



ANNUAL FORUM 2005

Trade and Uneven Development: Opportunities and Challenges



Exchange rate volatility and exports in South Africa

K.R. Todani, T.V. Munyama



UNITED NATIONS
UNIVERSITY

UNU-WIDER

World Institute for Development
Economics Research



Development Policy Research Unit
School of Economics, University of Cape Town

Exchange rate volatility and exports in South Africa¹

K.R. Todani

Research Department - South African Reserve bank

(012) 313 3922

Khathu.Todani@resbank.co.za

T.V. Munyama

Research Department - South African Reserve bank

(012) 313 3985

Victor.Munyama@resbank.co.za

November 2005

Abstract

This paper examines the characteristics of short-term fluctuations/volatility of the South African exchange rate and investigates whether this volatility has affected the South Africa's exports flows. In particular the paper investigates the impact of exchange rate volatility on aggregate South African exports flows to the rest of the world, as well as on South African goods, services and gold exports. The ARDL bounds testing procedures developed by Pesaran et al. (2001) were employed on quarterly data for the period 1984 to 2004. The results suggest that, depending on the measure of volatility used, either there exist no statistically significant relationship between South African exports flows and exchange rate volatility or when a significant relationship exists, it is positive. No evidence of a long run gold and services exports demand relations were found. These results are however not robust as they show great amount of sensitivity to different definitions of variables used.

Keywords: exchange rate volatility, ARDL, cointegration, GARCH.

JEL classification: F14, F17, F31.

¹ The views expressed are those of the author(s) and do not necessarily represent those of the South African Reserve Bank or Reserve Bank policy. While every precaution is taken to ensure the accuracy of information, the South African Reserve Bank shall not be liable to any person for inaccurate information or opinions contained herein.

1 Introduction

Exchange rates across the world have fluctuated widely particularly after the collapse of the Bretton Woods system of fixed exchange rates. Since then, there has been extensive debate about the impact of exchange rate volatility on international trade. The most commonly held belief is that greater exchange rate volatility generates uncertainty thereby increasing the level of riskiness of trading activity and this will eventually depress trade². A vast majority of economic literature, however, contains highly ambiguous and inconsistent theoretical and empirical results on this issue.

At a theoretical level, there are models that demonstrate that increased risk associated with volatility is likely to induce risk averse agents to direct their resources to less risky economic activities. Cote (1994) cited Hooper and Kohlhagen (1978), Clark (1973) amongst others as theoretical studies that concluded that volatility depresses trade. On the contrary, other theoretical models show that higher risk present greater opportunity for profits and, thus exchange rate volatility, to the extent that it increases risk, should increase trade. The ambiguity of theoretical predictions has made the debate to become a fundamentally empirical one. Unfortunately, much of the results from empirical literature are also fraught with the same ambiguity and inconsistencies³.

South Africa has not escape the debate, having witnessed consistent depreciation of her exchange rate to the lowest levels in December 2001 and a sharp appreciation thereafter. The debate in South Africa however is not just about the volatility of the exchange rate, but also its level. Conspicuous in South Africa's debate, however, is the fact that it is taking place in a research vacuum in which there is no convincing empirical evidence to substantiate either claim. It is for this reason that the debate in South Africa has been characterized by conflicting views about the true link between exports and exchange rate level and/or volatility. This paper seeks to provide some

² It is interesting to note that this belief has helped motivate monetary unification in Europe and is strongly related to currency market intervention by central banks (Bayoumi and Eichengreen 1998).

³ There are studies that found evidence that exchange rate uncertainty may induce marginal producers and traders to shift from trade to non-traded goods, thereby dampening trade volumes. See for example Chowdhury (1993). To the contrary, other studies produce evidence that seemingly supports that exchange rate volatility may stimulate trade. See for example, Giovannini (1988).

evidence on the relationship between exports and exchange rate volatility. It is organised as follows. Section 2 reviews the literature on exports and exchange rate volatility. The outline of empirical models used in this paper is discussed in section 3. Section 4 discusses the econometrics model employed, followed by a brief section on data description in section 5. Section 6 presents estimation and the results, whilst section 7 concludes.

2 Review of the literature

There exists an abundance of studies on this topic that have been undertaken internationally, both at theoretical and empirical levels. Two most popular and related approaches have been used in the analysis of trade and exchange rate volatility. One approach is to estimate a simple export demand equation generally with real exports as a dependent variable and exchange rate volatility together with relative prices and a measure of economic activity variable as regressors. The other approach is to use the so-called gravity equation models, which explain bilateral trade flows between countries as depending positively on the product of their GDPs and negatively on their geographical distance from each other⁴. This section reviews some of the empirical literature and their findings. This review will be brief and readers are referred to, for example, Cote (1994), McKenzie (1999), and Clark et al. (2004) for a more detailed and comprehensive surveys.

De Vita and Abbott (2004) used the ARDL econometrics technique to analyse the impact of exchange rate volatility on UK exports to the European Union (EU). The study estimated an export demand equation using disaggregated monthly data for the period 1993 to 2001 and concluded that UK export to the EU are largely unaffected by exchange rate volatility. Morgenroth (2000) obtain similar results while examining the case of Irish exports to Britain. Estimated error correction models by Doyle (2001), also for Irish export to Britain, reveal that both real and nominal volatility are significant determinants of changes in total exports and in a number of

⁴ Countries with larger economies tend to trade more in absolute terms, while distance can be viewed as a proxy for transportation costs, which act as an impediment to trade. In many applications, a host of dummy variables are added to account for shared characteristics, which would increase the likelihood of trade between two countries, such as common borders, common language, and a membership in a free trade association. To this basic equation researchers add some measure of exchange rate variability to see if this proxy for exchange rate risk

sectors. Both positive and negative short-run elasticities for exchange rate volatility were estimated, although positive elasticities predominate⁵. Wang and Barrett (2002) analysed the effect of exchange rate volatility on international trade flows by studying the case of Taiwan's exports to the United States from 1989-1999. They found that real exchange rate risk has insignificant effects in most sectors, although agricultural trade volumes appear highly responsive to real exchange rate volatility.

Dell' Ariccia (1999) used the gravity model and provides a systematic analysis of exchange rate volatility on the bilateral trade of the 15 EU members and Switzerland over a period of 20 years from 1975 to 1994. In the basic regressions, exchange rate volatility has a small but significantly negative impact on trade. Other papers that have employed the gravity equation model include Bayoumi and Eichengreen (1998), and Tenreyro (2004).

The conclusion drawn from empirical literature is that earlier studies tended to find insignificant relationship between export and exchange rate volatility. Cases where significant relations were found, it was both negative and positive. Recent literature that has begun to use error correction techniques together with more disaggregated data are beginning to find statistically significant relations between trade and exchange rate volatility.

3 The empirical export demand equation

We follow Arize et al. (2000) and de Vita and Abbott (2004), amongst others, and specify a demand equation of the following form:

$$EXP_t = \beta_0 + \beta_1 RELP_t + \beta_2 INC_t + \beta_3 VOL_t + \xi_t \quad (0.1)$$

has a separate, identifiable effect on trade flows after all other major factors have been taken into account. (Clark et al., 2004).

⁵ Note that although both Doyle (2001) and Morgenroth (2000) analysed Irish export to Britain, they differ in the sample periods and level of disaggregation. The fact that they arrive at different conclusion reinforces the sensitivity of these studies to both the level of aggregation as well as the sample period.

where EXP_t is real exports; $RELP_t$ is relative prices; INC_t is income in our trading partners and is an indicator of potential demand for our exports. VOL_t is the exchange rate volatility and measures uncertainty associated with fluctuations in the exchange rate. β_0 and ξ_t are a constant and a normally distributed error term, respectively. Equation (0.1) says that our exports depend on the relative prices, income in our trading partners and uncertainty/risk associated with exchange rate fluctuations. Theoretical priors dictate that we should expect⁶ $\beta_1 > 0$ and $\beta_2 > 0$ and as discussed in the introduction, the sign of β_3 is theoretically ambiguous.

There are different econometrics techniques that can be used to estimate equation (0.1). If all the variables are stationary (i.e. they are I(0)), then equation (0.1) can simply be estimated by ordinary least squares (OLS). If all or some variables are I(1) and not cointegrated, some data transformations may be necessary before estimating equation (0.1) by OLS. If there exist some cointegration among the variables in equation (0.1), then there are a number of approaches of different complexities to estimate the model. Some main approaches are the Engel (1987) two-step procedure and the Johansen (1991, 1995) maximum likelihood reduced rank procedure. Both these procedures work well when all variable are I(1). This paper follows de Vita and Abbott (2004), and employs the autoregressive distributed lag (ARDL) bounds testing approach to cointegration proposed by Pesaran et al. (2001). This methodology allows testing for the existence of cointegration irrespective of whether the underlying regressors are I(0), I(1) or mutually cointegrated. Below is an exposition of the ARDL approach⁷.

4 ARDL bounds testing approach

This procedure, developed by Pesaran et al. (2001), tests the existence of a level relationship between a dependent variable and a set of regressors when the order of integration of the regressors is not known with certainty. The procedure is based on

⁶ As will be seen in section 5, the exchange rate is defined as rands per one dollar and thus an increase is a depreciation. Hence, it is expected that depreciation make South African exports cheaper and thus should increase exports.

⁷ This exposition is rather brief and readers not familiar with the technique are referred to the original article, i.e. Pesaran et al. (2001).

the Wald or F-statistic in a generalized Dickey Fuller type regression used to test the significance of the lagged levels of relevant variables in a conditional unrestricted equilibrium correction model (ECM). Inferences are made by making use of two sets of asymptotic critical values corresponding to two extreme cases one assuming purely I(0) and the other assuming purely I(1), without the need to know the regressors' underlying order of integration. Consider the following vector autoregressive (VAR) model of order ρ :

$$\Phi(L)(z_t - \mu - \lambda t) = \varepsilon_t \quad (0.2)$$

where $t = 1, 2, \dots$, and L is the lag operator, μ and λ are unknown vectors of intercept and trend coefficient, respectively. ε is $N(0, \Omega)$ with the variance matrix Ω positive definite. Given certain assumptions as detailed in Pesaran, et al. (2001), relating to the exclusion of the possibility of seasonal and explosive roots, the following error correction form of (0.2) can be derived:

$$\Delta Z_t = \alpha_0 + \alpha_1 t + \Pi Z_{t-1} + \sum_{i=1}^{\rho-1} \Gamma_i \Delta Z_{t-i} + \zeta_t \quad (0.3)$$

where $t = 1, 2, 3, \dots$, $\Delta = 1 - L$ is the difference operator; α_0 and α_1 are unknown vectors of intercept and trend coefficients respectively. ζ_t is a normally distributed⁸ error term with mean zero and some positive definite variance matrix, Ω . The long run multiplier and short-run response matrices are denoted by Π and Γ_i , $i = 1, \dots, \rho - 1$, respectively⁹.

Now partition Z_t as $Z_t = (y_t, x_t')$. Pesaran et al. (2001) procedure is about the conditional modelling of the scalar variable y_t given the k -vector x_t and the initial and past values of Z_t . With further appropriate partitioning of ζ_t and the long run multiplier matrix Π conformably with Z_t , and similar partitioning of α_0 , α_1 , and Γ_i , together with some identifying assumptions, the conditional ECM of (0.3) becomes:

⁸ In commonly used symbols, we write $\zeta_t \sim N(0, \Omega)$

⁹ See Pesaran et al. (2001) for more technical details.

$$\Delta y_t = \delta_0 + \delta_1 t + \Pi_1 y_{t-1} + \Pi_2 x_{t-1} + \sum_{i=1}^{p-1} \Psi_i' \Delta Z_{t-i} + \mathcal{G}' \Delta x_t + \mu_t \quad (0.4)$$

Equation (0.4) forms the basis for estimation of the model represented in equation (0.1). More specifically, denote the variables in (0.1) in vector form as $Z_t = [EXP_t, RELP_t, INC_t, VOL_t]$. Now let $x_t = [INC_t, RELP_t, VOL_t]'$ which implies that $Z_t = [EXP_t, X_t]'$. Thus using equation (0.4) we have:

$$\Delta EXP_t = \alpha_0 + \alpha_1 t + \Pi_1 EXP_{t-1} + \Pi_2 x_{t-1} + \sum_{i=1}^{p-1} \Psi_i \Delta Z_{t-i} + \varpi' \Delta x_t + \zeta_t \quad (0.5)$$

which is the equation estimated in this paper. Four variants of equation (0.5) corresponding to different levels of aggregation of EXP_t are estimated following a brief data description in the next section.

5 Data description

Most previous studies use data on trade flows aggregated across sectors and overseas markets and on exchange rates averaged over time. This necessarily imposes the strong, undesirable assumption that the impact of exchange rate volatility is uniform across sectors and destination markets. Klein (1990), Bini-Smaghi (1991) and McKenzie (1999) argue strongly for sectorally disaggregated estimation of the trade-risk relationship and demonstrate that disaggregating uncovers significant intersectoral variation in the effect of exchange rate volatility on trade flows. For example, some sectors, such as agriculture, may be far more sensitive to exchange rate risk than others are¹⁰ (Maskus 1986, Pick 1990). However, data limitations often times dictate the level of aggregation that researchers can use. This

¹⁰ A related aggregation issue concerns the frequency of the data used in estimation. Due largely to data limitations, most studies employ lower frequency quarterly or annual data to examine the trade and risk relationship (McKenzie 1999). However, temporal aggregation necessarily dampens exchange rate variability, which may make identifying any true trade-risk relationship more difficult (Wang and Barrett, 2002). Moreover, where different sectors have different conventions for contracting and delivery or payment lags, intersectoral and intertemporal aggregation together could necessarily mute real trade-risk effects. For example, casual observation suggests that trade in services, electronics and transportation involve relatively short contracting lags as compared to trade in agricultural commodities, metals and intermediate inputs commonly sold on long-term contracts.

study uses seasonally adjusted quarterly data for the period 1980 until 2004. The data are constructed as follows:

5.1 Real exports (EXP_t)

Real exports are constructed as nominal exports deflated by the consumer price index (CPI) as follows:

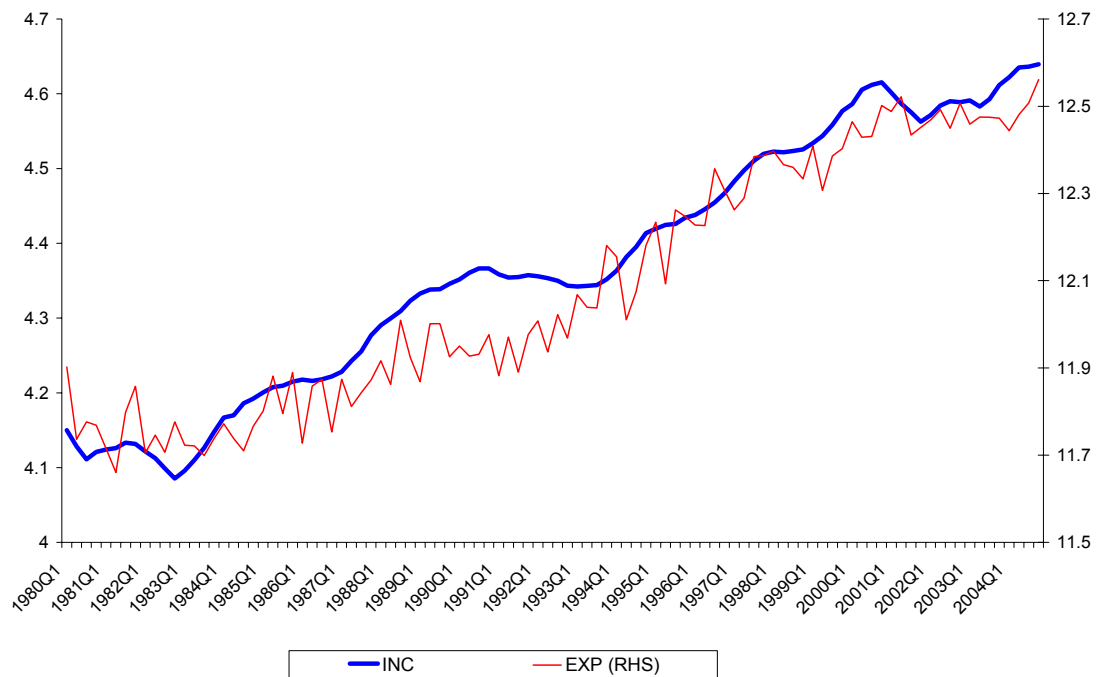
$$EXP_t = \ln\left(\frac{EXN_t}{CPI_t}\right) \quad (0.6)$$

where EXP_t is, as before, real exports, EXN_t is nominal exports, and CPI_t is the consumer price index.

5.2 Foreign income (INC_t)

Industrial production is used as a proxy for foreign income. While GDP, disposable income or any other national income measure for South African trading partners can be used as a measure of income, in general the tradition in the literature is to use industrial production as a proxy for income, a tradition which is maintain in this paper. Due to the difficulty in determining the true income for all South Africa's trading partners, two measures of industrial production are used. The first measure is industrial production for the G7 countries and is denoted INC_{oecd} and is sourced from the OECD. The second measure, which is denoted INC_{ifs} is industrial production for industrial countries and is sourced from the IMF's International Financial Statistics. These measures are chosen on the assumption that most of our exports are with the industrial and/or the G7 countries. Industrial production (INC_{oecd}) and real exports, both in log scale, are depicted in figure 1.

Figure 1 Exports and G7 countries' industrial production



5.3 Relative prices ($RELP_t$)

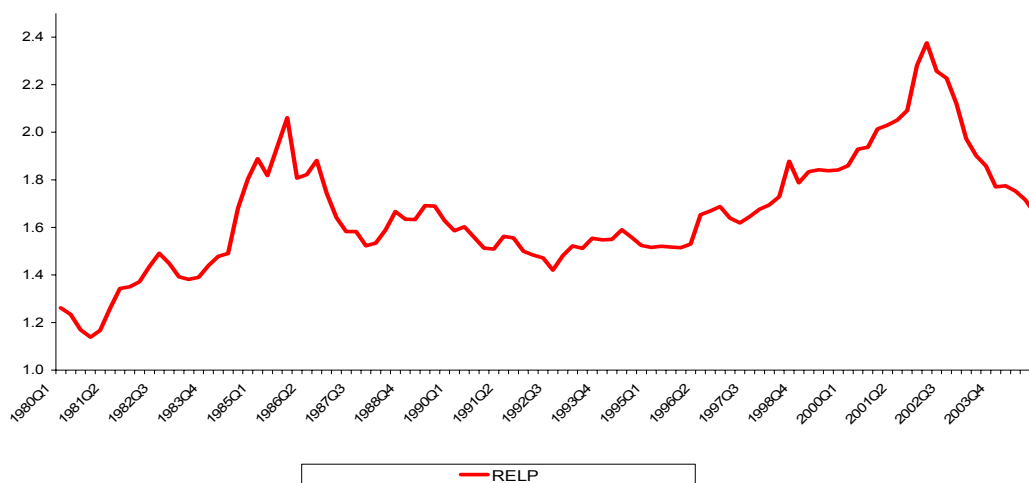
Bilateral trade between two countries depends upon, among other things, exchange rates and the relative price level of the two partners. Hence, the following definition of real exchange rates in SA captures both the effects related to the price of currencies, and of goods and services¹¹.

$$RELP_t = \ln \left(ER_t \times \frac{CPI_F}{CPI_{SA}} \right) \quad (0.7)$$

¹¹ Alternatively, other authors define this as $RELP_t = \ln \left(ER_t \times \frac{PX_F}{PX_{SA}} \right)$ with PX_f and PX_{SA} representing foreign and South African export prices respectively.

where CPI_F is inflation in a foreign country and CPI_{SA} is South Africa's inflation and ER_t is the rand/dollar exchange rate. These are depicted in Figure 2.

Figure 2 Relative prices



5.4 Exchange rate volatility

As already explained, exchange rate volatility is a measure that intends to capture the uncertainty faced by exporters due to unpredictable fluctuations in the exchange rates. Clearly, this is an unobservable variable and thus its measure is a matter of serious contention. Consequently the literature is not unanimous as to which measure is most appropriate. Recent literature, however, seems to be increasingly adopting the use of Bollerslev's (1986) generalized autoregressive conditional heteroscedasticity (GARCH) models, and the moving average standard deviations¹², and to a very less extent simple standard deviations. This paper follows recent literature and uses both the moving average standard deviation and the measures derived from the GARCH (1,1) model as measures of exchange rate volatility.

¹² Other measures include the standard deviation of the first difference of the logarithm of the monthly bilateral nominal and real exchange rate, the sum of the squares of the forward errors, and the percentage difference between the maximum and the minimum of the nominal spot rate. See Dell'

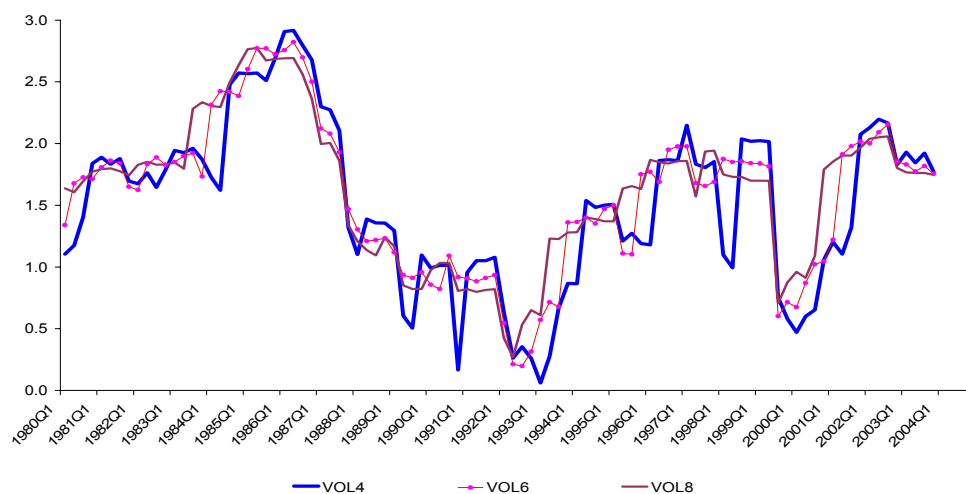
5.4.1 Moving Sample Standard Deviation

The moving sample standard deviation of the growth rate of both nominal and real exchange rate is one of the measures of exchange rate volatility that is employed in this study. The measure has been used by a number of authors such as de Vita and Abbot (2004), Das (2003), Chowdhury (1993) and Arize (2000). It is defined as follows:

$$VOL_{t+m} = \left[\frac{1}{m} \sum_{i=1}^m (ER_{t+i-1} - ER_{t+i-2})^2 \right]^{\frac{1}{2}}$$

where m is the order of moving average and other variables are defined as before. VOL_t was estimated for $m = 4, 6$, and 8 . We simplify the notation and denote VOL_{t+4} , VOL_{t+6} and VOL_{t+8} by VOL4, VOL6 and VOL8 respectively. Each measure is computed for both the nominal effective, real effective exchange rate and the rand/dollar exchange rates. Figure 3 depicts measures computed from the real effective exchange rate¹³.

Figure 3 Moving Average Standard Deviation



Arcia (1998) for details. See also Cheong (2002) and Kikuchi (2004) for references to other methods as well as some critical assessment of those methods.

¹³ This graph plots data up to the end of 2003 to minimise the end point problem associated with the moving average definition used here.

5.4.2 ARCH and GARCH Models

The second measure of exchange rate volatility is the conditional variance of the first difference of the log of exchange rate. We use both the autoregressive conditional heteroscedasticity (ARCH) proposed by Engel (1982) and the generalized conditional heteroscedasticity (GARCH), proposed by Bollerslev (1986), which is the generalization of ARCH model. Suppose that the exchange rate is generated by the following autoregressive process:

$$\Delta ER_t = \alpha_0 + \sum_{i=1}^p \partial_i \Delta ER_{t-i} + \mu_t \quad (0.8)$$

where α_0 is a constant, ∂_i 's are coefficients and $\mu_t | \Omega_{t-1} \sim N(0, \sigma^2)$. That is, the error term μ_t is normally distributed with mean zero and variance σ^2 . The set of available information at time $t-1$ is denoted by Ω_{t-1} . Engel (1982) allowed for the variance to vary over time and the idea behind the ARCH model is to characterize how this variance changes over time. The ARCH model assumes that the variance can be captured by the following autoregressive process:

$$\sigma_t^2 = \lambda_0 + \sum_{i=1}^p \phi_i \mu_{t-i}^2 \quad (0.9)$$

where σ_t^2 is the conditional variance of the exchange rate, μ_{t-i}^2 represents the squared residuals derived from equation (0.8) and ϕ_i 's are parameters to be estimated. To ensure that the predicted variance is always positive, the restriction that $\phi_i \geq 0$ is necessary. It is important to note here that in equation (0.8) the current levels of volatility is influenced by the previous levels of volatility and thus high or low periods of volatility will tend to persist. Bollerslev (1986) introduced the GARCH (p, q) process¹⁴, which is just an extension of the ARCH in which σ_t^2 becomes a function

¹⁴ In the GARCH (p, q) model, (p, q) in parentheses is a standard notation in which the first letter refers to the number of autoregressive lags, or ARCH terms that should appear in the equation, while the second letter refers to how many moving average lags are specified, which is often called the number of GARCH terms. Sometimes models with more than one lag are needed to find good variance forecasts (Engle, 1982).

not only of μ_{t-i}^2 but also of the lagged values of itself. The conditional variance in this case is estimated by:

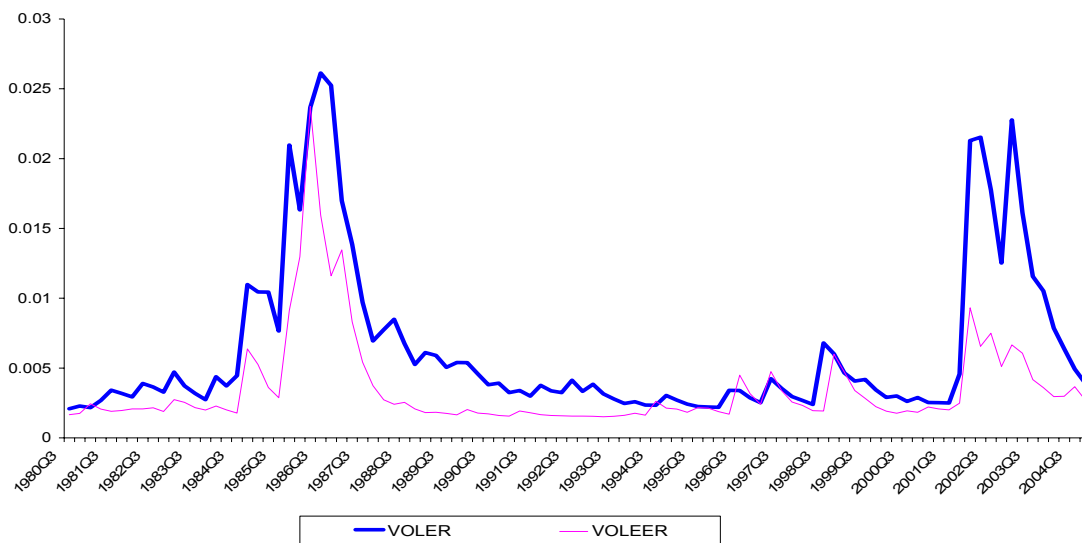
$$\sigma_t^2 = \lambda_0 + \sum_{i=1}^p \phi_i \mu_{t-i}^2 + \sum_{i=1}^q \delta_i \sigma_{t-i}^2 \quad (0.10)$$

All coefficients in equation (0.10) need to be positive to make sure that we have a positive variance. The most common form of equation (0.10) is the GARCH (1, 1), which can be represented as follows:

$$\sigma_t^2 = \lambda_0 + \phi_1 \mu_{t-1}^2 + \delta_1 \sigma_{t-1}^2 \quad (0.11)$$

which will form the basis of estimation in this paper. Two measures of exchange rate volatility are generated, one based on nominal effective exchange rate and the other on real effective exchange rate. Figure 4 presents the estimated measures of exchange rate volatility¹⁵ from a GARCH (1,1) model. Although GARCH measures based on different exchange rates have been computed only those based of the real effective (VOLEER) and the rand/dollar (VOLER) exchange rates are shown in Figure 4.

Figure 4 GARCH Estimated Volatility Measures



¹⁵ The estimated GARCH equations are not shown here. Measures from an ARCH (q) were also computed but do not yield any significantly different result

6 Estimation and Results

6.1 Estimation

Since the ARDL methodology does not require pre-testing¹⁶ for the integration properties of the individual series used in the empirical analysis, we proceed by applying the ARDL bounds testing procedure to equation (0.5). First, we make the usual assumption that the time series properties of the variables in the export equation (0.1) can be represented by a log linear VAR (ρ) model as in equation (0.2). This is augmented with a constant and a time trend¹⁷. Four main versions of equation (0.5) are estimated. First, the aggregate model is estimated, i.e. a model with aggregate/total exports as a dependent variable. Then we estimate disaggregated models in which services, gold and goods exports are, respectively, dependent variables.

The starting point for these types of models is to determine the lag length. This is done by estimating the conditional model (0.5) with and without the deterministic trend and the appropriate lag is selected on the bases of a careful analysis of the Akaike Information Criteria (AIC), the Schwarz's Bayesian Information Criteria (SBC) and the Lagrangean Multiplier¹⁸ (LM) test. With the appropriate lag selected, the next step is to test the existence of a long run relationship between the variables in different versions of the export demand equation. This is tested by conducting an F-test on the significance of lagged levels of variables in the error correction form (0.5). That is, we test the null hypothesis that all coefficients on lagged levels of variables are all equal to zero against the null that each one is not equal to zero.

The asymptotic distribution of the F-statistic is non standard irrespective of whether the regressors are $I(0)$, $I(1)$ or a mixture of both. The calculated F-statistic is compared with the critical value tabulated by Pesaran et al. (2001). If the calculated F-statistic falls above the upper bound, then we can make a conclusive decision that

¹⁶ Some authors do pre test the variables to make sure that they are not $I(2)$. We do not this here.

¹⁷ It is clear from Figure 1 that both exports and industrial production shows rising trends, suggesting that initially a linear trend should be included in the real exports equation.

¹⁸ The Lagrange Multiplier (LM) statistics is for testing the hypothesis of no serial correlation of order (4).

there exists a long run relationship, without needing to know whether the underlying variables are $I(0)$, $I(1)$ or fractionally integrated. If the calculated F-statistic falls below the lower bound, we cannot reject the null hypothesis of no cointegration. If the calculated F-statistic falls between the critical value bounds, the result is inconclusive. In this case, we may require prior knowledge of the order of integration of the underlying variables. That is, we may have to resort to the standard unit roots techniques.

Once the existence of a long run relationship is established, the long run coefficients are then estimated using the ARDL, after which an error correction form is estimated.

6.2 Results

Table 1 shows the AIC, SBC and the LM statistics for the aggregate exports equation. Lag order selection statistics for the disaggregated models are not shown, but suffice to say that they are very similar to those depicted in Table 1. The results are rather mixed, with different criterion giving rise to a different lag length as shown by bold numbers in the AIC and SBC¹⁹.

Table 1 Statistics for selecting the lag order of the total export equation

| p | Without Deterministic Trends | | | With Deterministic Trends | | |
|----------|------------------------------|---------------|---------|---------------------------|---------------|---------|
| | AIC | SBC | LM (4) | AIC | SBC | LM (4) |
| 1 | 128.55 | 113.10 | 16.15** | 130.36 | 113.62 | 11.91** |
| 2 | 130.71 | 110.11 | 6.74 | 131.27 | 109.38 | 3.35 |
| 3 | 133.53 | 107.89 | 4.28 | 132.87 | 105.94 | 3.33 |
| 4 | 130.30 | 99.65 | 3.32 | 129.30 | 97.37 | 4.36 |
| 5 | 127.66 | 92.05 | 7.70*** | 126.75 | 89.87 | 8.68*** |
| 6 | 125.42 | 84.90 | 6.07 | 124.43 | 82.64 | 6.10 |
| 7 | 126.21 | 80.82 | 2.32 | 125.98 | 79.33 | 1.81 |

Note: ** and *** represent 5% and 10% significance levels.

For the total exports model shown in Table 1, the lag order selected by the AIC is $\rho = 3$ irrespective of whether we include a deterministic trend or not, and it was larger than the lag selected by the SBC. The SBC gives estimates of $\rho = 2$ if a deterministic

¹⁹ Given the inconsistency with which different criteria chose the lag length, models with different lag length were also estimated and the model with three lags provides the best estimates.

trend is included and $\rho = 1$ without the deterministic trend. The LM (4) statistics seems to suggest using a relatively high lag order, 5 or more. On the bases of the AIC, we prefer the model with $\rho = 3$.

With appropriate lags imposed for each model the results for the critical value bounds obtained in Pesaran et al. (2001) are shown in Table 2. The results are somewhat dependent on which measures of income and volatility are used. Models with INC_{oecd} produced relatively better diagnostics than those with INC_{ifs} and thus Table 2 only reports bounds tests for models with INC_{oecd} , $RELP_t$ and various measures of volatility. Since all models contain three regressors, the 90% critical bounds from Table CI (Case IV) in Pesaran et al. (2001) are (2,97 ; 3,74). We find that the null hypothesis of no level long run relationship between the variables in the total/aggregate export equation (i.e. the model with aggregate exports as a dependent variable) is rejected in favour of the existence of a long run relationship except when VOL8 is used.

Table 2 Bounds tests for South African exports²⁰

| | F-stats | Critical Values – 10% | Optimal volatility measure |
|-------------------------|----------------|------------------------------|-----------------------------------|
| Total exports | | | |
| | 3,75 | 2.97 - 3,74 | VOLEER (GARCH) |
| | 4,02 | 2.97 - 3,74 | VOL4 |
| | 3,80 | 2.97 - 3,74 | VOL6 |
| | 3,56 | 2.97 - 3,74 | VOL8 |
| Goods exports | | | |
| | 4,11 | 2.97 - 3,74 | VOLEER (GARCH) |
| | 3,94 | 2.97 - 3,74 | VOL4 |
| | 3,71 | 2.97 - 3,74 | VOL6 |
| | 3,24 | 2.97 - 3,74 | VOL8 |
| Services exports | | | |
| | 1,74 | 2.97 - 3,74 | VOLEER (GARCH) |
| | 1,34 | 2.97 - 3,74 | VOL4 |
| | 1,37 | 2.97 - 3,74 | VOL6 |
| | 1,16 | 2.97 - 3,74 | VOL8 |
| Gold exports | | | |
| | 1,93 | 2.97 - 3,74 | VOLEER (GARCH) |
| | 2,98 | 2.97 - 3,74 | VOL4 |
| | 3,19 | 2.97 - 3,74 | VOL6 |
| | 2,85 | 2.97 - 3,74 | VOL8 |

²⁰ As pointed out in Pesaran, et al. (2001) Table CI (case IV) which sets the trend coefficient to zero under the null hypothesis of no level relationship is more appropriate in this case.

For the model with goods exports as a dependent variable, we also reject the null hypothesis of no long run relationship when VOLEER and VOL4 measures of volatility are used. The services and gold exports models, however, produced test statistic that falls either below or within the critical bounds regardless the measure of volatility used. Therefore, for the services and gold exports equations, we conclude that the null hypothesis of no level long run relationship between the variables cannot be rejected, i.e. there exist no long run level relationship between variables in the services and gold equations. For the goods and aggregate exports equations however, the null hypothesis of no level long run relationship is rejected and hence we find a strong evidence of a stationery long run cointegrating aggregate and goods exports demand functions for some measures of volatility as mentioned above. We estimate these using the ARDL approach.

6.2.1 Long run analysis

Table 3 shows estimates of the long run coefficients of both the aggregate/total exports and goods exports equations.

Table 3 Long run estimates for South African exports

| Models (ARDL lag specification) | Constant | INC_{oecd} | RELP | VOLEER | VOL4 | VOL6 |
|--|-----------------|--------------------------------|--------------------|-------------------|----------------|------------------|
| Total exports | | | | | | |
| Agex1 (ARDL 3,3,0,0) | 8,66 (3,48) | 0,77 (1,23) | -0,18 (-1,20) | 7,98 (1,12) | | |
| Agex2 (ARDL 3,0,3,1) | 10,05 (4,95) | 0,39 (0,77) | -0,09 (-1,03) | | 0,03 (1,25) | |
| Agex3 (ARDL 3,0,3,3) | 10,03 (4,94) | 0,39 (0,78) | -0,10 (-1,19) | | | 0,04 (1,84)** |
| Goods exports | | | | | | |
| Gex1 (ARDL 2,3,0,0) | 4,37 (1,79) | 1,67 (2,74)* | -0,23 (-1,78)** | 11,10 (1,64)** | | |
| Gex2 (ARDL 2,0,3,1) | 5,80 (2,52) | 1,28 (2,25)* | -0,12 (-1,19) | | 0,02 (0,98) | |

Note: *, ** and *** denotes 5%, 10%, and 1% significance levels, respectively. Figures in parentheses are T-ratios.

From the aggregate/total exports models, denoted by Agex1 through Agex3 in Table 3, three observations are clear. First, all income coefficients, as expected have positive signs implying that increases in incomes of South Africa's trading partners generates an increase in South Africa's exports. However, these coefficients are

statistically insignificant. Second, the coefficients on relative prices all have the wrong negative signs and are all statistically insignificant at conventional level of significance. Third, the coefficients on volatility are consistently positive, with VOL6 being the only volatility measure that is significant at 10 per cent significance level. We conclude therefore that when exchange rate volatility is measured as a moving average standard deviation of order 6, we find some evidence that exchange rate volatility does positively affect aggregate trade. However, when other measures of volatility are used, the relationship between volatility and aggregate trade is still positive but not statistically significant.

For the goods exports model, denoted Gex1 and Gex2 in Table 3, the coefficient on INC_{oecd} is also positive and significant at conventional levels of significance. Relative prices continue to produce unexpected negative signs, and it is not immediately clear why this is so. As was the case with the aggregate exports equation, volatility consistently continue to produces a positive sign with only the GARCH measure being at 10 per cent significance level.

Significant positive volatility effects could be a consequence of the open nature of the South African economy. It could be the case that exporters are aware that limited domestic market cannot absorb all excess supply that may arise if trading becomes more risky due to increased exchange rate volatility. To avoid any reduction in revenues arising from increased risk they therefore may export more. Insignificant relationship between volatility and exports, on the other hand, may be an indication of availability of hedging facilities in South Africa.

6.2.2 Short run dynamics.

The short run dynamics i.e. error correction regressions associated with models Agex3 and Gex1 of Table 3 are shown in Tables 4 and 5 respectively. These estimates provide additional evidence on the complicated and often inconsistent dynamics that exist between real exports and its main determinants. The coefficients on ECM_{t-1} in both models are statistically significant and negative as expected and support the validity of the equilibrium relationship between the variables in the long run equations.

Table 4. ECM of the ARDL (3,3,3,0) total export equation

| Regressors | Coefficient | Std. Error | T-Ratio |
|---------------------|-------------|------------|---------|
| Constant | 4,53 | 1,40 | 3,23* |
| Trend | 0,00 | 0,00 | 2,53* |
| ΔEXP_{t-1} | -0,41 | 0,11 | -3,52* |
| ΔEXP_{t-2} | -0,26 | 0,09 | -2,73 |
| $\Delta RELP$ | 0,18 | 0,09 | 1,97* |
| $\Delta RELP_{t-2}$ | 0,12 | 0,08 | 1,34 |
| $\Delta RELP_{t-3}$ | 0,18 | 0,08 | 2,07* |
| $\Delta VOL6$ | 0,00 | 0,01 | 0,46 |
| $\Delta VOL6_{t-1}$ | -0,00 | 0,02 | -0,42 |
| $\Delta VOL6_{t-2}$ | -0,08 | 0,02 | -2,97* |
| ΔINC | 0,17 | 0,23 | 0,76 |
| Ecm(-1) | -0,45 | 0,11 | -3,99* |

Note: *, ** and *** denotes 5%, 10%, and 1% significance levels, respectively

Table 5 ECM of the ARDL(2,3,0,0) goods export equation

| Regressor | Coefficient | Std. Error | T-Ratio |
|----------------------|-------------|------------|---------|
| Constant | 2,33 | 1,53 | 1,52*** |
| Trend | 0,00 | 0,00 | 1,46 |
| $\Delta GOODS_{t-1}$ | -0,25 | 0,09 | -2,62* |
| $\Delta RELP$ | 0,13 | 0,12 | 1,05 |
| $\Delta RELP_{t-2}$ | 0,15 | 0,13 | 1,16 |
| $\Delta RELP_{t-3}$ | 0,20 | 0,12 | 1,64*** |
| $\Delta VOLEER$ | 5,92 | 3,33 | 1,77*** |
| ΔINC | 0,89 | 0,31 | 2,82* |
| Ecm(-1) | -0,53 | 0,11 | -4,66* |

Note: *, ** and *** denotes 5%, 10%, and 1% significance levels, respectively.

The ECM_{t-1} coefficients are relatively large indicating a fast adjustment process and they show what proportion of the disequilibrium is corrected each quarter. For example, for the aggregate exports equation, about 45 per cent of the disequilibria of the previous quarter's shock adjust back to equilibrium in the current quarter. For the goods exports equation about 53 per cent adjust back to equilibrium in the current quarter.

Despite some insignificant coefficients in the error correction models in Table 4, the diagnostic tests, shown in Table A1 in the Appendix, show that the models do pass some critical diagnostics tests. Both models pass the functional form test, implying that the linear relationship is appropriate for these models. Both models however fail the serial correlation and heteroscedasticity tests. Both models however pass the normality, heteroscedasticity and the functional form tests. However, evidence of serial

autocorrelation still remains in both models. Heteroscedasticity should be expected in these models since the time series in the models may be of different order of integration. Serial correlation on the other hand may be a problem even though ADRL is known to be robust with respect to the presence of some serial autocorrelation. The aggregate model passes the normality test whereas the goods model fails.

7 Conclusion

This study was an attempt at analysing the impact of exchange rate volatility on South Africa's exports. An ARDL bounds testing procedures proposed by Pesaran, et al, (2001) were used. The results show the sensitivity of the models to the variable definitions used. We find that, depending on the measure of volatility used, exchange rate volatility either does not have a significant impact on South Africa's exports flows or it has a positive impact does have a positive impact on aggregate and goods exports.

These results, which are still considered preliminary, are plausible and are in line with other findings in the literature. They are, however, indicative of additional work to be done, given their lack of robustness with respect to the variables definition used. As a point of departure for further research measurements of the regressors, especially the income and exchange rate volatility need to be considered. Overall, the aggregate exports and goods equations presented in this paper do provide profound basis for further research.

Appendix

Table A1 Diagnostic tests for the aggregate and goods exports equations.

| Diagnostic Tests: Aggregate exports equation | | |
|--|---------------------------|-------------------------|
| ***** | | |
| * Test Statistics | LM Version | F Version |
| ***** | | |
| * A: Serial Correlation | CHSQ (4) = 9.1626[.057] | F(4, 76)= 2.0520[.095] |
| * B: Functional Form | CHSQ (1) = .014293[.905] | F(1, 79)= .012014[.913] |
| * C: Normality | CHSQ (2) = 1.7303[.421] | Not applicable |
| * D: Heteroscedasticity | CHSQ (1) = 3.3564[.067] | F(1, 92)= 3.4066[.068] |
| Diagnostic Tests: Goods exports equation. | | |
| ***** | | |
| * Test Statistics | LM Version | F Version |
| ***** | | |
| * A: Serial Correlation | CHSQ(4) = 15.4446 [.004] | F(4, 80)= 3.9322[.006] |
| * B: Functional Form | CHSQ(1) = 1.5466 [.214] | F(1, 83)= 1.3885[.242] |
| * C: Normality | CHSQ(2) = 17.5721 [.000] | Not applicable |
| * D: Heteroscedasticity | CHSQ(1) = 7.4151 [.006] | F(1, 92)= 7.8789[.006] |
| ***** | | |
| A: Lagrange multiplier test of residual serial correlation | | |
| B: Ramsey's RESET test using the square of the fitted values | | |
| C: Based on a test of skewness and kurtosis of residuals | | |
| D: Based on the regression of squared residuals on squared fitted values | | |

References

- Aguirre, A., Ferreira, A. and Notini, H. 2003. "The impact of exchange rate volatility on Brazilian manufactured exports", www.cepe.ecn.br/export_0.pdf.
- Arize, A.1990. "An econometric investigation of export behaviour in seven Asian developing economies", *Applied Economics*, No. 22, pp. 891-904.
- Arize, A. C. and Malindretos, J. 1998. "The long-run and short-run effects of exchange rate volatility on exports: The case of Australia and New Zealand", *Journal of Economic and Finance*, Vol. 22, no. 2-3, pp. 43-56.
- Arize, A. C. Osang, T. and Slottje, D. J. 2000. "Exchange-Rate Volatility and Foreign Trade: Evidence from Thirteen LDCs". *Journal of Business and Economic Statistics*, 18, pp. 10-17.
- Baum, C. F., Caglayan, M. and Barkloulas, J. T. 2001, "Exchange Rate Uncertainty and Firm Profitability", *Journal of Macroeconomics*, 23, pp. 565-576.
- Bayoumi, T. and Eichengreen, B. 1998. "Is regionalism simply a diversion? Evidence from the evolution of the EC and EFTA", *CEPR discussion papers*.
- Bini-Smaghi, L. 1991. "Exchange variability and trade: Why is it difficult to find any empirical relationship?", *Applied Economics*, Vol. 23, pp. 927-936.
- Bollerslev, T. 1986. "Generalised Autoregressive Conditional Heteroscedasticity", *Journal of Econometrics*, Vol. 31, pp. 307-327.
- Caporale, T and Khosrow, D. "Exchange rate variability and the flow of international trade", *Economics Letters*, 46, 1994, 49-54.

- Cheong, C. 2004. "Does the risk of exchange rate fluctuation really affect international trade flows between countries?." *Economics Bulletin*, Vol. 6, No. 4, pp. 1-8
- Choudry, A. R. 1993. "Does exchange rate volatility depress trade? Evidence from error correction models", *Review of Economics and Statistics*. Vol. 75, pp. 700-706.
- Clark, P. 1973. "Uncertainty, exchange risk and the level of international trade", *Western Economic Journal*. Vol. 11, pp. 302-313.
- Clark, P. et al. 2004. "Exchange rate volatility and trade flows - Some new evidence", *IMF working paper*.
- Cote, A. 1994. "Exchange rate volatility and trade: A survey", *Bank of Canada Working Paper*, No.94-5.
- Das S K. 2003. "Effects of exchange rate volatility on international trade: An empirical analysis", *Mimeo*. Department of Economic, Vanderbilt University.
- Dell' Ariccia, G. D. 1998. Exchange rate fluctuations and trade flows: Evidence from the European Union. IMF working paper WP/98/107.
- de Vita, G. and Abbott, A. 2004. "The impact of exchange rate volatility on UK exports to EU countries", *Scottish Journal of Political Economy*, Vol. 51, No. 1, pp. 63-81.
- Doyle, E. 2001. "Exchange rate volatility and Irish-UK trade, 1979-1992". *Applied Economics*, Vol. 33, pp. 249-265.
- Engel, R. 1982. "Autoregressive Conditional Heteroscedasticity with estimates of the variance of the United Kingdom inflation", *Econometrica*, No. 50, pp. 987-1007.

- Engel, R. 2001. "GARCH 101: The use of ARCH/GARCH models in applied econometrics", *Journal of Economic Perspective*, Vol. 15, No. 4, pp. 157-168.
- Engel, R. 2002. "New frontiers for ARCH models", *Journal of Applied Econometrics*, No. 17, pp. 425-446.
- Engel, R. and Granger, C. W. J. 1987. "Cointegration and error correction: Representation, estimation and testing", *Econometrica*, No. 55, pp. 251-276.
- Farrell, G N. 2001. Capital controls and the volatility of South African exchange rates. South African Reserve Bank Working Paper, WP 01/05
- Giovannini, A. 1988. "Exchange rates and traded goods prices". *Journal of International Economics*, No. 34, pp. 45-68.
- Granger, C W J. 1986. "Developments in the study of cointegrated variables", *Oxford Bulletin of Economics and Statistics*, 48, pp. 424-38.
- Hooper, P. and Kohlhagen, W. 1978. "The effects of exchange rate uncertainty on the prices and volume of international trade", *Journal of International Trade*, No. 8, pp. 483-511.
- Johansen, S. 1991. "Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models", *Econometrica*, No. 59, pp. 1551-1580.
- Johansen, S. 1995. "Likelihood-based inference in cointegrated vector autoregressive models", Oxford: Oxford University Press.
- Kikuchi, T. 2004. "The Impact of Exchange Rate Volatility on Bilateral Exports in East Asian Countries", Thesis submitted to the Graduate School of Systems and Information Engineering in partial fulfilment of the requirements for the Degree of Master of Finance, University of Tsukuba.

- Klein, M. 1990. "Sectoral effects of exchange rate volatility on United States exports", *Journal of International Money and Finance*, No. 9, pp. 299-308.
- Maskus, K. E. 1986. "Exchange rate risk and US trade: a sectoral analysis", Federal Reserve Bank of Kansas City.
- McKenzie, M. D. 1999. "Impact of exchange rate volatility on trade flows", *Journal of Economic Surveys*, No. 13, pp.71-106.
- Morgenroth, L. W. 2000. "Exchange rate and trade: The case of Irish exports to Britain", *Applied Economics*, No. 32, pp. 107-110.
- Pesaran, M. H., Shin, Y. and Smith, R. J. 2001. "Bounds testing approaches to the analyses of level relationships", *Journal of Applied Econometrics*, No. 16, pp. 289-326.
- Pick, D.H., August 1990. "Exchange Rate Risks and U.S. Agricultural Trade Flows," *American Journal of Agricultural Economics* 72, , 694-700.
- Sercu, P and Vanhulle, C. "Exchange rate volatility, international trade, and the value of exporting firms," *Journal of Banking and Finance*, 16, 1992, 155-182.
- Siregar, R. and Rajan, R. S. 2002. "Impact of exchange rate volatility on Indonesia's trade performance in the 1990s", University of Adelaide, Center for International Economics studies (CIES), *Discussion Paper*, No. 0205.
- Tenreyro, S. 2004. "On the trade impact of nominal exchange rate volatility", Federal Reserve Bank of Boston, *Working Paper* 03-2.
- Wang, K L. and Barrett, C B. 2002. A New Look at the Trade Volume Effects of Real Exchange Rate Risk. Cornell University Department of Applied Economics and Management Working Paper, No. WP 2002-41