results indicate that the determinants of ERPT have a modest effect on domestic price inflation over the post-Bretton Woods era. Furthermore, ERPT is found to be stronger in countries with a larger import share.
Nell (2000) South Africa	Quarterly data stretching from 1971:Q1 to 1998:Q4	Methodology based on Distributed Lag (DL) and Auto Regressive Distributed Lag (ARDL) models.	The long-run pass-through estimates are found to be 72 percent and 82 percent in rates of change and levels respectively.
Webber (2000) Asia-Pacific countries	Quarterly data, spanning from 1980:Q2 to 1997:Q3 for all countries with the exception of the Philippines and Malaysia for which the data series runs from 1983:Q1 to 1997:Q3 and 1987:Q3 to 1997:Q3 respectively.	Methodology based on the Johansen (1988) and Engle and Granger (1987) procedures.	The results of the study give strong evidence in support of the asymmetric adjustment of import prices to exchange rate fluctuations in 5 of the 7 Asia-Pacific countries.

Darvas (2001) Four EU candidate countries - Czech Republic, Hungary, Poland and Slovenia	Quarterly data from 1993 to 2000. Indexes include NER, equilibrium RER. Domestic fundamental prices are defined as non-food, non-energy and non-administered prices.	Analysis done in a simultaneous time-varying error correction framework, using a state model and Kalman filter.	The results indicate higher pass-through estimates for Hungary and Slovenia (40 percent each) than Poland (20 percent) and the Czech Republic (15 percent).
Gagnon and Ihrig (2001) Multi-country study for 20 industrialised countries	Quarterly data from 1971:Q1 to 2003:Q4. Variables used include the respective countries' quarterly CPI, trade-weighted exchange rate, and trade-weighted foreign CPI.	ERPT estimated using the Monte Carlo technique	The results of the study show a decline in the size of ERPT across the 20 industrialised countries. Furthermore, ERPT is seen to decline more in countries where monetary policy has shifted strongly toward inflation targeting.
Campa and Goldberg (2002) multi-country study	Quarterly data from 1975 to 1999. Nominal exchange rate defined as domestic currency per unit of foreign currency. Price proxies include domestic price index, import price index, all in local currency. Inflation rate based on the CPI from the International Financial Statistics database.	Analyses ERPT through a log-linear regression specification	The average pass-through to import prices across 25 OECD countries is 61 percent in short run and 77 percent in the long run.
Bhundia (2002) South Africa	Monthly data from 2000 to 2001. ER proxied by NEER, import prices are proxied by the import price index (IMP), producer prices = PPI excluding imports, and consumer prices = CPIX – excluding interest on mortgage bonds.	A vector autoregression (VAR) framework is estimated, following McCarthy (2000)	ERPT to CPIX is 12 percent. Pass-through of producer price shocks to CPIX is 72 percent.

SARB (2002) South Africa	Monthly data running from January 1980 to December 2001. The study uses NEER as the ER variable, the imported component of the (PPI) as the proxy for import prices, and an index of foreign wholesale price indices weighted on the same basis as the NEER as the proxy for foreign prices.	Methodology based on VAR framework and ECMs that are estimated using a Johansen-type VECM.	The results show that ERPT to South African import prices is approximately 78 percent in the long-run and half of this adjustment occurs in just less than one year.
Devereux and Yetman (2003) Multi-country study	Data from 122 countries for which there are at least 10 annual observations in the post-Bretton Woods period (1970 – 2001), except for Hong Kong for which there is hardly any nominal exchange rate volatility. Data source: IFS.	Regression analysis and impulse response functions.	The results show significant evidence of price stickiness in determining the extent of ERPT.
Hyder and Shah (2004) Pakistan	Monthly data from January 1988 to September 2003. The main source of data is the IFS.	Methodology used in the study based on a recursive VAR approach.	The findings of the study suggest that ERPT is low; however it was stronger in WPI relative to CPI.
Pollard and Coughlin (2004) U.S. multi-industry study	Data from 1978:Q1 to 2000:Q4.	Methodological framework is based on a profit maximization model, estimated using simple OLS.	ERPT is found to be asymmetric with respect to appreciations and depreciations, as well as large and small currency changes in many of the investigated industries. However, there is no clear direction in this asymmetry across industries. Overall, ERPT is reported to be incomplete in all the studied industries.

Wickremasinghe and Silvapulle (2004) Japan	Monthly data series from 1975:M1 to 1997:M6.	The methodology uses asymmetric unit root and cointegration tests and asymmetric models, namely the threshold autoregressive (TAR) model and the momentum threshold autoregressive (MTAR).	The results show that the estimated Japanese ERPT coefficients corresponding to an appreciation and depreciation of the currency are 98 percent and 83 percent respectively. These coefficients are shown to be significantly different, implying ERPT asymmetry.
Campa *et al*. (2005) Euro area multi-industry study	Monthly unit value indexes for the period 1989:1 to 2004:5.8	ERPT estimated using the Johansen cointegrating tests and a vector error correction model.	ERPT is high, albeit incomplete – averaging 80 percent, and is different across industries and countries.
Ito *et al*. (2005). 8 Asian countries: Indonesia, Korea, Thailand, Malaysia, Singapore, the Philippines, Hong Kong and Japan	Monthly data from 1995:M1 to 2004:M8. Some of the variables used in the study include local currency IMP, CPI, REER, NEER, real GDP, and the US dollar-basis oil price index.	ERPT is analysed using impulse response and variance decomposition functions based on a VAR framework.	ERPT estimates to import prices are high and significant for four of the eight countries – Hong Kong (49 percent), Japan (99 percent), Indonesia (100 percent) and Thailand (166 percent). The results of the other countries, Korea, Singapore, Taiwan and the Philippines are found to be insignificant. ERPT to consumer prices is found to be relatively lower than import prices, but among the countries, it is found to be higher for Indonesia (57 percent), Thailand (26 percent), Singapore (20 percent), the Philippines (15 percent) and Korea (13 percent).

Kardasz and Stollery (2005) Canadian industries	Annual data for the period 1971 to 1989. True price indices are used for all prices.	Methodology consists of a two step regression analysis, making use of OLS.	The paper finds that the direct and indirect ERPT elasticities are approximately equal in size for domestic goods, while the direct effect is stronger for imports. Furthermore significant determinants of the direct (indirect) elasticities are the import share and non-tariff barriers.
Kiptui *et al*. (2005) Kenya	Data from 1972 to 2003. The variables used in the study include: IMP; NEER (bilateral); export price index, CPI; and the domestic competing product price proxied by manufacturing output.	Methodology based on a VAR framework which involves pair-wise Granger-causality tests, cointegration, error correction modelling, impulse response functions and variance decompositions.	ERPT in Kenya is incomplete supporting the presence of pricing-to-market effects. Exchange rate changes account for about 70 percent of import price changes, as well as explaining 46 percent of the variation in consumer prices in the first period.
Korhonen and Wachtel (2005) Commonwealth Independent States (CIS) countries.	Monthly data from 1999 to 2004.	Methodology based on a VAR framework that also makes use of impulse response functions and variance decompositions.	The extent and speed of ERPT in the CIS countries is fairly high. In most cases the full pass-through effect is transmitted to domestic prices in less than 12 months. The results obtained in the examination of ERPT asymmetry show that in some countries there seems to be some asymmetry in the pass-through, but the results across countries are far from robust.

Gust *et al*. (2006) USA imports	Monthly data from 1980 to 2004. Trade prices were constructed using industry-level price indexes, and productivity indexes were constructed using GDP in 1990 US dollars at purchasing power parity.	Methodology consists of calibrated models and OLS estimation.	The study finds that as trade integration increased, exporters became more responsive to their competitors' prices, and this change in pricing behaviour attributed to the significant portion of the observed decline in ERPT.

CHAPTER 3: AN OVERVIEW OF THE SOUTH AFRICAN ECONOMY

3.1 Introduction

This chapter provides an overview of the South African macroeconomic environment and policies, and the implications of these for ERPT. Attention is given to inflation trends globally and in South Africa, to provide a background for the investigation of ERPT in South Africa. In order to establish the likely channel(s) of ERPT in South Africa, this chapter reviews the exchange rate and trade policies and trends in South Africa. Furthermore, the structure and composition of trade, as well as the competitiveness of the South African market, are also reviewed.

3.2 Trends in Inflation: Globally and in South Africa

This section examines the trends in inflation and related policies from the 1970s to the mid-2000s, globally and in South Africa. The general consensus among authors such as Rogoff (2003), Pivetta and Reis (2003), Levin and Piger (2003) and Batini (2006) is that the world economy has been experiencing disinflation over the past decade, as seen by the drop in inflation levels world-wide to levels that seemed highly unachievable in the 1970s, 1980s and early 1990s. These latter periods were abounding with countries experiencing high inflation and hyperinflation especially in African, Latin American and other transition economies (Rogoff, 2003).

However, in the past ten years, global inflation has dropped from 30 percent to 4 percent. More specifically, the inflation average in industrialised countries fell from an average of 9 percent in the first half of the 1980s to an average of 2 percent since the beginning of the 2000s. Developing countries have also experienced falling inflation: the 1980 to 1984 average inflation rate was 31 percent; however, by 2000 to 2003 the average had fallen to levels under 6 percent. Africa and Latin America had average inflation levels of 40 percent and 230 percent respectively from 1990 to 1994, but by 2003 both regions had average inflation rates of about 10 percent (Rogoff, 2003).

Rogoff (2003) and Levin and Piger (2003) identify the forces that have been driving the disinflation phenomenon. Chief among these forces are the inflation targeting focus of most central banks and the institutional changes that most of these central banks have undergone, which include increasing central bank independence and having the banks governed by conservative anti-inflation-oriented central bankers. Other factors include increased economic competitiveness promulgated by deregulation and globalisation, a decreased role for governments in many economies coupled with more prudent fiscal policies, and higher productivity growth. Rogoff (2003) argues that as more countries become economically competitive, prices become more elastic, thus reducing the effect of unanticipated inflation on output. Furthermore, any incentive the monetary authorities might have to raise output systematically dissipates, resulting in the central bank's anti-inflation credibility being enhanced and subsequently reducing inflationary expectations and inflation itself (Rogoff, 2003).

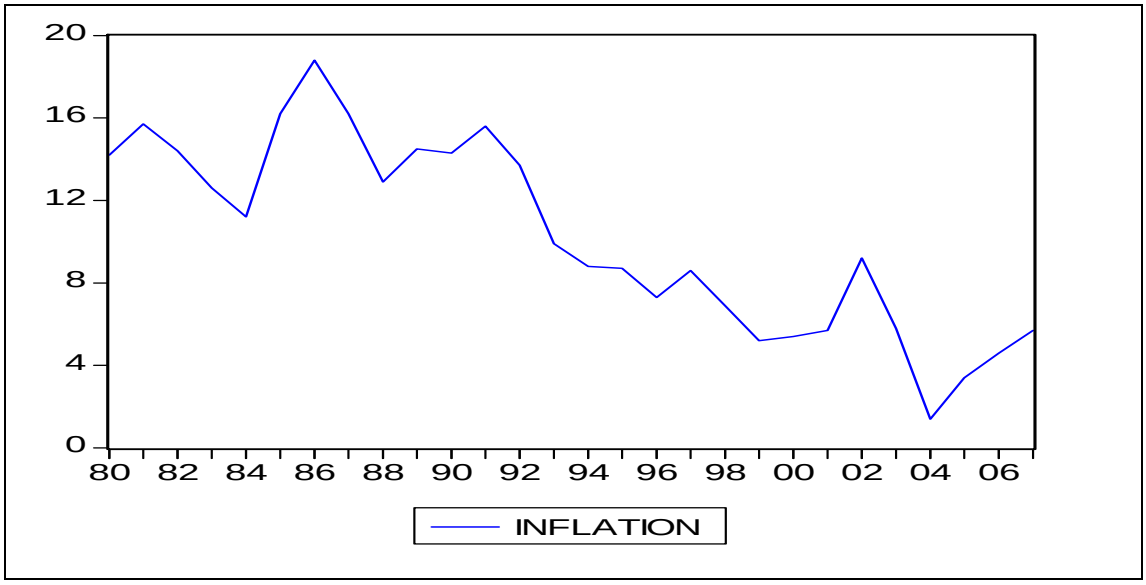
South Africa has not been an exception to global inflation movements and policy trends. Figure 3.1 below shows the annual percentage inflation rates from 1980 to 2007[5]. Inflation in South Africa has been generally downward trending (as is global inflation), although there have been significant spikes in the mid-1980s and early 2000s. During the 1970s and 1980s, the country experienced high and accelerating inflation. Nell (2000: 14) suggests that these features could have resulted from the oil price shocks in 1973 to 1974 and the exchange rate devaluations during the early 1970s which saw South Africa's inflation rate increasing from an annual rate of about 2.5 percent during the 1960s to double digit figures in the early 1970s. Strydom and Steenkamp (1976) show that successive exchange rate devaluations during the early 1970s increased import prices, which subsequently led to a sharp increase in price inflation.

Nell (2000: 2) reports that when inflation rose to an all-time high of 18 percent in 1986, the South African Reserve Bank (SARB) implemented a stern deflationary policy to reduce inflation to lower levels. This policy was successful in bringing inflation down to single-digit levels, and by 1994 to 1999, inflation averaged around

[5] The annual percentage inflation rate for 2007 is a forecasted figure.

7.8 percent. However, with the exception of 1999 when the annual average inflation rate was 5 percent, the policy at the time did not manage to achieve the SARB's unofficial inflation target range of between 1 and 5 percent consistently, which was in line with the average inflation rate of South Africa's major trading partners (Casteleijn, 1999). Thus, according to the theory of purchasing power parity (PPP) this scenario would be expected to have a negative impact on South Africa's price competitiveness against its trading partners and competitors, as rand prices would be higher due to higher inflation levels.

Figure 3.1: South Africa's Annual Inflation Rates (in percentages): 1980 - 2007



Source: International Monetary Fund (2006)

Consequently, inflation targeting in South Africa was formally introduced on 23 February 2000 with the announcement of a 3 to 6 percent target for 2002 (Mboweni, 2003: 1). The rationale for shifting to formal inflation targeting was based on four reasons (van der Merwe, 2004). The first reason was that informal inflation targeting sometimes created uncertainties among the public with regard to the monetary policy stance adopted by the SARB. For example, the expansion in money supply and bank credit extension in the 1990s exceeded the guidelines of the authorities for considerable periods. In such circumstances, public expectations would have been an increase in short-term interest rates. However, after assessing the situation, the SARB realised that the increasing growth in the monetary aggregates was primarily due to structural changes in the economy emanating from the liberalisation of the financial system. Thus, contrary to market expectations, the SARB did not enforce more

stringent monetary policy measures, and the general public did not understand this course of action (van der Merwe, 2004: 12). However, according to general economic theory, when formal inflation targeting is instituted, intermediate objectives fall away and monetary policy becomes more transparent, as policy changes depend on expected developments in inflation (van der Merwe, 2004: 12).

Secondly, inflation targeting was seen to improve the harmonisation between monetary policy and other economic policies provided that the inflation rate target and other economic objectives were consistent (van der Merwe, 2004: 12). Thirdly, formal inflation targeting was seen to be helpful in disciplining monetary policy and improving the Central Bank's accountability by setting comprehensible targets which the Central Bank has to achieve. In the event that the SARB fails to meet the set inflation target, it has to explain to the public what went wrong. The fourth reason behind the rationale for formal inflation targeting was that the authorities believed that the application of inflation targeting would influence inflationary expectations. If the general public perceived inflation targets to be credible, this would form the basis for future price and wage setting (van der Merwe, 2004: 13).

Thus, upon the introduction of formal inflation targeting in South Africa, it was decided that inflation targets would be specified in terms of an annual average rate of increase in the CPIX. A multi-year target approach was undertaken by specifying the inflation target as an average annual rate of increase of between 3 to 6 percent in the CPIX for the years 2002 and 2003 and an increase of between 3 to 5 percent for the years 2004 and 2005 (van der Merwe, 2004: 6). However, prior to this, CPIX had been on an upward trend in 2000 when it peaked at 8.2 percent, but it subsequently fell below 6 percent in 2001. In 2002 CPIX inflation increased from 2001 levels, averaging 9.3 percent, and peaking at 11.3 percent, following a 37 percent depreciation of the rand (SARB, 2004: 14).

Since then, one of the key issues on the SARB's agenda has been the pass-through effect of exchange rate changes on local prices (SARB, 2004: 15). Prior to 2002, the ERPT effect had been "unexpectedly" low, but when the depreciation of the rand accelerated, the rate of inflation increased significantly (SARB, 2004: 15). When it became apparent that the inflation target would not be achieved for a fairly prolonged

period due to a sharp decrease in the external value of the rand and a number of other exogenous shocks, the target range for 2005 was revised from 3 to 5 percent to 3 to 6 percent (van der Merwe, 2004: 6).

3.3 South Africa's Exchange Rate Policies and the Behaviour of the Rand

As stated before, prior to 2002, the influence of exchange rate fluctuations on inflation was low. However, after the accelerated depreciation of the rand and the subsequent spike in inflation levels, the SARB began to take a keen interest in the extent of the effects of exchange rate changes on domestic price levels (SARB, 2004). The exchange rate is an important transmission mechanism of monetary policy because it may have a major impact on inflation. Mishkin (2001) states that small open economies are more vulnerable to exchange rate movements than developed countries. This has been validated by empirical studies such as Goldfajn and Werlang (2000), who find that the degree of pass-through is higher in emerging markets, such as South Africa, than in established markets, which constitute the greater part of South Africa's trading partners.

Thus, in order to analyse the extent, speed and asymmetry of pass-through of exchange rate fluctuations to domestic prices in South Africa, an understanding of the country's exchange rate policies and the rand's behaviour is essential. This section starts with a brief overview of South Africa's exchange rate policy from 1971 to 2005[6]. Thereafter a discussion of the behaviour and movement of the rand is given.

According to du Toit (2005: 25), seven periods characterise the evolution of the South African exchange rate system. Firstly, there was the gold standard, 1874 to 1914, which was abandoned at the start of World War 1. The second era was the inter-war period of 1922 to 1936. This was followed by the Bretton Woods agreement, which had a relatively long lifespan in relation to other exchange rate systems and its demise came in 1971. The subsequent eight years, from 1971 to 1979, were characterised by attempts to restore exchange rate stability. A period of reform followed from 1979 to 1985. From 1985 to 1994 strict exchange rate controls were implemented. However,

[6] Although the study investigates ERPT from 1980 to 2005, due to the unavailability of uniform time series data for some variables in the analysis, this review of South Africa's exchange rate system starts from 1971 for completeness.

the same period was characterised by the devaluation of the rand against the major world currencies. In the last period, from 1994 to the present, attempts have been made to align the exchange rate system of South Africa with international trends (du Toit, 2005: 25). The regimes and the behaviour of the rand from 1971 to 2005 are discussed in more detail in the ensuing paragraphs.

After the collapse of the Bretton Woods agreement in 1971, and during the turbulent eight-year period from 1971 to 1979, efforts were made to re-establish the rand's stability. In 1977 the State President appointed a Commission of Inquiry into the monetary system and monetary policy in South Africa, named the De Kock Commission. As part of its inquiry, the Commission investigated the South African exchange rate system, and by January 1979 the Commission had found that the existing exchange rate system had serious deficiencies (du Toit, 2005: 26). The Commission reported that fixed dollar pegging in a relatively undeveloped foreign exchange market was not beneficial to the attainment of the optimum combination of economic growth, balance of payments equilibrium and internal economic stability. These findings brought the pegging of the rand to the US dollar officially to an end and the system of a managed floating exchange rate was introduced. The De Kock Commission suggested fundamental reform of the foreign exchange market and policies related to the market. The long-term objective was a unitary exchange rate system, within which the rand would be allowed to find its own level in a competitive environment (du Toit, 2005: 26). The De Kock Commission also recommended that the SARB intervene by way of buying and selling foreign currency in order to keep the rand stable. Exchange controls would be temporarily instituted but abolished in the long-term. A dual exchange rate system consisting of a commercial rand and a financial rand was introduced[7] in an attempt to discourage large outflows of foreign currency from the country. South Africa entered the floating exchange rate era with a dual exchange rate system, coupled with additional measures to protect the external value of the rand (du Toit, 2005:26).

[7] The commercial rand would be an independent, market-determined currency; however, the free-floating would be "managed" by the central bank. The financial rand would be a freely floating rate (du Toit, 2005:26).

According to du Toit (2005: 26), in 1983 the monetary authorities implemented steps to move closer towards the long-term objectives set out by the De Kock Commission. Exchange controls for non-residents were lifted in February 1983 and this effectively abolished the dual exchange rate system. In the same year, the foreign exchange market was further developed through the introduction of the foreign exchange forward market which functioned independently from the SARB. Administrative reforms also took place to make the market more competitive.

According to Nell (2000:13), from 1973 to 1983 the exchange rate levels and rates of change remained fairly stable because of the ability of the Reserve Bank to maintain a fixed exchange rate system over this period which was mainly supported by substantial capital inflows and high gold prices. However, after 1983 there were a number of factors that led to the depreciation of the rand. These included a drop in the dollar gold price, substantial capital outflows following increased political instability, United Nations sanctions and the immediate stand-still of foreign debt repayments in 1985. The SARB was forced to revert to tighter foreign exchange controls. In 1985 the financial rand was re-introduced for foreigners who wanted to repatriate capital out of the country. This policy remained until its abolishment in March 1995 (du Toit, 2005: 27), after the political situation in 1994 brought relief to the foreign exchange market with the first democratic elections in South Africa. The country once again became a borrower in the world capital markets, and significant steps were made to relax exchange controls, such as the rescheduling of international debt repayments and the removal of the financial rand as mentioned above (du Toit, 2005: 27).

However, the policy of a market determined rand and the relaxation of exchange controls have exposed the currency to domestic and external shocks, consequently increasing its volatility. In 1997 and 1998, the South Africa rand weakened by 20 percent against the US dollar as a result of the contagion effect that emanated from the Asian crisis (IMF, 2004). In response to the rand's depreciation the Central Bank increased interest rates to sway the value of the rand indirectly (du Toit, 2005). However, the persistent negative sentiments towards emerging market economies in general and the "bad neighbourhood syndrome"[8] saw the continued depreciation of

[8] The volatile political and socio-economic situation in Zimbabwe.

the nominal effective exchange rate of the rand by 17.4 percent and 34.4 percent in 2000 and 2001 respectively.

After the sharp currency depreciation that occurred in the second half of 2001, the positive investor sentiments towards South Africa provided a major boost in South Africa's foreign exchange market activity during much of 2002. According to the IMF (2004), in 2002 the rand subsequently recovered in value, appreciating by about 40 percent on a trade-weighted basis since the end of 2001 in real terms. The SARB (2004) reports that the nominal effective exchange rate of the rand appreciated by 24 percent in 2002, 16.2 percent in 2003 and 11.7 percent in 2004; and in 2004 the exchange rate was around the level prevailing in the second half of 2000. Much of the appreciation reflected a reversion to long-term equilibrium following the overshooting that took place in 2001, but fundamentals had also contributed to a strengthening of the exchange rate (IMF, 2004). The fundamentals included firmer export commodity prices, widening interest rate differentials with overseas capital markets when domestic credit conditions were tight, increasing appetite by global investors for emerging market assets, and a strong external current account position. However, in the first half of 2005, the nominal effective exchange rate of the rand dropped by 9 percent due to interest rate cuts amidst rising global interest rates, decreasing international commodity prices of South Africa's main export products and a significant current account deficit in the balance of payment (SARB, 2005: 41).

Figure 3.2 below shows the behaviour of the nominal effective exchange rate from 1975 to 2005 as discussed above. Although the volatility of the rand has increased significantly since the Central Bank allowed the exchange rate to be market oriented, the general trend of the nominal effective exchange rate has been downward, implying a general depreciation in the nominal value of the rand. The implication of such a downward trend in the nominal effective exchange rate for ERPT to import, producer and consumer prices is that these prices will rise as more rand are needed to purchase the same imported goods and services. The size, speed and asymmetry of the pass-through will depend on the channel of pass-through as determined by, amongst other

factors[9], the nature of the imported goods and services. If the imported commodities are primarily capital goods and/or raw materials, the pass-through can be depicted as:

Schematic 3.1

where a depreciation in the nominal effective exchange rate (NEER) will be passed directly to import prices (IMP), then producer or wholesale prices (PP), and finally consumer prices (CP); as importers pass on some of the costs spurred by the currency depreciation to their customers. Alternatively, if the imported commodities are predominantly finished goods and services for final consumption, the pass-through will be transmitted directly from the change in NEER to IMP to CP, illustrated in the schematic below:

Schematic 3.2

However, although Schematics 3.1 and 3.2 mirror the direct transmission of ERPT as represented in Schematics 2.1 and 2.2 respectively, the indirect channels illustrated by Schematics 2.3 and 2.4 in Chapter 2 also show the implication of such a downward trend in the nominal effective exchange rate for domestic, producer and consumer prices, given the resultant change in aggregate demand.

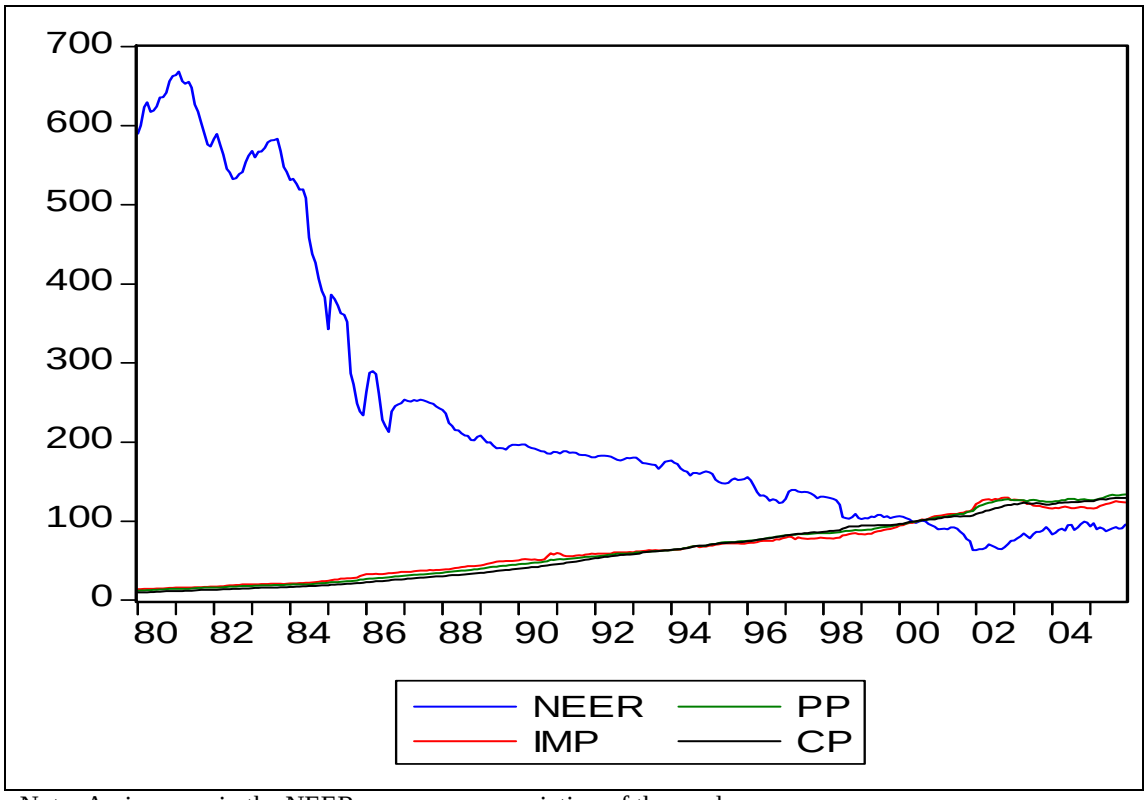
As mentioned above, the volatility of the rand has increased significantly as a result of the free floating exchange rate regime that the Central Bank has been implementing, which allows the value of the rand to be market determined. The implications of exchange rate volatility for ERPT are that the greater the volatility the more importers become wary of changing prices and the more willing they become to adjust profit margins accordingly, to either an appreciation or depreciation.

Figure 3.2 illustrates the behaviour of the nominal effective exchange rate versus that of import, producer and consumer prices from 1975 to 2005. As expected, domestic prices have been increasing as the nominal value of the rand has been decreasing. This suggests that the cost implications of the depreciation in the value of the rand have

[9] See Section 2.2.3 on the determinants of ERPT.

been passed on to import, producer and consumer prices. However, visual observation is, of course, not sufficient to determine the rate of pass-through of changes in the nominal effective exchange rate to domestic prices. This is fully investigated in subsequent chapters.

Figure 3.2: The behaviour of the nominal exchange rate of the rand versus domestic prices, 1975-2005



Note: An increase in the NEER means an appreciation of the rand.
Source: SARB (2007)

After investigating the relationship between the exchange rate and the domestic prices in South Africa, and identifying the possible pass-through channels, a clearer picture of ERPT in South Africa can be obtained by examining the country's trade policies, structure and composition. This analysis is presented in the following section.

3.4 South Africa's Trade Policies, Trade Composition and Market Competitiveness

The magnitude, speed and asymmetry of pass-through at the aggregate level are also affected by the structure of the economy, with respect to trade and market competitiveness. The objective of this section is to determine the extent of ERPT and model its channel(s) in South Africa by investigating the extent of trade liberalisation,

the size of trade versus total GDP, the size and composition of imports versus exports, and the level of competition in South African markets.

3.4.1 Trade Policies

Historically, South Africa's industrialisation took place through the process of import substitution, which focused on the production of previously imported manufactured goods, mainly for the domestic market (Bell, 1993: 3). The trade policies that were implemented and supported import substitution included quantitative restrictions (QRs) on imports, in the form of import quotas or licences, and customs tariffs or duties on imports. However, by 1972, the first signs of trade liberalisation in South Africa began to emerge as policy shifted from the traditional import-substituting strategy to export oriented industrialisation (Bell, 1997: 71). The change in policy was borne out of initiatives such as the Commission of Inquiry into the Export Trade of the Republic of South Africa, named the Reynders Commission. However, according to Bell (1993: 4) the report produced by the Reynders Commission did not argue that import liberalisation was a necessary condition for accelerated export expansion. Even though the Commission envisaged trade liberalisation as important in overcoming any anti-export bias inherent in the trade policy at that time, it focused more on export promotion than on import liberalisation.

According to Fedderke and Vaze (2001), in the 1970s, trade liberalisation in South Africa focused on the replacement of import quantitative restrictions with import tariffs. Although the applied import tariffs were high, the net result was a reduction in the level of protectionism as the raised tariffs were lower than the tariffs implicit in the QRs that had been abolished (Bell, 1997: 72). Furthermore, new export incentives were introduced, such as a tax allowance for export marketing expenses. However, trade liberalisation in 1972 to 1976 was hindered by the large real appreciation of the rand during the gold-led boom of 1973 to 1974. Throughout the rest of the decade, the real exchange rate of the rand appreciated steadily, effectively reversing the trade liberalisation achieved earlier in that period (Bell, 1997: 72).

In the 1980s, there was renewed vigour to further trade liberalisation in South Africa, after the setback experienced in the late 1970s. By 1985, the proportion of the value of

imports subject to QRs had fallen to 23 percent from 77 percent in 1983 (Bell, 1997: 72). Gunnar and Subramanian (2000: 200) further suggest that by 1985, South Africa had changed from a positive list of permitted imports, that is, imports subject to licensing, to a negative list of prohibited imports which covered 23 percent of imports, implying that approximately 77 percent of total imports would be exempt from licensing. Another contributing factor towards South Africa's trade liberalisation was the depreciation of the rand towards the end of 1983 until the end of 1985. Overall there was a significant reduction in levels of protection of manufactured goods during 1983 to 1985, which was a major step in the process of trade liberalisation (Bell, 1997).

The period between 1985 and the early 1990s was characterised by further relaxations of QRs. According to Bell (1997: 73), the percentage of tariff items subject to QRs declined from 28 percent in 1985 to less than 15 percent by September 1992. However, this progress in trade liberalisation was hampered by the imposition of sanctions and the debt standstill in 1985. Gunnar and Subramanian (2000: 200) report that an import surcharge of 10 percent was introduced in 1985, which rose to 60 percent for selected items in August 1988. By 1990 there were differentiated rates for the surcharge on goods not bound by the General Agreement on Tariffs and Trade (GATT). These rates were 10, 15 and 40 percent.

In terms of export incentives, the government at the time introduced structural adjustment programmes for specific industries, notably the motor vehicle, and textile and clothing sectors in March and April 1989 respectively (Sellars, 2000: 492). The programmes involved a system of duty-free imports for exports, and moreover, represented a shift towards greater export orientation in these industries (Bell, 1997: 73). In April 1990 the individual programmes were consolidated into one powerful system of export subsidies, the General Export Incentive Scheme (GEIS). The scheme provided a tax-free subsidy to exporters relative to the value of exports, the extent of processing of the exported product, the degree of local content embodied in exports and the size of overvaluation of the exchange rate (Gunnar and Subramanian, 2000: 200). Despite the significant strides made towards liberalisation in the 1980s, South Africa still had a complex tariff regime. By the end of the 1980s, South Africa had the most tariff lines and tariff rates (more than 13,000, and 200 ad valorem equivalent

rates, respectively), the widest range of tariffs and the second highest degree of dispersion in tariff rates among developing countries (Gunnar and Subramanian, 2000: 201).

In the 1990s, South Africa adopted a two-pronged approach to trade liberalisation. These included unilateral trade liberalisation and multilateral trade liberalisation in the context of the Uruguay Round of trade negotiations. Between 1990 and 1994, the main emphasis of trade liberalisation was the elimination of the remaining import licensing procedures and reducing import tariffs. On average, tariffs were reduced from 28 percent to 16 percent and the import surcharge was eliminated (Gunnar and Subramanian, 2000: 201). In 1994, South Africa announced a schedule of unilateral tariff liberalisation that superseded the Uruguay Round commitments. The schedule was due to expire in 1999. By 2000, the average import-weighted tariff was below the level committed by South Africa to the World Trade Organisation (WTO), by more than 5 percentage points (Gunnar and Subramanian, 2000).

In terms of the multilateral trade liberalisation approach, in 1994, South Africa made an offer at the Uruguay Round where it agreed to implement a 5-year tariff reduction and rationalisation programme. Among the terms of the agreement, South Africa had to reduce the number of tariff categories from over 100 to 6, and the average weighted import duties had to be reduced. Other targets set in the offer included the reduction of industrial protection over a 5-year period from an average of 12 percent in 1994 to 5 percent in 2001, the average import weighted tariff rates were to be decreased from 34 to 17 percent for consumer goods, 8 to 4 percent for intermediate goods and from 11 to 5 percent for capital goods (Trade and Industry Policy Strategies (TIPS), 2001: 11). Gunnar and Subramanian (2000: 7) report that the average import weighted tariffs, since the implementation of the offer, declined from 28 to 10 percent in 1998, and, by 2000, tariffs had fallen from 11.4 to 8.6 percent for industrialised products.

South Africa's offer to the WTO demonstrates a commitment to opening the economy to foreign international competition. The country has also entered into regional trade agreements, such as the SADC Trade Protocol of 1996. One of the goals of the Protocol is that 69 percent of the SADC imports to South Africa should be zero rated

upon the full implementation of the Protocol, with complete liberalisation by 2012 (TIPS, 2001). Evidently the South African trade regime appears to be significantly liberalised. TIPS (2001: 14) reports that most QRs have been eliminated; the number of tariff bands decreased from over 200 to 35, and the tariff lines decreased from over 13,000 in 1990 to 7,831 in 2001. By 2002 South Africa's trade regime was relatively simplified as the number of lines facing a specific tariff was halved from 500 to 227 (TIPS, 2001: 14). More recently, trade volumes have trended upwards. Between 2000 and 2005 import volumes grew rapidly in real terms, averaging 7.6 percent per year, almost twice the growth rate in GDP over the same period (Edwards and Lawrence, 2006: 13).

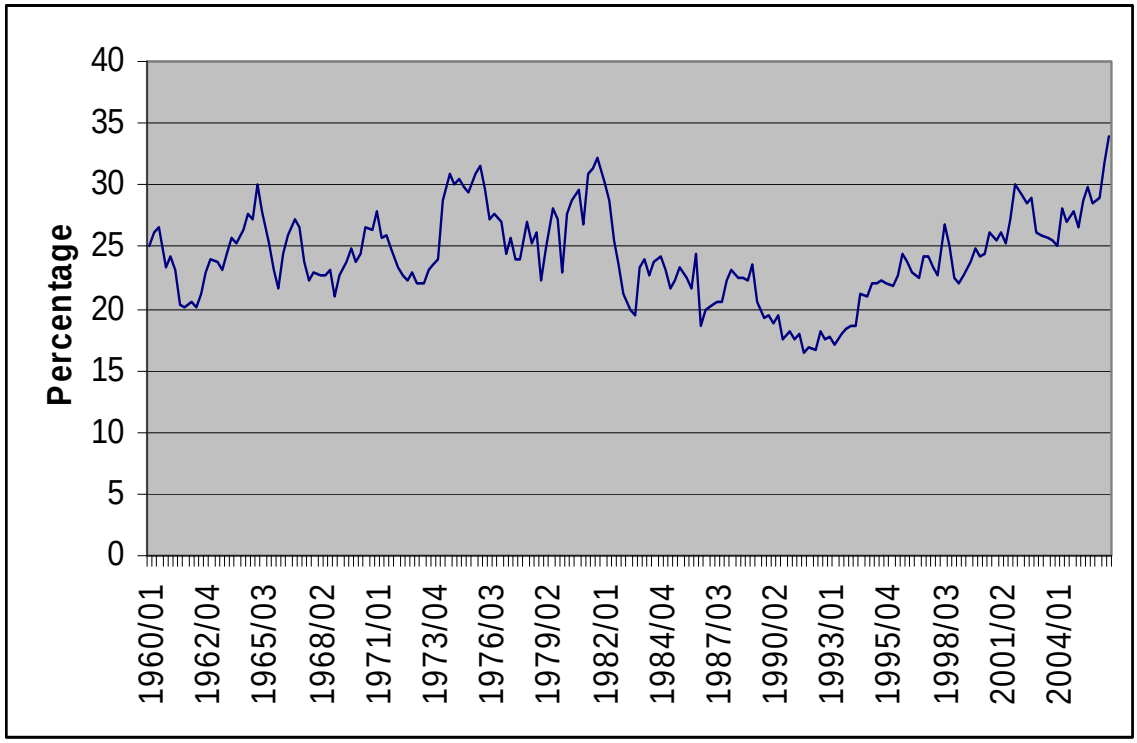
The openness and liberalisation of trade in South Africa, as advocated by the country's policies, is expected to have an increasing effect on the size and speed of ERPT. As more imports are brought into the country at the different stages of production, the more likely changes in the exchange rate are to be passed on to import, producer and consumer prices, as firms pass on the cost or saving of a depreciation or appreciation, respectively, in the exchange rate.

3.4.2 Trade Structure and Composition

As previously indicated, the size of trade relative to a country's economy or total output is important in assessing the presence and importance of ERPT within that economy. If international trade by a country, that is, importing and exporting activity is minimal, then ERPT will not be important as domestic prices will not be considerably influenced by fluctuations in the country's exchange rate. However, if the ratio of trade to the country's gross domestic product (total aggregate output) is high, the country is likely to experience notable levels of pass-through. In the case of South Africa, trade plays a pivotal role in the growth of the country's economy. According to statistics from the SARB (2006), the percentages of total imports and total exports to GDP have averaged 24.2 percent and 27.2 percent from 1960:Q1 to 2006:Q3 respectively (see Figure 3.3 and Figure 3.4). Figure 3.3 shows that the ratio of imports to total GDP has been trending upwards since the first quarter of 1993, implying an increase in the import component of total GDP. Furthermore, the SARB (2006) statistics show that South Africa's nominal GDP has been steadily increasing

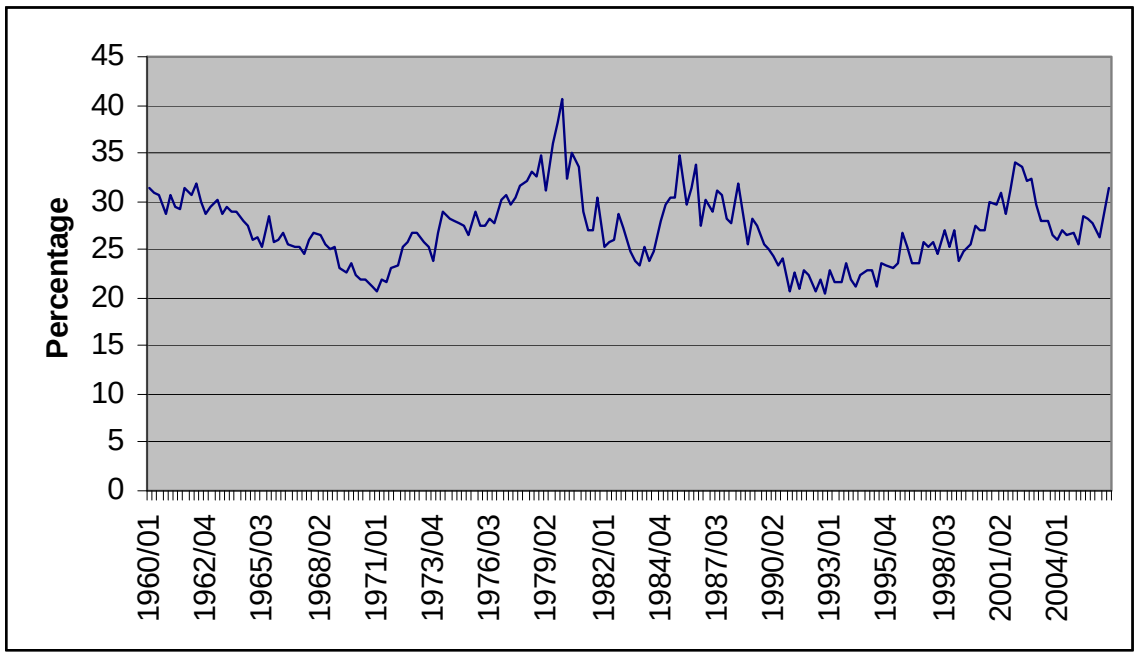
over time, therefore the increase in the imports to GDP ratio has increased not because of a decline or stagnation in the level of GDP (see Figure 3.5).

Figure 3.3: Ratio of Total Imports to GDP (percentage)



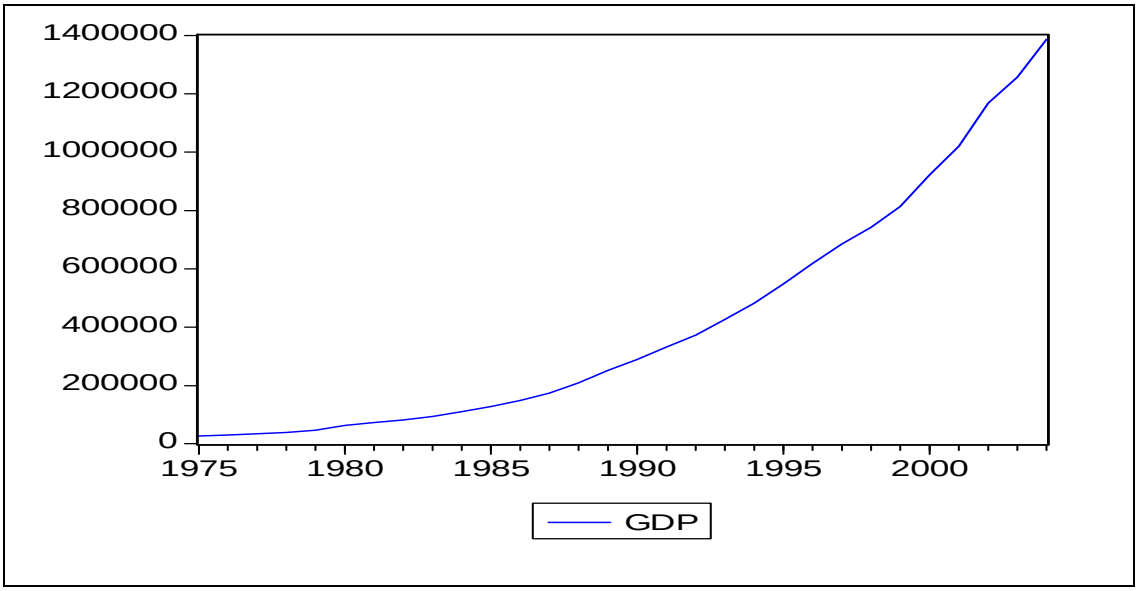
Source: SARB (2006)

Figure 3.4: Ratio of Total Exports to GDP (percentage)



Source: SARB (2006)

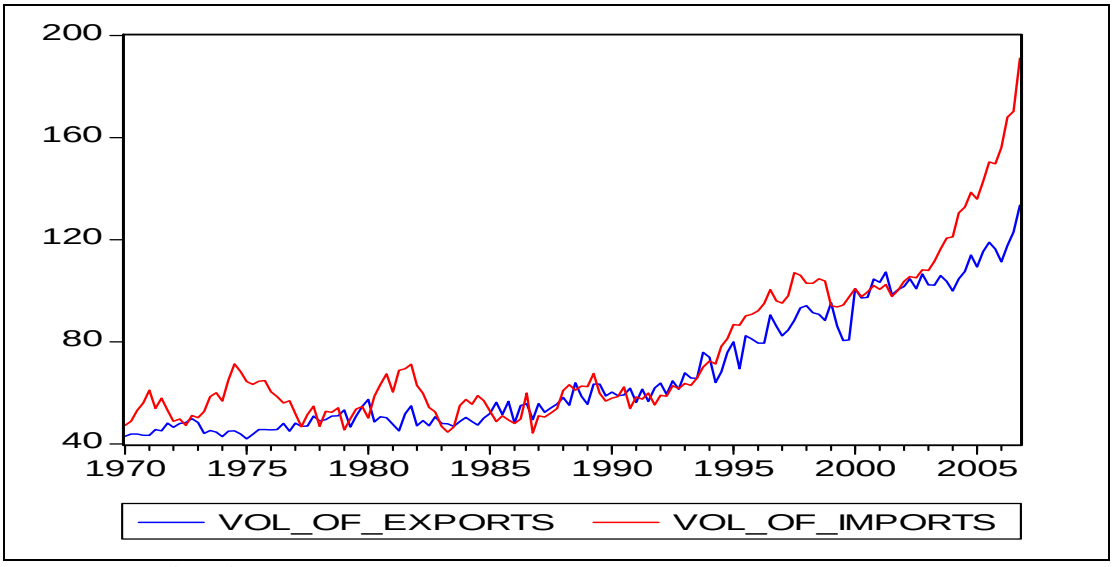
Figure 3.5: South Africa's Nominal GDP



Source: SARB (2006)

Although South Africa's trade policies over the years, such as the export incentive schemes of 1972, 1980 and GEIS (from 1990 to 1994), have sought to encourage more growth in exports relative to imports (Bell, 1993; Gunnar and Subramanian, 2000), the statistics show the converse. Figure 3.6 and Table 3.1 show the total trade volumes and average annual growth in South Africa's trade from 1970 to 2006 and 1960 to 2004 respectively.

Figure 3.6: Total Trade Volumes in South Africa



Source: SARB (2006)
Notes: Index 2000 = 100. Seasonally adjusted

Table 3.1: South Africa's Trade: Average Annual Growth

	Export Volume	Import Volume	GDP	Terms of Trade	Real E.R.
1960 – 1970	4.5	7.8	5.7	-0.7	
1971 – 1980	0.9	1.9	3.4	4.9	1.4
1981 – 1990	1.4	0.3	1.5	-1.7	-1.2
1991 – 2000	5.3	6.0	1.9	-0.9	-1.5
2001 – 2004	1.1	6.6	3.2	2.0	3.4

Source: Edwards and Lawrence (2006: 5)
Note: Decade averages in percentages

The above illustrations show that growth in import volumes has generally outpaced export volume growth over the decades. Even in the 1970s, when South Africa experienced commodity booms (which would imply greater exports[10]) and the terms of trade improved by an annual average rate of 4.9 percent (see Table 3.1), the average growth rate of imports still outstripped the average growth rate of exports by one percent. The only exception was in the period from 1981 to 1990, when South Africa faced economic stagnation and the rand experienced an average depreciation of 1.5 percent during that period, resulting in the average annual growth in exports surpassing that of imports by 1.1 percent (Edwards and Lawrence, 2006: 5). Although the trade liberalisation policies, such as the reduction of tariffs in the 1990s, were instrumental in stimulating exports in general to the extent that they reduced the anti-export bias, at the sectoral level, the effect of such policies were stronger in stimulating imports (Edwards and Lawrence, 2006: 7).

The structure of South Africa's trade is analysed in terms of the total imports and exports of three main sectors, namely, manufacturing, mining and agriculture, while the remaining exports and imports are classified as 'other'. South Africa's major exports include gold, diamonds, other metals and minerals, and machinery and equipment. The country's major imports are machinery and equipment, foodstuffs, chemicals, petroleum products, and scientific instruments. The majority of this trade is conducted with the European Union, United States, Japan and China (DTI, 2006).

[10] South Africa's major exports are commodities such as gold, platinum, other minerals and metals.

Figures 3.7 and 3.8 below show the structure of South Africa's imports and exports from 1992 to 2005. Figure 3.9 illustrates the trade balances over the same period.

Figure 3.7

Source: DTI (2006)

Figure 3.8

Source: DTI (2006)

Figure 3.9

Source: DTI (2006)

Figure 3.10 Trade Balance

Source: DTI (2006)

Figure 3.7 shows that the majority of exports since 1995 have been goods from the manufacturing sector, while Figure 3.8 shows that the majority of imports since 1992 have been commodities for the manufacturing sector. Furthermore, although DTI (2006) statistics show that South Africa has enjoyed positive trade balances for most of the years, the trade balance of the manufacturing sector was negative throughout the period 1992 to 2005. The importance of trade within the manufacturing sector can be seen (see Figures 3.9 and 3.10) by the overturn of South Africa's trade balance in 2004 and 2005, from positive to negative territory. The negative trade balance of the manufacturing sector outstripped the positive trade balances of the other sectors by ZAR10.68 billion and ZAR20.26 billion in 2004 and 2005 respectively, and is still growing (DTI, 2006).

Theoretically, the significant growth in the volume of imports relative to the growth in exports would suggest that South Africa is prone to the ERPT phenomenon. According to theory, assuming that a country's import share is a reliable proxy for the import penetration faced by firms in that country, then countries with a larger import share should have a greater pass-through of exchange rate and import price fluctuations to domestic prices (McCarthy, 2000: 3). Evidently, South Africa is heavily dependent on imported capital goods and services, especially for the manufacturing sector. Thus the pass-through of exchange rate fluctuations to domestic prices in the country would be expected to flow directly to import prices and then be passed on to producer and consumer prices. However, because of the upward trend in

exports (as shown in Figure 3.6 and Table 3.1), an indirect transmission of exchange rate fluctuations to producer and consumer prices can also be identified in the case of South Africa. Hyder and Shah (2004) suggest that as the demand for local exports increases, the prices of substitute goods and the exports themselves increase in local currency terms. The end result is an increase in domestic price levels.

3.4.3 Market competitiveness

The apartheid era in South Africa established a historical legacy of concentrated ownership in some sectors of the country's economy. During this period, a large fraction of the South African population was barred from owning or participating in business enterprises. Furthermore, the National Party-led government's policies from 1961 to 1994 restricted some successful companies such as South African Breweries, Anglo American (including De Beers) and SASOL from investing abroad. Consequently, such companies expanded their activities locally and gained considerable market power and market share in the South African marketplace (United States Trade Representative (USTR), 2006: 434).

However, since the political emancipation of South Africa in 1994, this situation has been changing. The country's economy has been undergoing structural transformation as macroeconomic policies aimed at encouraging domestic competitiveness, growth and employment, and increasing the economy's outward orientation, have been implemented (DTI, 2006). Many of the larger and long-established South African companies have expanded their interests internationally and some have even listed on foreign stock exchanges. Such changes, coupled with the more effective competition authority and strong sectoral initiatives through the black economic empowerment (BEE) programme to enlarge the share of black participation in the economy, have seen the South African business environment becoming more competitive and more open to new entrants from across the globe (USTR, 2006: 434). However the level of competitiveness in the broader South African markets and certain key sectors such as telecommunications, energy and mining, and the retail banking sector, is relatively low and could still improve. For example, Falkena *et al*. (2004) report that in the South African banking sector, the 'Big Four' banks (ABSA, First Rand, Nedcor and Standard Bank) held 83 percent of South Africa's total deposits in June 2003. Furthermore, each of these banks has at least 25 percent market share in one or more

of the retail banking market segments. In the case of the telecommunications sector, South Africa has one fixed line operator, Telkom, which also has a considerable shareholding in one of the country's largest mobile phone operators, Vodacom (Tattersall, 2001).

According to an "Ease of doing Business" survey by the World Bank (2005), South Africa ranked 28th out of 155 survey ranked countries. This would suggest that the country has been progressive in creating a conducive business environment, which allows for easier access by foreign and domestic investors. In another survey by the World Economic Forum (2005), the Global Competitiveness Report 2005, South Africa ranked 42 out of 117 countries. South Africa has made significant strides in instituting industrial support measures to enhance the competitiveness of its industrial base. Such measures include placing more emphasis on supply-side than demand-side policies, for example, lower tariffs and expensive export support programmes (DTI, 2006: 4).

South Africa has also established a well-developed and regulated competition regime based on best international practice, through the Competition Act of 1998. The Act has helped reform the country's competition legislation, and has strengthened the powers of the competition authorities along the lines of the European Union, USA and Canadian models. "The law places various prohibitions on anti-competitive conduct, restrictive practices (such as price fixing, predatory pricing and collusive tendering) and abuses by dominant firms (firms with a market share of 35 percent or more)" (DTI, 2006: 4). Competition authorities such as the Competition Commission of South Africa have been instituted to monitor the implementation and adherence to the law, and regulators have been assigned to watch over natural monopolies and promote universal access to utilities (DTI, 2006: 4).

South Africa's trade and industrial policies have been set to encourage openness of trade and competition within the economy. The openness of the economy allows for more participation of foreign players and increased imports of capital, intermediate and final goods and services. However, the South African markets are still largely oligopolistic in nature and it would be expected that ERPT in South Africa would be relatively high but incomplete.

3.5 Concluding Remarks

South Africa's macroeconomic policies have evolved notably over the years. Inflation has become a formal target for monetary policy, from being an indirect one. This policy stance by the South African monetary authorities has promulgated the importance and need to study exchange rate pass-through.

As discussed above, since the 1970s, South African policy makers have been on a mission to liberalise the economy and allow free market principles to govern the markets. Upon the recommendations of the De Kock Commission in 1979, the determination of the value of the rand changed from being pegged to managed-floating, with the ultimate aim being to allow the rand to be a completely free floating currency. In the same vein, South Africa's trade policy has also been subject to change. The focus of the country's trade regime has been export biased for obvious reasons, such as to improve the balance of payments by reducing the current account deficit, and to encourage industrial self-sustenance given the international sanctions imposed on the country in the 1980s. However, South Africa's trade statistics show that import volumes have outpaced exports over the years as the economy became more liberalised.

The South African economy has been opened to the rest of the world, a move which is inline with the current phenomenon of globalisation. Consequently, the South African economy has become prone to changes or shocks in the global economy including fluctuations in exchange rates. Thus taking into account the behaviour of the rand and its increased volatility, the South African trade structure which shows a greater influx of capital and intermediate manufacturing goods, as well as the slow but improving competitiveness of the South African markets, the main channel of pass-through in South Africa is expected to be the direct transmission channel represented by Schematic 3.1, where a change in the exchange rate is passed on directly to import prices, then producer prices and finally consumer prices. The pass-through is expected to be relatively high but not complete because of the oligopolistic nature of the South African markets. However, given the increasing competitiveness in the country's business environment, factors such as market share, menu costs and binding quantity

constraints are expected to have an impact on the size and speed of ERPT, as well as the asymmetric pass-through of changes in the exchange rate to import prices.

CHAPTER 4: ANALYTICAL FRAMEWORK

4.1 Introduction

Based on the theoretical and empirical analysis of Chapters 2 and 3, the transmission mechanism of ERPT can be described in two ways: firstly exchange rate fluctuations can be transmitted through prices of imported goods, affecting domestic prices directly, or there is the second transmission which involves the indirect pass-through of exchange rate changes to domestic producer and consumer prices due to changes in aggregate demand which may exert up or downward pressures on these prices depending on the movement of the currency. Furthermore, within the direct transmission channel, the pass-through can be classified into 2 stages. The first stage describes the pass-through of exchange rate fluctuations to import prices, while the second stage is the pass-through of changes in the exchange rate and import prices to producer and consumer prices.

However, as mentioned in Chapter 3, the expected channel of pass-through in South Africa entails the direct transmission of changes in the exchange rate to import prices, which then affects producer prices and consequently consumer prices. It is this channel that this chapter endeavours to model. In doing so, the chapter focuses on three main areas: firstly attention is given to the empirical issues involved in the estimation of ERPT. The issues dealt with in this section include alternative methods and techniques of measuring the size and speed of pass-through, and pass-through asymmetry. The second focus area is on the variable types and measures used in the estimation of ERPT. The main variables of interest are the exchange rate, and prices, that is, import, producer and consumer prices. The third area specifies and discusses the methodology and data used in this study.

4.2 Empirical Issues

4.2.1 A Review of ERPT Estimation Techniques (Size and Speed)

ERPT was defined in Chapter 2 as the responsiveness of domestic prices, that is, import, producer and consumer prices, to exchange rate fluctuations. Thus one of the ways to estimate pass-through is to find the coefficient from regressing changes in prices on movements in exchange rates. However, simple as it may seem, a number of specification issues have arisen in ERPT literature (Sekine, 2006: 2).

Different techniques and models have been used to estimate ERPT. The estimation techniques have ranged from simple classical regression models to variations of the vector autoregressive (VAR) models such as the threshold and momentum threshold autoregressive (TAR and MTAR respectively) models, to cointegration based techniques such as the Engle-Granger and Johansen methods. However, as highlighted in the review of empirical literature in Chapter 2, the most prominent techniques used are OLS regression, the VAR technique in conjunction with impulse response and variance decomposition functions, and the Johansen (1988) and Johansen and Juselius (1990a) cointegration techniques combined with vector error correction modelling. This section reviews each of these methods in the context of ERPT estimation, starting with the OLS regression method, the VAR framework and the Johansen cointegration technique. Table 4.1 (which is based on the empirical literature survey of Table 2.2 in Chapter 2) lists the authors who have used these techniques in estimating ERPT.

Table 4.1: Summary of Studies that Used Three of the Popular ERPT Estimation Techniques

OLS Regression	VAR	Johansen cointegration
Athukorala (1991)	Bhundia (2002)	Adolfson and Malin (1997)
Feinberg (1986, 1991)	Devereux and Yetman (2003)	Campa, Goldberg and González-Mínguez (2005)
Gust, Leduc, and Vigfusson (2006)	Hyder and Shah (2004)	Dwyer, Kent and Peace (1994)
Kardasz and Stollery (2005)	Ito, Sasaki and Sato (2005)	Kim (1998)
Knetter (1994)	Kiptui, Ndolo and Kaminchia (2005)	Kiptui, Ndolo and Kaminchia (2005)
Mann (1986)	Korhonen and Wachtel (2005)	SARB (2002)
Marston (1990)	McCarthy (2000)	Webber (2000)
Pollard and Coughlin (2004)	SARB (2002)	
Woo (1984)	Rowland (2003)	

4.2.1.1 OLS Regression Techniques

According to Davidson and MacKinnon (1993), the least squares method is the most commonly used, and in some ways the most important estimation technique in econometrics. It is not surprising, therefore, that most of the earlier studies on ERPT used OLS as an estimation technique (Menon, 1995). The OLS regression technique

seemed appropriate for analysing pass-through because of the fundamental principle of regression analysis, which is to describe the relationship between a given variable and other variables within the same system. More specifically, regression analysis attempts to explain the movements in one variable by reference to movements in one or more other variables within the same model (Brooks, 2002: 42). Hence, the OLS method could be seen as being able to explain the movements in prices given movements in the exchange rate.

However, in order to use OLS, the model and data being estimated must be linear and stationary respectively. Although there are ways to get round this, such as transforming a non-linear model into a linear exponential regression model, these two conditions must be met (Brooks, 2002: 54). The weakness of OLS in investigating ERPT is highlighted by Nelson and Plosser (1982: 140), who argue that past studies generally did not fully consider the time series properties of their data. Furthermore, there was and still is growing evidence that most macroeconomic data, such as exchange rates and prices, are non-stationary. Thus, if OLS is used to estimate a non-stationary series, the regression results are likely to be spurious (Menon, 1995: 223). Menon (1995) further argues that, because the data used to estimate ERPT usually follows a trend, previous estimates of pass-through based on the OLS technique could have been biased due to the non-stationarity of the data. Hendry (1986) provides evidence to back Menon's (1995) arguments. The evidence shows that a large number of OLS based studies record high R^2 and low Durbin-Watson (DW) statistics, a situation which may reflect non-stationary residuals, and more so when $R^2 > DW$, the likelihood of 'spurious' relationships is extremely high (Menon, 1995: 223).

4.2.1.2 VAR Techniques

Although various forms of the VAR technique have been used in estimating ERPT, the most common has been the ordinary VAR framework which is interpreted using impulse response and variance decomposition functions. In the more recent studies the VAR method has become more popular in investigating the second stage of pass-through, which describes the transmission of exchange rate and import price changes to producer and consumer prices.

The popularity of the VAR method in estimating ERPT can be traced to its characteristics. Davidson and MacKinnon (1993: 684) suggest that VARs are the 'easiest' type of multivariate time series models to estimate. This is largely because OLS can be used to estimate each equation in a VAR framework, as proved by Kruskal's Theorem[11]. Sims (1980 in Davidson and MacKinnon, 1993 and Brooks, 2002: 330) strongly encourages the use of VAR models to estimate dynamic relationships among jointly endogenous variables without the imposition of strong *a priori* restrictions.

A major advantage of VAR modelling is the fact that there is no need to specify which variables are endogenous and which are exogenous (Davidson and MacKinnon, 1993: 684). Brooks (2002: 332) notes that this is an important point because, although the identification of endogenous and exogenous variables should naturally arise from financial and economic theory, in reality, theory may be vague in its suggestions of which variables should be treated as exogenous. This gives the investigator the discretion with respect to classifying the variables in modelling exchange rate pass-through. Other advantages of the VAR method are that it allows the values of the variables to depend on more than their own lags or combinations of white noise error terms, offering a 'rich structure' which allows more features of the data to be captured. As mentioned above, VARs allow the use of OLS on each individual equation within the framework, provided that there are no contemporaneous terms in the equations (Brooks, 2002: 332).

However, VAR modelling also has its flaws. VARs are a-theoretical because they use minimal theoretical information about the relationships between the variables to guide the specification of the model. This also increases the possibility of a researcher using the VAR approach to obtain spurious relationships by mining the data. Another flaw of the VAR method rests in the debate over the need for all the series in a VAR to be stationary. Brooks (2002: 333) argues that if one is using a hypothesis test to examine the statistical significance of the coefficients, then all the series in the VAR should be stationary. Furthermore, he (Brooks, 2002: 333) notes that the counterargument to the proposition of differencing series to induce stationarity is that differencing should not

[11] See Davidson and MacKinnon (1993: 292)

be done because the reason of VAR estimation is purely to examine the relations between the variables, and the use of differenced series will result in the loss of information on any long-run relationships. Davidson and MacKinnon (1993: 685) also note that VARs tend to require the estimation of a large number of parameters, and the consequence of this is that individual parameters may be estimated imprecisely.

Sekine (2006: 2) comments that the use of multivariate models such as the VAR method to estimate pass-through may produce different estimates to those of regression coefficients estimated by single equations. The difference in estimates lies in the fact that the VAR will measure ERPT as the responsiveness to an unexpected movement or shock, which cannot be predicted, in the exchange rate; the single equations assume, however, that any movement in the exchange rate is exogenous.

4.2.1.3 Johansen Cointegration Method

As mentioned above, most economic series are non-stationary in level terms and in most cases appear to be integrated of order one, that is, I(1). If these series are estimated using methods such as OLS, the resulting pass-through estimates are likely to be spurious. Davidson and MacKinnon (1993: 716) note that variables that are I(1) tend to diverge as the number of observations (n) grows to infinity because their unconditional variances are proportional to (n). Such variables may not be expected to obey any long-run equilibrium relationship, however, it is possible for two or more variables that are I(1), to be I(0) for certain linear combinations of those variables. If this is the case, then the variables are cointegrated and therefore obey a long-run equilibrium relationship even though they may diverge substantially from equilibrium in the short-run. The most popular method for testing and estimating cointegrating systems in ERPT models is the Johansen technique based on VARs.

The use of cointegration methods, particularly the Johansen method, in investigating pass-through has been common in studies that investigate mainly the first stage of the direct transmission of ERPT, which is the transmission of exchange rate fluctuations to import prices. Davidson and MacKinnon (1993: 715) and Brooks (2002: 388) note that economic theory suggests that two or more variables may be expected to be linked by a long-run equilibrium relationship. Among the examples in economics and finance where cointegration would be expected to hold is the ratio of relative prices

and the exchange rate. This relationship emanates for the theory of purchasing power parity (PPP), which states that the price of a bundle of goods should cost the same wherever it is purchased when converted into a common currency (Kiptui *et al*., 2005). Thus, the theory suggests that the ratio of relative prices in two countries and their exchange rate should be cointegrated (Brooks, 2002: 389). This would imply complete pass-through of exchange rate fluctuations to import prices. However, if there is no cointegration between the prices and the exchange rate, assuming zero transaction costs, then arbitrage would occur. The implication of this would be zero to less than one (incomplete) pass-through, as traders would buy goods in the cheaper country, sell them in the more expensive country, and convert the proceeds to the currency of the original country (Brooks, 2002: 389).

Adolfson (2002) and Heath *et al*. (2004) find that for some small open economies, such as Australia, New Zealand and Sweden, there is a long-run cointegration relationship among import prices, exchange rates and foreign prices, which corresponds to the PPP theory, implying that ERPT to import prices is complete in the long-run. Thus, based on these findings, their (Adolfson, 2002 and Heath *et al*., 2004) model specifications take the form of an error correction formula based on the Johansen cointegration technique. However, Sekine (2006) argues that the question of whether the PPP theory holds has been a long-standing debatable issue, especially for large industrial nations, where strategic considerations such as the degree of competitiveness, menu costs, etc., might avert firms from simply passing on exchange rate fluctuations. Furthermore, Sekine (2006) finds that various Johansen tests at preliminary investigations of ERPT fail to find any significant cointegration relationships among the relevant variables (import prices, exchange rate, foreign prices and commodity prices).

Nonetheless, the preference of the Johansen technique(s) over other cointegrating techniques such as Hendry (1986), Engle and Granger (1987), and Stock and Watson (1988) arise from the strengths of the Johansen method over the others. For instance, the Engle and Granger (1987) method does not allow the testing of hypotheses on the cointegrating relationships themselves, but the Johansen technique does. Furthermore the Johansen method permits the researcher to test a hypothesis about one or more coefficients in the cointegrating relationship (Brooks, 2002: 408). The Johansen

method also does not suffer from the problem of simultaneous equation bias if the causality between variables is bidirectional, as is the case with the Engle-Granger technique (Brooks, 2002: 394).

4.2.2 A Review of ERPT Asymmetric Modelling Techniques

According to Bussiere (2006), one of the usual assumptions in the empirical literature on ERPT is that the degree of pass-through is symmetric, implying that large and small changes, and appreciations and depreciations in exchange rates have an effect of the same magnitude. As discussed in the aims and objectives of this thesis in Chapter 1, this study undertakes to explore two questions regarding the asymmetric properties of pass-through in South Africa. The first question is: does the direction of the change in the rand exchange rate have an impact on ERPT in South Africa? In other words, do appreciations and depreciations of the rand result in different pass-through rates to import prices in South Africa? Secondly, does the size of the change in the exchange rate have an effect on the extent of pass-through to import prices? As indicated in Chapter 2, the empirical literature on pass-through asymmetry is relatively scanty; however, in this section the study reviews the few asymmetric modelling techniques.

4.2.2.1 Asymmetry in ERPT: Appreciations versus Depreciations

Pollard and Coughlin (2003) analyse ERPT and the asymmetry of pass-through to USA import prices in 30 industries. The model used to analyse pass-through under conditions of appreciations and depreciations in the USA starts off from Equation (4.1) below (Pollard and Coughlin, 2003: 11):

$$\Delta \ln p^{US} = \beta_{1,i} \Delta \ln e + \beta_{2,i} \Delta \ln p^{y} + \beta_{3,i} \Delta \ln w + \beta_{4,i} \Delta \ln I^{US} + qd \qquad (4.1)$$

where p^{US} is the price of imported goods in US dollars; e is the exchange rate; p^{y} is the price of domestic import substitutes; w is the foreign marginal cost of production; I^{US} is the United States expenditure on all goods in the economy; qd are quarterly dummies; β represents parameters to be estimated; and Δ is the difference operator. All variables in the model are sector specific including the exchange rate. However, Equation (4.1) assumes pass-through to be the same regardless of whether the domestic currency is appreciating or depreciating. Thus, to determine the asymmetric nature of pass-through with regard to the direction of the change in the exchange rate,

Pollard and Coughlin (2003) create two dummy variables that differentiate between quarters in which the dollar appreciated and when it depreciated. These are shown below:

$$A_t = \begin{cases} 1 \text{ when } \Delta \ln e_t > 0 \\ 0 \text{ otherwise} \end{cases} \quad \text{and} \quad D_t = \begin{cases} 1 \text{ when } \Delta \ln e_t < 0 \\ 0 \text{ otherwise} \end{cases}$$

where A_t is an appreciation of the dollar at time t and D_t represents a depreciation of the dollar. Substituting $\beta_{1,i}$ $\Delta \ln e$ in Equation (4.1) with β_{1A} (A_t $\Delta \ln e_t$) + β_{1D} (D_t $\Delta \ln e_t$) gives different estimates for ERPT under appreciations and depreciations.

Wickremasinghe and Silvapulle (2004) use a different approach to investigate the direction of pass-through under exchange rate appreciations and depreciations. They start off by estimating Equation (4.2) below, which shows the long-run relationship between the import prices (pm_t), the exchange rate (er_t) and the cost of production (c_t):

$$pm_t = \beta_0 + \beta_1 er_t + \beta_2 c_t + \beta_3 c^*_t \qquad (4.2)$$

Wickremasinghe and Silvapulle (2004: 8) then construct and add a new variable to Equation (4.2), based on Webber (2000)'s equation of the exchange rate (er) shown in Equation 4.3:

$$er_t = er_0 + er_A + er_D \qquad (4.3)$$

where er_t is the initial exchange rate, er_A is the accumulated sum of appreciation periods and er_D is the accumulated sum of depreciation periods. Thus, in order to test for long-run asymmetry, Wickremasinghe and Silvapulle (2004: 8) state that only one of the data series relating to one of the periods is included in the ERPT Equation (4.2). In their (Wickremasinghe and Silvapulle, 2004) case, only the series for depreciation episodes is added in the test for long run asymmetry, giving a new ERPT Equation (4.4):

$$pm_t = \beta_0 + \beta_1 er_t + \beta_2 er^D_t + \beta_3 c_t + \beta_4 c^*_t \qquad (4.4)$$

where ($\beta_1 + \beta_2$) and β_1 are the long-run ERPT coefficients, corresponding to currency depreciations and appreciations respectively. Hence, the restriction that the long-run depreciation pass-through is equal to zero ($\beta_2 = 0$) is the test of long-run asymmetry of the import price to exchange rate fluctuations. Wickremasinghe and Silvapulle (2004) proceed to test Equation (4.4) within both the Engle and Granger (1987) and Johansen (1991) and (1995) cointegration frameworks. If pm_t, er_t, c_t and c^*_t are cointegrated, the next step is to test the short-run asymmetry by estimating Equation (4.5) below, which is an asymmetric error correction model:

$$\Delta pm_t = \Phi + \sum_{i=1}^{k-1} \acute{\omega}_i \, \Delta pm_{t-1} + \sum_{i=1}^{k-1} \theta_i \Delta^{+} er_{t-1} + \sum_{i=1}^{k-1} \theta_i \Delta^{-} er_{t-1} + \sum_{i=1}^{k-1} \gamma_i \Delta c_{t-1} + \sum_{i=1}^{k-1} \lambda_i \Delta c^{*}_{t-1} + \varphi \varepsilon_{t-1} + \upsilon_t \qquad (4.5)$$

where Δ is the difference operator, ε_{t-1} is the error term lagged for one period from the cointegrating equation, and υ_t is a white-noise error term. The response of the import price to positive and negative changes in the exchange rate is tested using the Wald-F-test. Wickremasinghe and Silvapulle (2004: 9) estimate Equation (4.5), the asymmetric error correction model and a symmetric or standard error correction model for comparison purposes.

4.2.2.2 Asymmetry in ERPT: Large versus Small changes

The main technique for investigating pass-through asymmetry with regards to the magnitude of the change in the exchange rate was developed by Pollard and Coughlin (2003) and cited by Wickremasinghe and Silvapulle (2004), and Bussiere (2006), whose works are among the main investigations of pass-through asymmetry and non-linearity. The modelling technique derives its roots from the menu costs model of asymmetric pass-through[12]. Pollard and Coughlin (2003) argue that if menu costs are important in the pricing decisions of firms, then it would be expected that the magnitude of pass-through would be positively correlated with the magnitude of the exchange rate change. The test is given as follows:

[12] See Section 2.2.4 on the models of ERPT asymmetry.

$$L_t = \begin{cases} 1 \text{ when } |\Delta \ln e_t| \geq 3\% \\ 0 \text{ otherwise} \end{cases} \quad \text{and} \quad S_t = \begin{cases} 1 \text{ when } |\Delta \ln e_t| < 3\% \\ 0 \text{ otherwise} \end{cases}$$

where L_t and S_t represent large and small changes in the exchange rate respectively. Following the same procedure as in modelling pass-through asymmetry with respect to appreciations and depreciations, Pollard and Coughlin (2004: 18) interact the two dummy variables L_t and S_t with the exchange rate variables, and substitute $\beta_{1,i}\ \Delta \ln e$ in Equation (4.1) with $\beta_{1L}\ (L_t\ \Delta \ln e_t) + \beta_{1S}\ (S_t\ \Delta \ln e_t)$, thus providing different estimates for pass-through under large and small fluctuations in the exchange rate.

4.2.3 A Review of ERPT Variables and Data

Three key aspects of data used in the estimation of pass-through arise in ERPT literature: the measurement of the exchange rate, the measurement of price proxies, and the use of disaggregated data in analysing ERPT (Menon, 1995).

4.2.3.1 Exchange Rate Measurement

The measurement of the exchange rate used in the analysis of ERPT has received considerable attention as the works of Woo (1984) and Feinberg (1991), previously reviewed in Chapter 2, have shown. In support of these authors, others such as Klien and Murphy (1988), Citrin (1989), and Athukorala and Menon (1994), agree that the use of different exchange rate proxies yield different ERPT estimates. Most of the studies reviewed in this paper, including Adolfson (1997), Athukorala (1991), Bhundia (2002), Campa and Goldberg (2002), Darvas (2001), Dwyer *et al*. (1994), Kiptui *et al*. (2005), and SARB (2002) use the nominal effective exchange rate (NEER) as a proxy for the exchange rate. Other authors, such as Ito *et al*. (2005), use both the NEER and the real effective exchange rate (REER) in their analysis of ERPT.

However, Athukorala and Menon (1994: 274), for the first time in ERPT literature, use a contract currency-weighted index as a proxy for the exchange rate, instead of a trade-weighted exchange rate proxy such as the NEER or REER. Athukorala and Menon (1994: 274) argue that the limitation of using trade-weighted exchange rate proxies is that most destination (or importing countries) currencies may be over-

represented because the US dollar is often the invoicing currency in world trade. Thus, for some countries like Japan, which has less than 30% of its exports invoiced in yen, the United States tends to receive a disproportionately high share of exports compared with real exports to the USA. Furthermore, Menon (1995: 209) argues that a contract currency-weighted index is a true representation of the exchange rate changes faced by the exporting country. It is important to note, however, that the contract currency-weighted index used in Athukorala and Menon (1994) is employed to analyse ERPT at the sector level and not at the aggregate level because of the difficulty in obtaining the necessary data at the aggregate level.

Of the studies that use trade-weighted exchange rate indices to represent the exchange rate, Woo (1984), Menon (1995), and Feinberg (1991) highlight considerations such as the number of currencies included and the weighting scheme used in the construction of such indices. Menon (1995: 209) reports that such factors are likely to affect the extent to which the index will over-or-understate the changes in the currency of interest. Consequently, this will have a significant bearing on the estimates of ERPT.

4.2.3.2 Measurement of Price Proxies

The measurement of price proxies for import, export, producer and consumer prices, have also received attention in ERPT literature. Most studies prior to 1995 relied on unit values to represent the abovementioned prices. However, some of the studies reviewed in this thesis use true price indices such as the import price index, export price index, producer or wholesale price index and the consumer price index.

Lipsey *et al*. (1991) examine the construction of price indices, as they argue that price measures such as unit value indices are subject to some defects. Lipsey *et al*. (1991: 2) highlight that unit value indices have a long history of adverse appraisals of their accuracy, the primary reason being that in most countries, the unit values are combined with inconsistent weights, and different index number formulas are used. Alterman (1991) highlights the bias introduced into ERPT estimates as result of errors inherent in the measurement of price proxies. He (Alterman, 1991) compares the pass-through estimates obtained using import prices against those obtained using import

unit values, and reports that the discrepancy in results is significant to warrant concern over the reliability of ERPT estimates obtained using price proxies.

4.2.3.3 The Disaggregation of Data

The third empirical issue concerning variables and data used in the analysis of ERPT is the use of an appropriate disaggregation of data in estimating pass-through (Menon, 1995). Although the minority of ERPT studies use the disaggregation approach, the issues relating to the approach have become increasingly important in pass-through literature. The works of Citrin (1989) and Lawrence (1990) have shown that much of the 'pass-through puzzle' lies in the data and not in actual behaviour. Furthermore, a concern of possible aggregation bias has grown, given the findings of Feinberg (1986), Feenstra (1989), Marston (1990), Menon (1993), and Adolfson and Malin (1997), which suggest significant differences in the pass-through estimates of different products. Athukorala and Menon (1994) motivate the use of the disaggregation approach with the fact that individual countries vary in their demand and cost conditions, and estimates at the aggregate level are likely to mask such differences. Hooper and Mann (1989) also argue that the disaggregation of data allows for the accurate estimation of the time lags in the transmission of exchange rate fluctuations to prices. Nonetheless, the disaggregation approach remains largely suitable for the estimation of ERPT at the sector or industry level, and not at a broader national level.

4.3 Methodology and Data

This section specifies the models and data used in this study to estimate the size and speed of ERPT, as well as to analyse pass-through asymmetry in South Africa. The methods and data chosen are based on the objectives of the thesis as outlined in Chapter 1 and the ability of the data and estimation techniques to address these objectives. Furthermore, the data and estimation methods are also chosen based on the review of empirical issues regarding the estimation of ERPT given in Section 4.2.

4.3.1 Model Specification

As mentioned in Chapter 3, the direct transmission channel of ERPT is expected to be the most prominent in the South African context. The channel consists of two main

stages. In the initial stage, fluctuations in the exchange rate are transmitted to the prices of imported goods. Thus when the rand depreciates, it is expected that import prices will rise. If the effect of the depreciation is wholly transmitted to import prices, ERPT is said to be complete, but if a fraction of the depreciation is transmitted, then ERPT is described as partial or incomplete. The second stage of ERPT describes the pass-through of changes in the exchange rate and import prices to producer and consumer prices respectively.

After reviewing the ERPT estimation techniques in Section 4.2, and taking into consideration the expected channel of pass-through in South Africa, the most appropriate techniques to estimate the first and second stages of ERPT are the Johansen (1991) and (1995) cointegration approach with a vector error correction model, and impulse response and variance decomposition functions, as well as block exogeneity tests based on a VAR framework, respectively. These techniques are chosen because they are multivariate methods that are able to handle non-stationary and trending data, unlike the OLS method. Furthermore these techniques have been used by a number of authors on the subject (see Table 4.1), and therefore the results obtained in this study can be compared to the results of other studies that used similar techniques.

The theoretical background of modelling the first stage of ERPT (the transmission of exchange rate fluctuations to import prices) is based on the Law of One Price. The theory is used to determine the prices of imports. This is inline with Dwyer *et al*. (1994), Campa and Goldberg (2002), SARB (2002), Campa *et al*. (2005) and Kiptui, *et al*. (2005), who argue that the determination of import prices can be based on the Law of One Price, which states that the domestic price of a traded good will be the same in other foreign markets when expressed in a common currency (Kiptui *et al*., 2005). The theory assumes that there are no tariffs, transport costs and other distortions to trade, and that arbitrage will ensure that the theory holds (SARB, 2002: 4). Therefore import prices (IMP) can be expressed as:

$$IMP = P^* NEER \qquad (4.6)$$

where NEER is the nominal effective exchange rate and P* is the world price of the imports. Foreign producers of traded commodities are assumed to set their export

prices (P*) with a markup (λ*) on their marginal cost of production in foreign currency terms (EPC). Thus the export price can be written as:

$$P^* = \lambda^* EPC \qquad (4.7)$$

However, assuming the Law of One Price holds, all profits (λ*) are arbitraged away, and thus the import price in local currency terms becomes:

$$IMP = P^* NEER = EPC.NEER \qquad (4.8)$$

Equation (4.8) suggests that the local currency import prices are influenced by the foreign costs of production and the exchange rate. Thus the long-run relationship of the pass-through of exchange rate changes to import prices can be estimated from a log-linear transformation which allows for a constant, given as:

$$\text{Log } IMP_t = \beta_1 + \beta_2 \text{Log } EPC_t + \beta_3 \text{Log } NEER_t + \varepsilon_t \qquad (4.9)$$

where ε_t is the stochastic error term, β_2 is the coefficient of exporters' production costs and β_3 represents the elasticity of exchange rate pass-through to import prices. Thus, if the rand depreciates, that is a decrease in NEER (given the definition of the variable NEER in Chapter 3 – the nominal effective exchange rate), then import prices are expected to rise. It is expected that $0 \leq \beta_3 \leq 1$. As such, if $\beta_3 = 1$ then there is complete pass-through, but if $\beta_3 = 0$, then there is no pass-through at all. Anything in between is partial pass-through. It is also expected that a rise in the exporters' production costs will result in an increase in import prices. If the Law of One Price holds, then $0 \leq \beta_2 \leq 1$, and $\beta_2 = \beta_3$, implying that the coefficient of exporters' costs should be equivalent in magnitude to the exchange rate coefficient.

Equation (4.9) is transformed into an error correction model of the form shown in Equation (4.10), in order to estimate the short-run pass-through relationship:

$$\Delta\text{Log } IMP_t = \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta\text{Log (IMP)}_{t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta\text{Log (EPC)}_{t-i} + \sum_{i=1}^{k} \alpha_{3i} \Delta\text{Log (NEER)}_{t-i} + \delta ECM_{t-1} \qquad (4.10)$$

where Δ is a difference operator, α_{ji} are the short-run adjustment coefficients and δECM_t is an error term.

The second-stage of ERPT (the pass-through of changes in the exchange rate and import prices to domestic prices – producer and consumer prices) is determined by estimating impulse response functions, variance decompositions and conducting block exogeneity Wald tests based on the VAR system represented by Equations (4.11) to (4.14) below. This is done by setting up an unrestricted VAR framework similar to that used by authors such as McCarthy (2000), Rowland (2003) and Kiptui *et al*. (2005). The framework incorporates a distribution chain of prices, modelling inflation at each distribution stage – import, producer and consumer. The VAR model comprises four variables in the following order, in log difference form[13]: the nominal effective exchange rate (ΔLNEER), import prices (ΔLIMP), producer prices (ΔLPPI) and consumer prices (ΔLCPI).

$$\Delta LNEER_t = \sum_{i=1}^{k} \gamma^{i}_{11}\Delta LNEER_{t-i} + \sum_{i=1}^{k} \gamma^{i}_{12}\Delta LIMP_{t-i} + \sum_{i=1}^{k} \gamma^{i}_{13}\Delta LPPI_{t-i} + \sum_{i=1}^{k} \gamma^{i}_{14}\Delta LCPI_{t-i} + \varepsilon_{1t} \quad (4.11)$$

$$\Delta LIMP_t = \sum_{i=1}^{k} \gamma^{i}_{21}\Delta LNEER_{t-i} + \sum_{i=1}^{k} \gamma^{i}_{22}\Delta LIMP_{t-i} + \sum_{i=1}^{k} \gamma^{i}_{23}\Delta LPPI_{t-i} + \sum_{i=1}^{k} \gamma^{i}_{24}\Delta LCPI_{t-i} + \varepsilon_{2t} \quad (4.12)$$

$$\Delta LPPI_t = \sum_{i=1}^{k} \gamma^{i}_{31}\Delta LNEER_{t-i} + \sum_{i=1}^{k} \gamma^{i}_{32}\Delta LIMP_{t-i} + \sum_{i=1}^{k} \gamma^{i}_{33}\Delta LPPI_{t-i} + \sum_{i=1}^{k} \gamma^{i}_{34}\Delta LCPI_{t-i} + \varepsilon_{3t} \quad (4.13)$$

$$\Delta LCPI_t = \sum_{i=1}^{k} \gamma^{i}_{41}\Delta LNEER_{t-i} + \sum_{i=1}^{k} \gamma^{i}_{42}\Delta LIMP_{t-i} + \sum_{i=1}^{k} \gamma^{i}_{43}\Delta LPPI_{t-i} + \sum_{i=1}^{k} \gamma^{i}_{44}\Delta LCPI_{t-i} + \varepsilon_{4t} \quad (4.14)$$

The variables at time (t) are determined by the previous period's expectation and their respective shocks, or expectational errors, ε_{nt} (which are independent and identically distributed). γ^{i}_{nm} represent parameters to be estimated, and k is the maximum lag length.

The ordering of the variables is specific because the model assumes that causality runs from the nominal effective exchange rate to import, producer and then consumer prices, and that the degree of endogeneity increases in that order. Furthermore, the model assumes that pricing decisions at the import and production stages can have a

[13] The log difference form is used because we want to investigate the rate of change in the prices due to a change in the exchange rate.

simultaneous impact on consumer prices, but not vice versa (McCarthy, 2000 and Bhundia, 2002). However, Bhundia (2002) notes that there is a potential weakness in the recursive structure of the model because prices can feed back to the exchange rate within one period of time as determined by the frequency of the data set – in this case one month. To overcome this drawback, Bhundia (2002) suggests estimating alternative orderings of the variables to verify the robustness of the initial ordering.

As previously mentioned in Section 4.2, theoretically, the advantage of modelling using a VAR framework is that there is no need to specify which variables are endogenous or exogenous. Consequently, all variables are assumed to be endogenous. The VAR framework also allows the value of a variable to depend on more than just its own lags or combinations of white noise terms, making it a more flexible modelling framework compared with other frameworks such as the univariate autoregressive (AR) models (Brooks, 2002: 376).

4.3.2 Description of Variables and Data Sources

For the empirical analysis, 26 years of monthly data, from January 1980 to December 2005, is used. 1980 is chosen as the starting year, due to the availability of data for all the series from that period onwards. The primary source of data is the IMF International Financial Statistics CD-ROM February 2006, unless stated otherwise. The variables used in the models as specified above are:

NEER - the nominal effective exchange rate is the proxy for the exchange rate (**ER**). The index expressed on the base 2000 = 100 represents the ratio of the rand's period-average exchange rate to a weighted geometric average of exchange rates of the currencies of South Africa's main trading partners including the Euro area. The NEER corresponds to line **nec** of the IMF International Financial Statistics, implying that the index is based on a methodology that accounts for each country's trade in both manufactured goods and primary products. The NEER series is measured in foreign currency terms, thus an increase in this variable indicates an appreciation of the rand, while a decrease indicates depreciation.

IMP - is the import component of production prices, and is used to proxy the import price index. The index is seasonally adjusted and is expressed on the base 2000 = 100. The import price index is sourced from the SARB and is time series KBP7049N.

PP - is the producer prices expressed as an index of goods and services for domestic consumption, excluding imports. Expressed as index numbers (2000 = 100); period averages. The producer price index corresponds to line 63 of the IMF International Financial Statistics.

CP - is the consumer prices also expressed as an index (2000 = 100); period averages. It includes food and other volatile items, and mortgage interest. The consumer price index corresponds to line 64 of the IMF International Financial Statistics.

EPC – is the exporter's production cost proxied by the export price index of foreign producers of South Africa's imports. The EPC is calculated by finding the weighted mean of export price indexes for South Africa's four major trading partners, that is, Germany (which is also considered as a proxy for the European Union), the USA, UK and Japan. Three types of weights are used to construct three options of the EPC variable: EPC1, EPC2 and EPC3. The rationale behind this approach is to assess the whether there will be any major differences in the estimation of pass-through in South Africa given the different possible currency weighting scales. The weights used for EPC1 are the SARB's nominal effective exchange rate weights (Macdonald and Ricci, 2003). EPC2 currency weights are taken from the SARB Quarterly Bulletin (2006: S103), while EPC3 weights are obtained by calculating the total annual average imports (1998 to 2005) from all four countries to South Africa and apportioning the weights according to the percentage contribution of total imports from each country[14]. The different weights are shown in Table 4.2 below. The export indexes for all four countries are period averages (2000 = 100), and are all true price indexes, reported in the IMF International Financial Statistics.

[14] Germany is used as a proxy for the European Union, while all other countries not included among the four mentioned are proxied by the United States, as it is assumed that imports from these countries are invoiced in US dollars. Furthermore, 1998 is used as the starting year due to the availability of data for all countries from that year. Data is sourced from the IMF International Financial Statistics (2006).

Table 4.2: Currency Weights

Country (source of imports)	Currency Weight (%) for EPC		
	1	**2**	**3**
Germany	47	36.38	33.15
U.S.	20	15.47	52.91
U.K.	20	15.37	7.33
Japan	13	10.43	6.61

The choice of variable proxies used in this thesis is based on the review of empirical issues concerning variables and data in Section 4.2.3. The NEER is chosen as the proxy for the exchange rate because of its wide use in other ERPT studies, which allows for standard result comparisons with other studies. All price proxies are true price indices and not unit value indices, for reasons highlighted in Section 4.2.3.2.

4.4 A Review of the Model Estimation Techniques – the VAR and Johansen Cointegration Methods

As previously stated in Section 4.3.1, this study uses the Johansen (1991) and (1995) cointegration methods, and impulse response and variance decomposition functions, together with block exogeneity Wald tests based on a VAR framework, to estimate the first and second stages of ERPT, respectively. The estimation of the pass-through entails the following steps:

i. Determining the stationarity of the data series by carrying out unit root tests;
ii. Testing for cointegration using the Johansen methods;
iii. Establishing the first-stage long-run and short-run ERPT by estimating Equation (4.9)
iv. Determining the second-stage of ERPT by estimating the impulse responses, variance decompositions and block exogeneity Wald tests based on the VAR system comprised of Equations (4.11) to (4.14)

4.4.1 Testing for stationarity

Evidence has shown that most time series data on economic indicators is non-stationary (Hendry and Clements, 1999), and the problem that arises from this is that if a model is estimated using non-stationary data series, the estimation will generate spurious results (Gujarati, 2003: 806). Johnston and DiNardo (1997: 215) and Gujarati

(2003: 806) concur that computing the mean of a non-stationary or random walk series for a range of subsets of the data will not yield sensible results as the results would vary with the subset used. In the words of Gujarati (2003: 806), "the dependent variable of a non-stationary series will follow the drift of its explanatory variables, producing meaningless results". Furthermore, Gujarati (2003: 806) notes that the estimations of the non-stationary data may produce significant t-ratios and high R^2 values even though the drifting variables are completely unrelated.

In order to eliminate the undesirable implications of the non-stationarity of a data series, Johnston and DiNardo (1997: 215) suggest that it is necessary to identify possible transformations that may induce stationarity, a state that is also a pre-condition for the estimation of a VAR model and the performance of cointegration tests and parameter estimations. The tests for stationarity can be grouped into two main categories, graphical analysis and formal statistical tests for unit roots (Johnston and DiNardo 1997: 215). A third category, formal stationarity tests, is also considered to provide "confirmatory data analysis" as suggested by Brooks (2002: 382)

4.4.1.1 Graphical Analysis

This is the initial stage of any time series analysis. Visual plots generally paint a picture of the possible nature of the time series before a formal test for stationarity is conducted. Graphs also give an indication of the behaviour of the series, whether or not they have a trend. However, the weakness of graphical analysis is that it is not easy to conclude whether a series is stationary or non-stationary on the basis of visual inspection alone. Hence, formal unit root and stationarity tests are needed to provide a more accurate conclusion on the stationarity of a series.

4.4.1.2 Unit Root Tests

The unit root test is a formal test for stationarity. The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests are used in this thesis to provide comparative results. The ADF and the Dickey-Fuller (DF) test have been widely cited in literature and are the most frequently used of the unit root tests. The DF test is performed to regressions executed as in the form represented by Equation (4.15):

$$\begin{aligned}\Delta X_t &= (\rho - 1)X_{t-1} + \mu_t \\ &= \delta X_{t-1} + \mu_t \\ &= (X_t - X_{t-1})\end{aligned} \qquad (4.15)$$

where X_t represents a time series, $\delta = (\rho - 1)$ and Δ is the first difference operator, μ_t is a stochastic error term that has a zero mean, constant variance and is non-autocorrelated. If $\rho = 1$, then the stochastic variable X_t has a unit root. However if the error term μ_t is autocorrelated, the series is modified as follows:

$$\Delta X_t = \alpha + \beta_t + \delta X_{t-1} + \sum_{j=2}^{q} \varphi_j \Delta X_{t-j} + \varepsilon_t \qquad (4.16)$$

where lagged difference terms are introduced to the series. The number of lagged difference terms introduced is determined empirically, the objective being to include enough terms so that the error term in equation (4.16) is serially independent (Gujarati, 2003: 819). The null hypothesis is that $\delta = 0$, meaning that the series X_t has a unit root and is therefore non-stationary. When the Dickey-Fuller test is applied to equations like equation (4.16), it is referred to as the augmented DF test (ADF). Both the DF and ADF tests have the same asymptotic distribution, and thus the same critical values can be used.

However, both the DF and ADF have various flaws. Amongst these is the weakness of the tests in detecting a false null hypothesis. According to Brooks (2002: 381), the two tests have low power in detecting unit roots, especially when the series is stationary but with a root close to the non-stationary boundary. However, Brooks (2002: 382) suggests several solutions to overcoming the weaknesses of the DF and ADF unit root tests. These include increasing the sample size, although this may be hampered by the availability of data, and combining the unit root tests with a stationarity test, so that one test can confirm the findings of the other.

Phillips and Perron (1988) developed a more complete theory of unit root non-stationarity. The Phillips-Perron (PP) tests are similar to ADF tests; though they include an automatic correction to the DF tests to allow for autocorrelated residuals. Nonetheless, the PP tests often produce the same results as the ADF tests and are also

prone to the same limitations as the ADF tests. Thus, as suggested by Brooks (2002: 382) we use a stationarity test in addition to the unit root tests, to overcome the weaknesses of the ADF and PP tests. This is done by confirming whether the results of the stationarity tests and the unit root tests concur.

4.4.1.3 Stationarity Test

Stationarity tests differ from unit root tests in that the null hypothesis in a stationarity test is that a series is stationary, whereas in unit root tests, the null is that the series is non-stationary. In this study, the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) (1992) test used to provide confirmatory data analysis with the ADF and PP tests. The KPSS (1992) test assumes that the series are trend-stationary under the null hypothesis. A calculated LM (KPSS) statistic is compared with the KPSS (1992) critical values in order to make a conclusion about the stationarity of a series. If the calculated LM statistic is less than the given critical values, the null hypothesis is accepted and it can be concluded that the series is stationary. The opposite holds true for a non-stationary series.

4.4.2 Cointegration and Vector Error Correction Modelling

Several methods for testing cointegration are common in econometrics literature. However, chief among these are residual based methods such as the Engle-Granger approach and methods based on maximum likelihood estimation using a VAR system such as the Johansen method. This thesis uses the latter approach because it is able to overcome some of the weaknesses of the former method. The residual based methods, such as the Engle-Granger approach, are prone to the usual finite sample problem of a lack of power in unit root and cointegration tests; simultaneous equation bias forcing the researcher to treat variables asymmetrically even though there may be no theoretical reason for doing so; and it is unable to perform any hypothesis tests about the actual cointegrating relationship estimated (Brooks, 2002: 394). Harris (1995: 76) and Seddighi *et al*. (2000), note that the Engle-Granger method is unable to detect more than one cointegrating relationship in a model, and also that, if there is more than one cointegrating relationship, the method produces incoherent results.

As mentioned above, the Johansen method is employed in this study. More specifically, the Johansen (1991) and (1995) methods are used to establish whether

any cointegrating relationships exist amongst the variables of interest, and to test for long-run equilibrium relationships among the variables. One of the advantages of using these methods is that they permit the identification of all cointegrating vectors within a given set of variables as well as better asymptotic properties. Thereafter, a vector error correction model (VECM) is estimated to test for the short-run dynamics.

The Johansen Procedure

The Johansen (1991) and (1995) procedures use a maximum likelihood approach. The procedure is specified as shown in Equation (4.19): where y_t is an n x 1 vector of I(1) variables, such that y_t = [Log (IMP), Log (EPC), Log (NEER)] with a vector autoregressive (VAR) model representation of order k:

$$y_t = z + \sum_{i=1}^{p} \Lambda_i y_{t-i} + \varepsilon_t \qquad (4.19)$$

z is a (n x 1) vector of deterministic variables, Λ_i is a (n x n) matrix of coefficients and ε_t is a (n x 1) vector of white noise error terms.

Equation (4.19) above is converted into a VECM, given as:

$$\Delta y_t = z + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + \prod y_{t-1} + \varepsilon_t \qquad (4.20)$$

As defined above, y_t is the vector of I(1) variables, Δy_t is the differenced form of y_t, thus representing all I(0) variables, Δ is the first difference operator, Γ_i is a (n x n) coefficient matrix and Π is a (n x n) matrix whose rank determines the number of cointegrating relationships among the variables. Thus, if Π is of full rank, that is, r = n, this suggests that the variables are level stationary, and if r = 0, this means that there are no cointegrating vectors. However, if Π has a reduced rank $r \leq (n - 1)$, then it can be decomposed to the following form:

$$\Pi = \alpha\beta \qquad (4.21)$$

where α is a n x r matrix which is the matrix of error correction, representing the model's speed of adjustment to the preceding period's deviations from the equilibrium relationship. β is a r x n matrix of long-run coefficients or the matrix of coefficients of the cointegrating vectors.

There are two important procedures that are undertaken before proceeding to test for the rank of Π to determine the number of cointegrating vectors, and these are determining the optimal lag length and choosing the deterministic trend assumption that is required in testing for cointegration. According to Brooks (2002: 335) financial theory has little to say on what an appropriate lag length used for a VAR model should be and how long changes in the variables should persist to work through the system. However, the optimal lag length selected should produce the number and form of cointegration relations that conform to all the *a priori* knowledge associated with economic theory (Seddighi *et al*. 2000: 309).

The study employs information criteria to determine the optimal lag length. The objective of the information criteria (IC) method is to select the number of parameters which minimise the value of the IC. The three most popular ICs are the Akaike (1974) information criterion (AIC), Schwarz's (1978) Bayesian information criterion (SBIC) and the Hannan-Quinn information criterion (HQIC). However, these information criteria sometimes produce conflicting VAR order selections, thus this thesis makes use of both the information criteria and the *a priori* knowledge from economic theory to select the appropriate lag order.

The second step before testing for the rank of Π (to determine the number of cointegrating vectors), is selecting the deterministic assumptions. Quantitative Micro Software (Eviews 5) (2004), an econometric software package, provides options to test for the following deterministic trend assumptions: assumption 1 presupposes that there is no deterministic trend in the data and no intercept or trend in the VAR and in the cointegrating equation; assumption 2 assumes no deterministic trend in the data, but an intercept in the cointegrating equation and no intercept in VAR; assumption 3 presupposes a linear deterministic trend in the data and an intercept in the cointegrating equation and test VAR; assumption 4 assumes that there is a linear deterministic trend in data, intercept and trend in the cointegrating equation and no trend in VAR; and assumption 5 presupposes a quadratic deterministic trend in data, intercept and trend in the cointegrating equation and linear trend in VAR. Recommendations of the Eviews 5 manual (Quantitative Micro Software, 2004: 725) are that, assumption 2 is to be used if none the series has trend. Assumption 3 can be

used if the series have stochastic trends, and assumption 4 can be used if some of the series are trend stationary. According to Eviews 5 (Quantitative Micro Software, 2004: 725), assumptions 1 and 5 are seldom used in practice. In this study, the selection of the deterministic trend assumption is done by analysing the graphical plot of the series and the results of the unit root tests.

Once the two abovementioned procedures are completed, the rank of the Π matrix can then be tested. Johansen (1988) provides two different likelihood ratio tests to determine the value of r. These are the trace test:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{n} \ln (1-\lambda_i) \qquad (4.22)$$

and the maximum Eigenvalue test statistics:

$$\lambda_{max}(r, r+1) = -T \ln (1-\lambda_{r+1}) \qquad (4.23)$$

where r is the number of cointegrating vectors under the null hypothesis, and λ_i is the i-th largest Eigenvalue of the Π_i matrix in Equation (4.19) (Brooks, 2002: 405). The trace test (λ_{trace}) is a joint test where the null hypothesis is that the number of cointegrating vectors is less than or equal to r, against an unspecified alternative that there are more than r. On the other hand, the maximum Eigenvalue test (λ_{max}) tests the null hypothesis that the number of cointegrating vectors is r against the alternative of r+1 (Brooks, 2002: 405).

Johansen and Juselius (1990a) provide critical values for both λ_{trace} and λ_{max}. If the test statistic is greater than the critical values, the null hypothesis that there exists r cointegrating vectors against the alternative hypothesis that there are r + 1 (for λ_{trace}) or more than r (for λ_{max}) is rejected. However, to establish the rank of Π matrix, the test statistics of the trace and Eigenvalue tests are measured against the critical values from Osterwald-Lenun (1992), which are slightly different from those provided by Johansen and Juselius (1990), as the former provides a more complete set of critical values for the Johansen test. However, sometimes the trace and the maximum Eigenvalue test statistics yield conflicting results. In dealing with such a problem,

Luintel and Khan (1999: 392) demonstrate that the trace test is more robust than the maximum Eigenvalue statistic in testing for cointegration. On the other hand, Johansen and Juselius (1990) propose that one investigates the estimated cointegrating vector and bases the selection of results on the interpretability of the cointegrating relations.

After identifying the number of cointegrating vectors in the model, the next step is to estimate the VECM represented by Equation (4.20). The estimation is done by specifying the number of cointegrating vectors, deterministic trend assumption, and normalising the model on the true cointegrating relationship(s). Diagnostic checks for serial correlation, normality and heteroscedasticity are then performed on the residuals from the VECM.

4.4.3 Diagnostic checks

Diagnostic checks are most often used to detect model misspecification and as a guide for model improvement (Norat, 2005: 256). These checks which include tests for residual serial correlation, normality and heteroscedasticity, aid in the validation of the parameter estimation outcomes achieved by the model.

4.4.3.1 Test for Serial Correlation

Testing for serial correlation helps to identify any relationships that may exist between the current values of the regression residuals (μ_t) and any of its lagged values (Brooks, 2002: 156). Such tests can be done via graphical exploration or by using formal statistical tests such as the Durbin-Watson test or the Lagrange Multiplier (LM) test. Although the first step in testing for autocorrelation would be to plot the residuals and look for any patterns, graphical methods may not be easy to interpret (Brooks, 2002: 156). In this study, the LM test is used to investigate residual serial correlation. According to Harris (1995: 82), the lag order for the LM test should be the same as lag order chosen for the VAR. The null hypothesis of the LM test is that the residuals are not serially correlated, while the alternative is that the residuals are serially correlated

4.4.3.2 Test for heteroscedasticity

According to Brooks, (2002: 445), heteroscedasticity describes a scenario where the variance of the errors in a model is not constant. Thus a problem arises when errors are heteroscedastic but are assumed to be homoscedastic (constant variance). The result of such an assumption would be that the standard error estimates might be wrong (Brooks, 2002: 445). In this study, the test for heteroscedasticity is done using an extension of White's (1980) test to systems of equations, as supported in Eviews 5[15]. The null hypothesis of the test is that the errors are homoscedastic and independent of the regressors, and that there is no problem of misspecification. In performing the test, each of the cross products of the residuals is regressed on the cross products of the regressors, testing for the joint significance of the regression. If the test statistic produced from this process is significant, the null hypothesis of homoscedasticity (no heteroscedasticity) and no misspecification will be rejected.

4.4.3.3 Test for Normality

In this thesis the Jarque-Bera normality test is used to ascertain whether the regression errors are normally distributed. Under the null hypothesis of normally distributed errors, the test statistic has a Chi-Square distribution with two degrees of freedom (Brooks, 2002: 181). Thus, if the Jarque-Bera statistic is not significant, that is, the p-value is greater than 0.05, then the null of normality is not rejected at the 5% level of significance (Brooks, 2002: 181).

4.4.4 Impulse response, Variance decomposition and Block exogeneity Wald test

As previously mentioned, the second-stage of ERPT is analysed by estimating the impulse responses and variance decompositions of domestic prices (producer and consumer prices) to shocks from exchange rate and import price changes, as well as the block exogeneity Wald tests. These tests are important in determining whether changes in the exchange rate and import prices have a positive or negative effect on the producer and consumer prices, determining how long it would take for that effect to work through the system, as well as establishing the variables in the model that have a significant impact on the future values of each of the other variables in the system (Brooks, 2002).

[15] White's test for heteroscedasticity was modified by Kelejian (1982) and Doornik (1995).

4.4.4.1 Impulse response function

An impulse response can be described as a shock to the *i-th* variable that not only affects the i-th variable directly, but is also transmitted to all the other endogenous variables through the dynamic (lag) structure of the VAR. According to Brooks (2002: 341) and Elder (2003: 1), impulse responses determine the responsiveness of the dependent variables in the VAR to fluctuations of each of the other variables. Thus, for each variable from each equation, a unit shock to the error is analysed in order to determine the effects upon the VAR system over time (Brooks 2002: 341). In the case of this study, the impulse response function will be able to reveal the sign, size and persistence of shocks from the exchange rate and import prices to producer and consumer prices.

Two approaches are commonly used in econometrics literature to estimate impulse responses. These are the generalized impulse response and the Cholesky decomposition. The main advantage of the generalised impulse response is that it does not require orthogonalization of innovations and is invariant of the ordering of the variables in VAR (Pesaran and Shin, 1998: 17 in Aziakpono, 2006: 8). However, similar to Kiptui *et al*. (2005), this study uses the Cholesky decomposition because, unlike other approaches, it incorporates a small sample degrees of freedom adjustment when estimating the residual covariance matrix used to derive the Cholesky factor (Lutkepohl, 1991). Furthermore the ordering of the variables is important because the model assumes that causality runs from the nominal effective exchange rate to import prices, then producer prices and finally, consumer prices, and that the degree of endogeneity increases in that order.

4.4.4.2 Variance decomposition

Variance decompositions highlight the proportion of the movements in the dependent variables that are a result of their own shocks, versus shocks from the other variables. In other words, variance decomposition shows the importance of shocks within the producer and consumer prices themselves versus shocks from the exchange rate and import prices. Brooks (2002: 342) notes that in practice, self or own series shocks explain most of the (forecast) error variance of the series in a VAR.

4.4.4.3 Block exogeneity Wald test

The block exogeneity Wald tests are performed to determine which set of variables have a significant effect on each dependent variable by placing a zero restriction on the lags of the independent variable (Brooks, 2002: 340). Such a test can help determine whether changes in one variable may cause changes in another based on the significance of the effect of the former variable on the latter. Although the block exogeneity Wald test and other causality tests, such as the Granger-causality test, identify the variables in the model that have statistically significant influences on the future values of each of the variables in the system, they cannot show whether changes in a value of a given variable have a negative or positive effect on the other variables in the system, neither can they reveal the time taken for the effect to work through the system (Brooks, 2002: 341). Consequently, the impulse response and variance decomposition functions described above are used to reveal such important information.

4.5 Model Specification: Pass-through Asymmetry

Based on the modelling techniques of ERPT asymmetry reviewed earlier in this chapter, and the rarity of such techniques, this thesis follows and adapts the approach used by Wickremasinghe and Silvapulle (2004) to estimate pass-through asymmetry to import prices, with respect to appreciations and depreciations, as well as the size of change in the exchange rate. This approach is chosen over others, such as Pollard and Coughlin (2004) because the framework is similar to that used in investigating first-stage pass-through, and can be tailored to suit the objectives of this study, with regard to the investigation of ERPT asymmetry.

In order to establish the long-run asymmetry of ERPT to import prices, new variables are constructed to capture the periods of appreciation and depreciation, as well as large and small changes. Following Webber (2000), the appreciation and depreciation series are constructed such that the exchange rate[16] at time *k* can be expressed as:

$$ER_k = ER_0 + ER^A + ER^D \qquad (4.24)$$

where ER_k is the initial exchange rate,

[16] ER is represented by the variable Log NEER in the actual model.

$$ER^{A} \equiv \sum_{i=1}^{k} \theta \, (ER_i - ER_{i-1}) \qquad (4.25)$$

where $\theta = 1$ for $ER_i > ER_{i-1}$ and $\theta = 0$ for $ER_i < ER_{i-1}$; and

$$ER^{D} \equiv \sum_{i=1}^{k} \theta^{*}(ER_i - ER_{i-1}) \qquad (4.26)$$

where $\theta^{*} = 1$ for $ER_i < ER_{i-1}$ and 0 for $ER_i > ER_{i-1}$.

ER^{A} and ER^{D} are represented as ACC_A (the accumulated sum of appreciation periods) and ACC_D (the accumulated sum of depreciation periods) respectively. Although there is no standard measure of a large or small change in the exchange rate, the construction of the large and small exchange rate change series is similar to that of Pollard and Coughlin (2004)[17], where a large change is defined as being 3 percent and above, while a small change is below 3 percent. Thus:

$$L_t = \begin{cases} 1 \text{ when } |\Delta \ln ER_k| \geq 3\% \\ 0 \text{ otherwise} \end{cases} \quad \text{and} \quad S_t = \begin{cases} 1 \text{ when } |\Delta \ln ER_k| < 3\% \\ 0 \text{ otherwise} \end{cases}$$

However, as in Wickremasinghe and Silvapulle (2004), episodes of large and small changes are then accumulated separately, such that:

$$ER^{L} \equiv \sum_{i=1}^{k} \theta \, (ER_i - ER_{i-1}) \qquad (4.27)$$

where $\theta = 1$ for $(ER_i - ER_{i-1}) \geq 3\%$ and $\theta = 0$ for $(ER_i - ER_{i-1}) < 3\%$; and

$$ER^{S} \equiv \sum_{i=1}^{k} \theta^{*}(ER_i - ER_{i-1}) \qquad (4.28)$$

where $\theta^{*} = 1$ for $(ER_i - ER_{i-1}) < 3\%$ and 0 otherwise.

Thus, ACC_L represents the accumulated sum of large exchange rate change episodes (ER^{L}) and ACC_S represents the accumulated sum of small change episodes (ER^{S}).

[17] Pollard and Coughlin (2004) use different measures of large and small changes to test the robustness of their results. They analyse alternative values of the threshold for a large change. Firstly, they use 3.5, 4.0 and 5.0 percent and find that as the threshold increases, the frequency of small changes also increases. Secondly, they define large as a change that is greater than the sample standard deviation, and thirdly, they sort the absolute values of the exchange rate changes and define large as any change in the highest quartile. The threshold for this quartile ranges from 2.2 percent to 5.2 percent. The results using either the second or third measure are found to be similar to those using the 3 percent threshold measure.

4.5.1 ERPT Asymmetry: Direction – Appreciation versus Depreciation

Two alternative models are estimated to investigate the sizes of the long-run and short-run pass-through of a rand appreciation and depreciation to import prices. The first model, represented by Equation (4.29), follows Wickremasinghe and Silvapulle's (2004) approach of including one of the series relating to either episodes of appreciation or depreciation in the pass-through equation. The depreciation series (ACC_D) is included in the long-run pass-through Equation (4.9) to test for asymmetry. Thus:

$$\text{Log IMP}_t = \beta_1 + \beta_2 \text{ Log EPC1}_t + \beta_3 \text{Log NEER}_t + \beta_4 \text{ACC\_D}_t + \varepsilon_t \quad (4.29)$$

The second model (Equation (4.30)) also follows Wickremasinghe and Silvapulle (2004). However, instead of including only one of the data series relating to periods of appreciation or depreciation, both the appreciation (ACC_A) and depreciation (ACC_D) series are included in the long-run pass-through equation, in place of the nominal effective exchange rate variable (Log NEER). Thus:

$$\text{Log IMP}_t = \beta_5 + \beta_6 \text{ Log EPC1}_t + \beta_7 \text{ACC\_A}_t + \beta_8 \text{ACC\_D}_t + \varepsilon_t \quad (4.30)$$

4.5.2 ERPT Asymmetry: Size – Large versus Small

Again, following Wickremasinghe and Silvapulle (2004), one of the series relating to either large or small change episodes is included in the long-run pass-through Equation (4.9). In this analysis both small and large changes are included in separate equations given below:

$$\text{Log IMP}_t = \beta_9 + \beta_{10} \text{ Log EPC1}_t + \beta_{11} \text{Log NEER}_t + \beta_{12} \text{ACC\_S}_t + \varepsilon_t \quad (4.31)$$

$$\text{Log IMP}_t = \beta_{13} + \beta_{14} \text{ Log EPC1}_t + \beta_{15} \text{Log NEER}_t + \beta_{16} \text{ACC\_L}_t + \varepsilon_t \quad (4.32)$$

The long-run asymmetry Equations (4.29) to (4.32) are estimated using the Johansen cointegration (1991) and (1995) methods.

4.6 Concluding Remarks

This chapter set out to outline and discuss the analytical framework in which ERPT in South Africa is investigated in terms of its size, speed and asymmetric properties in this study. After reviewing the theoretical and empirical literature from Chapters 2 and 3, as well Chapter 4 itself, and taking into consideration the availability of data, empirical models were constructed to provide answers to the key questions of this study, chiefly, what is the size and speed of ERPT at all price levels in South Africa and does the pass-through of exchange rate changes to import prices differ during periods of appreciation and depreciation, and large and small changes?

Two main stages of ERPT were identified: in the initial stage fluctuations in exchange rates are transmitted to the prices of imported goods. Thereafter, the second stage of ERPT entails the pass-through of changes in the exchange rate and import prices to domestic prices, that is, producer and consumer prices. The first stage is estimated using the Johansen (1991) and (1995) cointegration techniques, while the second stage is determined by estimating impulse response functions, variance decompositions and block exogeneity Wald tests. Wickremasinghe and Silvapulle's (2004) approach to estimating pass-through asymmetry of exchange rate changes to import prices is adopted and modified to suit the models and objectives of this study. The next chapter reports the results of these estimation techniques and models using South African data, with the goal of achieving the aims and objectives of this thesis, as outlined in the first chapter.

CHAPTER 5: EMPIRICAL ANALYSIS AND RESULTS

5.1 Introduction

This chapter reports the results of the empirical analysis based on the econometric framework discussed in Chapter 4. The empirical analysis is conducted in four major steps. Step one investigates the first stage pass-through using the Johansen (1991) and (1995) cointegration methods. Step two employs impulse response and variance decomposition functions as well as block exogeneity tests based on the VAR framework outlined in Chapter 4 to estimate the second stage pass-through. Steps three and four investigate the asymmetric properties of the pass-through in terms of appreciation and depreciation, and size of change respectively, following the method of Wickremasinghe and Silvapulle (2004).

5.2 First Stage Pass-Through Results

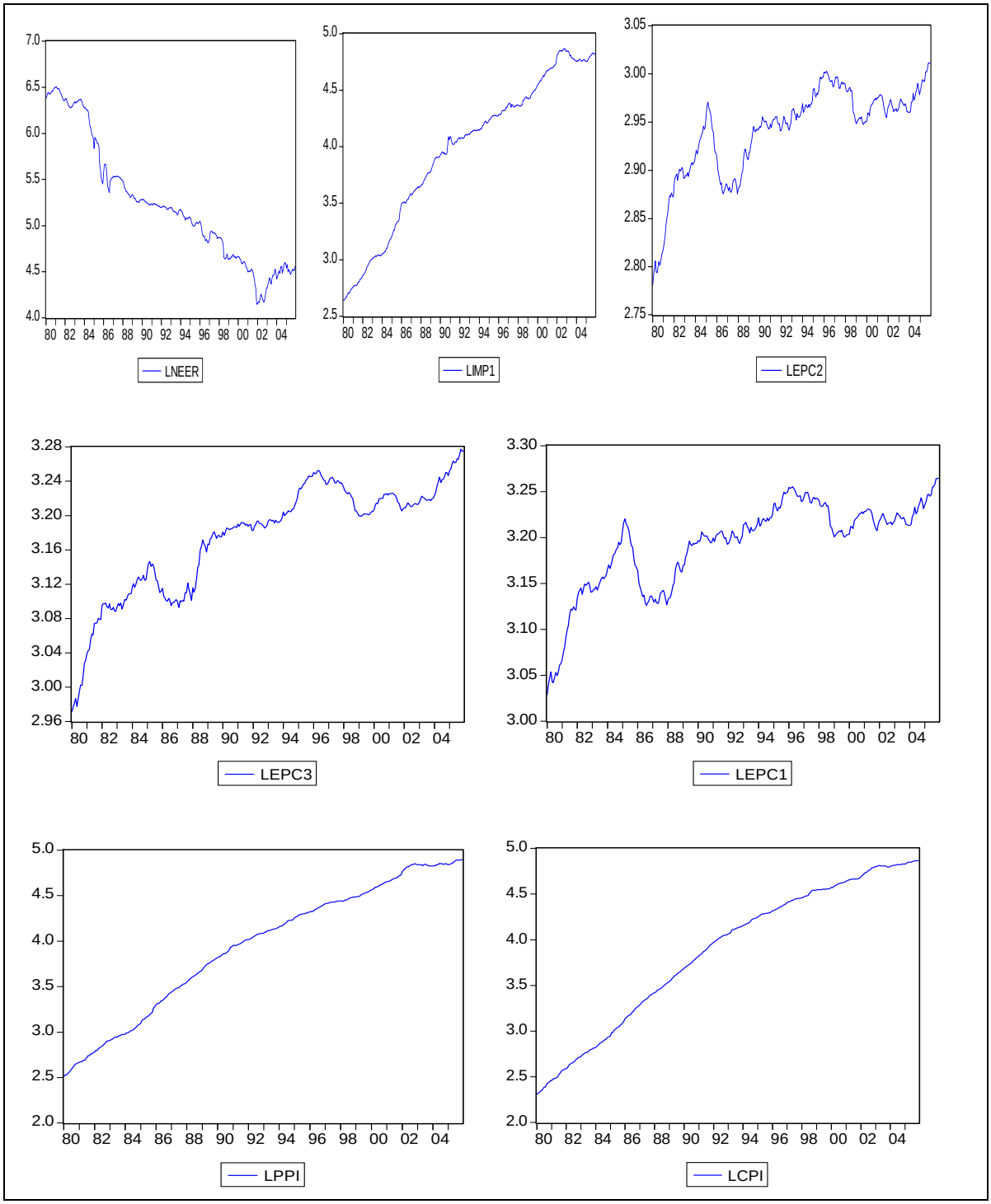
As previously mentioned, the Johansen (1991) and (1995) cointegration methods are used to estimate the pass-through of exchange rate fluctuations to import prices, which makes up the first stage of ERPT. The section begins by reporting the unit root test results and then presents the results of the cointegration analysis between the exchange rate, import prices and exporters' production costs in determining the magnitude and speed of long-run ERPT in South Africa.

5.2.1 Unit Root Test Results

The initial step in employing the Johansen cointegration technique is to establish the order of integration of the series by undertaking stationarity tests, thus determining the existence or otherwise of unit roots in the series. This study uses one informal test, two formal unit root tests and one stationarity test. The informal test consists of graphical analysis which is useful in identifying trends and the stationarity of the series, as well as detecting structural breaks and/or any data capturing errors in the data set. The graphs of the series are plotted below in Figure 5.1. Visual inspections show that the nominal effective exchange rate (LNEER) is downward trending albeit with fluctuations. On the other hand, all the prices, that is, import, producer and consumer prices (LIMP, LPPI and LCPI) are trending upwards. The different proxies of exporters' production costs, LEPC1, LEPC2 and LEPC3 appear to be upward

trending although with significant fluctuations. The graphical plots of the seven series appear to show a trend in the data over time, suggesting that all series are non-stationary.

Figure 5.1: Plots of the LNEER, LIMP, LEPC1, 2 and 3, LPPI and LCPI: 1980:1 – 2005:12



The formal tests carried out in the analysis of the time series data are the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) tests to determine the presence of unit roots and stationarity. However, it is first established which test equation(s) to include in the unit root tests for all the variables to determine the relevant trend and/or intercept assumption. Following Seddighi *et al*. (2000: 272), the test for the conditional hypothesis with the Dickey-Fuller tests is conducted by estimating Equation (4.16) in Chapter 4 and Equation (5.1), both indicated below.

$$\Delta X_t = \alpha + \beta_t + \delta X_{t-1} + \sum_{j=2}^{q} \delta_j \Delta X_{t-j} + \varepsilon_t \qquad (4.16)$$

$$\Delta X_t = \alpha + \delta X_{t-1} + \sum_{j=2}^{q} \delta_j \Delta X_{t-j} + \varepsilon_t \qquad (5.1)$$

where Δ is the difference operator, α is the constant term or drift, β is the linear deterministic trend, and ε_t is a white noise error term. The series X_t is said to be stationary if $\delta = 0$ using the τ (tau) statistics. Seddighi *et al*. (2000: 272) report the symmetrical critical values for the DF τ_{ij} statistics: $\tau_{\tau\alpha,}$ $\tau_{\beta\tau}$ and $\tau_{\alpha\mu}$, for testing whether α and/or β are individually significant, conditionally upon $\delta = 0$. The conditional hypotheses are specified as follows:

1. when the DF regression equations of the form (4.16) are used:
   H_0: $\alpha = 0$ given that $\delta = 0$, if $|t| < |\tau_{\tau\alpha}|$
   H_1: $\alpha \neq 0$ given that $\delta = 0$, if $|t| > |\tau_{\tau\alpha}|$

2. when the DF regression equations of the form (4.16) are used:
   H_0: $\beta = 0$ given that $\delta = 0$, if $|t| < |\tau_{\beta\tau}|$
   H_1: $\beta \neq 0$ given that $\delta = 0$, if $|t| > |\tau_{\beta\tau}|$

3. when the DF regression equations of the form (5.1) are used:
   H_0: $\alpha = 0$ given that $\delta = 0$, if $|t| < |\tau_{\alpha\mu}|$
   H_1: $\alpha \neq 0$ given that $\delta = 0$, if $|t| > |\tau_{\alpha\mu}|$

The results of the conditional hypothesis tests are reported in Table 5.1, which also indicates whether the respective variables have a drift and/or deterministic trend.

Table 5.1: Conditional Hypothesis Testing Results

Series	Stochastic trend ($\tau_{\tau\alpha}$)	Deterministic trend ($\tau_{\beta\tau}$)	Intercept only ($\tau_{\alpha\mu}$)	Conclusion
LNEER	1.300204	1.046367	1.229436	None
LIMP	1.559978	0.413702	3.74966****	Intercept
LEPC1	3.160946**	1.759480	2.889602***	Intercept
LEPC2	3.156926**	1.737974	2.878642***	Intercept
LEPC3	3.43209***	2.660447**	2.283375*	Trend and intercept
LPPI	1.151726	0.299611	3.915412****	Intercept
LCPI	0.890109	3.344575***	10.02688****	Trend and intercept

Note: *, **, *** and **** indicate the rejection of the null hypothesis at 10%, 5%, 2.5% and 1% level of significance respectively.

The results show that most of the series, that is import prices (LIMP), exporters' production costs (LEPC1 and 2) and producer prices (LPPI), have an intercept, while LEPC3 and LCPI indicate the presence of both deterministic trend and intercept. Consequently, both trend and intercept are included in the test equations for all series using the three test types: the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS). The results are summarised in Table 5.2 below.

Table 5.2: Unit Root Results

Variable	ADF		Phillips-Perron		KPSS		**I(d)**
	Level	1st Diff	Level	1st Diff	Level	1st Diff	
LNEER	-1.430	-13.580	-1.149	-13.388	0.286	0.066	I(1)
LIMP	-1.013	-9.704	-0.671	-14.672	0.454	0.092	I(1)
LEPC1	-3.123	-12.893	-3.397	-12.925	0.230	0.109	I(1)
LEPC2	-3.117	-12.892	-3.390	-12.921	0.223	0.109	I(1)
LEPC3	-3.403	-4.503	-3.440****	-16.119	0.335	0.123	I(1)
LPPI	-0.356	-5.293	-0.169	-15.903	0.495	0.071	I(1)
LCPI	1.555	-16.242	1.274	-16.400	0.514	0.163****	I(1)

Note: The critical value for both ADF and PP tests at 5% is -3.424387.
The critical value for the KPSS at 5% is 0.146
**** represents 1% significant levels

5.2.2 Cointegration results

Based on the results of the formal unit root tests and stationarity test, which indicate that all the series are integrated of order one, the next step is to investigate the presence of cointegration relationships between the nominal effective exchange rate,

import prices and exporters' production costs, as represented by Equation (4.9) in Chapter 4, in order to estimate the first stage pass-through. The results of the cointegration tests and the relevant residual diagnostic tests are summarised in Tables 5.3 and 5.4.

The aim of the cointegration analysis is to establish the extent to which fluctuations in the nominal effective exchange rate are passed on to import prices in South Africa after controlling for other variables determining import prices. Based on the review of the South African macroeconomic environment (Chapter 3), the magnitude and speed of the first stage pass-through is expected to be relatively high, although not complete (size-wise) due to the oligopolistic nature of South African markets.

Table 5.3: Johansen Cointegration Test Results

OPT	Null	λ_{trace}	5% C.V	λ_{max}	5% C.V
1	r = 0	66.319	42.915	42.721	25.823
	r <= 1	23.598	25.872	13.859	19.387
	r <= 2	9.738	12.518	9.738	12.518
2	r = 0	65.961	42.915	42.523	25.823
	r <= 1	23.437	25.872	13.679	19.387
	r <= 2	9.758	12.518	9.758	12.518
3	r = 0	67.547	42.915	41.253	25.823
	r <= 1	26.294	25.872	18.760	19.387
	r <= 2	7.534	12.518	7.534	12.518

Note: Critical values (C.V) are obtained from Osterwald-Lenum (1992).

The results in Table 5.3 (above) and Table 5.4 (below) are based on the estimation of Equation (4.9), with lag 2 selected by FPE, AIC, SC, and HQ information criteria. The options (OPT) 1, 2 and 3 represent Equation (4.9) with the different variants of exporters' production costs, LEPC1, LECP2 and LEPC3 respectively. Given that the unit root tests accepted the inclusion of trend and intercept in the test equation, Assumption 4 in Eviews, which assumes a trend and intercept in the cointegrating equation but no trend in the VAR, is chosen. Under Assumption 4, both the Johansen trace and maximum Eigenvalue tests indicate one cointegrating relationship at the 5 percent level for Options 1 and 2. However, for Option 3 the trace test indicates 2

cointegrating equations at the 5 percent level, while the maximum Eigenvalue indicates 1 cointegrating equation.

Table 5.4: Cointegration Analysis of LIMP, LEPC1, 2 and 3 and LNEER

OPT	r	k	A	Const	Weak Exogeneity Tests LIMP	LEPC	LNEER	β_2	β_3	α_1	α_2	α_3	R^2	S.Corr	J-Bera	Het
1	1	2	4	-2.211	18.465 [0.000]	8.381 [0.007]	0.167 [0.683]	-1.865 (0.334)	0.812 (0.054)	-0.057 (-5.253)	0.014 (3.456)	-0.014 (-0.458)	0.236	9.428 [0.399]	1353.799 [0.000]	2.949 [0.008]
2	1	2	4	-2.672	18.456 [0.000]	8.415 [0.004]	0.158 [0.691]	-1.874 (0.340)	0.816 (0.054)	-0.056 (-5.242)	0.014 (3.460)	-0.013 (-0.445)	0.235	11.568 [0.239]	1354.342 [0.000]	2.505 [0.022]
3	1	2	4	-1.754	14.455 [0.000]	3.866 [0.049]	0.658 [0.417]	-1.903 (0.272)	0.745 (0.045)	-0.067 (-5.16)	0.012 (2.529)	-0.033 (-0.898)	0.229	12.954 [0.165]	1192.319 [0.000]	3.4100 [0.003]

Notes:
For OPT 1, OPT 2 and OPT 3, exporters' production costs are represented by LEPC1, LEPC2 and LEPC3 respectively.
r: number of cointegrating vectors k: Lag length A: Deterministic trend assumption of test
β_2: exporters' production cost coefficient; β3: nominal effective exchange rate coefficient
α_1: import price error correction coefficient (e.c.c.); α_2: exporters' production costs e.c.c; α_3: nominal effective exchange rate e.c.c;
The parentheses [ ] are used to denote probability values, while ( ) represent t-values
Serial correlation (S.Cor): probabilities produced from Chi square distribution with 9 d.f.
Jarque-Bera (J-Bera) probabilities produced from Chi square distribution with 6 d.f.

Table 5.4 shows that for all options, the weak exogeneity tests indicate that import prices and exporters' production cost are endogenous, while the exchange rate variable is exogenous as expected. The fact that LEPC is found to be endogenous rather than exogenous is viewed as suspicious because, although the error correction coefficients for all LEPC options are significant, they are all incorrectly signed, implying that they are not truly endogenous. Hence, given the objective of this study, and the error correction terms, as well as the weak exogeneity tests, we normalise on LIMP to obtain the long-run pass-through terms.

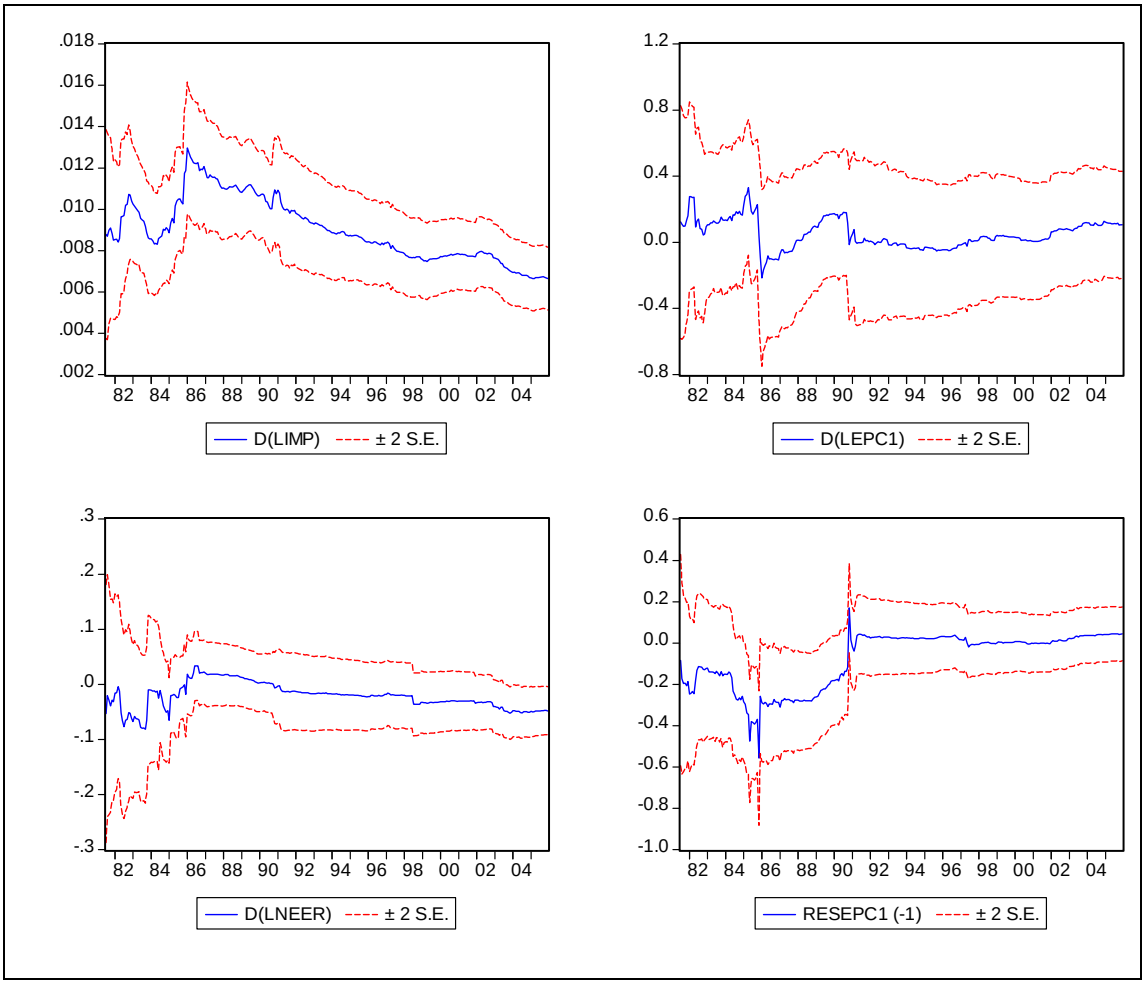
$$LIMP_t = 1.865\ LEPC1_t - 0.812\ LNEER_t \qquad (5.2)$$

$$LIMP_t = 1.874\ LEPC2_t - 0.816\ LNEER_t \qquad (5.3)$$

$$LIMP_t = 1.903\ LEPC3_t - 0.745\ LNEER_t \qquad (5.4)$$

Thus, a 100 percent depreciation of the rand is estimated to increase import prices by approximately 81 percent, 82 percent and 75 percent depending on the option of exporters' production costs. Although the ERPT coefficient is relatively high, it confirms that the first stage pass-through in South Africa is not complete. This result is consistent with the findings of Nell (2000) and SARB (2002), whose estimates for the pass-through coefficient are 82 percent and 78 percent respectively. Nell (2000) analyses South Africa's first stage pass-through from 1987 to 1997 using quarterly data, while the SARB (2002) study covers the period from 1980 to 2001 using monthly data. This suggests that the first stage ERPT in South Africa has remained fairly constant over time. This is substantiated by the results of the recursive estimates for the stability test shown in Figure 5.2.

Figure 5.2: Recursive Estimates' Graphs of Coefficients of D(LIMP), D(LEPC1), D(LNEER), and RESEPC1



As shown in Figure 5.2, the graph of D(LIMP) shows a steady decline in the rate of change of import prices, while the graph of D(LNEER) shows a fairly constant rate of change in the exchange rate. The graph of RESEPC1(-1) (the lagged residuals generated from the regression equation[18]) also shows relatively constant residuals after 1990. This implies that the pass-through of exchange rate fluctuations to import prices has been fairly constant over time.

Next, a likelihood ratio test is conducted to determine whether the Law of One Price holds; that is whether the coefficients of import prices and exporters production costs, β_1 and β_2 in Equation (4.9) are equal. The null hypothesis that $\beta_1 = \beta_2$ is rejected[19]. While this result is inconsistent with the findings of SARB (2002), it would be

[18] The regression equation estimated in Eviews: d(limp1) c d(lepc1) d(lneer) resepc1(-1).
[19] The likelihood ratio test statistic for $\beta_1 = \beta_2$, distributed as $\chi 2$ (1), is 21.57806 [0.000003].

reasonable to argue that price parity may not be present between South Africa and all its trading partners, particularly those included in the weighting used for the calculation of South Africa's exchange rate index and in the construction of the variable LEPC, because of differences in monetary policies and the management of exchange rates, as well as the presence of transaction costs arising from different trade polices among the respective countries.

The results also show that for all three options, the coefficients of exporters' production costs imply a positive long-run relationship with import prices; however, the relationship is not statistically significant. Furthermore, the error correction coefficient of $LIMP_t$, represented by α_1, shows that import prices gradually respond to shocks from the exchange rate. The coefficient α_1 is correctly signed and highly significant for all the options. On average, in the short-run, South African import prices adjust to equilibrium by about 6 percent of any disequilibrium in the long-run relationship each month. This result is also consistent with the findings of SARB (2002). In other words, a 10 percent depreciation of the rand will increase import prices by approximately 0.46 percent, 0.46 percent and 0.5 percent for Option 1, 2 and 3 respectively[20], and in each subsequent month, the disequilibrium will adjust by progressively smaller increments until the long-run pass-through is complete.

The results of the diagnostic tests are also reported in Table 5.4. The serial correlation tests for all options confirm that the residuals from the model are well behaved, that is, not serially correlated. The Jarque-Bera normality test for all options indicates that the residuals generated from the model are not normally distributed. The results of the heteroscedasticity test indicate that the variance of the residuals is not constant, that is, not homoscedastic. Greene (1993) suggests that heteroscedasticity may be caused by a number of reasons, including the non-normality of one of the variables in a model, or may be a consequence of data alteration. However, the finding of heteroscedasticity does not invalidate the analysis, as the estimators will still give unbiased coefficient estimates (Brooks, 2002). Heteroscedasticity becomes an issue when the estimated model is used for inference or forecasting purposes, as the estimate of the error variance is biased (Gujarati, 2003). Nonetheless, for the purposes

[20] Option 1: (8.12163 * 0.056785), Option 2: (8.15557 * 0.056242), Option 3: (7.45015 * 0.067473)

of this study, heteroscedasticity does not lessen the value of the findings since the main concern is the pass-through coefficient and not the forecasting powers of the model.

5.3 Second Stage Pass-Through Results

As previously mentioned, the second stage pass-through describes the transmission of the nominal effective exchange rate and import price changes to producer and consumer prices. The objective is to determine the main channel of ERPT in South Africa, and to establish the magnitude of the pass-through and how long it persists. This analysis is based on the impulse response and variance decomposition functions, as well as block exogeneity Wald tests on the VAR system (Equations (4.11) to (4.14)) in Chapter 4. The first two tests will aid in investigating the magnitude and speed of the pass-through respectively, while the third test (in conjunction with the first two) will help establish the channel(s). As indicated at the end of Chapter 3, the direct transmission channel of ERPT is expected to be more prominent in the case of South Africa. The channel is expected to consist of two stages where, in the first stage, pass-through runs from changes in the exchange rate to import prices and, in the second stage, pass-through runs from changes in the exchange rate and import prices to producer and consumer prices respectively. Although the indirect transmission channels of ERPT may be present in South Africa, these are expected to be less prominent than the channel described above.

Furthermore, the size of the exchange rate pass-through from each level of prices to the next, that is, from import to producer to consumer prices, is expected to be incomplete and smaller as one moves down the chain. It is also expected that the persistence or speed of ERPT is likely to be affected by the oligopolistic nature of South African markets, and therefore the pass-through is expected to persist more or take a longer time at every price level.

5.3.1 Impulse Response Results

Identifying the response of a model to an innovation in one of its variables and decomposing the forecast error variances have become standard tools for economic analysis (Lutkepohl, 1990). This section reports the responses of South African prices

(import, producer and consumer prices) to a one-period standard deviation shock in the innovations of the VAR system (Equations (4.11) to (4.14)). The VAR system is estimated using impulse response functions based on the Cholesky decomposition because, as mentioned in Chapter 4, the ordering of the variables is specific as the model assumes that causality runs from the nominal effective exchange rate to import, producer and lastly, consumer prices, and that the degree of endogeneity increases in that order. In addition, the model also assumes that pricing decisions at the import and production stages can have a simultaneous impact on consumer prices, but not vice versa (McCarthy, 2000; Bhundia, 2002).

The impulse response functions are illustrated in Figure A.1 (see Appendix). The results suggested by the impulse responses mirror those of the variance decompositions, which are discussed in detail in the next section. However, a noteworthy finding of the impulse response analysis is that the ERPT to South African prices is found to take less than a full year. Furthermore, the rate of pass-through is found to decrease from import to producer prices, then producer to consumer prices.

5.3.2 Variance Decomposition Results

Table 5.5 below, shows the variance decomposition results of the exchange rate, import prices, producer prices and consumer prices. In Panel 1 the variance estimates indicate that a greater portion of the variation in the nominal effective exchange rate is due to its own innovations. The variance due to the other variables (import, producer and consumer prices) is very small, implying that the exchange rate is truly exogenous. Panel 2 indicates that innovations in the nominal effective exchange rate make up a greater proportion of the movement in import prices, besides its (import prices) own innovations. By the 25^{th} month, exchange rate shocks explain 14 percent of the variation in import prices. This result supports the expectations discussed earlier that for the first stage pass-through, there is a direct channel from the exchange rate to import prices. Producer and consumer prices explain 5.43 and 0.44 percent respectively, of the variation in import prices by the 25^{th} month.

Table 5.5: Variance Decomposition Results

PANEL	PERIOD	D(LNEER)	D(LIMP)	D(LPPI)	D(LCPI)
1	1	100.000	0.000	0.000	0.000
	5	97.480	1.399	0.342	0.779
LNEER	10	97.464	1.403	0.353	0.780
	15	97.464	1.403	0.353	0.780
	20	97.464	1.403	0.353	0.780
	25	97.464	1.403	0.353	0.780
2	1	0.534	99.466	0.000	0.000
	5	13.690	80.655	5.260	0.395
LIMP	10	14.029	80.099	5.429	0.443
	15	14.033	80.092	5.431	0.444
	20	14.033	80.092	5.431	0.444
	25	14.033	80.092	5.431	0.444
3	1	0.083	27.061	72.856	0.000
	5	13.427	23.375	58.059	5.139
LPPI	10	13.887	23.181	57.791	5.141
	15	13.894	23.178	57.787	5.141
	20	13.894	23.178	57.787	5.141
	25	13.894	23.178	57.787	5.141
4	1	0.413	2.107	9.768	87.712
	5	9.332	5.017	17.578	68.074
LCPI	10	10.265	5.113	17.907	66.715
	15	10.282	5.114	17.913	66.691
	20	10.283	5.114	17.913	66.691
	25	10.283	5.114	17.913	66.691

Notes:
Panel 1: Variance Decomposition of D(NEER)
Panel 2: Variance Decomposition of D(LIMP)
Panel 3: Variance Decomposition of D(LPPI)
Panel 4: Variance Decomposition of D(LCPI)

Panel 3 results support the expected direct transmission and indirect transmission channels of pass-through in the second stage. Innovations in import prices explain 23 percent of the variation in producer prices, while the exchange rate explains 13.89 percent, implying that the direct transmission channel of pass-through (import price changes to producer prices) is stronger than the indirect channel (exchange rate changes to producer prices) in South Africa. The results in Panel 4 also suggest that the expected direct ERPT channel of producer price changes to consumer prices is more pronounced than the other direct channel of import price changes to consumer prices, and the indirect channel of exchange rate changes to consumer prices. This is shown by the proportion of movements in consumer prices due to innovations in producer prices (17.91 percent by the 25^{th} month), import prices (5.11 percent by the 25^{th} month) and the exchange rate (10.28 percent by the 25^{th} month) respectively. Interestingly, the indirect channel of exchange rate changes to consumer prices seems to be more prominent than the direct channel of import price changes to consumer prices.

The variance decomposition results confirm the expected direct transmission channel of pass-through outlined in Chapter 3. The results also show that variations in prices due to exchange rate shocks seem to decline from one price level to the other (14 percent variation in import prices, 13 percent in producer prices and then 10 percent in consumer prices), implying that the impact of an exchange rate change is weaker as one moves down the price chain. Furthermore, the size of the variation in each of the prices as explained by the preceding price level is greater than the variation explained by the other price. In other words, import prices explain a greater variation in producer prices than consumer prices, and producer prices explain a greater variation in consumer prices than import prices. This finding further reinforces the expected direct transmission

5.3.3 Block Exogeneity Wald Test Results

As mentioned previously in Chapter 4, the block exogeneity Wald test is used to determine whether changes in one variable may cause statistically significant changes in another variable within the system. Thus, the block exogeneity tests can aid in establishing the channel of ERPT, based on the significance of the effect of individual explanatory variables on each dependent variable. The results of the block exogeneity Wald tests are shown in Table 5.6.

Table 5.6: Block Exogeneity Wald Test Results

Panel	Dependent Variable	Excluded	Probabilities
1	D(LNEER)	D(LIMP) D(LPPI) D(LCPI)	0.147 0.477 0.215
2	D(LIMP)	D(LNEER) D(LPPI) D(LCPI)	0.000 0.001 0.679
3	D(LPPI)	D(LNEER) D(LIMP) D(LCPI)	0.000 0.042 0.000
4	D(LCPI)	D(LNEER) D(LMPI) D(LPPI)	0.000 0.996 0.000

The results in Panel 1 suggest that import prices, producer prices and consumer prices do not have a significant impact on the nominal effective exchange rate. This supports

the earlier results of the weak exogeneity test and the variance decomposition estimates, thus confirming that the exchange rate is truly exogenous. In the case of Panel 2, the findings suggest that the exchange rate has the most significant effect on import prices, followed by producer prices. This supports the expected direct channel of pass-through at the first stage of ERPT. The findings also show that consumer prices are not significant in explaining import prices.

Panel 3 shows interesting results. The nominal effective exchange rate has a significant effect on producer prices, implying that the indirect channel of transmission of exchange rate changes to producer prices is more prominent than the expected direct channel of import price changes to producer prices. This conflicts with the findings of the impulse response and variance decomposition functions, which find the opposite to be true. Moreover, the results also show that consumer prices have a greater effect on producer prices than import prices. This seems implausible given the nature of South African markets. The results of the impulse response and variance decomposition functions appear to be more plausible.

The results in Panel 4 show that both the exchange rate and producer prices have an equally significant effect on consumer prices. This suggests that the expected direct channel of pass-through of producer price changes to consumer prices and the indirect channel of exchange rate changes to consumer prices are equally prominent. However, given that the majority of imported commodities in South Africa are mainly targeted at the primary manufacturing, mining and agricultural sectors (DTI, 2006), it would be tenable to assume that the expected direct transmission channel as suggested by the variance decomposition and impulse response functions would be more significant than the indirect channel of exchange rate changes to consumer prices.

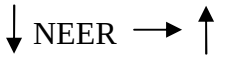
In summary, the findings of the cointegration analysis, impulse response, variance decomposition and block exogeneity Wald tests suggest that ERPT in South Africa is incomplete, that is, the pass-through of exchange rate changes to all prices, directly or indirectly, is less than 100 percent. Furthermore, the pass-through of exchange rate changes to South African prices takes less than a full year. However, the rate of ERPT decreases from import to producer prices and then producer to consumer prices.

The results also show that ERPT in South Africa follows both direct and indirect channels. The expected channel of direct pass-through from changes in the exchange rate to import prices, and the pass-through of changes in import prices to producer prices and then consumer prices, are supported by the findings of the impulse response and variance decomposition analysis. The block exogeneity Wald test results, however, only support the first stage direct pass-through of exchange rate changes to import prices, as indicated by the previous two tests, as well as the direct pass-through channel of producer price changes to consumer prices. In the case of the second stage pass-through, the block exogeneity test results suggest that the indirect channel of pass-through, that is, exchange rate changes to producer prices, is more prominent than the direct channel of import price changes to producer prices. Thus, although the expectations about first stage pass-through are supported by all three tests, the channel of ERPT in the second stage is not supported by the block exogeneity Wald test. However, considering that the majority of imports into South Africa take place at the primary levels of production, with the importation of capital and intermediate goods (DTI, 2006), and also taking the results of two of the three tests, we can argue that the main channel of ERPT in South Africa can be depicted as:

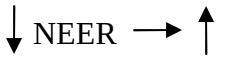
Schematic 5.1

Schematic 5.1 shows that a downward or negative shock in the nominal effective exchange rate (depreciation of the rand) is passed directly to import prices, causing them to rise. The shock from the first stage pass-through is transmitted to producer prices, via import prices and passed on from producer prices to consumer prices. The results also indicate the existence of other less prominent ERPT channels in South Africa. These channels, listed in order of prominence and represented below in Schematics 5.2, 5.3 and 5.4 respectively, are the indirect transmission channels of exchange rate changes to producer prices and consumer prices separately, and the other direct transmission channel of import price changes to consumer prices. Schematics 5.2 and 5.3 show that a pass-through of negative shocks in the nominal effective exchange rate, increases producer prices and consumer prices, respectively.

In Schematic 5.4, a decrease in the nominal effective exchange rate causes import prices to rise and subsequently consumer prices will rise.



Schematic 5.2



Schematic 5.3

Schematic 5.4

5.4 ERPT Asymmetry

The purpose of this section is to establish the asymmetric properties of the first stage of ERPT in South Africa. The analysis follows the approach used by Wickremasinghe and Silvapulle (2004), as mentioned in Chapter 4. The pass-through asymmetry issues under investigation in this thesis are whether the direction of change in the exchange rate (appreciation or depreciation) and the size of the change (large or small, based on a threshold of 3 percent) have any effect on the pass-through of exchange rate changes to import prices.

However, before estimating the pass-through asymmetry equations, unit root tests on the constructed asymmetry series in Chapter 4, namely, ACC_A, ACC_D, ACC_L and ACC_S, are conducted. The graphs of the series are shown in Figure A.2 in the Appendix, while the results of the ADF and Phillips-Perron tests are shown in Table 5.7 below. Based on the preliminary visual inspection of the graphs of all the series, which all seem to be trending, the trend and intercept are included in the test equations of both unit root tests.

Table 5.7: Unit root results for asymmetry series

Variable	ADF		Phillips-Perron		I(d)
	Level	1st Diff	Level	1st Diff	
ACC_A	0.846	-13.656	1.002	-13.630	I(1)
ACC_D	-1.387	-13.156	-1.400	-13.204	I(1)
ACC_L	-0.345	-13.061	-0.924	-14.654	I(1)
ACC_S	-2.491	-18.022	-2.560	-18.017	I(1)

Note: The critical value for both ADF and PP tests at 5% is -3.424387.

All series are found to be non-stationary in level terms but stationary at first difference.

5.4.1 ERPT Asymmetry: Direction – Appreciation versus Depreciation

As previously highlighted in Chapter 4, two alternative models are estimated to investigate the size of the long-run and short-run pass-through of a rand appreciation and depreciation to import prices. Both models are represented below in Equations (4.29) and (4.30) as stated in Chapter 4:

$$\text{Log IMP}_t = \beta_1 + \beta_2 \text{ Log EPC1}_t + \beta_3 \text{Log NEER}_t + \beta_4 \text{ACC\_D}_t + \varepsilon_t \quad (4.29)$$

$$\text{Log IMP}_t = \beta_5 + \beta_6 \text{ Log EPC1}_t + \beta_7 \text{ACC\_A}_t + \beta_8 \text{ACC\_D}_t + \varepsilon_t \quad (4.30)$$

Equations (4.29) and (4.30) are estimated using the Johansen cointegration (1991) and (1995) methods, and the results are presented in Table 5.8 below. In both equations, one cointegrating vector is found, and the lag length and deterministic trend assumption chosen are two and four respectively. These results are similar to those for the different options of Equation (4.9), reported in Table 5.4. In Equation (4.29) the long-run pass-through coefficients corresponding to appreciation and depreciation are β_3 and ($\beta_3 + \beta_4$) respectively. The results show that the appreciation ERPT coefficient is approximately 0.64 while the depreciation coefficient is approximately 0.72. In other words, for a 100 percent change in the exchange rate, the pass-through to import prices will be greater when the change is a depreciation (72 percent) than when it is an appreciation (64 percent). The error correction coefficient for import prices (α_1) is significant and correctly signed, implying that import prices do adjust to equilibrium after shocks in the explanatory variables. The other error correction coefficients (α_2, α_3, and α_4) which are not shown in Table 5.8 are insignificant. The likelihood ratio

(LR) test is performed to confirm whether the appreciation and depreciation coefficients are statistically significantly different. In the case of Equation (4.29), a restriction that the long-run depreciation pass-through coefficient (β_4) is equal to zero ($\beta_4 = 0$), is placed to test against the long-run asymmetry of import prices to rand movements. The results show that the null hypothesis ($\beta_4 = 0$) is rejected, suggesting that $\beta_4 \neq 0$ and therefore $(\beta_3 + \beta_4) \neq \beta_3$[21]. Thus there is long-run asymmetry of exchange rate pass-through to import prices.

The long-run ERPT coefficients in Equation (4.30), β_7 and β_8, are found to be approximately 64 percent and 72 percent respectively. These are the same as the coefficients in Equation (4.29). Similarly, the error correction coefficient of import prices is significant and correctly signed, however, unlike in Equation (4.29) where the rest of the error correction coefficients are insignificant, α_3 in Equation (4.30), the error correction coefficient for the appreciation series (ACC_A), is significant and correctly signed. The likelihood ratio test results[22] are found to be the same as the results of Equation (4.29), and thus the null hypothesis that $\beta_7 = \beta_8$ is rejected, implying that there is long-run asymmetry in the adjustment of import prices to rand fluctuations.

The results of Equations (4.29) and (4.30) indicate that, in the long-run, pass-through is significantly greater when the rand depreciates. This finding supports the *a priori* expectation that in an oligopolistic market such as that of South Africa, foreign firms will pass on the cost of a rand depreciation to local importers, assuming that invoices are rand denominated. Alternatively, if the invoices are denominated in US dollars (or the currency of the foreign firm), foreign firms will not adjust their markups to maintain the same rand price prior to the rand depreciation. Rather the foreign exporters would seek to gain from the rand depreciation and increase their profits. Thus, of the asymmetric pass-through theories, the binding quantity constraints model discussed in Chapter 2 best explains the phenomenon of greater pass-through during episodes of depreciation than in South Africa.

[21] The likelihood ratio test statistic for $\beta_4 = 0$, distributed as $\chi 2$ (1), is 3.795 [0.051].

[22] The likelihood ratio test statistic for $\beta_7 = \beta_8$, distributed as $\chi 2$ (1), is 3.795 [0.051].

The results of the short-run asymmetry investigation using Equations (4.29) and (4.30) are also reported in Table 5.8. The results show that in Equation (4.29), only the first difference of the nominal effective exchange rate lagged twice and the first difference of the accumulated depreciation series also lagged twice, have a significant short term impact on import prices. This suggests that there is asymmetry in the pass-through of exchange rate appreciation and depreciation to import prices in the short-run. However, in the case of Equation (4.30), only the first difference of the accumulated appreciation series lagged twice has a significant short term impact on import prices. This may imply that the size of ERPT changes significantly in periods of appreciation in the short-run.

5.4.2 ERPT Asymmetry: Size – Large versus Small

The analytical framework of Wickremasinghe and Silvapulle (2004) is adapted here to investigate the pass-through of large and small changes in the exchange rate to import prices. Following Wickremasinghe and Silvapulle (2004), one of the series relating to either large or small change episodes is included in the test for long-run asymmetry. In this analysis both small and large changes are included in separate equations given below:

$$\text{Log IMP}_t = \beta_9 + \beta_{10}\,\text{Log EPC1}_t + \beta_{11}\text{Log NEER}_t + \beta_{12}\text{ACC\_S}_t + \varepsilon_t \qquad (4.31)$$

$$\text{Log IMP}_t = \beta_{13} + \beta_{14}\,\text{Log EPC1}_t + \beta_{15}\text{Log NEER}_t + \beta_{16}\text{ACC\_L}_t + \varepsilon_t \qquad (4.32)$$

The estimation results of Equations (4.31) and (4.32) are also reported in Table 5.8. Both equations are estimated using the Johansen cointegration (1991) and (1995) methods. One cointegrating vector is identified in both equations. The lag length and deterministic trend assumption chosen in Equation (4.31) are one and four; while in Equation (4.32) the lag length and deterministic trend chosen are two and three respectively. The long-run ERPT coefficients in Equation (4.31) are ($\beta_{11} + \beta_{12}$) and $\beta_{11,}$ where the former corresponds to small changes and the latter refers to large changes in the exchange rate. In Equation (4.32), ($\beta_{15} + \beta_{16}$) is the coefficient of large changes, while β_{15} is the coefficient of small changes in the exchange rate.

The long-run asymmetry results of Equation (4.31) show that the small change ERPT coefficient is approximately 81.7 percent while the large change ERPT coefficient is approximately 81.4 percent. This suggests that the pass-through is more or less the same regardless of the size of the change in the exchange rate. The likelihood ratio test is conducted to confirm or reject whether the two coefficients are statistically equal. The results of the test[23] fail to reject the null hypothesis that $\beta_{12} = 0$, implying that $\beta_{11} + \beta_{12} = \beta_{12}$ and therefore that there is no long-run asymmetry with respect to the size of change in the exchange rate

The results of Equation (4.32) show that, in the long-run, the coefficient of a large change is 80.66 percent, while the coefficient of a small change is 80.70 percent. The implications seem to be the same as those for Equation (4.31). However, a closer inspection of the coefficients of both Equations (4.31) and (4.32) shows that the pass-through of exchange rate changes seems to be greater when there is a small change than when the change is large, as suggested by the signs of the coefficients.

The signs of the coefficients of ACC_S and ACC_L are positive and negative respectively, implying that there is some evidence of asymmetry in the pass-through of small and large changes in the exchange rate to import prices. This suggests that pass-through is greater during episodes of small exchange rate changes than during episodes of large changes. This phenomenon can be explained by the menu cost theory of asymmetric pass-through when imports are invoiced in the exporting firm's currency. The theory suggests that if imports are invoiced in the exporting firm's currency, then a small change in the exchange rate will have no effect on its invoice price, but the currency change will be fully reflected in the price charged in the importing country, implying complete ERPT (Pollard and Coughlin, 2003: 9). However, if the exchange rate change is large, the exporting firm will adjust its invoice price, thus reducing the amount of pass-through. In this case pass-through is greater when exchange rate changes are small. The adjustment of prices in the case of large changes can be explained by the market share theory. For example, exporting firms may be reluctant to increase their prices significantly in light of a large

[23] The likelihood ratio test statistic for $\beta_{12} = 0$, distributed as $\chi 2$ (1), is 1.191926 [0.274941].

exchange rate depreciation, and thus would rather pass on smaller changes in the exchange rate, so as not to risk losing their market share. Another reason could be that because of the oligopolistic nature of the South African markets, exporting firms may only pass on smaller changes when the rand appreciates, but if the appreciation is large, they would rather maintain their rand prices and earn higher profit margins.

However, the likelihood ratio test is conducted to validate these results. The test result[24] fails to reject the null hypothesis that ($\beta_{16} = 0$), implying that ($\beta_{15} + \beta_{16} = \beta_{15}$). This suggests that there is no significant long-run asymmetry in the pass-through of large and small changes in the exchange rate.

In the short run (up to the second month) none of the coefficients of the exchange rate changes are significant. This implies that there is no asymmetry in the pass-through of small or large changes in the short run.

The results of the error correction coefficient reported in Table 5.8 indicate that the speed of adjustment of import prices in the short run is statistically significant and correctly signed for all the asymmetric pass-through regressions, and is consistent with the estimates shown in Table 5.4. The residual diagnostic tests show that the residuals are serially uncorrelated at 5% level of significance, though the nulls of normality and no heteroscedasticity were rejected in all the models. However, as previously mentioned, the concern of this analysis is to establish unbiased estimates of the pass-through coefficients of changes in the exchange rate, which the selected models are able to capture.

In sum, the tests for ERPT asymmetry in South Africa, based on the direction and size of the change have shown that in the long run, pass-through is significantly greater when the rand depreciates. There is also some evidence of greater pass-through when the size of the change in the exchange rate is small, that is, less than 3%, though not significant. In terms of the direction of exchange rate change, some evidence is found

[24] The likelihood ratio test statistic for $\beta_{16} = 0$, distributed as $\chi 2$ (1), is 2.519563 [0.112442].

of short-run asymmetry, but in the case of the size of exchange rate change, no evidence of short-run asymmetry is found.

Table 5.8: Cointegration Analysis for ERPT Asymmetry: Direction and Size

Heteroskedasticity	408.721 [0.0000]	408.721 [0.0000]	290.378 [0.0000]	255.823 [0.0000]
Regression Equation	4.29	4.30	4.31	4.32
r	1	1	1	1
k	2	2	1	2
A	4	4	4	3
Long run terms:				
LIMP (-1)	1	1	1	1
LEPC1(-1)	-1.463 (0.205)	-1.463 (0.205)	-1.885 (0.322)	-1.925 (0.255)
LNEER (-1)	0.637 (0.048)		0.814 (0.053)	0.807 (0.041)
ACC_A(-1)		-0.637 (0.048)		
ACC_D (-1)	0.078 (0.039)	0.715 (0.032)		
ACC_L (-1)				-0.0004 (0.0002)
ACC_S (-1)			0.00317 (0.0026)	
Short-run terms:				
ΔLNEER (-1)	-0.067 [-1.612]		-0.037 (-1.669)	-0.042 (-1.913)
ΔLNEER (-2)	-0.116 [-2.785]		-0.035 (-1.565)	
ΔACC_D (-1)	0.053 (0.883)	-0.014 (-0.437)		
ΔACC_D (-2)	0.127 (2.094)	0.0105 (0.316)		
ΔACC_A (-1)		-0.067 (-1.612)		
ΔACC_A (-2)		-0.116 (-2.785)		
ΔACC_L (-1)				-0.00024 (-0.958)
ΔACC_S (-1)			0.00034 (0.439)	
ΔACC_S (-2)			0.0004 (0.529)	
Speed of adjustment (α_1)	-0.072 (-5.0616)	-0.072 (-5.0616)	-0.059 (-5.2647)	-0.067 (-6.455)
L.R. test	3.795[1] [0.0514]	3.795 [0.0514]	1.192 [0.2749]	2.520 [0.1124]
R-squared	0.234	0.234	0.237	0.233
Diagnostics:				
Serial correlation LM	25.172 [0.0669]	25.172 [0.0669]	23.965 [0.0903]	22.982 [0.1142]
Normality (Jarque-Bera)	2205.082 [0.0000]	7840.026 [0.0000]	783.999 [0.0000]	526.094 [0.0000]

Notes:
1. Likelihood ratio (LR) test statistics for $\beta_4 = 0$, $\beta_7 = \beta_{8,}$ $\beta_{12} = 0$ and $\beta_{16} = 0$ respectively, are all distributed as $\chi 2$ (1).
2.The parentheses [ ] are used to denote probability values, while ( ) represent t-values

CHAPTER 6: SUMMARY, POLICY RECOMMENDATIONS, LIMITATIONS AND CONCLUSION

6.1 Summary of Findings

This thesis analysed the pass-through of exchange rate fluctuations to import, producer and consumer prices in South Africa. The study also investigated ERPT asymmetry to import prices. A review of the theoretical and empirical literature on ERPT, an analysis of the South African macroeconomic environment with regard to exchange rate and trade policies from the 1970s to the 2000s, and the availability of data guided the construction of the empirical framework that was used to carry out the study.

Although various models and data specifications have been used to investigate ERPT across the world, the findings of most studies reviewed in this thesis indicate that exchange rate pass-through is incomplete in both developed and developing countries, with a varying magnitude from country to country. Furthermore, the literature on ERPT asymmetry, which mainly examines pass-through to import prices under currency appreciation versus depreciation, reports contrasting results and provides no clear evidence on the direction of asymmetry. In some cases the pass-through associated with depreciation exceeds appreciation (such as Webber, 2000, Goldberg, 1995 and Kadiyali, 1997), and in other cases, ERPT associated with appreciation exceeds depreciation, (such as Mann, 1986, Wickremasinghe and Silvapulle 2004). Feinberg (1986) and Athukorala (1991) find no evidence of pass-through asymmetry, suggesting that it would be imprudent to generalise the estimates of ERPT and its asymmetry in South Africa, based on literature.

South Africa's macroeconomic policies have evolved over the years. Since the 1970s, South African policy-makers have been on a mission to liberalise the economy and allow free market principles to govern markets. Upon the recommendations of the De Kock Commission in 1979, the determination of the value of the rand changed from pegged to managed-floating, with the ultimate aim being to allow the rand to be a completely free- floating currency. In the same vein, South Africa's trade policy has

also been subject to changes. The focus of the country's trade regime in recent years has been export-biased; however, South Africa's trade statistics show that import volumes have outpaced exports over the years as the economy has become more liberalised. The South African economy has been opened to the rest of the world and, consequently, the domestic economy has become prone to shocks in the global economy, including fluctuations in exchange rates.

Thus, having considered the behaviour of the rand and its increased volatility, the South African trade structure which shows a greater influx of capital and intermediate manufacturing goods, as well as the slow but improving competitiveness of South African markets, the main channel of pass-through in South Africa was expected to run from a change in the exchange rate directly to import prices, then producer prices and finally consumer prices. The pass-through was also expected to be relatively high but not complete because of the oligopolistic nature of South African markets. Furthermore, in the light of increasing competitiveness within South African markets, factors such as market share and menu costs were expected to have an impact on the size and speed of ERPT, as well as the asymmetry of pass-through of changes in the exchange rate to import prices.

The two stages of ERPT to import, producer and consumer prices and the asymmetry of pass-through to import prices in South Africa were investigated using different econometric frameworks. The first stage pass-through was analysed using the Johansen (1991) and (1995) cointegration methods, while the second stage was analysed using impulse responses, variance decompositions and block exogeneity Wald tests. ERPT to import prices was found to range from 75 percent to 82 percent in the long run, depending on the currency weights used to calculate exporters' production costs. In the short run, South African import prices were found to adjust to equilibrium by about 6 percent of any disequilibrium in the long-run relationship each month. These results were consistent with the findings of other South African studies, namely Nell (2000) and the SARB (2002).

The findings of the cointegration analysis, impulse response, variance decomposition and block exogeneity Wald tests suggested that ERPT in South Africa was incomplete and that the pass-through to all prices took less than a year. However, the magnitude

of ERPT was found to be decreasing from import to producer and then to consumer prices. The results also showed that ERPT in South Africa follows both the direct and indirect transmission channels. The expected direct ERPT channel consisting of direct pass-through from changes in the exchange rate to import prices, and then pass-through from changes in import prices to producer prices and finally consumer prices was supported by the findings of the impulse response and variance decomposition analyses. The block exogeneity Wald test results, however, supported the first stage direct pass-through of exchange rate changes to import prices, as indicated by the previous two tests, as well as the direct pass-through channel of producer price changes to consumer prices. In the case of the second stage pass-through, the block exogeneity test results suggest that the indirect channel of pass-through, that is, exchange rate changes to producer prices, is more prominent than the direct channel of import price changes to producer prices. Based on the argument that the majority of imports into South Africa take place at the primary levels of production (DTI, 2006) through the importation of capital and intermediate goods, and taking the results of two of the three tests, the main channel of ERPT in South Africa can be depicted as:

It was also investigated whether the direction of change in the exchange rate (appreciation or depreciation) and the size of change (large or small, based on a threshold of 3 percent) had any effect on the pass-through of exchange rate changes to import prices, by adapting the approach of Wickremasinghe and Silvapulle (2004). With regard to the direction of change in the exchange rate, the results showed that, in the long run, pass-through is greater when the rand depreciates than when it appreciates. This finding supported the *a priori* expectation that in an oligopolistic market such as that of South Africa, foreign firms will pass on the cost of a rand depreciation to local importers, assuming that invoices are rand denominated. Moreover, even if the invoices are denominated in US dollars (or the currency of the foreign firm), foreign firms will not adjust their foreign prices so as to maintain the same rand price prior to the rand depreciation. Rather, foreign exporters will pass on the cost of the rand depreciation and maintain their profit margins. Thus, of the asymmetric pass-through theories, the binding quantity constraints model best explains the phenomenon of the greater pass-through during episodes of depreciation

than during periods of appreciation. In the case of the size of exchange rate changes, there was some evidence that the pass-through of exchange rate changes is greater when there is a small change than when the change is large, that is, 3 percent and above. This phenomenon can be explained by the menu cost theory of asymmetric pass-through when imports are invoiced in the exporting firm's currency. However, the LR test results for size asymmetry suggested that there was no asymmetry.

6.2 Policy Implications and Recommendations

A number of factors may motivate the study of exchange rate pass-through from a policy- maker's point of view. Firstly, the degree of pass-through can be used as an approximation of international macroeconomic transmission and, therefore, has implications for forecasting inflation and for monetary policy responses to inflation shocks. Secondly, the study of ERPT at the macro- and microeconomic levels may give insights into the international market power, structure and competitiveness of local industries. Thirdly, it may also shed light on the sensitivity of trade flows to currency and price changes, and the implication(s) of these for the balance of payments accounts. For example, if the rate of pass-through is low and if trade flows respond sluggishly to relative price changes, then the overall balance of payments adjustment process could be significantly held back (Kiptui *et al*., 2005).

There is no doubt that monetary authorities tend to perceive the exchange rate as one of the major monetary transmission mechanism channels. Furthermore, theoretical and empirical literature suggests that in an open economy, fluctuations in the exchange rate affect inflation through direct changes in import prices as well as through aggregate demand, which is subject to changes in the relative price between foreign and domestic commodities (Adolfson, 2002). Therefore, in the case of small open economies with an inflation targeting outlook, such as South Africa, it is particularly relevant for policymakers to investigate and establish the extent to which domestic inflation is affected by changes in the exchange rate. Policymakers are faced with a trade-off in trying to mitigate the effects of exchange rate fluctuations on domestic inflation: they cannot even out demand without creating fluctuations in inflation, because the exchange rate affects both the demand and supply relations. Thus the trade-off becomes reduced output variability versus inflation variability.

Corsetti and Pesenti (2001) and Smets and Wouters (2001) suggest that the optimal trade-off is dependent on the degree of pass-through. If the degree of ERPT is small then the effectiveness of the exchange rate as a channel of transmitting monetary policy is reduced, implying less conflict between inflation and output objectives. However, a low ERPT also implies that larger exchange rate movements are necessary for relative price adjustments. On the other hand, if the degree of pass-through is high, then the role of the exchange rate as a channel for transmitting monetary policy becomes more prominent, thus implying greater conflict in the output variability versus inflation variability trade-off. Therefore, the optimal policy must balance the costs of exchange rate variability against the possible flaws of stabilizing the exchange rate.

The findings of this study suggest that ERPT is relatively high in the first stage of pass-through, but begins to decline at each subsequent price level of the pass-through chain. Furthermore, the findings also indicated that the inflationary impact of exchange rate fluctuations, particularly rand depreciations, are absorbed at the intermediate stage of production, and that shocks to producer prices have a significant impact on consumer prices. Thus, the South African policymakers, particularly the SARB, would better achieve their goals of price stabilisation and maintaining an inflation target of between 3 and 6 percent by implementing policies and strategies oriented towards eliminating inflationary pressures at the import and producer price levels. Besides the use of the repo rate, which has been an effective monetary policy tool in curbing inflation in South Africa, the SARB could reduce such inflationary pressures by establishing trust and confidence within the international and domestic business sectors. Such trust can be formed through various means, including the dissemination of medium-term numerical targets for inflation to business and the public at large; a firm commitment by the SARB to price stability as the main goal of monetary policy, to which other goals are subordinate; increased transparency within the SARB and the monetary policy strategy through efficient communication with the business sector and the general public about the plans, objectives and decisions of the Central Bank; and increased accountability of the SARB for attaining its inflation targets (Mishkin, 2001). However, although such a credible commitment to maintaining a low inflationary environment may have little or no effect on the pass-

through to import prices, which was found to be relatively high in this study, it may reduce the sensitivity of foreign and local firms to exchange rate changes and consequent price increases, resulting in lower pass-through to import, producer and consumer prices.

Furthermore, given that greater pass-through is realised during periods of rand depreciation, the SARB may need to forecast such periods based on the performance of the rand and the greater economy, and pre-plan their monetary policy stance to combat the inflationary pressures inherent in such episodes. This will improve the Central Bank's monetary policy timing and effectiveness in maintaining their inflation target. Alberola *et al*. (2000), show that the exchange rate and prices are jointly determined and that their co-movement may fluctuate across different types of shocks. Thus a recommendation to policymakers would be to identify the origins of the underlying shock(s) to the economy, and their impact on the exchange rate, as this would be essential in assessing the possible implications on domestic inflation, as well as the timing of the monetary policy response.

The findings of relatively high ERPT and the presence of the binding quantity constraints theory of asymmetric pass-through implies that much still needs to be done by trade and industry policy makers such as South Africa's Department of Trade and Industry to improve the competitiveness of South African markets. The results suggest that the country's markets are largely oligopolistic in nature, whereas establishing more competitive markets in South Africa could contribute immensely to the growth of the economy and the socioeconomic wellbeing of the South African people. Glatzer *et al*. (2006) find some theoretical and empirical evidence suggesting that globalisation may have reduced inflation, particularly in high-income countries, and show that the effect of increased global competition on producer prices in Austria moderately dampened relative producer prices in the Austrian manufacturing sector. A lesson that can be taken from this, given the findings of this thesis, is that South African monetary, fiscal and trade and industry authorities must work together to improve the global competitiveness of the country, which may have a beneficial impact of lowering inflation in the country. Institutions such as South Africa's Industrial Development Corporation (IDC) and the South African Development Fund

should be encouraged and supported to increase local participation in South Africa's business sector, and spur on competition within the country's markets.

6.3 Limitations of the Study and Areas for Further Research

Various methods, techniques and data specifications have been used to study ERPT in developed and developing countries. However, the availability of data, especially for emerging markets such as South Africa, continues to be a challenge for researchers, as was found to be the case in the process of carrying out this study. The implication of this was that some variables listed in the empirical model had to be excluded or proxies were found or constructed, such as exporters' production costs (EPC). The downside of such measures is that the model may not accurately capture the phenomenon under review. Furthermore, the use of proxies may not correctly represent the characteristics and behaviour of the actual variable, which may result in incorrect findings. Nonetheless, these problems did not significantly affect the findings of this study as the results reported were generally consistent with the theoretical literature as well as other empirical research on South Africa.

This study analysed the pass-through of exchange rate changes to import, producer and consumer prices. However, with regard to the asymmetry of pass-through, only the first stage of ERPT was investigated. As in the few studies on pass-through asymmetry, this thesis has left a gap in the analysis of ERPT asymmetry with respect to producer and consumer prices. Given the fact that, in South Africa, indirect channels of pass-through are present, from exchange rate shocks to producer and consumer prices separately, it may be important for policy purposes to research the respective asymmetries of these pass-through channels. Other areas for further research include investigating the effect of exchange rate volatility on the pass-through to domestic prices, and also exploring the pass-through in South Africa at a more disaggregated level using industry or sector-specific data.

6.4 Conclusion

This study set out to investigate the long run symmetric and asymmetric ERPT in South Africa. This was done against the backdrop of the need to ensure a credible inflation targeting framework, in the face of market determined exchange rates and

the ever-increasing liberal trade policy with the concomitant increase in imports into South Africa. The study estimated different models of symmetric and asymmetric ERPT using the Johansen maximum likelihood approach and quarterly data from 1980:1 to 2005:4.

The results show that long-run symmetric exchange rate pass-through to import prices is incomplete but relatively high. However, the rate of pass-through decreases from one price level to the next. The high pass-through of exchange rate changes to import prices highlights the vulnerability of the South Africa economy in the face of liberal exchange rate policies and the increasing openness of the economy. While it is not being advocated here that some control measures be adopted both in exchange rate and trade policies, it would, however, not be imprudent to monitor the development of exchange movements carefully so as to take prompt monetary policy action, in order to stem any inflation pressure from the external sector. The results also confirm a significant asymmetry with respect to the direction of change in exchange rates, with pass-through greater when the value of the rand falls than when it appreciates. This further suggests that in monitoring the movement of the rand, particular attention should be paid to developments that could lead to a fall in its value. The fact that the results show that there was no significant asymmetry with respect to the size of the change in exchange rates suggests that, in monitoring exchange rate movement, attention should not only be focused on large changes but also on relatively small changes.

As the quest for greater understanding of the influence of exchange rate changes on prices continues, it is recommended that future research on ERPT in South Africa could *inter alia* explore: (1) the pass-through from exchange rates through import prices to producer and consumer prices. In each of these stages, both the symmetric and asymmetric pass-through may be considered. (2) The effect of volatility of the exchange rate on the pass-through to domestic prices. (3) Since some empirical studies have shown that the pass-through may differ from one industry to another in a country, it may be necessary to explore the pass-through in South Africa at a more disaggregated level using industry or sector-specific data.

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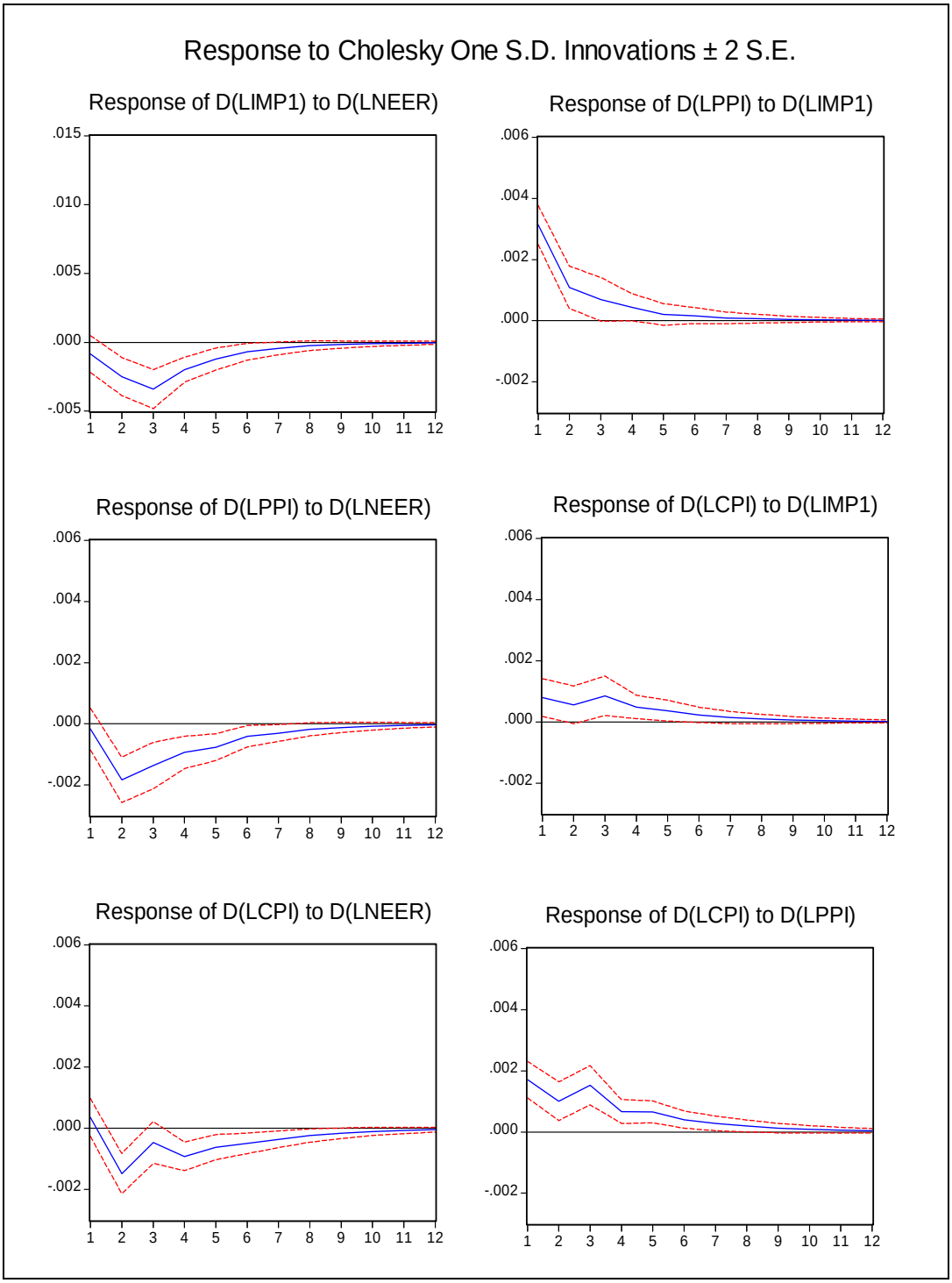
8. APPENDICES

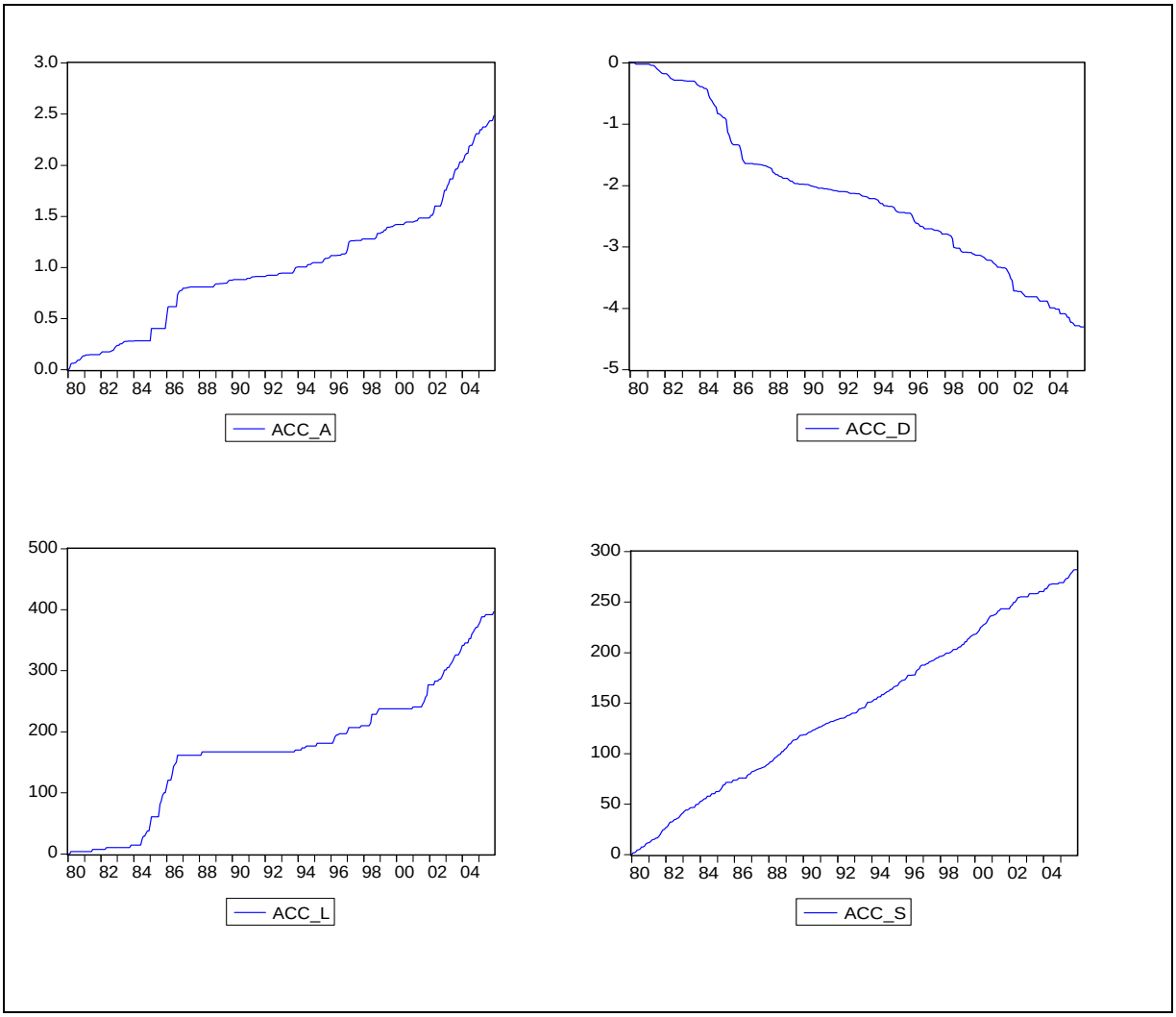
APPENDIX 1: Impulse Response test results

Figure A.1: Impulse Response Functions



APPENDIX 2: Graphical plots of Asymmetry series

Figure A.2: Plots of the ACC_A, ACC_D, ACC_L and ACC_S: 1980:1 – 2005:12



APPENDIX 3: South African Data used in the regressions

YEAR	LNEER	LIMP1	LPPI	LCPI	LEPC1	LEPC2	LEPC3
1980M1	6.38	2.64	2.51	2.31	3.03	2.78	2.97
1980M2	6.40	2.65	2.53	2.32	3.04	2.79	2.98
1980M3	6.44	2.65	2.53	2.33	3.05	2.80	2.98
1980M4	6.44	2.67	2.54	2.34	3.05	2.81	2.99
1980M5	6.43	2.67	2.56	2.35	3.04	2.79	2.98
1980M6	6.43	2.69	2.57	2.37	3.04	2.79	2.98
1980M7	6.44	2.71	2.59	2.39	3.05	2.80	2.99
1980M8	6.46	2.70	2.61	2.39	3.05	2.81	3.00
1980M9	6.46	2.71	2.63	2.42	3.05	2.80	3.00
1980M10	6.46	2.73	2.65	2.43	3.05	2.80	3.01
1980M11	6.49	2.74	2.65	2.44	3.06	2.81	3.03
1980M12	6.50	2.75	2.66	2.46	3.06	2.81	3.03
1981M1	6.50	2.76	2.67	2.46	3.07	2.82	3.04
1981M2	6.51	2.76	2.67	2.48	3.07	2.83	3.04
1981M3	6.49	2.77	2.67	2.48	3.08	2.83	3.04
1981M4	6.48	2.77	2.69	2.48	3.09	2.84	3.06
1981M5	6.49	2.77	2.69	2.49	3.10	2.85	3.06
1981M6	6.47	2.78	2.70	2.50	3.10	2.86	3.06
1981M7	6.44	2.80	2.72	2.53	3.12	2.87	3.07
1981M8	6.43	2.80	2.74	2.54	3.12	2.87	3.07
1981M9	6.40	2.82	2.74	2.56	3.12	2.87	3.07
1981M10	6.38	2.83	2.76	2.57	3.12	2.88	3.08
1981M11	6.36	2.83	2.76	2.58	3.12	2.87	3.08
1981M12	6.35	2.84	2.77	2.59	3.12	2.87	3.08
1982M1	6.37	2.86	2.78	2.59	3.13	2.88	3.10
1982M2	6.38	2.87	2.80	2.60	3.14	2.89	3.10
1982M3	6.35	2.87	2.80	2.62	3.14	2.89	3.10
1982M4	6.33	2.89	2.82	2.64	3.14	2.90	3.10
1982M5	6.30	2.91	2.83	2.65	3.14	2.89	3.09
1982M6	6.29	2.93	2.84	2.65	3.14	2.90	3.09
1982M7	6.28	2.95	2.85	2.66	3.15	2.90	3.10
1982M8	6.28	2.96	2.86	2.67	3.15	2.90	3.09
1982M9	6.29	2.97	2.87	2.69	3.15	2.90	3.09
1982M10	6.29	2.99	2.89	2.70	3.15	2.90	3.09
1982M11	6.32	3.00	2.90	2.72	3.15	2.90	3.09
1982M12	6.33	3.01	2.90	2.72	3.14	2.89	3.09
1983M1	6.34	3.01	2.91	2.72	3.14	2.89	3.09
1983M2	6.33	3.02	2.92	2.74	3.14	2.89	3.10
1983M3	6.34	3.02	2.92	2.75	3.14	2.89	3.10
1983M4	6.34	3.03	2.93	2.76	3.15	2.90	3.10

1983M5	6.35	3.03	2.94	2.77	3.14	2.89	3.09
1983M6	6.36	3.03	2.94	2.77	3.15	2.90	3.10
1983M7	6.37	3.04	2.94	2.78	3.15	2.90	3.10
1983M8	6.37	3.04	2.96	2.79	3.16	2.91	3.10
1983M9	6.37	3.04	2.96	2.80	3.16	2.91	3.11
1983M10	6.34	3.04	2.97	2.80	3.16	2.91	3.11
1983M11	6.31	3.03	2.97	2.82	3.16	2.91	3.11
1983M12	6.30	3.04	2.98	2.82	3.16	2.91	3.11
1984M1	6.28	3.05	2.98	2.82	3.17	2.92	3.12
1984M2	6.28	3.05	2.99	2.83	3.17	2.92	3.12
1984M3	6.27	3.06	2.99	2.85	3.17	2.92	3.12
1984M4	6.25	3.07	3.00	2.86	3.17	2.92	3.12
1984M5	6.25	3.07	3.01	2.87	3.18	2.93	3.13
1984M6	6.23	3.10	3.02	2.88	3.18	2.93	3.13
1984M7	6.13	3.10	3.02	2.89	3.18	2.93	3.13
1984M8	6.08	3.12	3.04	2.90	3.19	2.94	3.12
1984M9	6.06	3.15	3.04	2.91	3.19	2.94	3.13
1984M10	6.01	3.16	3.06	2.92	3.20	2.95	3.13
1984M11	5.97	3.18	3.08	2.93	3.19	2.94	3.12
1984M12	5.95	3.19	3.08	2.94	3.20	2.95	3.13
1985M1	5.84	3.21	3.10	2.95	3.21	2.96	3.14
1985M2	5.96	3.24	3.13	2.99	3.22	2.97	3.14
1985M3	5.94	3.26	3.14	2.99	3.22	2.97	3.15
1985M4	5.92	3.26	3.14	3.01	3.21	2.96	3.14
1985M5	5.89	3.30	3.16	3.02	3.21	2.96	3.14
1985M6	5.89	3.31	3.17	3.04	3.21	2.96	3.14
1985M7	5.86	3.33	3.18	3.04	3.20	2.95	3.13
1985M8	5.66	3.34	3.19	3.05	3.19	2.94	3.12
1985M9	5.61	3.34	3.20	3.06	3.19	2.94	3.12
1985M10	5.52	3.35	3.22	3.08	3.18	2.93	3.12
1985M11	5.48	3.43	3.26	3.09	3.17	2.92	3.11
1985M12	5.45	3.46	3.28	3.11	3.17	2.92	3.11
1986M1	5.57	3.49	3.30	3.14	3.16	2.91	3.12
1986M2	5.66	3.50	3.31	3.15	3.15	2.90	3.11
1986M3	5.67	3.51	3.31	3.16	3.15	2.90	3.10
1986M4	5.66	3.51	3.33	3.18	3.14	2.89	3.10
1986M5	5.57	3.51	3.34	3.18	3.14	2.89	3.10
1986M6	5.43	3.50	3.35	3.19	3.14	2.89	3.10
1986M7	5.40	3.52	3.36	3.21	3.13	2.88	3.10
1986M8	5.36	3.53	3.38	3.22	3.13	2.88	3.09
1986M9	5.47	3.53	3.38	3.24	3.13	2.88	3.10
1986M10	5.50	3.55	3.40	3.25	3.13	2.88	3.10
1986M11	5.51	3.56	3.42	3.27	3.14	2.89	3.10
1986M12	5.52	3.58	3.43	3.28	3.14	2.89	3.10
1987M1	5.54	3.58	3.44	3.29	3.13	2.88	3.10
1987M2	5.53	3.58	3.45	3.30	3.13	2.88	3.09
1987M3	5.53	3.59	3.46	3.32	3.13	2.88	3.10
1987M4	5.54	3.61	3.47	3.33	3.13	2.88	3.10
1987M5	5.53	3.61	3.48	3.34	3.13	2.88	3.10
1987M6	5.54	3.62	3.48	3.35	3.13	2.88	3.10
1987M7	5.53	3.63	3.49	3.36	3.14	2.89	3.11
1987M8	5.53	3.63	3.50	3.37	3.14	2.89	3.11
1987M9	5.52	3.64	3.51	3.39	3.14	2.89	3.12
1987M10	5.52	3.64	3.53	3.40	3.14	2.89	3.11

1987M11	5.50	3.64	3.53	3.41	3.13	2.88	3.11
1987M12	5.49	3.65	3.54	3.41	3.13	2.88	3.10
1988M1	5.48	3.66	3.55	3.42	3.13	2.88	3.12
1988M2	5.46	3.66	3.57	3.43	3.13	2.88	3.11
1988M3	5.41	3.67	3.58	3.44	3.13	2.88	3.11
1988M4	5.40	3.69	3.59	3.45	3.14	2.89	3.13
1988M5	5.37	3.71	3.60	3.46	3.15	2.90	3.14
1988M6	5.37	3.72	3.61	3.47	3.15	2.90	3.14
1988M7	5.35	3.73	3.62	3.48	3.17	2.91	3.16
1988M8	5.34	3.75	3.63	3.49	3.17	2.92	3.16
1988M9	5.34	3.76	3.64	3.50	3.17	2.92	3.17
1988M10	5.31	3.77	3.65	3.51	3.17	2.92	3.17
1988M11	5.31	3.77	3.66	3.52	3.16	2.91	3.16
1988M12	5.33	3.78	3.67	3.53	3.16	2.91	3.16
1989M1	5.34	3.78	3.69	3.55	3.17	2.92	3.17
1989M2	5.32	3.81	3.71	3.56	3.17	2.92	3.17
1989M3	5.30	3.83	3.72	3.57	3.18	2.93	3.17
1989M4	5.30	3.85	3.74	3.59	3.18	2.93	3.17
1989M5	5.28	3.87	3.75	3.60	3.19	2.94	3.18
1989M6	5.26	3.89	3.75	3.61	3.20	2.95	3.18
1989M7	5.26	3.90	3.76	3.62	3.19	2.94	3.18
1989M8	5.26	3.90	3.78	3.64	3.19	2.94	3.17
1989M9	5.25	3.91	3.78	3.64	3.19	2.94	3.18
1989M10	5.27	3.91	3.79	3.65	3.19	2.94	3.18
1989M11	5.28	3.91	3.80	3.66	3.19	2.94	3.17
1989M12	5.28	3.91	3.81	3.68	3.19	2.94	3.18
1990M1	5.28	3.93	3.82	3.69	3.20	2.95	3.18
1990M2	5.28	3.94	3.83	3.70	3.20	2.94	3.18
1990M3	5.28	3.95	3.83	3.71	3.20	2.95	3.18
1990M4	5.27	3.95	3.84	3.72	3.21	2.96	3.19
1990M5	5.26	3.94	3.86	3.73	3.20	2.95	3.18
1990M6	5.26	3.95	3.86	3.74	3.20	2.95	3.18
1990M7	5.25	3.93	3.86	3.75	3.20	2.95	3.18
1990M8	5.24	3.93	3.87	3.76	3.20	2.95	3.18
1990M9	5.24	3.94	3.89	3.78	3.20	2.95	3.19
1990M10	5.22	4.01	3.90	3.78	3.20	2.95	3.19
1990M11	5.22	4.09	3.94	3.80	3.19	2.94	3.19
1990M12	5.23	4.06	3.93	3.81	3.20	2.94	3.19
1991M1	5.23	4.09	3.95	3.82	3.20	2.95	3.19
1991M2	5.23	4.08	3.96	3.84	3.20	2.94	3.19
1991M3	5.24	4.04	3.95	3.84	3.20	2.95	3.19
1991M4	5.24	4.02	3.96	3.86	3.20	2.95	3.19
1991M5	5.23	4.02	3.96	3.87	3.20	2.95	3.19
1991M6	5.23	4.02	3.97	3.88	3.21	2.95	3.19
1991M7	5.23	4.04	3.98	3.89	3.21	2.96	3.19
1991M8	5.22	4.04	3.98	3.91	3.21	2.96	3.19
1991M9	5.21	4.04	3.99	3.92	3.20	2.95	3.19
1991M10	5.21	4.06	4.01	3.94	3.20	2.95	3.19
1991M11	5.21	4.07	4.01	3.95	3.20	2.95	3.19
1991M12	5.20	4.08	4.02	3.96	3.19	2.94	3.18
1992M1	5.20	4.07	4.02	3.97	3.19	2.94	3.18
1992M2	5.21	4.07	4.02	3.98	3.20	2.95	3.19
1992M3	5.21	4.08	4.03	3.99	3.20	2.95	3.19
1992M4	5.21	4.08	4.04	4.00	3.21	2.96	3.19

1992M5	5.21	4.08	4.05	4.01	3.21	2.95	3.19
1992M6	5.20	4.08	4.06	4.02	3.20	2.95	3.19
1992M7	5.19	4.10	4.06	4.03	3.20	2.95	3.19
1992M8	5.18	4.10	4.07	4.04	3.20	2.95	3.19
1992M9	5.18	4.11	4.08	4.05	3.20	2.94	3.19
1992M10	5.18	4.10	4.08	4.05	3.19	2.94	3.19
1992M11	5.19	4.11	4.08	4.05	3.20	2.95	3.19
1992M12	5.19	4.11	4.09	4.05	3.20	2.95	3.19
1993M1	5.20	4.11	4.09	4.06	3.21	2.96	3.19
1993M2	5.19	4.13	4.10	4.07	3.21	2.96	3.20
1993M3	5.18	4.13	4.10	4.08	3.22	2.96	3.19
1993M4	5.16	4.13	4.11	4.11	3.21	2.96	3.19
1993M5	5.15	4.14	4.11	4.11	3.21	2.96	3.19
1993M6	5.15	4.15	4.12	4.12	3.20	2.95	3.19
1993M7	5.14	4.14	4.12	4.12	3.21	2.96	3.19
1993M8	5.14	4.15	4.13	4.13	3.21	2.96	3.19
1993M9	5.11	4.14	4.13	4.13	3.21	2.95	3.19
1993M10	5.13	4.14	4.14	4.14	3.21	2.96	3.19
1993M11	5.17	4.15	4.14	4.14	3.21	2.96	3.19
1993M12	5.17	4.15	4.15	4.15	3.21	2.96	3.20
1994M1	5.17	4.15	4.15	4.16	3.22	2.97	3.20
1994M2	5.16	4.16	4.16	4.16	3.21	2.96	3.20
1994M3	5.15	4.16	4.16	4.17	3.21	2.96	3.20
1994M4	5.12	4.16	4.17	4.17	3.22	2.97	3.20
1994M5	5.10	4.18	4.19	4.18	3.22	2.97	3.21
1994M6	5.09	4.19	4.19	4.19	3.22	2.97	3.20
1994M7	5.06	4.21	4.21	4.20	3.22	2.97	3.20
1994M8	5.08	4.22	4.23	4.22	3.22	2.97	3.21
1994M9	5.08	4.23	4.23	4.23	3.22	2.97	3.21
1994M10	5.07	4.21	4.23	4.23	3.22	2.97	3.21
1994M11	5.09	4.22	4.23	4.24	3.22	2.97	3.22
1994M12	5.09	4.22	4.24	4.24	3.23	2.97	3.22
1995M1	5.09	4.23	4.25	4.25	3.24	2.98	3.23
1995M2	5.07	4.24	4.26	4.26	3.24	2.98	3.23
1995M3	5.03	4.25	4.27	4.27	3.23	2.98	3.23
1995M4	5.01	4.26	4.28	4.28	3.23	2.98	3.23
1995M5	5.00	4.27	4.29	4.28	3.23	2.98	3.24
1995M6	4.99	4.28	4.29	4.28	3.23	2.98	3.24
1995M7	5.00	4.27	4.30	4.29	3.24	2.98	3.24
1995M8	5.03	4.28	4.30	4.29	3.24	2.99	3.24
1995M9	5.04	4.28	4.30	4.29	3.25	3.00	3.25
1995M10	5.03	4.27	4.31	4.29	3.25	2.99	3.25
1995M11	5.03	4.27	4.31	4.30	3.25	3.00	3.25
1995M12	5.03	4.27	4.32	4.31	3.25	3.00	3.25
1996M1	5.05	4.28	4.32	4.32	3.25	3.00	3.25
1996M2	5.02	4.29	4.33	4.32	3.25	3.00	3.25
1996M3	4.98	4.29	4.32	4.33	3.25	3.00	3.25
1996M4	4.92	4.29	4.34	4.33	3.26	3.00	3.25
1996M5	4.88	4.31	4.35	4.34	3.25	3.00	3.25
1996M6	4.89	4.32	4.35	4.35	3.25	3.00	3.25
1996M7	4.87	4.32	4.36	4.36	3.25	2.99	3.25
1996M8	4.84	4.32	4.37	4.36	3.24	2.99	3.24
1996M9	4.85	4.32	4.37	4.37	3.25	2.99	3.24
1996M10	4.84	4.35	4.39	4.38	3.25	2.99	3.24

1996M11	4.81	4.34	4.39	4.38	3.24	2.99	3.24
1996M12	4.82	4.36	4.40	4.39	3.24	2.99	3.24
1997M1	4.85	4.37	4.41	4.41	3.24	2.99	3.24
1997M2	4.92	4.39	4.41	4.41	3.25	3.00	3.24
1997M3	4.94	4.38	4.42	4.42	3.25	3.00	3.24
1997M4	4.94	4.35	4.42	4.43	3.25	3.00	3.24
1997M5	4.92	4.38	4.43	4.43	3.24	2.99	3.24
1997M6	4.92	4.36	4.43	4.43	3.24	2.99	3.24
1997M7	4.92	4.36	4.43	4.44	3.24	2.99	3.24
1997M8	4.92	4.35	4.43	4.45	3.24	2.99	3.24
1997M9	4.90	4.36	4.43	4.45	3.24	2.99	3.24
1997M10	4.89	4.36	4.44	4.45	3.24	2.99	3.24
1997M11	4.86	4.36	4.44	4.45	3.24	2.99	3.24
1997M12	4.87	4.37	4.44	4.45	3.24	2.99	3.24
1998M1	4.87	4.37	4.44	4.46	3.24	2.99	3.23
1998M2	4.87	4.36	4.44	4.47	3.23	2.98	3.23
1998M3	4.87	4.36	4.44	4.47	3.23	2.98	3.23
1998M4	4.85	4.36	4.45	4.48	3.23	2.98	3.23
1998M5	4.84	4.37	4.45	4.48	3.24	2.98	3.23
1998M6	4.80	4.37	4.45	4.48	3.24	2.99	3.23
1998M7	4.65	4.41	4.46	4.51	3.23	2.98	3.22
1998M8	4.65	4.41	4.47	4.52	3.23	2.98	3.22
1998M9	4.64	4.43	4.48	4.54	3.22	2.97	3.21
1998M10	4.65	4.44	4.48	4.54	3.21	2.96	3.21
1998M11	4.69	4.44	4.49	4.54	3.21	2.96	3.21
1998M12	4.64	4.43	4.48	4.54	3.21	2.95	3.20
1999M1	4.63	4.43	4.48	4.55	3.20	2.95	3.20
1999M2	4.64	4.42	4.49	4.55	3.20	2.95	3.20
1999M3	4.64	4.43	4.49	4.55	3.20	2.95	3.20
1999M4	4.66	4.43	4.50	4.55	3.21	2.95	3.20
1999M5	4.66	4.45	4.51	4.55	3.21	2.95	3.20
1999M6	4.68	4.47	4.52	4.55	3.21	2.95	3.20
1999M7	4.68	4.48	4.52	4.56	3.21	2.96	3.20
1999M8	4.66	4.49	4.53	4.55	3.20	2.95	3.20
1999M9	4.66	4.50	4.53	4.56	3.20	2.95	3.20
1999M10	4.65	4.50	4.54	4.56	3.20	2.95	3.20
1999M11	4.66	4.51	4.55	4.56	3.20	2.95	3.20
1999M12	4.66	4.53	4.55	4.56	3.20	2.95	3.20
2000M1	4.67	4.55	4.56	4.57	3.20	2.95	3.21
2000M2	4.66	4.56	4.57	4.57	3.21	2.96	3.21
2000M3	4.64	4.57	4.57	4.58	3.21	2.96	3.21
2000M4	4.63	4.58	4.59	4.59	3.21	2.96	3.21
2000M5	4.60	4.58	4.59	4.60	3.22	2.97	3.22
2000M6	4.59	4.60	4.60	4.60	3.22	2.97	3.22
2000M7	4.60	4.61	4.61	4.61	3.22	2.97	3.22
2000M8	4.61	4.63	4.62	4.62	3.22	2.97	3.22
2000M9	4.60	4.62	4.62	4.62	3.23	2.97	3.22
2000M10	4.57	4.64	4.63	4.63	3.23	2.97	3.22
2000M11	4.55	4.65	4.64	4.63	3.23	2.97	3.23
2000M12	4.53	4.67	4.65	4.63	3.23	2.97	3.22
2001M1	4.50	4.67	4.65	4.64	3.23	2.98	3.23
2001M2	4.50	4.67	4.66	4.65	3.23	2.98	3.23
2001M3	4.51	4.68	4.66	4.65	3.23	2.98	3.23
2001M4	4.50	4.69	4.67	4.66	3.23	2.98	3.23

2001M5	4.52	4.69	4.68	4.66	3.23	2.98	3.22
2001M6	4.53	4.70	4.68	4.67	3.23	2.98	3.22
2001M7	4.51	4.70	4.69	4.66	3.23	2.97	3.22
2001M8	4.47	4.70	4.70	4.66	3.22	2.97	3.22
2001M9	4.42	4.71	4.70	4.67	3.21	2.96	3.21
2001M10	4.35	4.72	4.71	4.66	3.21	2.96	3.21
2001M11	4.32	4.72	4.72	4.67	3.21	2.95	3.21
2001M12	4.15	4.75	4.73	4.68	3.21	2.96	3.21
2002M1	4.15	4.80	4.76	4.69	3.22	2.97	3.21
2002M2	4.18	4.82	4.78	4.70	3.22	2.97	3.21
2002M3	4.17	4.84	4.79	4.71	3.22	2.97	3.21
2002M4	4.20	4.85	4.81	4.73	3.23	2.97	3.21
2002M5	4.26	4.85	4.82	4.74	3.22	2.97	3.21
2002M6	4.23	4.84	4.82	4.74	3.22	2.97	3.21
2002M7	4.21	4.85	4.83	4.76	3.21	2.96	3.21
2002M8	4.18	4.85	4.84	4.76	3.22	2.96	3.21
2002M9	4.17	4.86	4.84	4.77	3.22	2.96	3.21
2002M10	4.20	4.87	4.85	4.79	3.22	2.96	3.21
2002M11	4.26	4.87	4.85	4.79	3.21	2.96	3.21
2002M12	4.32	4.84	4.84	4.79	3.22	2.96	3.21
2003M1	4.33	4.85	4.84	4.80	3.22	2.97	3.22
2003M2	4.36	4.84	4.84	4.80	3.22	2.97	3.22
2003M3	4.39	4.84	4.84	4.81	3.23	2.97	3.22
2003M4	4.43	4.83	4.84	4.81	3.22	2.97	3.22
2003M5	4.40	4.80	4.83	4.81	3.22	2.97	3.22
2003M6	4.36	4.81	4.84	4.81	3.22	2.97	3.22
2003M7	4.43	4.78	4.85	4.81	3.22	2.97	3.22
2003M8	4.46	4.78	4.84	4.81	3.22	2.97	3.22
2003M9	4.46	4.78	4.83	4.81	3.22	2.97	3.22
2003M10	4.48	4.77	4.83	4.80	3.21	2.96	3.22
2003M11	4.53	4.77	4.83	4.79	3.21	2.96	3.22
2003M12	4.49	4.76	4.83	4.80	3.21	2.96	3.22
2004M1	4.42	4.75	4.83	4.80	3.21	2.96	3.22
2004M2	4.45	4.76	4.83	4.81	3.21	2.96	3.23
2004M3	4.49	4.76	4.83	4.81	3.22	2.97	3.24
2004M4	4.51	4.77	4.84	4.82	3.22	2.97	3.24
2004M5	4.48	4.77	4.84	4.82	3.23	2.98	3.24
2004M6	4.55	4.77	4.85	4.82	3.23	2.97	3.24
2004M7	4.56	4.76	4.85	4.82	3.23	2.98	3.24
2004M8	4.49	4.76	4.85	4.82	3.23	2.98	3.24
2004M9	4.52	4.76	4.84	4.82	3.24	2.98	3.25
2004M10	4.56	4.77	4.85	4.83	3.24	2.99	3.25
2004M11	4.60	4.77	4.85	4.83	3.24	2.99	3.25
2004M12	4.59	4.76	4.84	4.83	3.23	2.98	3.25
2005M1	4.54	4.76	4.84	4.83	3.24	2.98	3.25
2005M2	4.58	4.75	4.84	4.83	3.24	2.99	3.25
2005M3	4.50	4.76	4.85	4.84	3.25	2.99	3.26
2005M4	4.52	4.78	4.86	4.85	3.25	2.99	3.26
2005M5	4.51	4.79	4.86	4.85	3.24	2.99	3.26
2005M6	4.47	4.80	4.88	4.85	3.25	2.99	3.26
2005M7	4.49	4.81	4.89	4.86	3.26	3.00	3.27
2005M8	4.51	4.82	4.89	4.86	3.26	3.00	3.27
2005M9	4.53	4.83	4.89	4.86	3.26	3.00	3.27
2005M10	4.51	4.83	4.89	4.86	3.26	3.01	3.28

2005M11	4.51	4.82	4.89	4.86	3.26	3.01	3.27
2005M12	4.56	4.82	4.89	4.86	3.26	3.01	3.28

Sources: IFS and SARB