ESTIMATING ELASTICITIES OF DEMAND AND SUPPLY FOR SOUTH AFRICAN MANUFACTURED EXPORTS USING A VECTOR ERROR CORRECTION MODEL

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Elasticities of demand and supply for South African manufactured exports are estimated using a vector error correction model in order to address simultaneity and non-stationarity issues. Demand is highly price-elastic, with elasticities ranging from –3 to –6. The price elasticity of supply is generally about 1, but some estimates are as low as 0.35. Competitors' prices and world income are important determinants of demand, but domestic capacity utilization is not an important determinant of export supply. Many different data alternatives are sourced, constructed and estimated, showing the results can be sensitive to the choice of series.

1: INTRODUCTION

Many trade studies have tried to find the reason why some countries are successful exporters. The main issue is *"...whether manufactured exports ... are predominantly dependent upon the economic prosperity of [the countries'] trading partners or ... their ability to compete in export markets on the basis of price"* (Abbott & De Vita, 2002:1025).

South Africa's *Growth, Employment and Redistribution* (GEAR) policy document states that promoting export led growth requires measures designed to lower unit costs and enhance competitiveness (RSA, 1996). Implicit in this is the view that South Africa competes on the basis of price. While a policy of pursuing competitive export prices / real exchange rates is certainly more active than one of simply hoping the world economy grows, it may not work if demand is not sensitive to prices.

If, on the other hand, South Africa is a price-taker, export quantities are determined solely by export supply. Policy must then concentrate on making exports more profitable for producers relative to domestic sales. Its effectiveness would depend on the price elasticity of export supply.

Another important consideration is the relationship between exports and the domestic business cycle. Using the late 1980s as an example, one view is that South African producers export only when domestic demand is insufficient relative to capacity. This suggests a negative association between exports and growth (Belli, Finger & Ballivian, 1993). Other studies find a positive relationship (Goldstein & Khan, 1985), thus supporting the view that exports are an exogenous component of Keynesian-style aggregate expenditure.

While this study contributes to these debates, its main aim is to derive elasticities of demand and supply for manufactured exports using time series data. These can be used as inputs into other studies, especially in the growing computable general equilibrium model arena.

Following the generally accepted specification in Goldstein & Khan (1985), the underlying model is based on the standard laws of demand and supply. However, the choice of which specific variables to use is fairly wide. Section 2 discusses this, motivates adding competitors' prices to the established framework and justifies representing domestic income separately as potential output and capacity utilization.

While the specification of variables is fairly standard, this study runs numerous estimations with different combinations of data sets. The aim is to gauge the robustness of the estimates to different representations of a given variable. This requires the sourcing, combination and construction of long data sets. This process is described in section 3

There are two standard flaws in other studies. The first flaw is the estimation of a single equation when a system of two equations, one for demand and one for supply, is appropriate. An estimate of (say) the single demand equation produces biased estimates, unless supply is perfectly price elastic, which should not be assumed. The second flaw is a failure to account for non-stationary data, which may cause spurious regressions (Gujarati, 1995).

Section 4 proposes a method that addresses both flaws. This study uses a vector error correction model (VECM) to explain changes in exports in terms of lagged changes in all the variables in the system and in terms of adjustment to long run equilibrium. The long run equilibrium is governed by a cointegrating regression. The elasticities are contained in this cointegrating relationship (Patterson, 2000).

Section 5 finds that export demand is highly price elastic, ranging from -3 to -6, and that competitors' prices are important demand factors. The price elasticity of supply is about 1, but there seems to be no clear relationship between capacity utilization and exports. Section 6 provides a brief summary and interpretation and suggests avenues for extending the study.

2. THEORY

2.1 BASIC FRAMEWORK

Most empirical work on the determinants of export performance draw upon the imperfect substitutes model, as outlined by Goldstein & Khan (1985). Exports are a function of a system of export demand and export supply equations. These can be expressed as:

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\begin{aligned}
X^s &= f(\overset{+}{p^e}; \overset{-}{p^d}; \overset{+}{y^d}) \\
X^d &= g(\overset{-}{p^e}; \overset{+}{p^f}; \overset{+}{p^c}; \overset{+}{y^f})
\end{aligned}
\tag{2.1}
$$

X^s is the volume of exports supplied; X^d is the volume of exports demanded; p^e is the export price

p^d is the domestic price; y^d is a measure of income, capacity or capacity utilization in the exporting country

p^f is the foreign price; p^c is competitors' prices; y^f is foreign income

In this model, goods for the export and domestic market are differentiated and the decision whether to produce export or domestic goods depends on relative prices. Similarly, consumption of foreign or domestic goods is a function of relative prices. This model is particularly appropriate in the manufacturing sector, where goods are differentiated.

A higher price for exports raises profitability absolutely. Lower domestic prices lower input costs and make selling domestically less attractive, so they also promote export supply (Goldstein & Khan, 1985). As section 2.4 discusses, many authors include measures of production capacity or capacity utilization because they can affect export supply in various ways.

Higher GDP in foreign countries leads to higher demand in those countries. A foreign country can choose between the exporter's products, the foreign country's domestically produced alternatives and other countries' exports. The demand function therefore includes foreign income and price variables for South African exports, competitors' exports and the foreign country's domestically produced substitutes.

2.2 SIMULTANEITY

There are two equations, export demand and export supply. Orcutt (1950, in Goldstein & Khan, 1985) states that, because quantities and prices are related, single equation estimates of elasticities are biased downward.

International Studies have traditionally focussed on demand elasticities, assuming that supply elasticities are perfectly elastic to justify single-equation estimates (Goldstein & Khan, 1978; Senhadji & Montenegro, 1999).

In contrast, Bhorat (1998) and Fallon & Pereira de Silva (1994) estimate South African supply equations only. Bhorat justifies this by saying South Africa is a small open economy and therefore faces a perfectly elastic demand curve for its exports. While this is a plausible argument for homogenous commodities, it is less likely to hold in manufacturing. The uncertainty alone motivates an estimate of price elasticities of demand.

Given that neither demand nor supply can be assumed to be perfectly elastic, one option is to convert the structural equations into reduced form equations. Tsikata (1999) uses a single reduced form equation for South Africa. She specifies the structural equations in terms of p^e, sets them equal to each other and sets export supply equal to export demand to estimate an equation for a single export quantity. Wood (1995) directly presents a single equation model for South Africa's share of exports that includes both traditional supply and demand factors.

However it is seldom possible to extract or identify elasticities from such equations. Both Wood (1995) and Tskiata (1999) answer interesting questions with their models, but don't give price elasticities. To estimate price elasticities, a method that can deal with structural simultaneous equations is necessary (Goldstein & Khan, 1985).

To estimate price elasticities, a method that can deal with structural simultaneous equations is necessary. This study therefore uses a vector-error-correction model to identify and estimate the export supply and export demand equations.

2.3 PRICES AND EXPORT QUANTITIES

A correctly specified model has four different price variables:
 i. The price in the country being exported to or a weighted average of countries being exported to, or some international price, henceforth *foreign prices* (p^f)
 ii. Competitors' export prices, henceforth *competitors' prices* (p^c)
 iii. The price of goods made for domestic consumption, henceforth *domestic prices* (p^d)
 iv. The exporting country's export price, henceforth *export prices* (p^e)

To study the factors affecting South African export quantities, Tsikata (1999) specifies the real effective exchange rate in her demand equation and has the export price in her supply equation[1]. In similar studies, Fallon & Pereira de Silva (1994) employ the real effective exchange rate, and Wood (1995) uses the deviation of the exchange rate from purchasing power parity and the ratio of South African prices to trading partners' prices.

The real exchange rate is clearly appropriate when the question being asked is the effect of changes in the exchange rate on exports, but this study does not ask this question. Generally, only trading partners, not competitors, determine effective exchange rates[2]. Therefore, real effective exchange rates are especially inappropriate for this study.

Within a certain industry, trade theory predicts that the products a country imports from a variety of sources are distinct in some way from the products it produces domestically. Therefore, the products exported to a country by two or more rival exporters should be closer substitutes for each other than for products produced by the importing country. There is therefore a strong argument for including competitors' export prices in the demand equation.

While export prices and export volumes are the two separate variables traditionally solved for. "*Trade data, however, are oblivious to this theoretical nicety and are most readily available in value terms*" (Goldstein and Khan, 1985:1054). An export price index based on actual export contracts or transactions is in principle the first choice. Export price indices are usually not available for developing countries, long time periods or disaggregated data. There are two alternative deflators.

The first alternative is a unit value index. It is constructed by dividing export values by export volumes. The main drawback in price indices of aggregated goods is that a change in the composition of exports in favour of higher-quality or higher-value goods results in higher unit values (Mahdavi, 2000). The second alternative is the domestic producer price index (PPI). It suffers from the serious shortcoming that it contains both tradable and non-tradable goods (Goldstein and Khan, 1985). One of the key elements of the model is relative export and domestic prices, so PPI is not a useful proxy.

For domestic prices, Golub (2000) lists many drawbacks of consumer prices, making producer prices the better option. Goldstein & Khan (1985) argue the index should exclude non-tradable goods, rendering the wholesale price index or GDP deflator sub-optimal. In South African studies, Wood

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[1] Because data and econometric difficulties motivate her estimating a reduced form equation, the export quantity is dropped, leaving the real exchange rate as the only price measure.
[2] The IMF is working on new real effective exchange rates that capture third-country competition more accurately (Golub, 2000).

(1995) and Bhorat (1998) use sectoral PPI, while Fallon & Pereira de Silva (1994) capture all relative prices using the real effective exchange rate.

Some authors use the foreign countries' export prices as the foreign country price variable (eg Bhorat, 1998). Wood (1995) uses sectoral producer prices in South Africa's most important trading partners. Others incorporate foreign prices by using the real effective exchange rate. As is so for the exporting country, foreign countries' export price indices are a better option when available.

However, foreign countries' import price indices should be used instead. After all, the products a foreign country imports and the domestic country exports are likely to be closer substitutes than both countries' exports. Furthermore, an import price index should track domestically produced substitutes for imports more directly than the export price index.

Because the quantity of exports demanded is restricted to equal the quantity of exports supplied, the same variable appears in both the demand and supply equations when the two equations are estimated. Wood's (1995) variation is to use South Africa's share of world exports while Fallon & Pereira de Silva (1994) use exports divided by gross output.

2.4 INCOME OR PRODUCTION CAPACITY

The higher a country's production capacity, the higher its export supply is (Goldstein & Khan, 1985). While the relationship between potential GDP and exports is straightforward, the relationship between cyclical or actual GDP and exports is subject to debate.

The "vent-for-surplus" argument, found in Fallon & Pereira de Silva (1994) for example, is that producers only export if they cannot sell their products domestically. Furthermore, higher capacity utilization means the country's production ability is used up. These arguments suggest that causality runs from domestic income to exports and higher income leads to lower exports. In contrast, simple Keynesian models list exports as a component of aggregate expenditure, where exports are determined by international factors, not domestic demand. The implication is that exports drive capacity utilization.

The conflicting arguments above have their own policy implications. A key component of GEAR is export-led growth (RSA, 1996) and Bhorat (1998) argues South African firms should seek export opportunities actively instead of being "residual" (pg 8) exporters. If this is the attitude amongst producers, their mindsets will have to be changed for exports to be a growth driver. This is especially the case if exports are supply driven.

Using actual output, which is a combination of production capacity and capacity utilization, is unlikely to be informative. For example, the "vent-for-surplus" argument may dominate the Keynesian-type argument, but might be overwhelmed by the production capacity effect. The resulting positive coefficient is inconclusive. As the appendix shows, using actual output effectively restricts the coefficients on capacity utilization and potential GDP equal to each other.

Using both capacity utilization and potential GDP allows one to separate the influence of production capacity from cyclical factors. One way to measure these variables is to use an index of the physical volume of production and a time variable, as in Bhorat (1998). Tsikata (1999) uses manufacturing capacity utilization while Fallon & Pereira de Silva (1994) represent cyclical income using the

deviation of actual from potential output. Wood (1995) uses South African capacity utilization relative to that of her major trading partners.

3. DATA ISSUES

This section discusses issues of data length. It also discusses the variables chosen for estimation and, in some cases, the alternative sources and/or construction methods used to represent these variables. Testing the robustness of the results to the choice of source or method is a major element of this paper. Because many of the series did not exist before this study, they are available from the authors on request.

Vector autoregressions require many observations (Patterson, 2000). They also require long time spans to allow sufficient opportunity for enough shocks to take place and for adjustment to those shocks to occur. Bhorat (1998) estimates monthly data from 1995-2000. While this may be a high number of observations, the time span is insufficient.

Existing databases do not go back far enough, so some data were captured manually from printed sources. Long time series are prone to definitional adjustments and inconsistencies. In some cases, data from various sources was merged. In others, proxies were necessary. This is a serious drawback. This study uses quarterly data from 1975-2000. Given the VECM's need for observations over a reasonable time span and the relatively large number of variables employed, the advantages of longer time series outweigh the disadvantages.

Another major issue is the choice of data series. Section 2 discussed the details of alternative representations of a variable. This study in particular has alternative data sources and constructions for the same series, as explained in the rest of this section and the appendix. When there are a variety of options, it is especially important to investigate the robustness of the results to the choice of data. After all, advances in econometric methodology cannot compensate for poor data quality or selection (Dezhbakhsh, 2002). Sourcing and constructing various time series and testing the robustness of the results to the choice of source or method is a major element of this paper.

The trade and industrial policy secretariat (TIPS) has Standard Industrial Classification (SIC) data for manufacturing sub-sectors from 1988 onwards. Data from 1975 to 1995 was taken from various issues of the *Quarterly Bulletin of Statistics*, published by Statistics South Africa. The series were inexplicably discontinued in 1996.

There is an eight-year period of overlap (1988-1995) between the two sources. The values are inexplicably greater in the data sourced from Statistics South Africa over this period. Therefore, two separate series are employed in separate sets of estimations. Both use combinations of TIPS and Statistics South Africa data. One uses TIPS data (henceforth TIPS series) from 1988 onwards, using Statistics South Africa data for the rest, while the other uses TIPS data from 1996 onwards only (henceforth SSA data).

There are two variables for export prices – export unit values and a producer price index for exports. The former are derived by dividing export value by export volume while the latter are based on direct measures of prices of exported goods.

Export unit value data was taken from exactly the same sources as export volumes. There are again disparities between the sources. Any regressions that use SSA volumes will use SSA unit values and the same applies for TIPS data. Export price indices required substantial construction, as explained in the appendix. The export PPI and unit values differ, although they tend to converge towards the end of the time period. The TIPS measure is especially different.

Manufacturing import price indices for the United States, United Kingdom, Germany and Japan are used to create the foreign price index. These countries were South Africa's four largest total export destinations throughout the 1990s (ABSA, 2001). The data are weighted by real import volumes, derived using nominal values and price indices.

The competitors are Mexico, Hungary and South Korea, representing competitors close to export markets in North America, Eastern Europe and South East Asia. The data are subject to the same aggregation procedure.

The United States, United Kingdom, Germany and Japan were chosen to represent foreign income. Two methods are used to standardize the GDPs. The first converts each country's GDP into US Dollars at the nominal exchange rate. Exchange rates are seldom at their "equilibrium" level, so Schreyer & Koechlin (2002) recommend using purchasing power parities (PPPs) instead. These are important when one is trying to standardize volumes of production rather than values. Both methods are used and compared.

Real GDP and manufacturing capacity utilization are used to derive potential GDP for South Africa, as explained in the appendix.

4. ECONOMETRIC METHODOLOGY

The primary aim is to estimate possible long run relationships governing export demand and export supply. Correct specification of long run relationships requires an equilibrium correction term (Patterson, 2000). Doing so while accounting for simultaneity motivates the use of a Vector Error Correction Model (VECM).

Augmented Dicky-Fuller (ADF) tests with linear trend do not reject the I(1) hypothesis at all lags for all variables except capacity utilization. Capacity utilization is sometimes included in non-logarithmic format (CAPUTNL). The ADF test fails to reject the I(1) hypothesis for CAPUTNL at the correct lag length in terms of the Akaike information (AIC) and Schwarz Bayesian (SBC) criteria, but not for the other lags. It is important to include capacity utilization in the cointegrating vector as its sign is of particular interest. However, only the flimsiest evidence would justify doing so so far. Therefore, the alternative Phillips-Perron test is also used (see Pesaran & Pesaran, 1997). This test unambiguously does not reject the I(1) hypothesis, so CAPUTNL is included as an I(1) series.

At all lags, the ADF test with no linear trend convincingly rejects the hypothesis that the variables are I(2). The variables are I(1) and and candidates for a long run relationships.

Equation 4.1 is Vector Autoregression (VAR) of order ρ representing each of m endogenous variables as a function of lagged values of all m endogenous and n exogenous variables. $\mathbf{y_t}$ is a vector of length m

and the $\mathbf{z}_{t\text{-}i}$ are vectors of length $m+n$ (see Patterson, 2000). $\mathbf{u}_t$ is a vector of constants and $\boldsymbol{\varepsilon}_t$ is a vector of residuals.

$$\mathbf{y_t} = \mathbf{u_t} + \mathbf{\Pi}_1 \mathbf{z}_{t-1} + \mathbf{\Pi}_2 \mathbf{z}_{t-2} + ...\mathbf{\Pi}_\rho \mathbf{z}_{t-\rho} + \boldsymbol{\varepsilon}_t \tag{4.1}$$

The AIC and SBC aid in order selection while log-likelihood ratio (LR) tests test the hypothesis that the order is ρ and not $\rho+1$. The statistical criteria are characteristically (Patterson, 2000) ambiguous in this study. The advice of Pesaran & Pesaran (1997) is followed, who suggest making order selection subject to the absence of serial correlation in the individual equations.

The corresponding Vector Error Correction Model (VECM) is (Pesaran & Pesaran, 1997; Patterson, 2000):

$$\Delta\mathbf{y_t} = \mathbf{a}_0 + \mathbf{a}_1 t + \mathbf{\Pi w}_{t-1} + \mathbf{\Gamma}_1 \Delta\mathbf{w}_{t-1} + \mathbf{\Gamma}_2 \Delta\mathbf{w}_{t-2} + ...\mathbf{\Gamma}_{\rho-1} \Delta\mathbf{w}_{t-(\rho-1)} + \boldsymbol{\psi}\mathbf{D}_t + \boldsymbol{\varepsilon}_t \tag{4.2}$$

$\Delta\mathbf{y_t}$ is a vector length m of changes in each of the endogenous variables in the underlying VAR. Vectors $\mathbf{w}$ and $\Delta\mathbf{w}$ have the m endogenous variables as well as q I(1) exogenous variables. $\mathbf{\Pi} = \boldsymbol{\alpha}\boldsymbol{\beta}'$ is a square matrix of dimension $m+q$. $\boldsymbol{\beta}'$ is the matrix of coefficients generating long run equilibrium. Each row of length $(m+q)$ corresponds to one of r cointegrating vectors. $\boldsymbol{\alpha}$ is an $(m+q)\times r$ matrix containing the coefficients that show the speed of adjustment to long run equilibrium (Patterson, 2000).

The number of long run relations (r) depends on the eigenvalues of the companion matrix $\mathbf{C}$ corresponding to equation 4.1[3]. Johansen develops an ML technique for estimating the coefficients in the companion matrix (Johnston & DiNardo, 1997) and testing for r (Patterson, 2000). The maximum eigenvalue statistic and the trace test are sometimes ambiguous but our theoretical prior that there are 2 long run relationships exert a bias in favour of $r=2$.

In a few cases, the Johansen procedure strongly suggests more than 2 vectors. In such a case, one can either continue to estimate 2 vectors or try to estimate more. Both options present specification error; the former ignores possible cointegrating relations while the latter misspecifies them by omitting many variables, biasing estimates in all the vectors (Banerjee, Dolado, Galbraith & Hendry, 1993). These few cases always produced poor results, regardless of the option chosen.

Assuming world GDP and foreign prices are exogenous tends to reduce the value of r forwarded by the test statistics, suggesting the assumptions mitigate misspecification. This factor, together with theoretical support for these variables being exogenous motivates the assumption. However, all satisfactory results are tested for robustness to changing the assumption. This had an important effect in some cases.

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[3] $\mathbf{C} = \begin{pmatrix} \mathbf{\Pi}_1 & \mathbf{\Pi}_2 & . & \mathbf{\Pi}_{\rho-1} & \mathbf{\Pi}_\rho \\ \mathbf{I} & 0 & . & 0 & 0 \\ 0 & \mathbf{I} & . & 0 & 0 \\ 0 & 0 & . & 0 & 0 \\ . & . & . & . & . \\ 0 & 0 & . & \mathbf{I} & 0 \end{pmatrix}$

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The values in $\mathbf{\Gamma_1}$ show the instantaneous effects of the changes in each I(1) variable on all the endogenous variables in the subsequent period. The effects of longer lags are also captured. Vector $\mathbf{D_t}$ contains the n I(0) exogenous variables. $\mathbf{\Psi}$ contains coefficients of the effects of each I(0) exogenous variable on each of the endogenous variables.

$\mathbf{a_0}$ is an intercept and $\mathbf{t}$ is a trend variable. The critical values used to choose r depend on the restrictions placed on $\mathbf{a_0}$ and $\mathbf{a_1}$ (Pesaran & Pesaran, 1997). This study will leave $\mathbf{a_0}$ unrestricted, allowing for both a constant in the cointegreating regressions and for linear trends in the data. $\mathbf{a_1}$ will either be restricted to zero or to the value of the time coefficients in the cointegrating vectors. An unrestricted coefficient would allow for quadratic trends in the underlying data.

When there are two cointegrating vectors, there must be at least two restrictions per vector for $\mathbf{\alpha}$ and $\mathbf{\beta}$ to be identified (Patterson, 2000). In this study, two cointegrating vectors are identified as demand and supply equations. Besides normalizing each vector by imposing a coefficient of 1 on export quantity, domestic prices and domestic income are restricted to zero in the vector representing export supply and competitors' prices and foreign income are restricted to zero in the vector for export demand.

In addition, price restrictions can be imposed. Price homogeneity has substantial microeconomic theoretical justification, but the extent to which it applies in an aggregated trade context is not established empirically. For this reason, estimations are attempted with and without price homogeneity restrictions.

System 4.3 is an explicit example of equation 4.2. The $\mathbf{\Pi}$ matrix is broken up into $\mathbf{\alpha}$ and $\mathbf{\beta}$. There is one matrix of lagged coefficients because the order of the VAR is often 2. $\mathbf{a_1}$ is restricted to zero here. The matrix of deterministic terms $\mathbf{D}$ is empty in this example, but could contain the I(0) capacity utilization variable. No price homogeneity restrictions are imposed on 4.3.

$$
\begin{pmatrix} \Delta X \\ \Delta p^e \\ \Delta p^d \\ \Delta CU \\ \Delta p^f \\ \Delta y^f \end{pmatrix}_t = \begin{pmatrix} a_{01} \\ a_{02} \\ a_{03} \\ a_{04} \\ a_{05} \\ a_{06} \end{pmatrix} + \begin{pmatrix} a_{11} & a_{21} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \\ \alpha_{41} & \alpha_{42} \\ \alpha_{51} & \alpha_{52} \\ \alpha_{61} & \alpha_{62} \end{pmatrix} \begin{pmatrix} 1 & \beta_{12} & \beta_{13} & \beta_{14} & \beta_{15} & 0 & 0 & 0 \\ 1 & \beta_{22} & 0 & 0 & 0 & \beta_{26} & \beta_{27} & \beta_{28} \end{pmatrix} \begin{pmatrix} X \\ p^e \\ p^d \\ CU \\ y^p \\ p^c \\ p^f \\ y^f \end{pmatrix}_{t-1}
$$

$$
+ \begin{pmatrix} \Gamma_{21} & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot \\ \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \cdot & \Gamma_{68} \end{pmatrix} \begin{pmatrix} \Delta X \\ \Delta p^e \\ \Delta p^d \\ \Delta CU \\ \Delta y^p \\ \Delta p^c \\ \Delta p^f \\ \Delta y^f \end{pmatrix}_{t-1}
$$

(4.3)

X is export quantity, p^e is export price, p^d is domestic price, CU is capacity utilization (when included in the long run vector), y^p is potential output, p^c is competitors' price, p^f is foreign price and y^f is world GDP. The last two are usually assumed exogenous.

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5. RESULTS

The results of a wide range of estimations are summarised in table 5.1. Results or ranges separated by a semi-colon are reported when there is an obvious break in the range of estimates. If so, the values are listed in descending order of prevalence. These breaks were often the result of the use of a particular combination of data series.

LONG RUN COEFFICIENTS	
Supply Equation	
Price elasticity of Supply	0.7 to 1.3; 0.35
Domestic Prices	−0.7 to −1.3; −0.35
SA Potential GDP	2.6 to 3.9
SA Capacity Utilization*	−0.02 to 0.12
SA GDP	2.7 to 3.7
Demand Equation	
Price elasticity of Demand	−3 to −6
Competitors' Prices	2.5 to 4
Foreign Prices	1.5 to 2.5
Foreign GDP (PPP)	3.5
Foreign GDP (USD)	2 to 2.5

Table 5.1: Summary of long run coefficient estimates. A semi-colon represents a break in the range of elasticity estimates; values/ranges are listed in descending order of importance. For example −0.7 to −1.3; −0.35 means elasticities generally ranged from −0.7 to −1.3, but there were a few estimates close to −0.35 . * denotes not in log format, so the coefficient must be interpreted differently to the others.

Price elasticity estimates range from −3 to −6. While the range is wide, these estimates are unequivocally large. This suggests demand for South African manufactured exports is highly elastic, so lower export prices would raise export revenues, not only volumes. However, such large elasticities could be pointing to demand that is nearly perfectly (infinitely) elastic and that exports are therefore supply determined.

The mode of the price elasticity of supply estimates is 1.2, but this value is mainly generated by the SSA series. TIPS series have lower estimates. Using actual GDP instead of potential GDP and capacity utilization lowers price elasticity estimates to about 0.35 for both series.

The coefficient on potential GDP is as expected positive, with estimates ranging from 2.6 to 3.9. Capacity utilization, when included in the VAR in non-logarithmic format, is generally positive. Using actual GDP yields estimates ranging from 2.7 to 3.7, producing similar results to potential GDP. The similarity between actual and potential GDP and the inconclusive capacity utilization results suggest the relationship between GDP and exports operates solely through the production potential influence and not through aggregate demand or capacity utilization.

The coefficients on foreign prices and competitors' prices are consistent when exogenous foreign prices are assumed. While the coefficients on prices in South Africa's markets range from 1.5 to 2.5, the coefficients on the prices offered by competitors range from 1 to 4. Competitors' prices, which have

been ignored in other studies, are certainly an important determinant of demand for South African exports. The results also assert that absolute competitiveness improvements may not be sufficient to increase export demand. If our competing exporters continue to offer cheaper goods, lower South African export prices will be required merely to preserve market share.

Competitors' prices, which have been ignored in other studies, are certainly an important determinant of demand for South African exports. The results also assert that absolute competitiveness improvements may not be sufficient to increase export demand. If our competing exporters continue to offer cheaper goods, lower South African export prices will be required merely to preserve market share.

There is a distinct and consistent difference between estimates on foreign GDP standardized in US Dollars and in PPP terms. The former has coefficients ranging from 2 to 2.5 while the latter has coefficients of about 3.5.

The range of estimates is in some cases indicative of the sensitivity of the results to the data used and restrictions imposed. Furthermore, some of the estimations produce theoretically inconsistent results. Many of the imperfect estimates have the correct coefficients except for the two price variables on the supply side, namely export price and domestic price. A negative export price coefficient and a positive domestic price coefficient are common. Price homogeneity restrictions regularly switch the signs of the price coefficients around.

Theoretically inappropriate results also result when foreign prices and foreign GDP are not assumed exogenous. Not assuming exogeneity often means the Johansen Technique finds more than 2 long run relationships and introduces the specification issues discussed earlier.

Satisfactory long run estimates motivate the study of error correction models for exports. The coefficients on the error correction terms in α are as expected negative. If export demand or supply is higher than suggested by the other variables in the cointegrating relationship, it should fall and vice versa. About half the equilibrium correction coefficients for the supply equations are significant; all the significant ones are −0.07 or higher. There are a greater number of significant demand equation terms, but the range of coefficients is slightly wider.

SHORT RUN COEFFICIENTS	
Supply Error Correction Coefficient	−0.02 to −0.09
Demand Error Correction Coefficient	−0.03 to −0.17
Capacity Utilization – I(0)	−0.047 to +0.034

Table 5.2: Selected short run coefficient estimates. The error correction terms are as expected negative, albeit quite low. The coefficient on changes in capacity utilization is insignificantly different from zero.

A coefficient of −0.03 means that a change of 1% caused by lagged changes in the other variables rises to a change of 1.03% or falls to a change of 0.97% because of adjustment to equilibrium. This suggests very slow adjustment; it would take 23 quarters for half of the error to be corrected for.[4] Even the highest satisfactory coefficient of −0.17 means a 10% positive shock to the error term will only cause an additional downward adjustment of 1.7%. The half-life of the disequilibrium is 4 quarters.

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[4] The half-life formula is $Q=ln2/\beta$ (Haeussler & Paul, 1996).

Slow adjustment is a typical symptom of there being some positively autocorrelated variable missing from the model, or perhaps a structural break.[5] The lower coefficients for supply suggest switching production from one market or product to another takes time. As is the case in studies of purchasing power parity, slow adjustment could be symptomatic of thresholds that must be crossed before a change in behaviour is introduced. Once the data permits it, there may be gains from using methods allowing for non-linear adjustment to equilibrium (Sarno & Taylor, 2002).

The lagged differenced I(0) version of capacity utilization is sometimes included in the full VECM. The short run coefficients range from –0.047 to 0.034 and are statistically insignificant, but almost all terms in the ECM are insignificant (α being an important exception). Nonetheless, evidence from the I(0) and I(1) specifications is not strong enough to assert capacity utilization and export supply are positively or negatively related. This is very disappointing, as the estimations cannot evaluate the relative strengths of the "vent-for-surplus" and the "exports-generate-demand" arguments.

All ECMs based on satisfactory long-run estimates were highly significant, with F-statistics ranging from 0.000 to 0.005.

The nature of the other South African studies limits direct comparability. Bhorat (1998) estimates the price elasticity of supply for total exports to be 1.3, which is close to this study's estimates despite assuming perfectly elastic demand. The coefficient on domestic price is –4.7. Fallon & Pereira de Silva (1994) find that their relative price variable has the incorrect sign and is insignificant. Their other regressions find the real exchange rate significant, but with elasticities of less than – 0.5. Tsikata (1999) also finds the exchange rate deviation from the purchasing power parity level significantly negative.

Fallon & Pereira de Silva (1994) find capacity utilization is statistically significant with a coefficient exceeding –1, but Tsikata (1999) and Wood (1995) advance capacity utilization is not important. Bhorat (1998) estimates the coefficient on domestic output to have an elasticity of –1.8, suggesting the "vent-for-surplus" argument prevails and is strong enough to outweigh the likely positive effects of potential income. Both Fallon & Pereira de Silva and Wood (ibid.) find world income to be insignificant.

6. CONCLUSION

Export supply is a function of the price of exports, the prices of domestic production substitutes and inputs, production capacity and domestic demand conditions. Export demand is a function of the price of exports, the price of substitute products in the export market, the price of substitute products produced by competitors and world income. Choosing the data series is not straightforward. This paper required the substantial sourcing, capturing and merging of series from different sources and the construction of other series.

VECMs are used because they provide an integrated way of estimating systems of simultaneous equations using non-stationary data. The Johansen Technique is used to validate the theoretical assertion that there are two cointegrating relations in this study. Estimating the coefficients entails finding combinations of the variables that are cointegrated. By imposing theoretically motivated

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[5] As pointed out by John Muellbauer.

restrictions, separate demand and supply equations are identified. This allows the coefficients to be interpreted as long run elasticities.

This paper concentrates on finding the coefficients of the long run cointegrating relationships, improving on existing South African studies by using the VECM technique, by using a relatively large data set, and by introducing some new variables, notably competitors' export prices, to the standard specification.

The wide range of some coefficient estimates shows the selection and construction of the data series can affect the results. Nonetheless, some broad patterns emerge.

The price elasticity of demand is –3 to –6, suggesting lower export prices would result in increased export revenue, but not dismissing the possibility of perfectly elastic demand. The income elasticity of demand depends on whether income is measured in US Dollars or in terms of purchasing power parities, ranging from 2 to 3.5. The conclusion is that, while world income is relevant, active competitiveness measures can materially affect export performance.

This conclusion is affirmed by the positive coefficients on foreign prices and competitors' prices. Cross elasticities ranging from 1 to 4.5 suggest absolute competitiveness improvements may not be enough to improve exports. Competitiveness enhancements may be necessary merely to preserve export shares.

The price elasticity of supply is about 1, with a mode of 1.2 and some estimates as low as 0.35. The coefficient on domestic prices is about –1. Production potential is positively related to exports, having a coefficient of 2.6 to 3.9, but capacity utilization does not seem to be important; the relationship between domestic output and exports is expressed fully through potential GDP.

The adjustment to the long run equilibrium relationship is a significant determinant of changes in export quantities, but adjustment to equilibrium is slow.

While the specification is fairly standard, there is scope for alternative variable constructions, which perhaps study the role of real exchange rates more directly. Slightly different specifications could be attempted, and identifying restrictions imposed, to test whether South Africa is a price taker or not. If it is, policy should concentrate on export supply. If it isn't, the high demand price elasticities suggest a strong role for price-competitiveness measures.

In a few years, research should also have the luxury of using long time series from a single source, avoiding some of the data inconsistencies encountered by this study. The data would also include the effects of the Rand's sharp depreciation in 2000 and 2001 and its subsequent appreciation.

The focus of this study has been on long-run elasticities, but the VECM approach provides many opportunities for in depth analysis of dynamics. There is a nascent literature dealing with structural breaks and regime shifts in the VECM context. This should allow for improved treatment of the removal of sanctions and policy changes in export orientation. Allowance for non-linear equilibrium adjustment could also be a productive improvement.

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Variable	Source	Construction / Notes
Export Volume - TIPS	Statistics South Africa in 1995 R values (1975-1987); Trade and Industrial Policy Secretariat index (1988-2000)	The period of overlap was carefully studied for a ratio or linear relationship between the data series. No such relationship was apparent, ruling out an adjustment to one of the series. Given the inherent difference between the series, it is essential to try both series and investigate the robustness of the results to the choice of series.
Export Volume - SSA	Statistics South Africa in 1995 R values (1975-1995); Trade and Industrial Policy Secretariat index (1996-2000)	
Export Price – unit value index based on US Dollars - TIPS	Statistics South Africa index(1975-1987); Trade and Industrial Policy Secretariat index (1988-2000)	
Export Price – unit value index based on US Dollars - SSA	Statistics South Africa index(1975-1995); Trade and Industrial Policy Secretariat index (1996-2000)	
Export Price index based on US Dollars	Statistics South Africa PPI data and South African Reserve Bank Export:GDP ratio as a percentage.	The construction is based on the following formula: $T = \alpha D + (1-\alpha)E$ PPI for all goods (T) is a weighted average of price indices for domestic goods (*D*) and for exported goods (*E*). α is the share of production that is consumed domestically. As a result, the export price index is $E = T - \dfrac{\alpha D}{1-\alpha}$, where $\alpha = \dfrac{M^{D}}{D} \div \dfrac{M^{T}}{T} \times \dfrac{D}{T} = \dfrac{M^{D}}{M^{T}}$ Finding values for α is not straightforward. While manufacturing's share of domestic goods and of all goods is available, it was only possible to calculate manufacturing's share of exports directly from very recently. This is why an alternative measure for export PPI was constructed. Data on manufacturing's share of all goods (M^{T}/T) and on manufacturing's share of domestic goods (M^{D}/D) are available. To derive the share of manufactures that is consumed domestically (M^{D}/M^{T}) requires multiplication by the share of all South African output produced for domestic consumption.
Foreign Price index based on US Dollars	OECD import price indices and nominal import volumes for US, UK, Germany and Japan.	Import values weighted by import volume. Although import volume measures are available, they are unsatisfactory, so they are calculated using import values and import prices.
Competitors' Price index based on US Dollars	OECD import price indices and nominal import volumes for Mexico, Korea and Hungary.	

Variable	Source	Construction / Notes
World Income – US Dollars	IMF data on real GDP for US, UK, Germany and Japan and index of production for Japan. IMF exchange rate data.	Japan GDP data not available pre-1980, so index of production used to extrapolate GDP data backwards. Each country's GDP converted to US Dollars at the nominal exchange rate. GDPs aggregated without any weighting.
World Income - PPP	IMF data on real GDP for US, UK, Germany and Japan and index of production for Japan. PPP values sourced from OECD.	Japan GDP data not available pre-1980, so index of production used to extrapolate GDP data backwards. PPPs for 1995 used to deflate GDPs for all countries before aggregation without any weighting.
GDP	Real GDP from South African Reserve Bank	Capacity utilization is manufacturing output divided by potential manufacturing output. Therefore, potential manufacturing output is constructed by dividing actual output by the capacity utilization percentage. Unfortunately, actual and potential GDP apply to the entire economy while capacity utilization only applies to manufacturing. In log terms: $$\ln CU = \ln(\frac{Y}{Y*})$$ $$\ln Y* = \ln(\frac{Y}{CU})$$ $$\ln Y = \ln Y * + \ln CU$$ Y is actual GDP, $Y*$ is potential GDP and CU is percentage capacity utilization. The second line shows the calculation. The third line shows that only using actual GDP imposes a restriction that sets the coefficients of potential income and capacity utilization equal to each other.
Capacity Utilization	% utilization of manufacturing capacity from South African Reserve Bank	
Potential GDP	% utilization of manufacturing capacity and real GDP from South African Reserve Bank	