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Inflation dynamics and trade openness: with an application to South Africa

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Abstract: Evolving openness to trade is hard to measure, despite its relevance to models of growth, inflation and exchange rates. Our innovative technique measures trade openness encompassing both observable trade policy (tariffs and surcharges) and unobservable trade policy (quotas and other non-tariff barriers), capturing the latter by a smooth non-linear stochastic trend in a model for the share of manufactured imports in home demand for manufactured goods, controlling for the business cycle and exchange rate. The evidence for South Africa suggests that increased openness has significantly reduced the mean inflation rate and has reduced the exchange rate pass-through into wholesale prices.

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1. *Introduction*

With globalisation, many emerging market and developing economies have undergone or are undergoing trade liberalisation. Many of the same economies have recently adopted inflation targeting, or intend to, and therefore increasingly rely on forecast models for output and inflation in the formulation of interest rate policy. Ideally these models require long time series for reliable modelling and forecasting performance. Evolving trade liberalisation represents a structural break, the omission of which can bias the determinants of inflation and output. For instance, a greater degree of openness due to trade liberalisation is likely to lower the rate of inflation and may alter the influence of the real exchange rate on growth, via the impact on the demand for exports and leakage of demand into imports (Aron and Muellbauer, 2002). Long time series measures of openness should improve the modelling and forecasting of output and inflation. This paper offers an innovative technique to measure evolving trade openness, and provides evidence for the role of openness in explaining inflation.

Unfortunately, attempts to measure trade policy are fraught by measurement problems for observable components (such as tariffs), and by the presence of difficult to quantify components of policy (such as quotas and a range of other non-tariff barriers). Our literature survey suggests considerable controversy over the validity of trade policy measures used, for instance, in the growth literature.

Our measure of trade openness overcomes many of the shortcomings of existing measures, and encompasses both observable and unobservable trade policy. The general principle of the method is to measure structural changes making full use of economic and institutional information. The method involves choosing a variable (or variables) closely related to the structural shift to be measured, here the ratio of imports to home demand. The effects of other economic influences on the chosen variables are purged, e.g. the growth rate of demand and the exchange rate on the import ratio. The residual fluctuation is defined as the indicator of structural change, here trade openness.[1] The indicator can help explain economic behaviour, here for instance, an indicator of trade liberalisation can help explain the inflation process (see also Bowdler and Nunziata, 2005).

The most commonly used measures of trade policy outcomes, such as trade flows to GDP (in real or nominal terms), are endogenous measures influenced by a range of factors including country size. Administrative or incidence-based measures, such as weighted tariff rates and coverage ratios for non-tariff barriers, though not endogenous, both suffer from measurement problems, especially severe for non-tariff barriers. Composite measures of trade policy have emerged as a possible solution, combining both quantitative and subjective measures for a gamut of trade policy related variables, including black market premia and measures of capital controls. However, they have been criticized by Rodrik and Rodriguez (2001), see below. Finally, relative price index measures of openness conflate the effects of various domestic tariffs and subsidies on exports and imports and do not give an unambiguous indication of trade policy with respect to international prices (even assuming purchasing power parity holds at all times).

Our model uses trade flows that reflect the effects of non-tariff barriers, but controls for endogeneity with respect to other influences on trade by including various determinants of demand. We measure observable trade policy with trade-weighted tariffs, and unobservable trade policy with a stochastic trend. The trend is likely also to reflect such factors as the lifting of capital controls and unification of dual exchange rates where relevant (as often used in the composite measures above), and in some cases externally imposed trade sanctions. Thus, our measure captures a broader sense of "openness" than is only due to trade policy.

Our technique is applied to an emerging market country, South Africa, that began targeting inflation in 2000, and where the role of openness in inflation, exchange rates and growth is highly relevant (e.g. Aron, Muellbauer and Smit, 2004). There have been extensive changes in South African trade policy. Another factor pertinent in South Africa's case is the lifting of externally imposed trade sanctions in the 1990s, first imposed after 1976. Unfortunately, there is no index of effective protection combining the effects of surcharges, tariffs and quotas (these last are important in South African trade policy until the mid-1990s). Annual, consistent measures of effective protection (that neglect the effects of non-tariff barriers) date only from 1988 (Edwards, 2005), too brief a series for robust modelling and forecasting. We derive a quarterly measure of openness for South Africa from 1971 to 2005, and test the relevance of the measure in models for wholesale price inflation.

The outline of this paper is as follows. Section 2 reviews competing empirical trade policy measures, and summarises trade policy developments in South Africa since 1970. In Section 3 we describe our methodology for constructing an improved trade openness measure and apply the method to South Africa. In Section 4 the measure is employed in quarterly models of wholesale price inflation. Section 5 concludes.

2. Literature on measures of openness

2.1 Empirical measures of openness

Investigation of the still contentious role of trade liberalisation in promoting growth[2] has spawned a range of empirical measures for trade policy. Several authors have suggested the sheer complexity of factors influencing trade - including tariffs and surcharges, drawbacks, quotas and licences, other non-tariff barriers such as differing international standards, and exchange controls – argues against any single measure adequately proxying for trade policy. A comprehensive taxonomy of empirical measures of trade policy is given by Rose (2004), and critical surveys of empirical measures are offered by various authors (Rodrik and Rodriguez (2001), Pritchett (1996), Harrison (1996), Edwards (1998) and Greenaway *et al*. (2002)). The consensus appears to be that no measure of trade policy is free of methodological problems. A further concern is that the measures often correlate poorly with trade volumes, and may be mutually uncorrelated (e.g. Pritchett (1996) and Harrison (1996)). Recent empirical work therefore tests for robustness employing a wide range of measures (e.g. Edwards, 1998; Harrison, 1996).

We draw on this literature to compare and contrast trade policy measures, focusing on viable indicators for use in time series macro-modelling. The measures are chiefly applied in cross-section, and sometimes in short panels (Harrison, 1996). But many of the measures could be derived as a time series. Indeed, Harrison argues that the recent trend of averaging times series measures in cross sectional studies (Harrison, 1996, Table 1) neglects often stark differences in evolving trade liberalisation in individual countries.

Trade volume measures

Trade volume measures (aggregate trade or imports to GDP, either in constant or current prices) are widely-used and amenable to time series application. However, they are endogenous variables, influenced by a range of factors besides trade policy, including country size, the tradable natural resource base and the extent and ease of capital inflows. Frankel and Cavallo (2004) enumerate several ways in which trade flows are potentially endogenous. They are endogenous to income, since it is feasible for wealthier countries to liberalise tariffs given their developed domestic tax base, while poorer countries often depend for government revenue on trade taxes. Trade flows are endogenous to the degree of financial liberalisation (and two-way feedbacks between financial and trade integration have been empirically demonstrated by Aizenman and Noy (2004)). Trade liberalisation also frequently coincides with a range of other reforms, at least in developing and emerging market countries.

The endogeneity has been addressed in cross-section by instrumenting trade openness with the predicted ratio of trade to GDP based on gravity equations (e.g. Frankel and Romer (1999); Frankel and Rose (2002); Frankel and Cavallo (2004)). Trade between two countries is predicted by the distance between them, population, their land-areas, common language, shared land-borders and their landlocked status. Predictions for selected years of bilateral trade to GDP across trading partners are aggregated, and the ratio is apparently highly correlated with actual trade to GDP. However, this is not a useful methodology for time series work as the essentially static determinants of these regressions allow insufficient time variation within countries. The same argument applies to regressions based on theoretical factor proportions trade models (e.g. Leamer (1988); Pritchett (1996)).

Administrative measures of trade policy

Incidence-based indicators, such as nominal average tariffs and effective protection, and coverage of non-tariff barriers (NTBs), are free from endogeneity problems, and can be used in time series studies. However they suffer from measurement problems. Rodriguez and Rodrik (2001) argue these measures can effectively rank-order countries according to the restrictiveness of their trade regimes, but they and others (e.g. Dollar and Kraay, 2002) emphasise several measurement biases. The use of *unweighted* average tariffs will weight too heavily those commodities that are only a small fraction of imports. On the other hand, *trade-weighted* average tariffs (e.g. aggregate import duties or trade taxes divided by the volume of imports) give negligible weight to prohibitive tariffs since the corresponding imports are typically low.[3] If statutory measures are used, these may not necessarily be binding due to poor enforcement or even corruption. Moreover, tariff averages will be poor proxies for overall restrictions where NTBs are important.

The coverage of NTBs relative to total imports is widely used (see Pritchett, 1996), but Rose (2004) and others note this proxy of trade policy is certainly measured with error. Available data tend to report the number of tariff lines on which one of a small number of easily identifiable NTBs applies, and exclude less-easily quantifiable barriers to trade, such as local procurement requirements, or health and safety standards (Dollar and Kray, 2002). It also neglects effective barriers that exclude the most imports. If instead the percentage of product categories subject to import licenses is reported, it will be unclear how binding the NTBs are.

Subjective and composite measures of trade policy

A third set of indicators combines quantitative and qualitative trade measured for an overall index capturing different aspects of trade policy, or uses institutional information to generate a subjective judgement of "openness". Though data intensive such measures could be constructed for time series studies[4], but their value as trade policy measures is in doubt. For instance, the widely-cited composite trade policy indicator of Sachs and Warner (1995), where a dichotomous variable measures zero (closed) or one (open) based on various criteria[5], has been criticized by Rodríguez and Rodrik (2001). In a far-reaching review of growth and trade openness studies, they find the Sachs and Warner indicator explains growth due to two components being correlated with other determinants of growth, the black-market premium and state monopoly variables, with little contribution from its tariff and NTB components.

The same authors are critical of subjective indices which they judge as "highly contaminated by judgement biases or lack(ing) robustness to the use of more credible information from alternative data sources" (e.g. World Bank's trade orientation measures and Heritage Foundation Index as used in Edwards (1998)). For instance, the Heritage Foundation index of Economic Freedom (http://www.heritage.org/index/) comprises several components, of which "trade freedom" is an annual composite measure (from 1995) of the trade-weighted average tariff rate and a crude proxy for NTBs.[6] The trade component of the Fraser Institute's "Free the World" (http://www.freetheworld.com) is more complex but an arbitrarily weighted composite index based on several measures of average tariff and their dispersion, NTBs, actual trade versus predicted trade (discussed above), the presence of capital flow restrictions and the size of the black market premium.

Greenaway *et al.* (2002) notes the difficulty of gaining an accurate measure of the start of liberalisation. He employs subjective indices in the form of dummy variables, for instance capturing a statement of intent, such as agreement date of a World Bank Structural Adjustment Loan, or dummies where timing is judged, based on tariffs, quotas, export impediments and promoters and exchange rate misalignment. A more sophisticated approach is taken by Wacziarg and Wallack (2004), who update subjective *de jure* openness measures of the dates of trade liberalisation (from Sachs and Warner (1995), page 24, footnote 44). The onset of liberalisation is dated by a country having a *de jure* trade liberalisation, followed by a sustained *de facto* trade liberalisation demonstrated by a year-on-year increase of 5 percent or more in the ratio of trade to GDP. Trade indicators of pre- and post liberalisation periods are created based on the initial *de jure* year and the duration of the subsequent liberalisation.

Price-based measures of trade policy

A fourth set of indicators involves international price comparisons, often suitable for time series analysis. Harrison (1996) contends that price comparisons between goods sold in domestic and international markets could provide an ideal measure of the impact of trade policy, in the absence of domestic policy distortions. This idea lies behind the well-known ‘‘price distortion’’ index of Dollar (1992), criticized by Rodrik and Rodriguez (2001). Dollar uses the relative price of consumption goods from Summers and Heston (1988) and tries to 'purge' it of its non-traded component by taking the residual from a regression on urbanisation, land, and population. Rodrik and Rodriguez (2001) demonstrate, even assuming that this method is successful, that the purged variable is theoretically inappropriate as a measure of trade restrictions when Purchasing Power Parity is violated over the sample, and/or when there are export taxes or subsidies in use. It is a well-established empirical fact that absolute and relative PPP do not hold over the medium-term, but the deviations even from relative PPP are very long-lived (Rogoff, 1996; Sarno, 2005). Moreover export taxes and subsidies are commonly applied, especially in developing countries. This casts doubt on the usefulness of Dollar’s price distortion index, and the index was found to produce implausible country rankings, both by Dollar (1992) and Wacziarg (2001).

2.2 Opening of trade in South Africa

South Africa’s trade policy can be divided into four distinct episodes (see summary in Table 1). The first episode of import-substituting industrialisation began in 1925 with the passing of the Customs, Tariff and Excise Duty Amendment Act. The Act provided protection to a large number of industries, and empowered the board overseeing protection to recommend tariffs. Tariff protection was moderate in this episode (Holden and Holden, 1975), but no estimate is available on the extent of protection due to the import control regime. Quotas, introduced from 1948, rapidly became the principal mode of industrial protection. Although the Viljoen Commission into the protection of industry a decade later recommended a switch to the use of tariffs from quotas and subsidies, quota dominance persisted. As late as 1969, under pressure from the GATT and the IMF, the government announced it would lift quotas - but this was not implemented. The outcome was a diversified but concentrated manufacturing sector with an anti-export bias, the establishment of a significant parastatal sector, and dependence on capital and intermediate imports.

The second episode of trade liberalisation began in 1972, with the Reynders Commission of Inquiry into export performance. There was concern over the high dependence on commodity exports (mainly gold) and unsustainable levels of capital and intermediate imports. Recommendations for export promotion were initiated in 1972 (details in Holden, 1992), later reinforced by the proposals of the Van Huyssteen Committee in 1978. A partial relaxation of quotas from 1972 succumbed in 1976 to industrial lobbying for protection.

The third liberalising episode began in 1983, as quotas were replaced by equivalent import tariffs. By 1985, only about 28 per cent of the manufacturing tariffs lines and 23 per cent of the value of imports were still covered by import permits (Holden, 1992; IDC, 1990). In the same year, the positive list was replaced with a negative list of permitted imports. Bleaney *et al.* (1999) suggest the majority of remaining quotas were in the agricultural sector, traditionally a support base of the government – these were dismantled only in 1994-1997, under the new government. The authors explain that the increased tariffs to offset quota removal occurred by a non-transparent system of import reference prices called formula duties: protection rose as the gap between the import price and an external reference price widened, but the protection lessened over time as there was no adjustment for inflation. Tariffs were flexible upwards, but had never been lowered. Coverage was widespread, with *ad valorum* duties covering 83 percent of all 11,544 tariff lines and formula duties applying to one sixth of all lines. Belli *et al.* (1993) find by the end of the 1980s that the coefficient of variation of South Africa's tariffs was the second-highest of 32 developing countries. The rules were complex and subject to frequent variation, so that collected rates were on average far lower than the statutory rates.

The liberalising effect of the dismantling of quotas was partly offset by periodic import surcharges addressing South Africa's balance of payments constraint. Particularly after the 1985 debt crisis, the government ensured current account surpluses through substantial import surcharges to help meet foreign debt repayments. Surcharges raised protection substantially, reinforcing the compensating tariff rises.[7]

The fourth episode marks the reintegration of South Africa with international and regional communities after the democratic elections of 1994. Several multi-lateral and bilateral trade agreements instituted tariff reduction for the first time (Table 1). The catalyst was the GATT Uruguay round of 1994 that rationalised tariff lines and removed quotas and export subsidies (phased out by 1997). Several studies have considered whether these tariff reforms achieved a reduction of effective rates of protection of industry. Fedderke and Vase (2001, 2004) argue that more of South Africa's output was protected by tariffs in 1998 than in 1988, while Rangasamy and Harmse (2003) contest this view. Neither study considers explicitly the effects of import surcharges and NTBs on protection. Edwards suggests methodological differences and limitations in both studies complicate comparisons and a definitive conclusion on the extent of liberalisation in the 1990s cannot be reached.

Using a consistent set of tariff data for 1988-2004, Edwards (2005) finds significant reductions in the level of nominal and effective protection during the 1990s[8], testing the sensitivity of his estimates of protection to the use of collections duties or scheduled tariff rates, and the choice of Supply-Use or Input-Output tables. Average nominal protection in manufacturing fell to 8.2 percent from 22.9 percent from 1994 to 2004, using scheduled tariff rates and taking account of import surcharges. Effective protection in manufacturing, including surcharges, fell from 48 to 12.7 percent over the same period. Protection also declines if surcharges are excluded and collection duties rather than scheduled rates are used. Reductions in protection occurred in almost all traded sectors. Edwards' annual industry level measures of effective protection and weighted nominal tariffs for 1988 to 2004 are illustrated in Figure 1. They include surcharges, and for nominal measures, use either scheduled or collection rates. Both graphs indicate the rationalisation of tariffs from 1993, levelling out from about 1999.

Edwards was not able to estimate the *ad valorem* equivalent of quotas, prevalent in some sectors prior to 1994. This biases estimates of effective protection, though, as he points out, not necessarily downwards. His sensitivity tests show that raising nominal protection on agriculture raises estimates of effective protection in agriculture, but lowers effective protection in manufacturing, particularly in those sectors such as food products that use agricultural products as intermediate inputs.

A range of other trade policy indicators for South Africa, of trade volume, composite indicators and price indices, in general, tell a similar story. Figure 2 illustrates the point nicely that nominal trade ratios can be misleading in countries where there are large terms of trade shocks, as the value of exports is sensitive to terms of trade fluctuations for primary exporters. The real and nominal import ratios and the *real* total trade ratios move similarly, and have all risen from the early 1990s. The real ratio rose more with the rand depreciation from the mid-1990s, which depressed imports but had less of an effect on total trade. We focus on imports in this paper because of our interest in modelling inflation. In broad outline, the growth in real imports since 1990 (and especially 1994), appears to correlate with the removal of the remaining quotas, and the sharp reduction in tariffs from 1994. However, business cycle effects and volatility in the real exchange rate are conflated with these effects, and one cannot interpret individual parts of the graph. The same remarks apply to the manufacturing nominal data in the graph below.

The composite indices both give an unreliable and erratic overall view of trade policy changes, though there are some plausible movements in the graph (Figure 3). The Heritage figures[9] show a huge liberalising leap in one year, 2005, and unexplained reversals after 1995. The Free the World index collapse from 1980 to 1985 is extreme relative to other values on the graph, and may reflect a changed methodology. Both series show a reversal, albeit too sharp, around 2003-2004, which accords with our own findings below and the tariff flattening out as seen in Figure 1.

Finally we turn to price ratios plotted in Figure 4. The first of these is the log ratio of import prices[10] for manufactures to the price index of manufactured exports for advanced countries, converted into Rands. There is a strong downward trend from the mid-1980s, but considerable short-term fluctuations connected with the exchange rate. The second is the log ratio of import prices to the domestic wholesale price index, both for manufactures, showing a strong decline from the early 1990s. The third is the weighted average[11] of the two, reflecting the mix of international and "pricing to market" influences on import prices. Thus, even with pricing to market factored into the denominator, there is a massive decline in import prices relative to its fundamental determinants (a mix of world and domestic prices). The period of 1980-85 appears to be the most trade restrictive, followed by a substantial decline from the early 1990s with the removal of remaining quotas and the decline in tariffs after 1994.

3. Estimating openness

3.1 Theory motivation and methodology

Trade openness depends on both tariffs and non-tariff barriers (NTBs), the latter being typically hard to measure. The innovation in this paper is to impute a measure of trade openness from a model for the import share in which unobservable NTBs and measurement biases in observable tariffs are proxied by an estimated stochastic trend, and tariffs are measured weighted by market shares. The import share - the share of manufactured imports in home demand for manufactured goods - is not itself employed as a direct measure of openness because it depends on other factors, such as fluctuations in domestic demand and the relative prices of imports or the exchange rate. Our aim is similar to Anderson and Neary's (2003, 2005), to measure openness (or its inverse, the rate of protection) from its impact on the volume of imports.[12]

To explain a stripped-down version of the model, let $\log(IMP/D)$ be the log-ratio of manufactured imports to domestic demand for manufactures, both measured in constant prices. Domestic demand for manufactures is defined as domestic output plus imports minus exports. Let p^{imp} be the import price index, and p^{man} the price index for domestic output of manufactures, and the log relative price, $\log(p^{imp}/p^{man})$. The model is then as follows:

$$\begin{aligned}\log(IMP/D) = \alpha_0 - \alpha NTB - \delta TARIFF - \theta\log(p^{imp}/p^{man}) \\ + \varphi\log D + \phi\Delta\log D\end{aligned} \qquad (1)$$

We now discuss the signs of the parameters. Trade openness, reflecting low tariff barriers ($TARIFF$) and NTBs, should increase the import share, so α and δ should be positive. The relative price of imports also has a negative effect, so θ should be positive. If the elasticity with respect to domestic demand is 1, then φ=0; but φ is positive for a demand elasticity that exceeds 1. However, short-term rises in demand tend to be reflected in a higher import share, since imports can be expanded more rapidly than domestic capacity, so ϕ should be positive.

Trade openness can be defined as the coefficient weighted sum of tariffs and NTBs, or $(-\alpha NTB - \delta TARIFF)$. However, if the price index for imports is inclusive of tariffs, part of the effect of tariff reductions will operate on the real import share via a lower relative price $\log(p^{imp} / p^{man})$. This implies that $(-\alpha NTB - \delta TARIFF)$ may understate the contribution of lower tariffs to trade openness. Interestingly, even if the import price index is inclusive of tariffs, there are good reasons for δ still to be positive if the tariff rate is measured as tariff revenue divided by the value of imports (as in our study). This is because this measure of the tariff rate likely underestimates the impact of tariffs on trade, see Section 2. A positive value of δ compensates for the underestimate of the true tariff rate in the tariff measure used.

It is also worth noting that $(-\alpha NTB - \delta TARIFF)$ does not measure the full general equilibrium effect of trade openness on the import share, even if the import price index were exclusive of tariffs. This is because the domestic price level will be influenced by trade openness: the greater is openness the lower is likely to be the markup over costs of domestic prices, see Section 4. Moreover, trade openness is likely to influence productivity growth which will influence domestic costs as well as domestic demand and its growth rate.

So far we have considered the import share defined in constant price terms. We can define a similar relationship to equation (1) for the import ratio in current prices. Let (IMP^N / D^N) be the above import ratio expressed in nominal terms ("N"). To a close approximation, $\log(IMP^N / D^N) \approx \log(p^{imp}) - \log(p^{man}) + \log(IMP / D)$.[13] This implies,

$$\begin{aligned} \log(IMP^N / D^N) = \alpha_0 - \alpha NTB - \delta TARIFF - \theta_1 \log(p^{imp} / p^{man}) \\ + \varphi \log demand + \phi \Delta \log demand \end{aligned} \tag{2}$$

where $\theta_1 \approx \theta - 1$.

An empirical version of the model for the import share could be generalised by including lags, testing alternative demand measures (other than home demand for manufactured goods as defined above) and the effect of capacity utilisation, adding terms relating to the composition and growth of demand, and allowing for alternative relative price or exchange rate effects. The model is

$$
\begin{aligned}
\log(IMP^N / D^N)_t = {} & \alpha + \delta TARIFF_{t-1} + \sum_{j=0}^{k} \delta_j \Delta TARIFF_{t-j} + \eta \log REER_{t-1} + \sum_{j=0}^{k} \eta_j \Delta \log REER_{t-j} \\
& + \theta \log(p^{imp} / p^{man})_{t-1} + \sum_{j=0}^{k} \theta_j \Delta \log(p^{imp} / p^{man})_{t-j} \\
& + \lambda \log TOT_{t-1} + \sum_{j=0}^{k} \lambda_j \Delta \log TOT_{t-j} + \varphi \log GDP_{t-1} + \sum_{j=0}^{k} \phi_j \Delta \log GDP_{t-j} \\
& + \gamma CAPUT_{t-1} + \sum_{j=0}^{k} \gamma_j CAPUT_{t-j} \\
& + \sum_{j=1}^{k} \omega \log(IMP^N / D^N)_{t-j} + dummies + \xi_t + \varepsilon_t
\end{aligned} \tag{3}
$$

where the unmeasured component of trade policy (e.g. quotas and other NTBs) is captured by a smooth non-linear stochastic trend, ξ_t , effectively the Kalman filter applied to a time-varying intercept, and defined as follows (Harvey, 1993; Harvey and Jaeger, 1993):

$$
\begin{aligned}
\xi_t &= \xi_{t-1} + \gamma_t + \eta_{1t} \\
\gamma_t &= \gamma_{t-1} + \eta_{2t}
\end{aligned} \tag{4}
$$

where η_{1t} are white noise errors. When $\text{var}(\eta_{2t}) = 0$, ξ_t is an I(1) trend with drift. When $\text{var}(\eta_{1t}) = 0$, ξ_t is a smoother I(2) trend. Both types of trend were individually investigated to capture the evolution of the unobservable component of trade policy. Such a non-linear trend can be estimated in the STAMP package (Koopman *et al*., 2000).

In equation (3), REER is the real effective exchange rate, which can be thought of as an alternative measure of relative import prices, fairly free[14] of the direct effect of tariffs. Given that import prices tend to lag behind the exchange rate, current exchange rate depreciation is a signal that import prices will rise, creating an incentive to speed up imports in anticipation (with the reverse for appreciation). The terms of trade, TOT, can reflect important demand composition effects in resource-rich economies. GDP is an alternative to domestic demand for imports of manufactures as defined above. CAPUT is a measure of capacity utilisation: if capacity utilisation is high, domestic producers will find it harder to meet increases in demand, allowing imports to take up the slack.

As noted above, the influences of openness operate both through the measured effects of import tariffs and surcharges, and through the unobservable effects captured in the stochastic trend. We therefore include both aspects of openness in our further empirical work.

3.2 An application to South Africa

We apply the methodology just explained to annual data from 1971 to 2005 for South Africa,[15] which necessarily simplifies the lag structure relative to the general formulation of equation (3). The variables are defined in Table 2 along with descriptive statistics. In terms of the stationarity statistics reported, the dependent variable is I(1) , and all the level variables on the right hand side of equation (3) are I(1) save for the terms of trade and capacity utilisation, which are I(0).

The dependent variable, the share of manufactured imports in home demand for manufactured goods in current prices[16], is defined as domestic production plus imports less exports, for the manufacturing sector. The measure of import tariffs is constructed by adding customs duties to import surcharges (see section 2.2), and taking the sum relative to merchandise imports. The data on the real effective exchange rate posed a difficulty because of the several redefinitions of the variable: the series was spliced in 1978Q1 and in 1990Q1.[17] The relative price of imports is defined as the price index for manufacturing imports divided by the producer price index for domestic output of manufacturing, (p^{imp} / p^{man}).

We can accept the hypothesis that φ=0, i.e. that the income elasticity of import demand is 1 in the long-run, irrespective of which demand measure is used. We checked three alternatives: log GDP, log GDE (gross domestic expenditure) and the manufacturing equivalent of log GDE. The log change of GDP is more significant than the two alternatives, while capacity utilisation is insignificant, though correctly signed.[18] The change in the terms of trade has an effect over three years. The tariff measures are significant but enter as one and two-year lags, suggesting a lagged response of import demand to tariff changes. Two dummies are employed to capture exchange rate effects during 1971 and 1972 at the end of the Bretton Woods era.

The potential endogeneity of the relative price of imports and of the real exchange rate, which could respond to current shocks in imports, is handled in two different ways. First, the lagged value of the log real exchange rate is used as a simple proxy for both. The results are shown in the first three columns of Table 3 for different samples (given that STAMP cannot generate Chow tests), showing a reassuring degree of parameter stability. Secondly, we used the fitted value from an instrumenting equation[19] for $\log(p^{imp} / p^{man})$, estimated in STAMP with a smooth stochastic trend (which confirms the dominant role of the lagged log real exchange rate). These results are shown in the last column of Table 3.

We can interpret openness (the combination of stochastic trend and tariff effects) like a shift dummy for a structural break. Subject to this, the log import share and the log real exchange rate or log relative price index are expected to be cointegrated I(1) variables. Though this can be checked using the mechanics of the Johansen procedure, treating openness as an exogenous shift dummy is not strictly valid, given that the stochastic trend is estimated jointly with the effects of other variables.

The stochastic trend for the nominal version of equation (3) and the resulting estimate of openness, DUMOPEN, are shown in Figure 5. The openness indicator, where a rise indicates trade liberalisation, is defined as the fitted stochastic trend plus the fitted effect of the tariff measures (e.g. from column 1 of Table 3, the latter is $-6.74TARIFF_{t-1} - 6.46TARIFF_{t-2}$). We can accept the hypothesis that the two components of tariff, the rates of customs and surcharges, have the same coefficients. The indicators suggest that the main period of trade liberalisation for imported manufactures was between 1992 and 2000, since when there has been only slight further liberalisation. The stochastic trend in the figure is consistent with the effect of tightened sanctions after the 1976 Soweto riots, and the trend reaches its lowest point in the early to mid-1980s as sanctions tightened. Thereafter, the effect of sanctions is mitigated by the liberalising effects of quota reduction. Repeating the regression using an I(1) trend gave similar results, and a more volatile trend that closely mirrored the rapid reductions in quotas in the 1970s and in the 1980s (Table 1), but gave a less easily interpretable pattern post 2000.

Over long periods, the stochastic trend might also be picking up some slowly evolving compositional changes in the structure of the economy or in imports, rather than only trade openness. For instance, the trend could reflect import composition effects by sector or type of good if liberalisation was not homogenous (e.g. if tariffs were reduced more rapidly on final consumer manufactured goods than intermediate manufactured goods). It could also capture slowly evolving preference changes for imports, and the effects on import demand from changing local content requirements for South African production. A positive feature is that any mismeasurement of effective protection by $TARIFF$, such as aspects discussed in Section 2.1 and the effect of rebates, could also be absorbed in the trend. In general, however, the estimated trend is consistent with the history of trade policy discussed in Section 2.2 and with the broad trends in the relative price indicators shown in Figure 4. The removal of business cycle effects, terms of trade and real exchange rate effects from the conventional trade volume measures results, we argue, in a more robust measure of the underlying movements in trade openness.

4. Openness and wholesale price inflation in South Africa

Trade openness has multiple influences on inflation. One, discussed in an extensive international literature (e.g. Rose (2004)) operates through productivity growth. Productivity growth reduces labour costs per unit of output, thus reducing output prices for a given mark-up. Trade openness also tends to reduce the market power of monopsonistic suppliers of labour and monopolistic competitors in goods markets. We focus on the last of these channels drawing on the mark-up literature. We demonstrate the relevance of openness for inflation modelling, applying our constructed openness measures to modelling wholesale price inflation in South Africa.

The mark-up pricing literature goes back to Hall and Hitch (1939). In recent years, a series of European Central Bank and other central bank working papers have produced survey evidence consistent with mark-up pricing with some stickiness in price adjustment (e.g. Fabiani *et al*., 2005; Amirault et al, 2004; Hall *et al*., 1997; and Hall *et al*., 2000). In the macro time series literature, de Brouwer and Ericsson (1998), Banerjee and Russell (2001), as well as many large macro-econometric models, incorporate reduced form mark-up models of price setting. At its simplest, the price of output in the long run is given by $(1+\mu)UC$ where UC is the unit cost of production and μ is the mark-up. Assuming lagged adjustment of prices to costs, and a proxy for expected inflation, results in a reduced form expression for the inflation rate, that can be expressed as an equilibrium correction model of the following general form:

$$\begin{aligned}\Delta \log P_t = \gamma(\alpha_0 + \mu(X_{t-1}) + \log UC_{t-1} - \log P_{t-1}) \\ + \sum_{i=1}^{n}\sum_{s=0}^{k} \beta_{i,s} \Delta X_{i,t-s} + \sum_{i=1}^{n}\sum_{s=0}^{k} \theta_{i,s} \left|\Delta X_{i,t-s}\right| \\ + \sum_{s=1}^{l} \lambda_s \Delta \log P_{t-s} + \varepsilon_t\end{aligned} \tag{5}$$

where $\mu \approx \log(1+\mu)$ and UC is unit cost, and ε_t is white noise. A vector of X variables is postulated as determinants for the mark-up, μ, and for other possible influences on inflation expectations. The terms in absolute values test for possible asymmetries in price responses.

For South Africa, our aim is to explain the domestic price component of the wholesale (producer) price index, WPI. The annual rate of change of producer prices is shown in Figure 6. The rate of inflation has trended downwards since 1986, but rose strongly, but temporarily, in the wake of exchange rate depreciations in recent years. Note that South African manufacturing experienced dramatic productivity growth between 1992 and 2000, coinciding with the increases in openness.

A simple estimate of a chain weighted index of unit costs, $\log(COST)$,is given by a weighted average of unit labour costs in manufacturing and import prices for manufacturing (weighting the latter by the ratio of manufactured imports to domestic production and the former by one minus that ratio). This unit cost measure excludes the costs of raw materials, but it can be argued it includes intermediary inputs and capital costs. Capital goods and intermediary inputs are manufactured domestically or imported, and so are indirectly dependent on unit labour costs, import prices and raw material costs. Potentially important raw material prices in South Africa are (raw) food prices and oil prices. We do not have data on the cost shares for the manufacturing sector of these inputs. However, the food and beverages sectors in recent years represent around 15 percent of manufacturing in South Africa, and other sectors will also have some indirect raw food costs. We thus define a composite log unit cost measure, $\log(COSTF)$, by assuming that the log of raw food prices has a weight of 10 percent, and that the combined unit labour costs[20] and import prices above, $\log(COST)$, has a weight of 90 percent.[21]

To fully capture UC in equation (5), the oil price (U.S. Brent oil price, in Rands) is entered separately as a log ratio to domestic wholesale prices at t-1, in addition to $\log(COSTF/WPI)_{t-1}$. We investigate the influences on the mark-up, μ, and inflation expectations in equation (5), with the following X vector of variables:

$$X = \{NTBtrend; TARIFF; \log(REER); \log(TOT); USSPREAD \\ OUTGAP; \log(CAPUT)\} \tag{6}$$

We conceive of the mark-up depending in the long-run on the components of trade openness (i.e. the NTB proxy represented by the stochastic trend shown in Figure 5, and the rate of tariffs, $TARIFF$ - later broken into its two components, $CUSTOM$ and $SURCHARGE$, see definitions in Table 2), the log real effective exchange rate[22], $\log(REER)$, the log terms of trade, $\log(TOT)$, and the international interest rate differential, $USSPREAD$. More restrictive trade policy should imply higher values of the mark-up as import competition is less effective. The higher the real exchange rate, the greater will be the downward international competitive pressure on domestic price setters. The spread between the short-term interest rate in South Africa and that in the U.S. indicates tight monetary policy, tending to constrain domestic demand and support the exchange rate, bearing down on inflation. The terms of trade in a resource-rich economy are likely to influence the demand for domestic manufactures from the mining sector, and so increase the mark-up.

In the short-run, the output gap, $OUTGAP$, or capacity utilisation, $\log(CAPUT)$, are cyclical indicators of excess demand: high demand gives producers more scope to raise prices. In the short-run, the change in log WPI is likely also to be influenced by changes in costs such as in unit labour costs, import prices, food prices, oil prices and the exchange rate, and in relative interest rates designed to appreciate the exchange rate. In part, such variables may also represent influences on inflation expectations.

The variables are defined in Table 2, together with statistics and stationarity characteristics for the data. Banerjee and Russell (2001), Banerjee, Cockerell and Russell (2001) and Banerjee, Mizen and Russell (2007) argue that inflation is non-stationary (i.e. I(1), so the log of the price level is I(2)) and is one of the long-run determinants of the mark-up, with a negative effect. On the face of it, the tests in Table 2 suggest $\log(WPI)$ is I(1), implying that inflation is stationary. Nevertheless, a plot of the annual WPI inflation rate suggests substantial persistence in the series indicated by a long-run trend. We therefore keep an open mind on the Banerjee-Russell hypothesis.

The results of regressions using equation (5) and variables in expression (6) are shown in Table 4. The PCGETS software (Krolzig and Hendry, 2001)[23] was used to find parsimonious forms of these equations for 1979q2 to 2005q3, from the start of the floating exchange rate regime in South Africa. Seven versions of the equation are shown. Generally speaking, when *TARIFF* is separated into its sub-components, customs duties, *CUSTOM*, and temporary surcharges, *SURCHARGE*, the former proves more significant than the latter, and the relative weight on the stochastic trend proxying NTBs differs from that found in the import share equation.

Column 1 shows the results with openness measured by *CUSTOM* and the stochastic trend proxying NTBs, and where the current log change in import prices is excluded from the general unrestricted model. Column 2 shows results when openness is measured by the composite openness indicator from the import share equation, DUMOPEN. Column 3 is a variant of column 1 with an identical goodness of fit, but it includes the log change in import prices which is instrumented with the fitted value from a parsimonious instrumenting equation.[24] Column 4 replaces our two measures for openness by one of Edwards' ERP measures, available for 1988-2004, see Figure 1. For this short sample, his measure works almost as well, with goodness of fit only slightly worse, and very similar parameter estimates. For comparison, column 5 shows the same specification as in column 1 but for this short sample, confirming parameter stability. Column 6 is also a variant of column 1, where we replace our two measures of openness by the ratio of trade volume to real GDP, which is the best fitting of the six crude proxies shown in Figure 2. Finally, column 7 adds an interaction effect which allows a composite openness measure (defined with weights based on the coefficients in the equation, see footnote 6 to Table 4) to influence the pass-through from the nominal exchange rate to wholesale prices.

The trade liberalisation measures are significant throughout, suggesting increased openness as a major reason for the decline in inflation in the 1990s. The stochastic trend (the NTB proxy), fits marginally better at a one year lag (but a one quarter lag would give very similar results). The smooth I(2) version shown in Figure 5 fits marginally better than the I(1) version. In columns 1, 3, 6 and 7, *CUSTOM* appears as a 2 year moving average, effectively as it does in the import share equation reported in Table 3, though there it is supplemented by the temporary surcharges.

It is of interest to compare, in Figure 5, our original composite openness indicator constructed from the import demand equation in Table 3, DUMOPEN, with the composite openness measure implied by the WPI equation in Table 4, column 1. The original measure, DUMOPEN, based on import data, comprises the stochastic trend for NTBs plus a (negatively) weighted moving average of tariffs including surcharges (section 2). The negative correlation between DUMOPEN and lagged temporary surcharges is apparent in Figure 5, reflecting the sensitivity of imports to temporary surcharges. In contrast, regression evidence suggests domestic prices are quite insensitive to temporary surcharges (as noted above), but are sensitive to the customs component of total tariffs, which are probably perceived as more permanent. Thus, the composite openness measure implied by the WPI equation comprises the stochastic trend for NTBs plus a (negatively) weighted moving average of tariffs *excluding* surcharges. The relative insensitivity of wholesale price inflation to temporary surcharges is consistent with our evidence for the slow adjustment of domestic prices to shocks. Indeed, when DUMOPEN defined for the import equation, is taken as the measure of openness for the WPI equation, the long-run solution is far less well determined and the fit deteriorates, see column 2, Table 4.

In the long-run solution, the real exchange rate, the terms of trade, and the interest rate spread are all significant in our preferred specifications (columns 1, 3 and 7), and sign priors are supported by the data. Figure 7 shows that interest rates in South Africa relative to the US tended to offset the real exchange rate: rising with a weak real exchange rate (as in 2001-2002 and 1985-1986), and falling when the real exchange rate rose. On average in the period, monetary policy has attempted to offset the implications of the real exchange rate for inflation.

In the short run dynamics, changes in unit labour costs, oil prices, food prices, and the interest rate spread all appear, as does the output gap. Interestingly, the asymmetric terms in food and oil price inflation, defined as the log change of prices if this is positive and zero otherwise, dominate their conventional log changes: this suggests that increases in these raw material prices tend to feed through into wholesale prices much more rapidly than decreases. Indeed, we failed to find a long-run oil price effect, presumably because oil prices are soon reflected in import prices for manufactured goods, including refined oil products.

As we have seen, there is an alternative specification which fits as well as column 1, shown in column 3, which replaces the oil price effect by the instrumented value of the current change in import prices. For column 1, the recursively estimated coefficients are shown in Figure 8, demonstrating good coefficient stability, though there is some drift in the coefficient on the four-quarter log-change in the nominal exchange rate. On economic considerations, it seems plausible that the pass-through from the exchange rate to domestic prices might decline with increased trade openness, see Gust et al (2006). In column 7, the interaction term between an openness indicator and the four-quarter log-change in the nominal exchange rate is significant at the 95 percent level, consistent with some decline in exchange rate pass-through with openness.

Other diagnostics, such as tests for residual autocorrelation and heteroscedasticity, are satisfactory for our preferred specifications. A linear time trend is insignificant in all specifications. The speed of adjustment is around 8.5 percent per quarter in our preferred specifications.[25] The general conclusions from Table 4 (for making the other comparisons e.g., with alternative indicators of openness) would be similar if the column 3 specification had been chosen instead of column 1.

As a further check on the robustness of these models, we replaced our two openness measures by an unrestricted stochastic trend of both the I(1) and I(2) variety, estimating the inflation equation in STAMP. Not only are all parameter estimates within one standard deviation of those reported in column 1 or 3, but the plots of the unrestricted stochastic trends are close to the implied openness measure of Table 4, column 1 (shown in Figure 5).

We can obtain expressions for the long-term movements in the mark-up from these empirical results, where initially we discount the Banerjee-Russell argument that the inflation rate is part of the long-run solution. For example, in column 1 of Table 4, the long-run solution for the mark-up (defined as $\log(WPI)-\log(COSTF)$), is given by

$$\begin{aligned} \mathrm{LRS1} = [&-0.0283\log(\mathrm{REERma2}) - 0.0524(\mathrm{NTB\ trend})_{t-4} \\ &- 0.0745(\mathrm{USSPREAD})_{t-2} + 0.425(\mathrm{CUSTOMma8})_{t-2} \\ &+ 0.0203\log(\mathrm{TOT})_{t-2}]/(0.0634) \end{aligned} \tag{7}$$

Plotting the long-run solution, LRS1, reveals a long-run divergence with the mark-up, which trends up relative to it (Figure 9). The Banerjee-Russell hypothesis provides an explanation. We regress the mark-up residual, RESMARKUP, defined as the mark-up minus its long-run solution from equation (7) (i.e. log(WPI)-log(COSTF)-LRS1), on a constant, time trend (Ttrend), lagged residuals and lagged quarterly log changes in WPI, import prices, unit labour costs and food prices. The trend and the WPI inflation rate are strongly significant, while import price inflation also has some effect:

$$\begin{aligned}\text{RESMARKUP} = \text{constant} + \text{DUMLIQCR} + \underset{(2.8)}{0.00057}\,\text{Ttrend} + \underset{(15.4)}{0.750}\ \text{RESMARKUP}_{\text{t-1}} \\ \underset{(4.1)}{-1.78}\,\Delta\log(\text{WPI})_{\text{t}} - \underset{(2.2)}{0.30}\Delta\log(IMPP)_{\text{t-1}} + \varepsilon_t\end{aligned} \qquad (8)$$

with an adjusted R^2 of 0.957, standard error for the equation of 0.032 and a Durbin Watson statistic of 1.82. Chow tests for breaks in 1992 and 2003 have p-values of 0.95 and 0.57 respectively, while other diagnostics are also satisfactory.

Equation (8) suggests a revised long-run solution, LRS2, for mark-up (where the first three terms are divided by $(1-0.75)$, i.e. the difference between the coefficients on RESMARKUP and its lag),

$$\begin{aligned}\text{LRS2} = \{&\,0.00057\,\text{Ttrend} - 1.78\,\Delta\log(\text{WPI})_{\text{t}} - 0.30\Delta\log(IMPP)_{\text{t-1}}\}/(1-0.75) \\ &+ [-0.0283\log(\text{REERma2}) - 0.0524(\text{NTB trend})_{\text{t-4}} \\ &- 0.0745(\text{USSPREAD})_{\text{t-2}} + 0.425(\text{CUSTma8})_{\text{t-2}} \\ &+ 0.0203\log(\text{TOT})_{\text{t-2}}]/(0.0634)\end{aligned} \qquad (9)$$

This is also shown in Figure 9 and tends to move more in line with the mark-up than does expression (8).

For the US, Banerjee, Mizen and Russell (2007) report a coefficient of -1.5 on the annual inflation rate (compared to around -2.1 for our equation (8)[26]), -0.32 on the real exchange rate (compared to -0.45 in equation (8)), and also a positive trend. They do not investigate terms of trade and trade openness effects, but one would expect these to be far more relevant in South Africa than in the US. Their results are therefore broadly consistent with ours.

Our results imply that the negative effects on the mark-up of increased openness have been substantially offset by a more depreciated real exchange rate, by lower inflation rates (the Banerjee-Russell effect), and more recently, the improvement in the terms of trade. In the short-run, even more important has been the fact that increased trade openness has dramatically lowered import prices and unit labour costs. Given our evidence for remarkably slow adjustment of output prices[27], this means that in the short-run, increased openness actually *raises* the mark-up before the longer-term effects of increased competition feed through. As in the US and most other countries studied by Banerjee and Russell (2001), there has also been a long-term upward trend in the mark-up, even after taking into account the effect of inflation on the mark-up. Exactly how to interpret such remaining trends, is unclear. There may be a tendency for some increasing costs, perhaps of a regulatory nature, to be omitted from conventional unit cost data (underestimating unit costs), so that measured mark-ups trend up. In South Africa, productivity growth may also have been over-estimated, providing another reason for the underestimation of unit costs. To a lesser extent, this may also be true in other countries, as the shift towards increased outsourcing has resulted in the overstatement of manufacturing productivity growth.

5. Conclusion

In this paper we have applied an innovative technique for measuring time-series movements in trade openness to data for imports and prices of manufactures in South Africa. Following the logic of Anderson and Neary (2003; 2005), we measure the impact of trade openness by its effect on import volumes. Trade openness should have its most obvious effects on the ratio of imports to home demand. By purging movements in the ratio of imports to home demand of the influences of other economic variables such as the growth rate, the real exchange rate and movements in the terms of trade, what remains is explained by variations in tariff rates and a stochastic trend, reflecting non-tariff barriers, NTBs. In the case of South Africa, the latter, for a time, included external trade sanctions. The stochastic trend plausibly reflects the history of these sanctions and of the liberalisation of NTBs. Graphs of measures of effective protection and of other indicators related to openness, such as trade to GDP ratios and ratios of import prices to foreign and domestic prices, and productivity trends for manufacturing can all be plausibly related to the two elements of trade openness we have measured.

We have argued that the domestic mark-up on costs that manufacturers are able to charge depends on trade openness, as well as on the terms of trade and the real exchange rate (though partially offset by monetary policy designed to suppress inflationary tendencies when there is depreciation). The NTB proxy obtained from the import equation and tariff rates (excluding temporary surcharges) have a powerful effect on the mark-up charged by manufacturers in the long-run. This results in a stable equation explaining the fluctuations in producer prices charged by manufacturers in South Africa during 1979-2005, a period when the economy experienced major structural changes. Paradoxically, given observed price stickiness, the negative effect of increased openness on labour and import costs probably *raised* the observed mark-up in the short-run. Regarding the behaviour of the price on unit cost mark-up for the manufacturing sector in South Africa, our evidence is also consistent with that of Banerjee and Russell (2001) and Banerjee *et al.* (2001, 2002), in suggesting that the mark-up is negatively related to the inflation rate in the long run. Finally, we have found evidence that the pass-through to wholesale prices from changes in the nominal exchange rate is reduced by increased trade-openness. Thus, not only the level of inflation but its dynamics appear to be influenced by openness.

Crude indicators of trade openness such as the trade to GDP ratio do less well in explaining the behaviour of producer prices. Other measures, such as the effective rate of protection are available for only part of the period (and neglect NTBs), while the 'Heritage' and 'Free the World' indices are both intermittent and highly erratic.

The technique is potentially of use to other emerging market countries, especially those that have adopted inflation targeting, where structural breaks due to trade liberalisation episodes tend to bias estimates in the modelling and forecasting of inflation.

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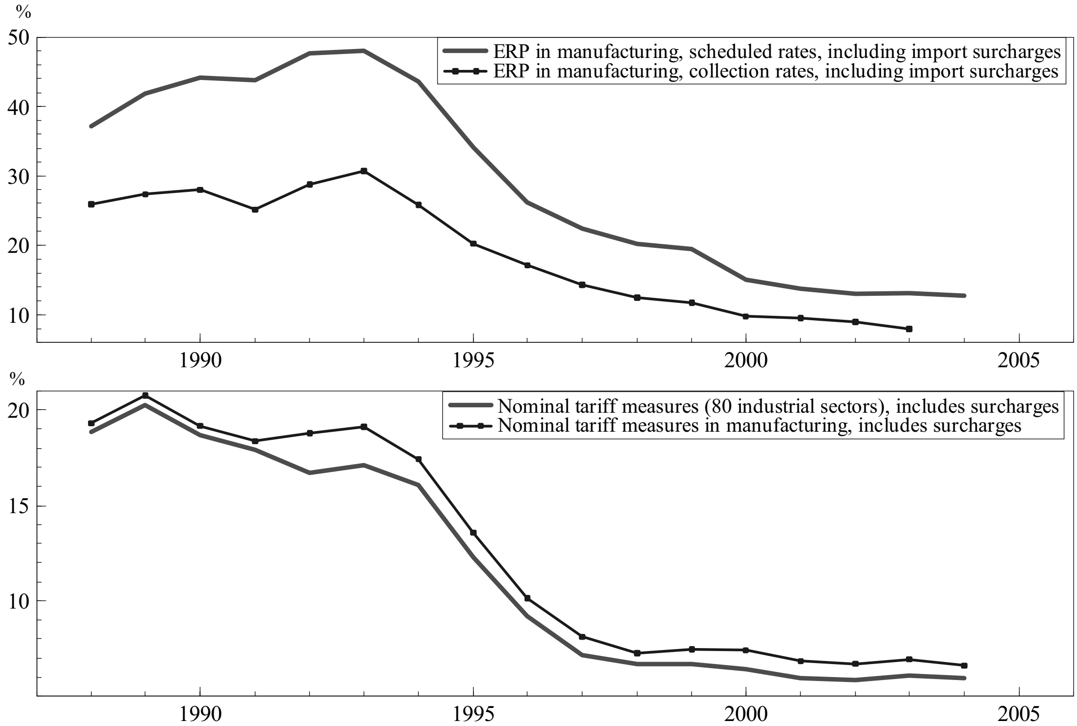
Figure 1: Effective rates of protection and nominal tariff measures for SA



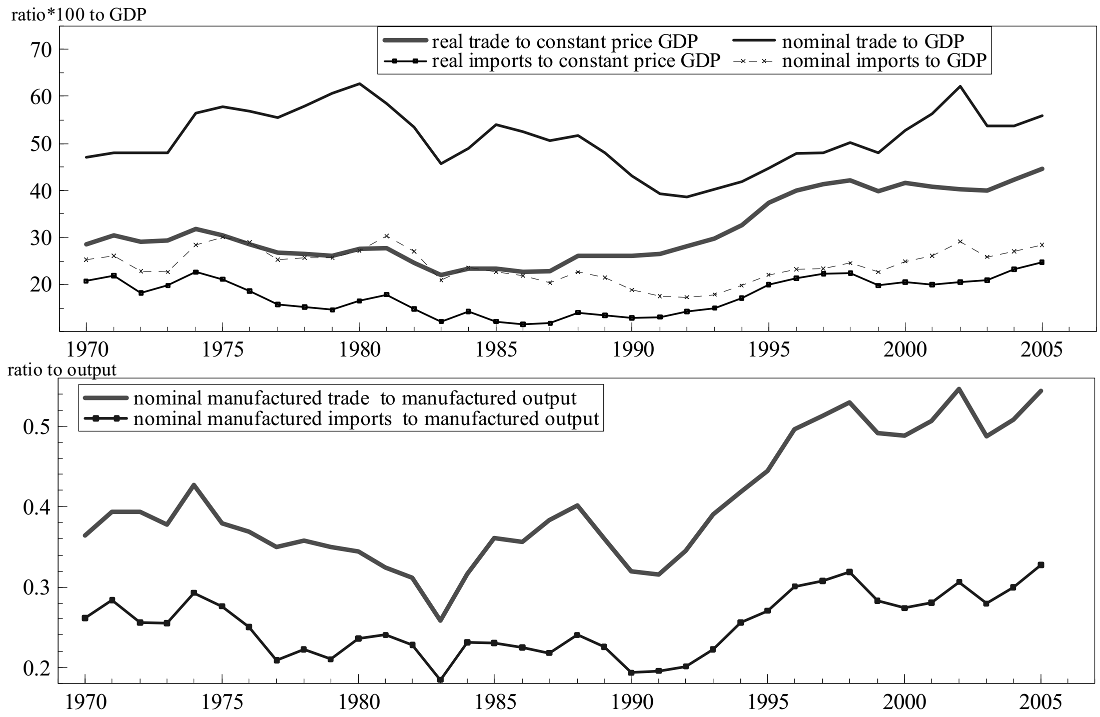
Source: Edwards (2005)

Notes:

(a) To facilitate comparability, the IO and SU tables (based on the 4th and 5th editions of the SIC system, respectively) were reduced to 43 industrial sectors. The ERP values for 1988 and 1989 are drawn from 1988 and 1989 IO tables. The ERP values 1993, 1998, 1999 and 2000 are drawn from their respective SU tables. The interim years are calculated as a weighted average using the estimated ERP of the two tables that bound the period (with a linearly declining weight).

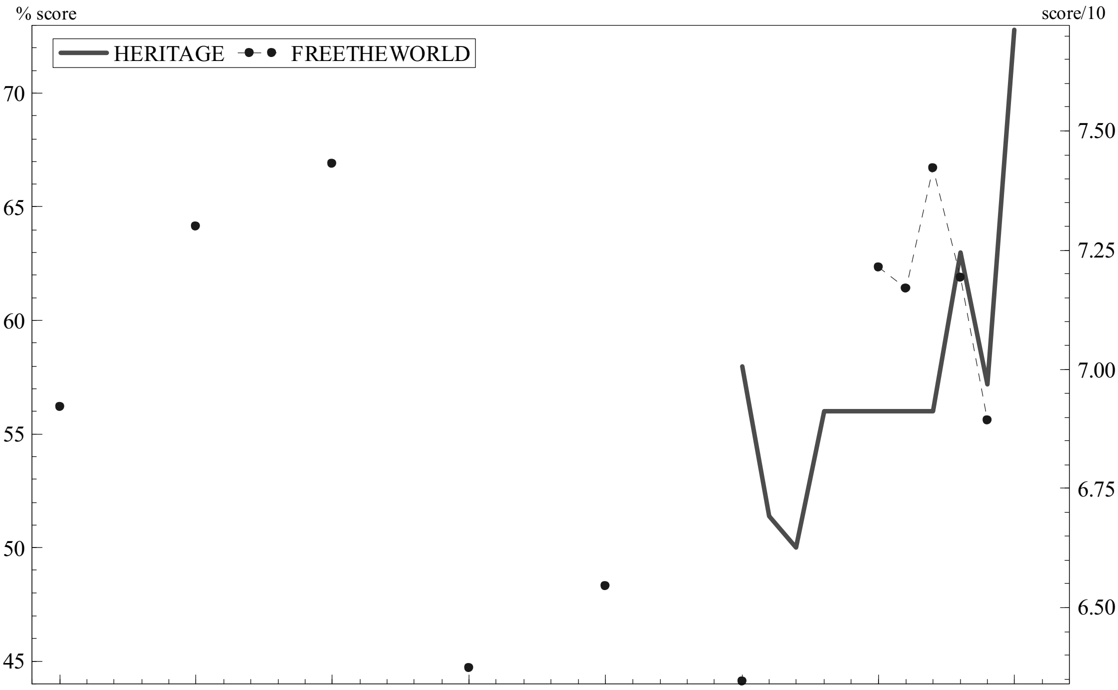
(b) Protection was measured using scheduled tariff rates at the HS8-digit level, and collection duties at the HS6-digit level, calculated by dividing customs revenue by the import value. Both the scheduled tariff and collection duty rates were adjusted to include surcharges calculated at the HS8-digit level using surcharge revenue obtained from Quantech Ltd., South Africa.

Figure 2: Real and nominal trade and imported trade volume measures for SA



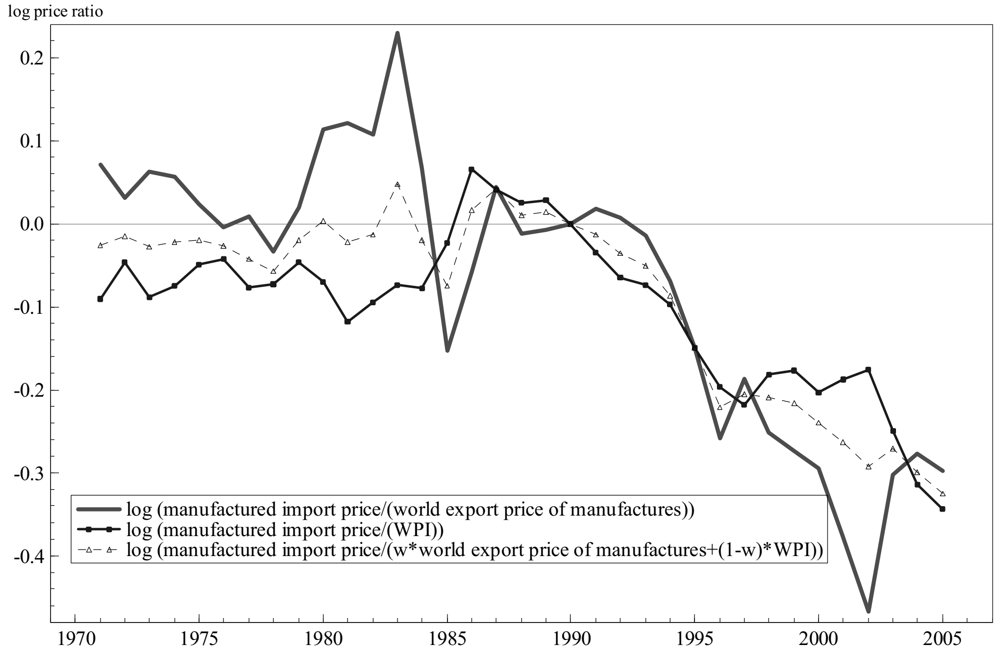
Source: SARB Quarterly Bulletins

Figure 3: Heritage Foundation and Free the World composite trade measures for SA



Source: Websites: http://www.heritage.org/index/ and http://www.freetheworld.com.

Figure 4: Relative price indices for SA

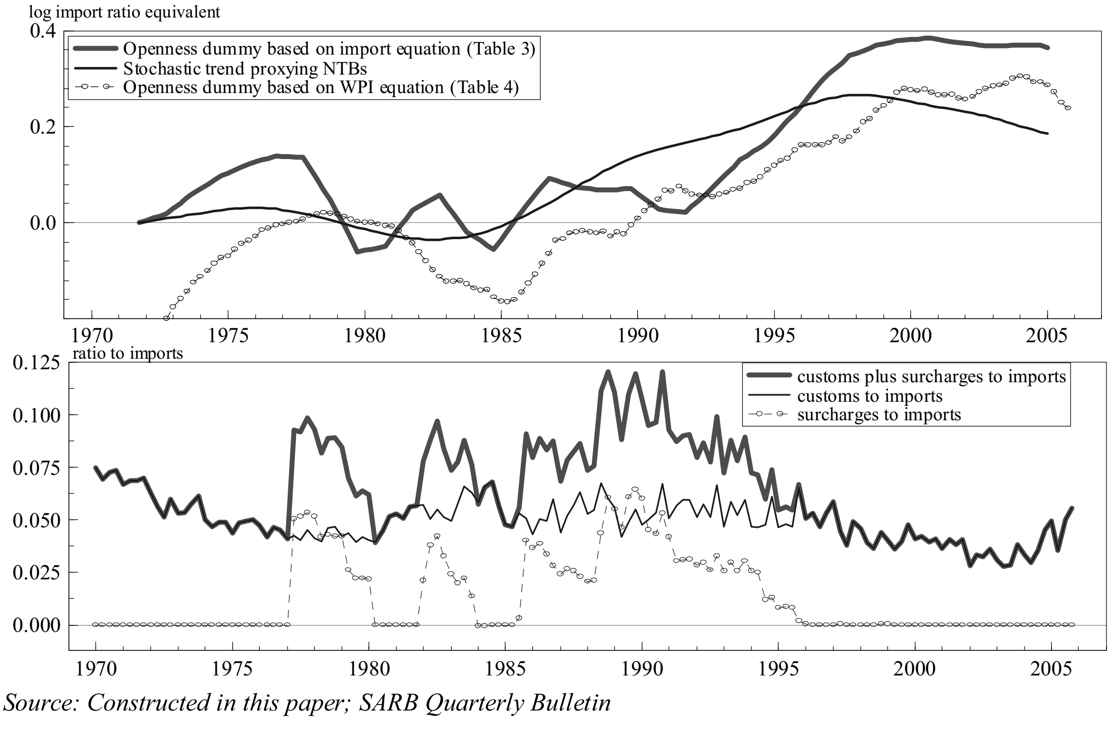


Source: World Economic Outlook, IMF, Statistics SA Yearbooks, SARB Quarterly Bulletin

Note: 1. The "world" export price of manufactures is proxied by the advanced countries' export price index of manufactures (U.S. dollars) from *World Economic Outlook*.

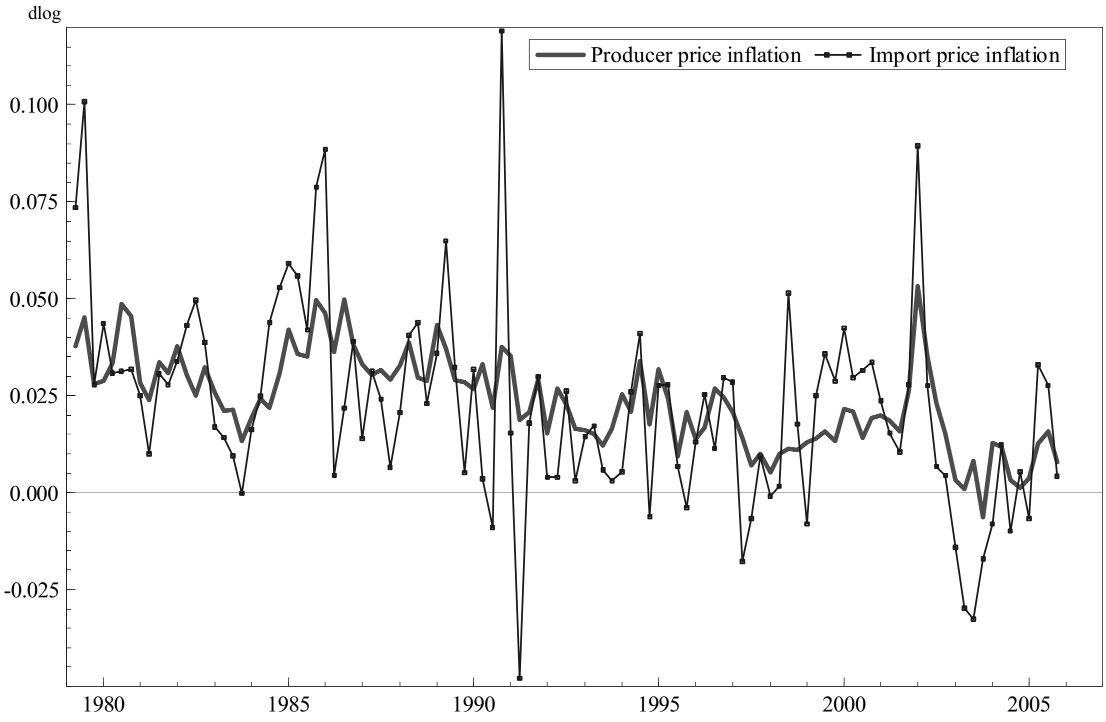
2. The price of manufactured imports obtained from *Statistics SA*, excludes the agricultural component, which is present with a weight of about 12 percent in the import price component of the WPI (published by the SARB).

Figure 5: Openness dummy and stochastic trend, plus the tariff ratios



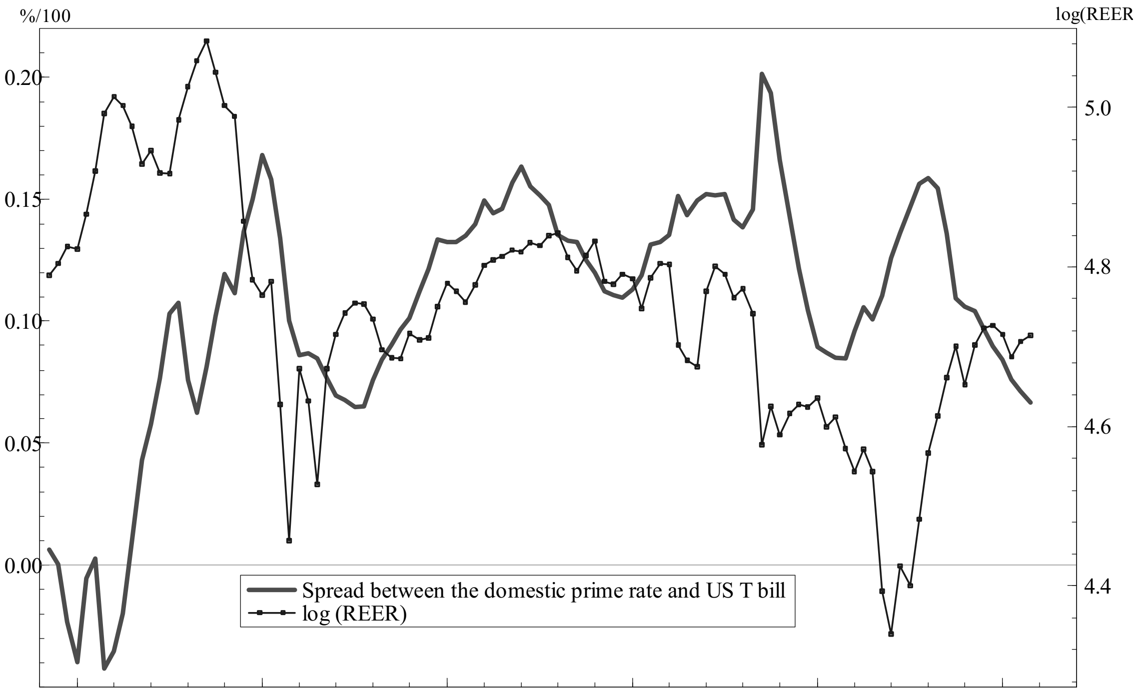
Source: Constructed in this paper; SARB Quarterly Bulletin

Figure 6: Log changes in wholesale and import prices



Source: SARB Quarterly Bulletin

Figure 7: Log real effective exchange rate and interest rate spread



Source: IFS (International Monetary Fund), SARB Quarterly Bulletin

Figure 8: Recursive estimates for Columns 1 of Table 4

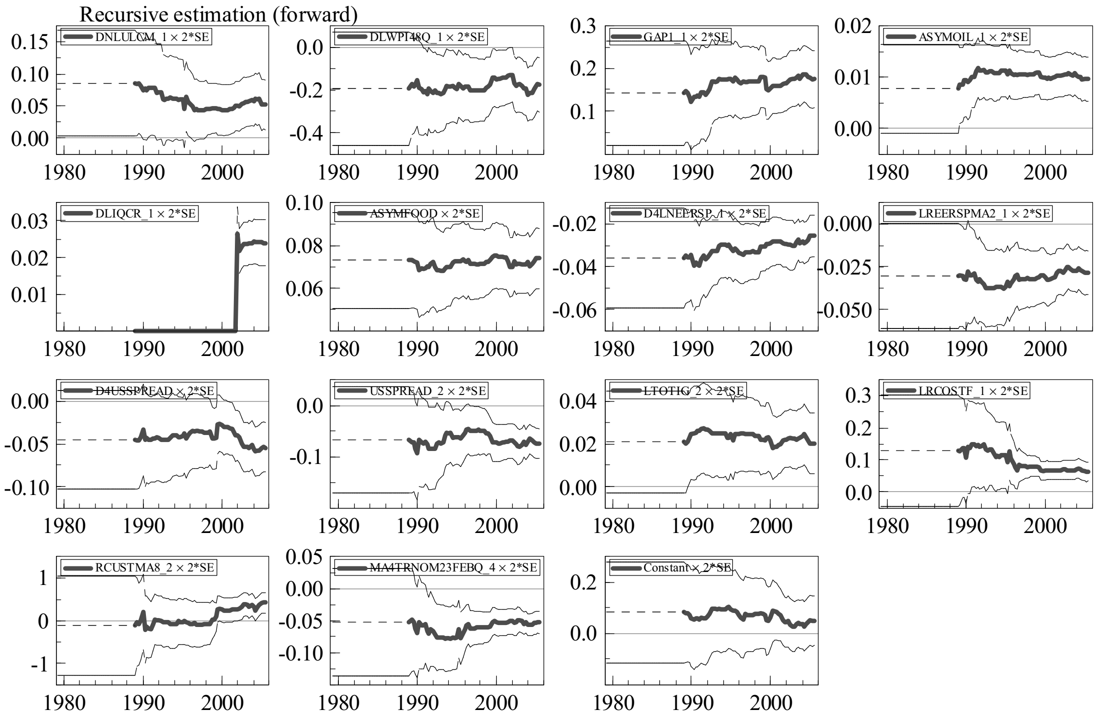
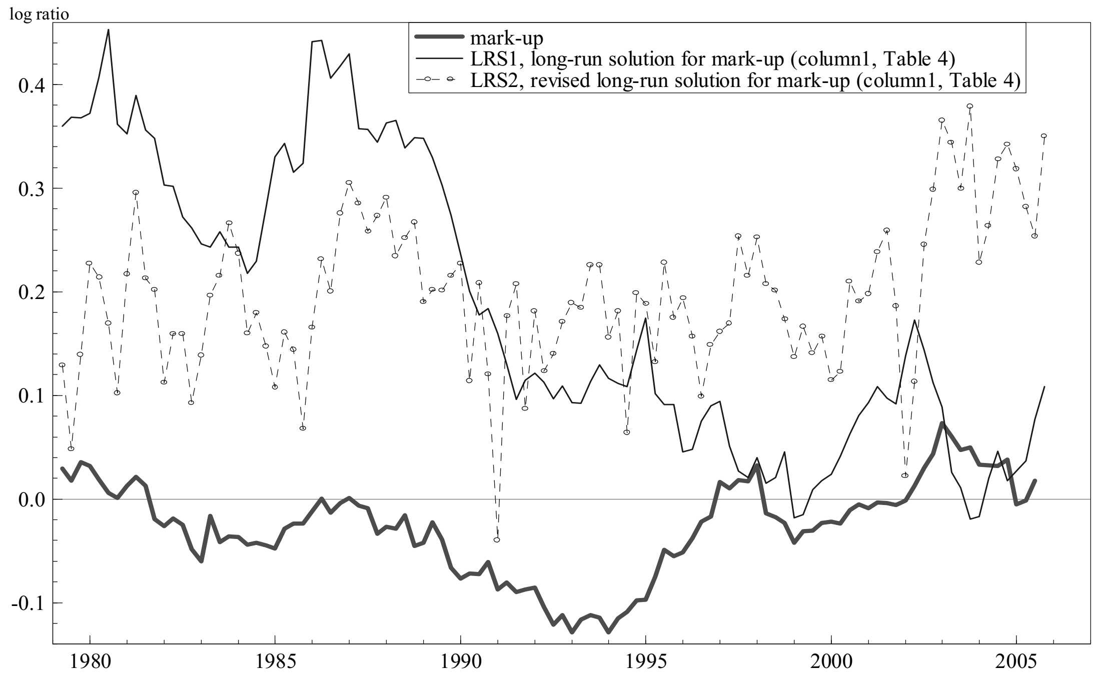


Figure 9: Long-run solutions for the mark-up



Note:

1. The long-run solutions for the mark-up, LRS1 and LRS2, are given by equations (7) and (9), respectively.
2. To view both long-run solutions and the mark-up on a single graph the former were adjusted by a constant.

Table 1. Episodes of trade liberalisation in South Africa

	Episode	*Key dates*
I.	***Import-substituting industrialisation***	**1925-1971**
	Customs, Tariff and Excise Duty Amendment Act	1925
	Introduction of quotas	1948
	Viljoen Commission (recommends tariffs not quotas or subsidies)	1958
	Government announces intention to lift quotas (not implemented)	1969
II.	***Export promotion***	**1972-1982**
	Reynders Commission of Enquiry into SA's export trade	1972
	Export incentives introduced	1972
	Quotas partially relaxed	1972-76
	Van Huyssteen Committee proposals reinforce export incentives	1978
Plus	Import surcharges introduced	1977
	Import surcharges progressively phased out	1977-1980
III.	***Replacing quotas with equivalent tariffs***	**1983-1993**
	Share of import value covered by quotas falls from 77 to 23%	1983-1985
	Permitted imports switched from a positive to a negative list	1985
	Further reductions in quotas implemented	1989
	Share of imports subject to quotas fall to below 15%	1992
Plus	Import surcharges introduced	1981
	Import surcharges progressively phased out	1981-1984
	Import surcharge of 10% introduced	1985 (Sept)
	Differential import surcharges introduced	1988
	Import surcharges reduced	1990-1991
	GEIS introduced, export subsidisation	1990
IV.	***Tariff reduction within international trade agreements***	**1994 -**
	GATT offer in Uruguay Round (implemented from 1995)	1994
	SADC free trade protocol (implemented 2000)	1996
	EU Trade Development and Cooperation agreement	2000
	AGOA agreement, preferential access to US	2000
	SACU agreement	2002
	SACU and MERCOSUR agreement	2004
Plus	Import surcharges abolished	1994-1995
	Deregulation of agricultural marketing and control boards	1994-97
	New Tariff Rationalisation Process	1996

Source: This summary table draws on reviews by Bell (1992, 1997), Belli *et al.* (1993), Bleaney *et al.* (1999), Edwards (2005), GATT (1993); Holden (1992), Hviding (2005) and WTO (1998, 2003).
Note: Abbreviations are: AGOA (African Growth and Opportunity Act); EU (European Union); GATT (General Agreement on Trade and Tariffs); GEIS (General Export Incentive Scheme); MERCOSUR (Southern Common Market); SACU (Southern African Customs Union); and SADC (Southern African Development Community).

Table 2. Variable definitions for parsimonious equations

Model and variable name	Variable definition	Mean	Standard deviation	I(1)[a,b]	I(2)[a,b]
Quarterly model 1979:2-2005:3					
log(WPI)	Log of domestic wholesale prices	3.89	0.754	-2.99*	-3.97**
log(ULC)	Log "normalized" unit labour cost measures were calculated by subtracting a measured (stochastic) trend in log productivity from the log wage in the manufacturing sector [see footnote 19]	6.89	0.782	-3.309*	-10.60**
log(FOODP)	Log of the raw price of food, from the agricultural food component of the CPI	4.04	0.644	-3.37*	-4.61**
ASYMFOOD	Δlog(FOODP) if Δlog(FOODP)>0, zero otherwise	0.0523	0.0558	-7.30**	-8.34**
log(POIL)	Log of the rand price of oil (Brent $)	4.25	0.734	-2.74	-8.975**
ASYMOIL	Δlog(POIL) if Δlog(POIL)>0, zero otherwise	0.139	0.182	-8.11**	-8.261**
OUTGAP	Output gap (uses HP filter, lambda=1600)	0.000839	0.0168	-4.18**	-
log(NEER)	Log of the SARB's nominal effective exchange rate	5.35	0.737	-2.39	-4.25**
log(REER)	Log of the SARB's real effective exchange rate	4.75	0.147	-3.46*	-4.87**
log (IMPP)	Log of SARB import prices (for manufacturing)	3.93	0.688	-2.76	-3.59**
DUMLIQCR	Dummy=1 in 2001:4-2002:1, and 0 otherwise	-	-	-	-
Stochastic trend	Quarternalised stochastic trend from Table 3, ma4	-	-	-	-
log(COST/WPI)	Accumulated Δlog(COST) from base of zero in 1970 minus log (WPI). Δlog(COST) is defined as the weighted sum of changes in normalised unit labour costs, ULC, and the import price component, IMPP, of the SARB's producer price index (the weight of the latter is the ratio of manufactured imports to manufactured output).	0.0132	0.0525	-1.78	-3.92**
log (FOODP/WPI)	Log ratio of the price of raw food to the domestic wholesale price index	0.149	0.126	-3.21	-8.56**
log(COSTF/WPI)	Calculated as: 0.9*log(COST/WPI) +0.1*log(FOODP/WPI)	0.0268	0.0460	-1.71	-10.97**
log(TOT)	Log of the terms of trade including gold	4.71	0.0770	-2.83	-13.95**
USSPREAD	Spread between SA prime rate and US government Treasury Bill rate	0.106	0.0498	-2.60	-6.87**
TARIFF	Ratio of customs plus import surcharges to merchandise imports	0.0637	0.0241	-1.25	-4.66**
CUSTOM	Ratio of customs to merchandise imports	0.0485	0.00967	-1.45	-3.83**
SURCHARGE	Ratio of import surcharges to merchandise imports	0.0153	0.0183	-2.61	-8.78**
Annual model 1971-2005					
log(IMPDEM)	Log share of imports in home demand	3.12	0.150	-2.07	-5.55**
log(CAPUT)	The log of capacity utilisation	4.38	0.0283	-3.90**	-4.58**
log(GDPCON)	Log of real GDP	13.5	0.209	0.2872	-4.08**
log(REER)	Log of the SARB's real effective exchange rate	4.74	0.125	-1.99	-4.85**

Model and variable name	Variable definition	Mean	Standard deviation	I(1)[a,b]	I(2)[a,b]
TARIFF	Ratio of customs plus import surcharges to merchandise imports	0.0633	0.0213	-1.66	-5.41**
log(TOT)	Log terms-of-trade (including gold)	4.71	0.0785	-4.83**	-6.13**
DUM71	Dummy=1 in 1971	-	-	-	-
DUM72	Dummy=1 in 1972	-	-	-	-
log (IMPP/WPI)	Log ratio of the import price excl. agriculture (*Statistics SA*) to domestic WPI	0.102	0.0951	-0.894	-4.28**

a. For a variable X, the augmented Dickey-Fuller (1981) statistic is the t ratio on π from the regression: $\Delta X_t = \pi X_{t-1} + \Sigma_{i=1,k} \theta_i \Delta X_{t-i} + \psi_0 + \psi_1 t + \varepsilon_t$, where k is the number of lags on the dependent variable, ψ_0 is a constant term, and t is a trend. The kth-order augmented Dickey-Fuller statistic is reported, where k is the last significant lag of the 5 lags employed. The trend is included only if significant. For null order I(2), ΔX replaces X in the equation above. Critical values are obtained from MacKinnon (1991). Asterisks * and ** denote rejection at 5% and 1% critical values.
b. Stationarity tests are performed for the variables in levels before time-transformation i.e. before taking moving averages and changes.

Table 3. Import demand equations

Dependent variable: log (IMPDEM)	1971 – 2005 **Coeff.**	**t-value**	1971 – 1997 **Coeff.**	**t-value**	1980 – 2005 **Coeff.**	**t-value**	1972 – 2005 **Coeff.**	**t-value**
log(REER)(-1)	0.258	2.7	0.354	3.3	0.235	2.2		
TARIFF(-1)	-6.46	-2.8	-5.71	-3.1	-5.35	-1.8	-3.56	-1.6
TARIFF(-2)	-6.74	-3.3	-6.83	-4.6	-7.32	-2.3	-7.77	-3.9
Fitted log(IMPP/WPI) #	-	-	-	-	-	-	0.568	1.6
log (IMPP/WPI)(-1) #	-	-	-	-	-	-	-0.985	-3.4
DUM71	0.233	2.8	0.270	3.3	-	-	-	-
DUM72	0.161	2.5	0.183	3.5	-	-	0.101	1.6
Δlog (GDPCON)	1.42	3.6	1.37	4.3	1.57	3.5	2.16	4.9
$\Delta_3$log (TOT)	0.399	4.3	0.398	4.9	0.414	3.1	0.215	2.3
Diagnostics								
Std.Error	0.0476		0.0364		0.0474		0.0452	
Normality	0.73		6.9		1.6		0.068	
H(11)	2.7		0.586		3.1		1.9	
r(1)	0.17		0.01		0.20		0.13	
DW	1.6		2.0		1.5		1.7	
Q(7, 6)	7.1		12		6.5		6.5	
Adjusted R^2	0.651		0.817		0.667		0.688	

1. See Table 2 for definitions of the variables (before transformation).
2. The equation includes an I(2) stochastic trend.
3. r(1) is first-order residual autocorrelation; R_D^2 is R-squared computed for first differences of the dependent variable.
4. The equation standard error and t ratios in STAMP are not adjusted for degrees of freedom.
5. # uses *Statistics South Africa*'s price of manufactured imports excluding the agricultural component (that is in the SARB's import price index).

Table 4. Producer price equations

Dependent variable: Δlog (WPI)	1979:2 – 2005:3		1979:2 – 2005:3		1979:2 – 2005:3		1988:4 – 2004:4		1988:4 – 2004:4		1979:2-2005:3		1979:2-2005:3	
	1		**2**		**3**		**4**		**5**		**6**		**7**	
	Coeff.	**t-value**	**Coeff.**	**t-value**	**Coeff.**	**t-value**	**Coeff.**	**t-value**	**Coeff.**	**t-value**	**Coeff.**	**t-value**	**Coeff.**	**t-value**
Long-run terms:														
Constant	0.050	1.0	-0.008	0.0	0.058	1.2	0.002	0.0	0.047	0.6	-0.024	-0.5	0.033	0.7
log($COSTF/WPI$) (-1)	0.063	4.2	0.021	1.6	0.055	3.6	0.079	1.8	0.105	3.2	0.031	2.6	0.064	4.4
log(REERma2)(-1)	-0.028	-4.4	-0.013	2.0	-0.030	3.7	-0.017	-1.6	-0.022	-1.7	-0.007	-1.5	-0.026	4.0
USSPREAD(-2)	-0.075	-5.1	-0.061	4.5	-0.080	-5.4	-0.974	-3.3	-0.070	-2.8	-0.064	-5.1	-0.091	5.6
log(TOT)(-2)	0.020	2.9	0.019	2.3	0.020	2.8	0.020	1.4	0.017	1.1	0.023	3.2	0.021	3.0
DUMOPEN(-4)			-0.038	4.8										
CUSTOM(ma8)(-2)	0.425	3.6			0.471	4.1			0.190	1.0			0.42	3.6
NTB trend (-4)	-0.052	-6.2			-0.044	-5.3			-0.046	-2.1			-0.038	-3.6
Alternative trade policy measures:														
Edwards' tariff measure *(see note 5)*							0.00073	2.1						
Trade volume measure *(see note 5)*											0.0078	-6.7		
Short-run terms:														
OUTGAP(-1)	0.175	5.3	0.113	3.3	0.161	5.0	0.264	3.9	0.278	4.0	0.185	5.3	0.145	4.1
DUMLIQCR(-1)	0.024	7.7	0.023	6.4	0.020	6.1	0.029	8.0	0.028	7.9	0.024	7.2	0.025	8.1
Δ_4USSPREAD	-0.054	-3.7	-0.038	2.3	-0.060	-4.2	-0.034	-1.3	-0.037	-1.5	-0.055	-3.6	-0.038	-2.3
$\Delta_4$log (NEER)(-1)	-0.026	-5.3	0.037	7.6	-0.017	-3.2	-0.026	-2.8	-0.022	-2.3	-0.041	-9.6	-0.025	-5.4
Fitted Δlog(IMPP)					0.109	5.2								
ASYMOIL(-1)	0.0096	4.5	0.011	4.4					0.010	3.4	0.0085	3.8	0.010	4.9
ASYMFOOD	0.074	10.5	0.068	8.5	0.066	9.3	0.071	6.9	0.071	6.9	0.072	9.8	0.076	11
Δlog (ULC)(-1)	0.051	2.7	0.051	2.3	0.049	2.6	0.048	1.4	0.054	1.7	0.033	1.6	0.051	2.7
Δlog (WPI)(-1)	-0.175	-2.8	-0.103	1.4	-0.166	2.5	-0.280	-3.0	-0.292	-3.1	-0.15	2.3	-0.15	-2.3

Dependent variable: Δlog (WPI)	1979:2 – 2005:3		1979:2 – 2005:3		1979:2 – 2005:3		1988:4 – 2004:4		1988:4 – 2004:4		1979:2-2005:3		1979:2-2005:3	
	1		**2**		**3**		**4**		**5**		**6**		**7**	
	Coeff.	**t-value**	**Coeff.**	**t-value**	**Coeff.**	**t-value**	**Coeff.**	**t-value**	**Coeff.**	**t-value**	**Coeff.**	**t-value**	**Coeff.**	**t-value**
Non-linear terms:														
INTERACT* $\Delta_4$log (NEER)(-1) *(see note 6)*													1.05	2.2
Diagnostics:														
Equation std. error	0.00374		0.00427		0.00374		0.00396		0.00394		0.00392		0.00366	
Adjusted R^2	0.903		0.874		0.903		0.863		0.864		0.893		0.906	
Chow (1999:4)	0.05		0.05		0.10		0.19		0.16		0.04		0.06	
Chow (mid-sample)	0.32		0.18		0.72		0.63		0.52		0.30		0.43	
Normality test	0.19		0.88		0.05		0.71		0.75		0.24		0.30	
AR 1-4 test	0.42		0.24		0.84		0.02		0.02		0.45		0.69	
ARCH 1-4 test	0.03		0.73		0.01		0.05		0.03		0.22		0.17	
hetero test	0.31		0.96		0.06		0.55		0.03		0.81		0.14	

1. See Table 2 for definitions of the variables (before transformation).
2. The output gap in column 3 is at a lag of 2.
3. All samples begin in 1979:2 (floating exchange rate regime), except for columns 4 and 5**,** which begin in 1988:4.
4. The Chow tests, normality, AR, ARCH and hetero tests report p-values. The Chow test for mid-sample occurs at 1996:4 for columns 4 and 5, and at 1992:3 otherwise.
5. Edwards' measure used in column 4 is based on nominal tariffs for 80 industrial sectors; the trade volume measure used in column 6 is the ratio to GDP of total imports plus exports, all in constant prices.
6. INTERACT=0.42*(CUSTOMma8(-2)- mean) – 0.038*(NTB trend (-4)- mean), using the respective means of each variable. The coefficients 0.42 and -0.038 are the estimated slope coefficients for CUSTOMma8(-2) and NTB trend (-4) from column 7.

Endnotes.

[1] A similar principle was used developing a credit conditions index for the UK in Fernandez-Corrugedo and Muellbauer (2006).

[2] Studies include Dollar (1992), Sachs and Warner (1995), Harrison (1996), Edwards (1998), Wacziarg (2001) and Greenaway et al. (2002).

[3] Anderson and Neary (2003; 2005) introduce an index of trade policy restrictiveness defined as the uniform tariff which maintains the same trade volume as a given tariff/quota structure. Their index overcomes the problems of the trade-weighted average tariff. However, the data requirements for its construction are rather onerous.

[4] For instance, Harrison (1996) uses a panel with an annual index of trade liberalisation for 1960-84, derived using country-specific information on exchange rate and commercial policies from Papageorgiou et al. (1991).

[5] The criteria, employing arbitrary thresholds and weighting, are whether: (i) NTB coverage exceeded 40 percent of imports; (ii) average tariffs exceeded 40 percent; (iii) the black-market exchange rate premium exceeded 20 percent in the 1970s or the 1980s; (iv) the economy was socialist; and (v) a state monopoly existed over major exports.

[6] The average tariff rate (mainly World Bank or WTO data) is subtracted from a maximum tariff rate (50 percent) and is given relative to the difference between the maximum and minimum average tariff rates (50 percent), with a further 20 percent penalty subtracted for the *presence* of non-tariff barriers.

[7] Some studies quote measures of effective protection within this period (1964 to 1988), but they are not comparable given the different methodology used (Holden and Holden (1978); Holden, (1992); Industrial Development Corporation (1990)).

[8] The types of customs duties include *ad valorem*, specific, mixed, compound and formula duties as well as their combinations. Up to the late 1990s, non-*ad valorem* tariffs such as formula duties and mixed duties were prevalent, especially within the clothing and textile sectors. Edwards replaces formula and mixed duties by collection rates if the latter exceeded the *ad valorem* component of the scheduled rates. This under-estimates protection since prohibitive protection would discourage the associated imports. There were also frequent exemptions on duty.

[9] The Heritage Foundation trade component is calculated as discussed above, and the 20 percent deducted for non-tariff barriers is justified as follows: "Import restrictions, weak

enforcement of intellectual property rights, service market barriers, sanitary and phytosanitary rules, non-transparent and inefficient bureaucracy, excessive regulation, and corruption add to the cost of trade. Consequently, an additional 20 percent is deducted from South Africa's trade freedom score to account for these non-tariff barriers." (http://www.heritage.org/index/)

[10] Note that import price indices in South Africa do reflect trade policy (tariffs, surcharges and non-tariff barriers). The publication of import unit value measures was discontinued by *Statistics SA* in 1997. The SARB publishes only import prices (overall and for manufacturing), based on data from *Statistics SA*.

[11] The weights of 0.4 on foreign prices and 0.6 on domestic prices were suggested by the import price equation in Aron, Muellbauer and Smit (2004).

[12] In our application in section 4 of this paper, we focus on the impact of openness on South Africa's wholesale price index (WPI). Ideally then openness would be defined over imported goods in each of the sub-categories of the WPI and aggregated using WPI weights. The available data on aggregate imports effectively uses the weights of each sub-category in overall imports.

[13] The equation would be exact if p^{man} was equal to domestic demand in current prices divided by domestic demand in constant prices.

[14] The published real exchange rate definition uses a domestic price measure in which import prices have a 27 percent weight and so is not completely free of the direct effect of tariffs.

[15] Quarterly and annual data on imports of manufactures are not published. We use annual data constructed by Quantec Ltd. from information obtained from the SA Revenue Services Customs Division. Figure 2 compares these data with published aggregate data.

[16] We do not have confidence in the price deflator used for manufacturing imports as it deviates implausibly from the *Statistics South Africa*'s import price index – hence we have only estimated the current price version of equation (3).

[17] The South African Reserve Bank publishes nominal and real effective exchange rate indices from 1970. Only after April, 1995, were the weights (based on total trade in goods and services) first published, later revised (January, 1999). From September, 1999, back to 1978, new weights were published based on the trade in and consumption of manufactured goods between S.A. and 14 major trading partners (see September, 1999, *Quarterly Bulletin*). Recently, a new measure was published back to 1990, excluding Zimbabwe (with its rampant inflation in recent years).

[18] Possible asymmetries in the log change of GDP were tested for, and found insignificant.

[19] The instrumenting equation is driven mainly by the log real exchange rate and a stochastic trend, with log changes in GDP, and changes in tariff rates playing a more minor role. IV estimation is not available in STAMP, so the standard errors reported in Table 2 are not quite accurate. However, as the fit and the parameter estimates are quite similar using the actual or the fitted values of $\log(p^{imp} / p^{man})$, the reported t-ratios should be close to the correct ones.

[20] The "normalized" unit labour cost measures were calculated by subtracting a measured (stochastic) trend in log productivity from the log wage in the manufacturing sector, derived as follows: the log of productivity was regressed on its lagged level, the level and change in the log of capacity utilisation (to capture cyclical effects), and a smooth I(2) stochastic trend using STAMP (Koopman *et al*. 2000).

[21] The hypothesis of a 10 percent weight is easily accepted in our econometric model.

[22] The REER measures the ratio of domestic to foreign wholesale prices in Rands.

[23] This software (version 2.01c) runs a range of tests, including tests for parameter stability, residual autocorrelation and heteroscedasticity.

[24] The instrumenting equation is driven by openness indicators, a few dummies for exchange rate events, and changes in the US WPI, in the nominal effective exchange rate, in lagged import prices and in rand oil prices (with asymmetric effects).

[25] This is computed as the sum of the coefficients on lagged $\log(WPI)$, which appears twice, in the log relative cost term, and in the negative $\log(REER)$ term. For the latter the weight is used of 73 percent, which is the weight of domestic wholesale prices in the overall wholesale prices index (e.g. summing the coefficients 0.063 and 0.73 x 0.028 in column1, Table 4).

[26] Converting from quarterly to annual inflation would multiply the inflation coefficients by 0.25, leaving the total inflation effect at $-1.78 - 0.3 \cong -2.1$.

[27] The sum of the dynamic effects reported in Table 4 for log changes in import prices, food prices, unit labour costs and lagged output prices is roughly zero, while the response to the equilibrium correction term is around 8.5 percent per quarter.