Exchange rate pass-through to import prices in South Africa: Is there asymmetry?

T D Karoro, M J Aziakpono & N Cattaneo

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Exchange Rate Pass-through to Import Prices in South Africa: Is there Asymmetry?*

T D Karoro[†], M J Aziakpono[‡] and N Cattaneo[§]

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Abstract

This paper examines the magnitude and speed of exchange rate pass-through to import prices in South Africa. It further 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 findings of the study 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 evidence to suggest that pass-through is slightly higher in periods of small changes than large changes in the exchange rate in harmony with the menu cost theory when the invoices are denominated in the exporters' currency.

Keywords: Exchange rate pass-through, Asymmetric pass-through, VECM, South Africa

JEL Classification: C32, E31

1 Introduction

The need to attain low inflation levels and price stability has led many central banks around the world to adopt inflation targeting monetary policy frameworks. This requires that countries monitor and, where possible, influence the determinants of inflation using monetary policy instruments. A major determinant of inflation is exchange rate movement. Both theoretical and empirical literature (for example, Branson, 1972; Kreinin, 1977; Mann, 1986; Dornbusch, 1987; Krugman, 1987; Feinberg, 1989, 1991; Menon, 1996; Devereux and Yetman, 2003; Kara and Nelson, 2003) suggest that a country's exchange rate fluctuations could significantly affect the level of inflation, especially when a country has a floating exchange rate as well as an open trade policy, allowing for a significant amount of imports (SARB, 2001). The transmission of exchange rate fluctuations to domestic prices is referred to as exchange rate pass-through (ERPT).

Following the current trend, South Africa formally adopted inflation targeting in 2000. In South Africa, exchange rate regimes have also evolved from being fixed, to managed-floating, to free-floating in recent years. In addition, South Africa has increasingly adopted a more liberal trade policy with a resultant increase in imports. This has left South Africa vulnerable to the effects of exchange rate changes on import, producer and consumer prices (SARB, 2001).

From a theoretical point of view, a number of other factors may affect the sensitivity of domestic prices to exchange rate movements. These include the behaviour of exporting firms which may adopt pricing-to-market strategies (Krugman 1987; Mann, 1986; Khosla and Treanishi, 1989; Marston 1990;

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[†]Department of Economics and Economic History, Rhodes University

[‡]Department of Economics and Economic History, Rhodes University

[§]Department of Economics and Economic History, Rhodes University

Kadiyali, 1997), specific industry and market characteristics - market share and competitiveness (Woo, 1984; Hooper and Mann, 1989; Knetter 1994), and the perceived nature of exchange rate changes - appreciation versus depreciation or whether the change is large or small (Knetter, 1994; Pollard and Coughlin, 2003; Wickremasignghe and Silvapulle, 2004). The upshot of these theories is that exchange rate pass-through may be complete or partial depending on the prevailing economic environment.

The response of prices to the direction and size of exchange rate changes is generally referred to as asymmetric or nonlinear price adjustment (Pollard and Coughlin, 2004). Several theoretical arguments have also been proposed for possible asymmetric adjustment in prices, such as market share, production switching, quantity constraints, and menu costs (Ware and Winter, 1988; Marston, 1990; Knetter, 1994; Webber, 2000; Pollard and Coughlin, 2003). 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 (Marston, 1990; Knetter, 1994), although this is debatable given that prices are generally sticky downwards. According to Pollard and Coughlin (2003), 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 that the asymmetry of ERPT depends on the size of a 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 the 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 the threshold defined as small (Pollard and Coughlin, 2003).

A large and growing body of empirical research has appeared that investigates the speed or magnitude and asymmetry of ERPT, albeit with much focus on industrialised nations such as the USA, the UK and other members of the European Union. With specific reference to the speed and magnitude of ERPT, examples include Woo (1984), Feinberg (1989), Goldberg and Knetter (1997), Kim (1998), Gagnon and Ihrig (2001) Campa and Goldberg (2002), Yang *et al.* (2004) and Campa *et al.* (2005), to mention a few. Menon (1995) conducted a comprehensive survey of some 43 empirical studies on exchange rate pass-through in both industrialised and developing 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), and Kiptui *et al.* (2005) investigate ERPT in emerging and developing countries.

The findings of the studies on the speed and magnitude of ERPT can be summarised into four elements. Firstly, in terms of the degree and dynamics of ERPT, Menon (1995) finds that incomplete pass-through is a common phenomenon. Secondly, 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. Most of the studies employ the conventional OLS method but a few, such as Kim (1998), use the vector autoregressive (VAR) approach.

The last element relates to the stability of the pass-through relationship over time. Of the studies that investigate this relationship[1], only a few note that the ERPT relationship remains stable throughout the period under study, while majority of the studies record structural breaks in their analysis.

Regarding ERPT asymmetry, the results from different studies have also been mixed. The most

[1] See Menon (1995: 226).

researched of the two asymmetric ERPTs is the direction of the change in the exchange rate, that is, appreciation versus depreciation. While some authors (Mann, 1986 and Feinberg, 1989 for the USA, and Athukorala, 1991 for Korea) fail to find significant asymmetry, others (Ohno, 1989, Marston, 1990 and Wickremasignghe and Silvapulle, 2004 for Japan) find evidence of significant asymmetry. Ohno's (1989) findings support the binding quantity constraint model of ERPT asymmetry, whereas Marston's (1990) findings support the market share model as well as the production switching model. Similarly, Goldberg (1995) and Kadiyali (1997), who investigate ERPT asymmetry in a single USA industry, find significant asymmetry. Both studies report that ERPT is higher when the dollar depreciates, a finding consistent with the binding quantity constraint theory. Likewise, Webber (2000), using aggregate trade data, finds significant support for asymmetric ERPT to 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, supporting the binding quantity constraint model of asymmetric pass-through.

Studies on ERPT with respect to size of change are quite scanty. One such study is Pollard and Coughlin (2004) which, in addition to investigating the magnitude and direction of ERPT, analyses the size effect of a change in the exchange rate. The authors find significant size effects on ERPT, with the pass-through significantly greater when there are large changes in exchange rates. This led the authors to contend that menu cost behaviour matters in determining ERPT.

Despite the growing literature on ERPT around the world, very few studies can be found in the case of South Africa. These include 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 the adoption of a more market-oriented exchange rate system. Nell (2000:13) formulates price and wage equations which are estimated using distributed lag (DL) and autoregressive distributed lag (ARDL) models. The results suggest that the long-run pass-through estimates are 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[2]. Bhundia (2002: 5) defines ERPT 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 autoregressive (VAR) model. The results indicate that, while the average pass-through is low, evidence from the structural VAR model suggests that it is much higher for nominal than real shocks. Exchange rate shocks result in a steady increase over time in the level of CPIX. The pass-through elasticity resulting from shocks to producer price inflation is approximately 72 percent after eight quarters, suggesting that favorable shocks to producer price inflation could possibly bring CPIX inflation back to target (Bhundia, 2002: 5).

The third study, by SARB (2002), investigates the first stage of ERPT, that is, the relationship between changes in the exchange rate and the domestic currency price of imports in South Africa. The methodological approach is based on Johansen-type vector error-correction models (VECM). The results suggest that approximately 78 percent of an exchange rate change is passed through to import prices in South Africa in the long run, and that half of this adjustment occurs in just less than one year. The results further suggest that import prices adjust to equilibrium by approximately 6 percent of any disequilibrium in the long-run relationship each month.

The conflicting findings of empirical studies on the size, speed and asymmetric properties of ERPT call for further studies, especially in developing countries where such studies are currently scant. In particular, to our knowledge, no study of ERPT asymmetry is available for African

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

countries, hence the need to fill this gap.

With specific reference to South Africa, although two of the earlier studies (Nell, 2000; SARB, 2002) tend to agree on the magnitude of the symmetric pass-through they focus on, the passage of time since they were conducted calls for renewed investigation of the phenomenon in South Africa, given the dynamic changes in the macroeconomic environment. More importantly, as noted by Pollard and Coughlin (2004), where there is significant asymmetric pass-through (either size and/or direction), imposing symmetrical pass-through could bias the pass-through estimates. It therefore becomes necessary to examine this aspect, since none of the previous studies has investigated asymmetric ERPT in South Africa.

Against this backdrop, this study investigates ERPT to import prices as well as the pass-through asymmetry of exchange rate changes to import prices in South Africa.

The rest of the paper is organised as follows: Section 2 provides an overview of the South African macroeconomic and policy environment and its implications for symmetric and asymmetric pass-through of exchange rate changes to import prices. The methodology and data are discussed in Section 3, and Section 4 reports the findings of the empirical analysis. Section 5 summarises the study's major findings.

2 South Africa's exchange rate policies and the behaviour of the Rand and inflation: a brief overview

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 De Kock Commission suggested fundamental reform of the foreign exchange market and policies related to the market. Implementation of the recommendations of the Commission 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 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 Reserve Bank 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[3] in an attempt to discourage large outflows of foreign currency. 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).

According to Nell (2000:13), from 1973 – 1983, 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, 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, U.N. sanctions and the immediate stand-still of foreign debt repayments in 1985. The SARB was forced to revert to tighter foreign exchange controls. The financial rand which was abolished in 1983 was re-introduced in 1985 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 multiracial democratic elections in South Africa. The country once again became a borrower in world capital markets, and significant steps were made to

[3] 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).

relax exchange controls, such as the rescheduling of international debt repayments and the removal of the financial rand mentioned above (du Toit, 2005:27).

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. Figure 1 illustrates the trend of the nominal effective exchange rate versus that of import price from 1980 to 2005. Although the volatility of the rand increased significantly after the Reserve 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 for ERPT to import price is that latter will rise, as more rand are needed to purchase the same imported goods and services. This suggests that the cost implications of the depreciation of the rand have been passed on to import prices.

More specifically, Figure 2 plots changes in exchange rates and import price inflation in South Africa which better demonstrates the effects of the former on the latter. The graph shows that there has been both appreciation and depreciation of the rand of different magnitudes over time. What is evident is that most exchange rate depreciations are followed by an increase in import price inflation; likewise an appreciation of the exchange rate is accompanied by a fall in import prices. It is particularly noteworthy that whenever there was major rand depreciation, such as in 1984/85, 1997/8, 2001/2, there was a sharp rise in import price inflation. Likewise, episodes of significant appreciation, such as 1986/87, 1997 and 2003, were followed by a fall in import prices; however such price decreases were noticeably lower than the appreciation of the rand. In addition, episodes of small changes in exchange rates also elicited changes in import price inflation. The exact magnitude of the pass-through of exchange rate changes to import prices in all these cases can only be determined empirically.

3 Analytical Framework

3.1 *Modeling framework: Pass-through symmetry*

Following the convention in many empirical studies (see Dwyer *et al.*, 1994; Campa and Goldberg, 2002; SARB, 2002; Campa *et al.* 2005; Kiptui, *et al.* 2005), the transmission of exchange rate fluctuations to import prices is based on the Law of One Price. The Law of One Price 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. Therefore import prices (IMP) can be expressed as:

$$IMP = P * ER \tag{1}$$

where ER is the nominal exchange rate and P* is the world price of imports. Foreign producers of traded commodities are assumed to set their export prices (P*) with a mark-up (λ*) on their marginal cost of production in foreign currency terms (EPC). Thus the export price can be written as:

$$P* = \lambda * EPC \tag{2}$$

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

$$IMP = P * ER = EPC.ER \tag{3}$$

Equation (3) suggests that the local currency import prices are influenced by the foreign costs of production and the exchange rate. Thus the long-run pass-through of exchange rate changes to import prices can be estimated from a log-linear transformation of Equation (3) which allows for a constant, given as:

$$LogIMP = \beta_1 + \beta_2 LogEPC + \beta_3 LogER + \varepsilon_t \tag{4}$$

where ε_t is the stochastic error term, β_2 is the coefficient of exporters' production costs and β_3 represents the elasticity of the exchange rate pass-through to import prices. Thus, if the rand depreciates, that is a decrease in ER, import prices are expected to rise. As noted earlier, the magnitude of β_3 would depend on a number of factors such as exchange rate policy, trade policy, the behaviour of exporting firms, as well as the specific industry and market structure. Thus, it is expected that $0 \leq \beta_3 \leq 1$, such that 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 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 would be equivalent in magnitude to the exchange rate coefficient.

Equation (4) is transformed into an error correction model of the form shown in Equation (5), in order to estimate the short-run pass-through relationship:

$$\begin{aligned} \Delta LogIMP \quad = \quad & \alpha_0 + \sum_{i=1}^{k} \alpha_{1i} \Delta Log(IMP)_{t-i} + \sum_{i=1}^{k} \alpha_{2i} \Delta Log(EPC)_{t-i} + \\ & \sum_{i=1}^{k} \quad \alpha_{3i} \Delta Log(ER)_{t-i} + \delta ECM_{t-1} \end{aligned} \tag{5}$$

where Δ is a difference operator, $\alpha_{ji}$are the short-run adjustment terms and δECM is an error term. The ERPT represented in Equations (4) and (5) is the long run and short run symmetric pass-through, which does not take into account the direction and size of a change in exchange rate. This is considered next.

3.2 *Pass-through asymmetry: direction – appreciation versus depreciation*

In order to estimate ERPT asymmetry, we follow the approach used in Wickremasinghe and Silvapulle (2004). This requires that new variables be constructed to capture episodes 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 at time k can be expressed as:

$$ER_k = ER_0 + ER^A + ER^D \tag{6}$$

where ER_0 is the initial exchange rate,

$$ER^A \quad \equiv \quad \sum_{i=1}^{k} \theta (ER_i - ER_{i-1}) \tag{7}$$

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

$$ER^D \quad \equiv \quad \sum_{i=1}^{k} \theta^* (ER_i - ER_{i-1}) \tag{8}$$

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

Following Wickremasinghe and Silvapulle (2004), ER^A and ER^D are then represented as the accumulated sum of appreciation episodes (ACC_A) and accumulated sum of depreciation episodes (ACC_D) respectively.

Two alternative models are then 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 (9), 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 accumulated depreciation series (ACC_D) is included in the long-run pass-through Equation (4) to test for asymmetry:

$$LogIMP_t = \beta_1 + \beta_2 LogEPC_t + \beta_3 LogER_t + \beta_4 ACC\_D_t + \varepsilon_t \tag{9}$$

The second model (Equation 10) also follows Wickremasinghe and Silvapulle (2004). However, instead of including only one of the series relating to episodes 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 exchange rate variable (Log ER), thus:

$$LogIMP_t = \beta_5 + \beta_6 LogEPC_t + \beta_7 ACC\_A_t + \beta_8 ACC\_D_t + \varepsilon_t \tag{10}$$

In Equation (9) and (10) the tests of asymmetry are conducted as follows. In the case of Equations (9) β_3 and $(\beta_3 + \beta_4)$ are the appreciation and depreciation respectively. The presence of long run asymmetry is tested by placing a zero restriction on the coefficient of the accumulated depreciation episodes, i.e. $\beta_4 = 0$, where a rejection of the null hypothesis will imply that long run depreciation pass-through exists, hence there is asymmetry; the reverse is the case if it is rejected. On the other hand, in Equation (10) if there is asymmetry in ERPT, the null of $\beta_7 = \beta_8$ is rejected meaning that in the long run the direction of change (appreciation or depreciation) does matter for ERPT.

3.3 *Pass-through asymmetry: size – large versus small*

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)[4], where a large change is defined as being 3 percent and above, while a small change is below 3 percent:

$$L_t = \begin{cases} 1 when\, |\Delta \ln ER_k| \geq 3\% \\ 0 otherwise \end{cases} \quad and S_t = \begin{cases} 1 when\, |\Delta \ln ER_k| < 3\% \\ 0 otherwise \end{cases} \tag{11}$$

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

$$ER^L \equiv \sum_{i=1}^{k} \theta(ER_i - ER_{i-1}) \tag{12}$$

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

[4] 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.

$$ER^S \equiv \sum_{i=1}^{k} \theta^*(ER_i - ER_{i-1}) \quad (13)$$

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

Thus, ACC_L represents the accumulated sum of large exchange rate change episodes and ACC_S represents the accumulated sum of small change episodes. 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). In this analysis both small and large changes are included in separate equations given below:

$$LogIMP_t = \beta_9 + \beta_{10} LogEPC_t + \beta_{11} LogER_t + \beta_{12} ACC\_S_t + \varepsilon_t \quad (14)$$

$$LogIMP_t = \beta_{13} + \beta_{14} LogEPC_t + \beta_{15} LogER_t + \beta_{16} ACC\_L_t + \varepsilon_t \quad (15)$$

The test of asymmetry in both equations is carried out in a similar fashion to the one described for Equation (9) above.

3.4 *Definitions and sources of data*

The variables required for estimation of the models are: import prices (IMP), a measure of exchange rate (ER) and a proxy for exporters' production costs (EPC). The variables were all transformed into natural logarithms. The sample covers the period 1980:1 to 2005:12. Each of the variables in the analysis and their sources are described below.

IMP - is the import price series and is represented by an import price index. The index is seasonally adjusted with base 2000 = 100. The import price index is sourced from the SARB corresponding to series KBP7049N.

ER - the nominal effective exchange rate (NEER) is used as a proxy for the exchange rate variable. The index, expressed on the base 2000 = 100, represents the period-average of the rand to a weighted geometric average of the currencies of South Africa's main trading partners including the Euro area. The NEER is obtained from the IMF International Financial Statistics (2006), corresponding to line **nec.** The index is based on a methodology that accounts for each country's trade in both manufactured goods and primary products. The series is measured in foreign currency terms, thus an increase in this variable indicates an appreciation of the rand, while a decrease indicates depreciation.

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, the USA, UK and Japan. Three types of weights are used to construct three options of the EPC variable (EPC1, EPC2 and EPC3). EPC1 is based on the weight used by the SARB for calculating the nominal effective exchange rate (Macdonald and Ricci, 2003). EPC2 currency weights are alternative weights used by the SARB and are obtained from the SARB Quarterly Bulletin (2006: S103), while EPC3 weights were calculated by the authors based on the total annual average imports (1998 to 2005) to South Africa from all four countries and apportioning the weights according to the percentage contribution of total imports from each country[5]. The different weights are shown in Table 1 below. The export price indexes for all four countries are period averages (2000 = 100), reported in the IMF International Financial Statistics (2006).

[5] 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.

4 Empirical Results

4.1 *Symmetric ERPT*

The long-run symmetric and asymmetric models are estimated using the Johansen cointegration (1991) and (1995) methods. The initial step in employing the Johansen cointegration technique is to establish the order of integration of the series by undertaking stationarity tests to determine the existence, or not, of unit roots in the series. This study uses two formal unit root tests - the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) tests, and one stationarity test - the Kwiatkowski, Phillips, Schmidt and Shin (KPSS) test. Both trend and intercept are included in the test equations for all series using the three test types. The results are summarised in Table 2 below. All the estimations were carried out following the routine performed in E-views 5.

Based on the results of the formal unit root tests and stationarity test, which indicate that all the series are integrated of order one, we investigate the presence of cointegration relationships between the nominal effective exchange rate, import prices and exporters' production costs, as represented by Equation (4), in order to estimate the symmetric pass-through. The results of the cointegration tests using trace test and maximum Eigenvalues statistics are reported in Table 3.

The results in Table 3 (above) are based on the estimation of Equation (4) with lag 2 selected by FPE, AIC, SC, and HQ information criteria. The options (OPT) 1, 2 and 3 represent Equation (4) with the different variants of exporters' production costs, EPC1, EPC2 and EPC3 respectively. Given that the unit root tests performed best with the inclusion of trend and intercept in the test equation, we chose Assumption 4 in Eviews, which assumes a trend and intercept in the cointegrating equation but no trend in the VAR. Under Assumption 4, both the Johansen trace and maximum Eigenvalue tests indicate one cointegrating relationship at the 5 percent level of significance 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 4 reports the long run parameters and error correction, as well as weak exogeneity test and residual diagnostic test results. The results show that for all options the weak exogeneity test indicate that import prices are endogenous, while the exchange rate variable is exogenous as expected. While LEPC rejects the null hypothesis of weak exogeneity, its error correction coefficients with positive signs are not well behaved. Thus, 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. These are given as follows:

$$LIMP_t = 1.865LEPC1_t - 0.812LNEER_t \tag{16}$$

$$LIMP_t = 1.874LEPC2_t - 0.816LNEER_t \tag{17}$$

$$LIMP_t = 1.903LEPC3_t - 0.745LNEER_t \tag{18}$$

Thus, 10 percent depreciation of the rand is estimated to increase import prices by approximately 8.1 percent, 8.2 percent and 7.5 percent depending on the option of exporters' production costs. Although the ERPT coefficient is relatively high, it confirms that the long run 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 8.2 percent and 7.8 percent respectively. Nell (2000) analyses pass-through for South Africa for the period 1987 to 1998 using quarterly data; while SARB's (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.

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) are equal. The null hypothesis that $\beta_1 = \beta_2$is rejected[6]. While this result is not consistent with the findings of SARB (2002), we feel it is not implausible. It is unlikely that price parity will 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 borne out of 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 in the rand will increase import prices by approximately 0.46 percent, 0.46 percent and 0.5 percent for Options 1, 2 and 3 respectively[7], 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 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 are not normally distributed. The results of the heteroscedasticity test indicate that the variance of the residuals is not constant, that is, not homoscedastic. This does not, however, invalidate our results since the presence of heteroscedasticity 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). Thus, given the purposes of this study, to obtain the pass-through coefficients rather than the forecasting powers of the model, heteroscedasticity does not lessen the value of our findings.

4.2 *ERPT asymmetry*

The pass-through asymmetries under investigation in this study 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. Before estimating the pass-through asymmetry equations, unit root tests on the constructed asymmetry series ACC_A, ACC_D, ACC_L and ACC_S are conducted. Based on the ADF, Phillips-Perron and KPSS tests, all series are found to be non-stationary in level terms and stationary at first differences.

4.2.1 *ERPT asymmetry: direction – appreciation versus depreciation*

Equations (9) and (10) are estimated using the Johansen cointegration (1991) and (1995) methods, and the results are presented in Table 5 below. In both equations, one cointegrating vector is found, and the lag length and deterministic trend assumption chosen are two and four respectively. In Equation (9) the long run pass-through coefficients corresponding to appreciation and depreciation are $\beta_3$and ($\beta_3+ \beta_4$) respectively. The results show that the pass-through to import prices is greater for a depreciation (72 percent), than 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,andα_4) which are not shown in Table 6 are insignificant. The likelihood ratio (LR)

[6] The likelihood ratio test statistic for $\beta_1 = \beta_2$, distributed as $\chi 2$ (1), is 21.57806 [0.000003].

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

test is performed to confirm whether the appreciation and depreciation coefficients are statistically significantly different. In the case of Equation (9), a restriction that the long-run depreciation pass-through coefficient (β_4) is equal to zero (β_4= 0) is placed, to test against the long-run asymmetry of import prices to rand movements. The results show that the null hypothesis (β_4= 0) is rejected at the 5% significance level, suggesting that $\beta_4 \neq 0$ and therefore $(\beta_3 + \beta_4) \neq \beta_3$[8]. Thus there is long-run asymmetry of exchange rate pass-through to import prices.

The long-run ERPT coefficients in Equation (10), $\beta_7$and $\beta_8$are found to be approximately 64 percent and 72 percent respectively. These are the same as the coefficients in Equation (9). Similarly, the error correction coefficient of import prices is significant and correctly signed, however, unlike in Equation (9) where the rest of the error correction coefficients are insignificant, $\alpha_3$in Equation (10), the error correction coefficient for the appreciation series (ACC_A), is significant and correctly signed. The likelihood ratio test results[9] are found to be the same as the results of Equation (9), 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 (9) and (10) 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 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 mark-ups to maintain the same rand price prior to the rand depreciation. Rather, foreign exporters seek to gain from the rand depreciation and increase their profits. Thus, of the asymmetric pass-through theories, the binding quantity constraints model best explains the phenomenon of greater pass-through during episodes of depreciation than appreciation in South Africa. Our results are also consistent with Ohno (1989) for Japan, and Goldberg (1995) and Kadiyali (1997) for the USA.

The results of the short-run asymmetry in both Equations (9) and (10) are also reported in Table 5. The results show that, in Equation (9), 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 run 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 (10), 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.

4.2.2 *ERPT asymmetry: size – large versus small*

The estimation results of Equations (13) and (14) are also reported in Table 5. One cointegrating vector is identified in both equations. The lag length and deterministic trend assumption chosen in Equation (13) are one and four, while in Equation (14) the lag length and deterministic trend chosen are two and three respectively. The long-run ERPT coefficients in Equation (13) are $(\beta_{11} + \beta_{12})$ and β_{11}, where the former corresponds to small changes and the latter refers to large changes in the exchange rate. In Equation (14), $(\beta_{15} + \beta_{16})$ 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 (13) 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 was conducted to confirm or reject whether the two coefficients are statistically equal. The results of the test[10] fail to reject the null hypothesis that

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

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

[10] The likelihood ratio test statistic for $\beta_{12} = 0$, distributed as $\chi^2(1)$is 1.1919[0.2749]

(β_{12}= 0), implying that (β_{11}+ $\beta_{12} = \beta_{12}$) and therefore there is no significant long-run asymmetry with respect to the size of the change in the exchange rate

The results of Equation (14) 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 (13). The likelihood ratio test result[11] fails to reject the null hypothesis that (β_{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.

However, a closer inspection of the coefficients of both Equations (13) and (14) 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 slightly 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 so as not to risk losing market share. In this case pass-through is greater when exchange rate changes are small.

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 speed of adjustment of import prices in the short-run are significant and correctly signed for all asymmetric pass-through regressions, and are consistent with the estimates reported in Table 4.

5 Conclusion

This study was 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.

Our results show that long-run symmetric exchange rate pass-through is incomplete but relatively high. The high pass-through of exchange rate changes to import prices highlights how vulnerable the South Africa economy could be with a liberal exchange rate policy 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. Our 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 paid to developments that could lead to a fall in its value. The fact that our results show that there was no significant asymmetry with respect to the size of 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.

[11] The likelihood ratio test statistic for $\beta_{16} = 0$, distributed as $\chi^2(1)$is 2.5196[0.1124]

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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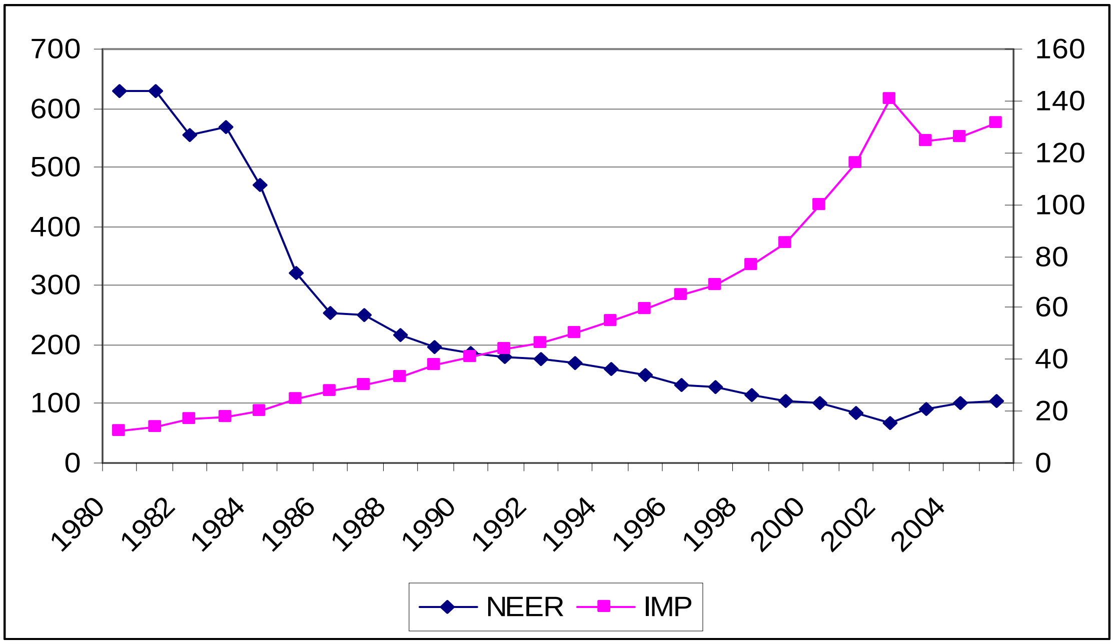
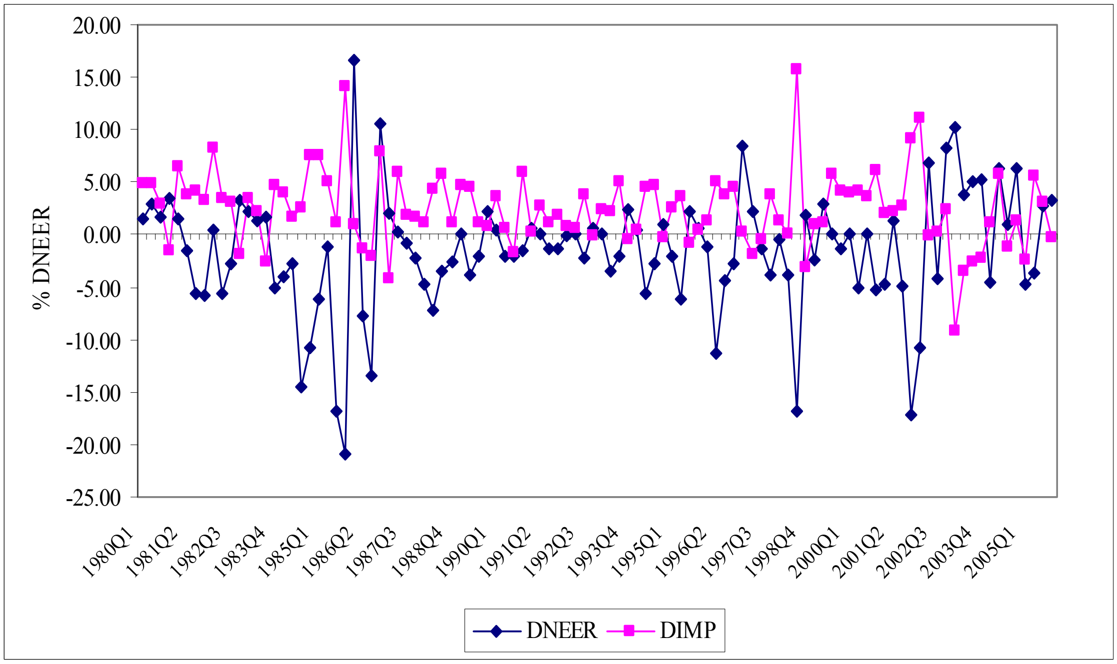
Figure 1: The behaviour of the nominal exchange rate of the rand versus domestic prices, 1980-2005



Note: An increase in the NEER means an appreciation of the rand.
Source: SARB (2006)

Figure 2: Percent changes in nominal effective exchange rate and import prices: 1980-2005



Note: DNEER is the change in nominal effective exchange rate and DIMP is the change in import price. The figures uses quarterly observations from 1980-2005
Source: International Monetary Fund (2006)

Table 1: Currency weights

Country (source of imports)	Currency Weight (%) for EPC		
	1	**2**	**3**
Germany	47.00	36.38	33.15
U.S.	20.00	15.47	52.91
U.K.	20.00	15.37	7.33
Japan	13.00	10.43	6.61

Table 2: Unit root results

Variable	ADF		Phillips-Perron		KPSS		Order of Integration
	Level	1st Diff	Level	1st Diff	Level	1st Diff	**I(d)**
LNEER	-1.430	-13.58	-1.149	-13.39	0.286	0.066	I(1)
LIMP	-1.013	-9.704	-0.671	-14.67	0.454	0.092	I(1)
LEPC1	-3.123	-12.89	-3.397	-12.93	0.230	0.109	I(1)
LEPC2	-3.117	-12.89	-3.390	-12.92	0.223	0.109	I(1)
LEPC3	-3.403	-4.503	-3.440*	-16.12	0.335	0.123	I(1)*
LPPI	-0.356	-5.293	-0.169	-15.90	0.495	0.071	I(1)
LCPI	1.555	-16.24	1.274	-16.40	0.514	0.163*	I(1)*

N.B: 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

Table 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-Lenun (1992).

Table 4: Cointegration Analysis of LIMP, LEPC1, 2 and 3 and LNEER

					Weak Exogeneity Tests			Slope Coefficients		ECM					
OPT	R	k	A	Const	LIMP	LEPC	LNEER	β_2	β_3	α_1	α_2	α_3	R^2	S.Corr	Het
1	1	2	4	-2.21	18.5	8.38	0.17	-1.87	0.81	-0.06	-0.014	-0.014	0.24	9.43	2.95[
					[0.00]	[0.01]	[0.68]	(-0.33)	(0.05)	(-5.25)a	(-3.46)a	(-0.46)		[0.40]	0.01]
2	1	2	4	-2.67	18.5	8.42	0.16	-1.87	0.82	-0.06	-0.014	-0.013	0.24	11.57[	2.51
					[0.00]	[0.00]	[0.69]	(-0.34)	(0.05)	(-5.24)[a]	(-3.46)a	(-0.45)		0.24]	[0.02]
3	1	2	4	-1.75	14.5	3.87	0.66	-1.90	-0.75	-0.07	-0.012	-0.03	0.23	12.9	3.41
					[0.00]	[0.05]	[0.42]	(-0.27)	(-0.05)	(-5.16)	(-2.53)	(-0.90)		[0.17]	[0.03]

Notes:
OPT 1: exporters' production costs are represented by LEPC1
OPT 2: exporters' production costs are represented by LEPC2
OPT 3: exporters' production costs are represented by LEPC3
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; α_2: EPC error correction coefficient; α_3: NEER error correction coefficient;
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: Cointegration Analysis for ERPT Asymmetry – Direction and Size

Regression Equation	(11)	(12)	(13)	(14)
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]		
Speed of adjustment (α_1)	-0.072 [-5.061]	-0.072 [-5.061]	-0.059 [-5.265]	-0.067 [-6.455]
L.R. test	3.795[1] {0.0514}	3.795[2] {0.0514}	1.192[3] {0.2749}	2.520[4] {0.1124}
R-squared	0.234	0.234	0.237	0.233
Diagnostics:				
Serial correlation LM	25.17 {0.067}	25.172 {0.067}	23.965 { 0.0903}	22.98 {0.114}
Normality (Jarque-Bera)	2205.0 {0.000}	7840.0 {0.0000}	783.99 {0.000}	526.09 {0.000}
Heteroskedasticity	408.72 { 0.000}	408.72 { 0.000}	290.38 { 0.000}	255.82 { 0.000}

Notes: 1. The likelihood ratio (LR) test statistic for $\beta_4 = 0$, distributed as $\chi 2$ (1), is 3.795 [0.051].
2. The likelihood ratio (LR) test statistic for $\beta_7 = \beta_8$, distributed as $\chi 2$ (1), is 3.795 [0.051].
3. The likelihood ratio (LR) test statistic for $\beta_{12} = 0$, distributed as $\chi 2$ (1), is 1.192 [0.275].
4. The likelihood ratio (LR) test statistic for $\beta_{16} = 0$, distributed as $\chi 2$ (1), is 2.520 [0.112].