Testing Creative Destruction in an Opening Economy: the Case of the South African Manufacturing Industries

Philippe Aghion,[1] Johannes Fedderke[2], Peter Howitt[3], Chandana Kularatne[4] and Nicola Viegi[5]

Working Paper Number 93

[1] Harvard University
[2] Economic Research Southern Africa and University of Cape Town
[3] Brown University
[4] University of Cape Town
[5] Economic Research Southern Africa and University of Cape Town

Testing Creative Destruction in an Opening Economy: the Case of the South African Manufacturing Industries

Philippe Aghion,[*] Johannes Fedderke,[†] Peter Howitt,[‡] Chandana Kularatne[§] and Nicola Viegi[¶]

January 2008

Abstract

This paper employs a theoretical framework that allows for both direct and indirect impacts of trade liberalization on productivity growth. Indirect impacts operate through both scale effects as well as a differential impact on firms conditional on their distance from the international technological frontier. Empirical results from panel estimations for the South African manufacturing sector are reported. Results confirm that the greatest positive impact of trade liberalization will be on small rather than large sectors of the manufacturing sector, while South African manufacturing sectors do not lag sufficiently behind the technological frontier for trade liberalization to exert a negative impact on productivity growth. While there does appear to be a positive direct impact of protection on productivity growth, the impact is small, and once indirect trade impacts are accoutned for, the net effect of liberalization on growth is positive for South African manufacturing. Further results confirm the positive impact of scale of production on productivity growth, while pricing power as well as industry concentration in the manufacturing sector are strongly negatively associated with productivity growth. Finally, while nominal depreciation of the exchange rate is associated with increased productivity growth in South African manufacturing, the effect is economically very small. Policy implications to follow from the analysis affirms the importance of trade liberalization as a means of raising productivity growth, and the inferiority of nominal exchange rate depreciation in raising productivity growth.

1 Introduction

The existing literature on trade and growth mentions a variety of factors that may potentially affect the impact of trade liberalization on economic development. For example, Alesina et al (2005) point to a *market size effect* or a *scale effect* whereby the larger the domestic economy relative to the world economy, the less innovation or learning-by-doing domestic producers gain by opening up to trade.[1] This is explained by the fact that small economies gain proportionately more from opening in terms of scale effects than do large producers. Other authors point to the possibility that growth might be less enhanced by openness in more advanced countries, reflecting a *knowledge spillover effect* whereby trade induces knowledge flows across countries, such that more advanced countries stand to gain proportionately less from such knowledge spill-overs.[2]

But there is an additional effect of trade on growth which has not been much analyzed so far: namely that trade liberalization tends to enhance *product market competition*, by allowing foreign producers to compete with domestic producers. This in turn should enhance domestic productivity for at least two reasons. First,

[*]Harvard University

[†]Economic Research Southern Africa and University of Cape Town

[‡]Brown University

[§]University of Cape Town

[¶]Economic Research Southern Africa and University of Cape Town

[1]This result was first pointed out by Alesina, Spolaore and Wacziarg (2003). In Aghion and Howitt (2007) scale is given by population size.

[2]This knowledge spillover effect has been analyzed at length by Keller (2004) - and see also Sachs and Warner (1995) and Coe and Helpman (1995).

by forcing the most unproductive firms out of the domestic market.[3] Second, by forcing domestic firms to innovate in order to escape competition with their new foreign counterparts.

In this paper we test for these effects in a middle income country context, using South African manufacturing sector data. The analysis of cross country growth regressions hides significant heterogeneity at the sectoral level. Schumpeterian growth theory operates on an understanding of firm level dynamics, while the national dimension strictly just provides the institutional background to firm's optimizing decisions. For an accurate picture of the relationship between trade policies and growth, analysis should be conducted at least at the industry level of a specific country, The case of South Africa is interesting because it appears as a natural experiment of gradual liberalization, it is sectorally heterogeneous and has significant internal market monopolies.

Previous studies have examined the relationship between pricing power of industry and growth,[4] market structure and growth,[5] investment in R&D and human capital and growth,[6] and one study has considered the relationship between openness and growth of total factor productivity in the South African context. It found a strong positive correlation, although mitigated by market imperfections, but the specification estimated did not capture the full set of theoretical considerations detailed below (as is true of most studies examining trade and growth effects).

The objective of this paper is to evaluate the composition and the nature of productivity gains (if any) that result from trade liberalization. Section 2 of the paper outlines the theoretical framework employed in the paper. Section 3 provides background on the nature and extent of South African trade liberalization. In section 4 the empirical strategy of the paper is explained, including the data sets employed, while section 5 reports estimation results. Section 6 concludes.

2 Theoretical Framework

We use the Schumpeterian model of endogenous growth, which we first describe for the case of a closed economy and then extend to the case of an open economy. This section draws unrestrainely from Aghion and Howitt (2007).

2.1 The Closed Economy Case

Consider first the closed-economy version of the model. A unique final good, which also serves as numéraire, is produced competitively using a continuum of intermediate inputs according to:

$$Y_t = L^{1-\alpha} \int_0^1 A_{it}^{1-\alpha} x_{it}^{\alpha} di, \ 0 < \alpha < 1 \tag{1}$$

where L is the domestic labor force, assumed constant, A_{it} is the quality of intermediate good i at time t, and x_{it} is the flow quantity of intermediate good i being produced and used at time t.

Each intermediate sector has a monopolist producer who uses the final good as the sole input, with one unit of final good needed to produce each unit of intermediate good. The monopolist's cost of production is therefore equal to the quantity produced x_{it}. The price p_{it} at which this quantity of intermediate good is sold to the competitive final sector is the marginal product of intermediate good i in (1). The monopolist will choose the profit maximizing level of output:

$$x_{it} = A_{it} L \alpha^{2/(1-\alpha)} \tag{2}$$

with profit level:

$$\pi_{it} = \delta A_{it} L \tag{3}$$

where $\delta \equiv (1-\alpha)\,\alpha^{\frac{1+\alpha}{1-\alpha}}$.

[3] For instance Trefler (2004) shows that trade liberalization in Canada resulted in a 6% increase in average productivity.
[4] See Aghion, Braun and Fedderke (2006).
[5] See Fedderke and Szalontai (2005) and Fedderke and Naumann (2005).
[6] See Fedderke (2006).

Equilibrium level of final output in the economy can be found by substituting the x_{it}'s into (1), which yields

$$Y_t = \zeta A_t L \tag{4}$$

where A_t is the average productivity parameter across all sectors $A_t = \int_0^1 A_{it} di$, and $\zeta = \alpha^{\frac{2\alpha}{1-\alpha}}$.

Equilibrium level of national income, N_t, differs from final sector output Y_t, since some final goods are used up in producing the intermediate products. There are only two forms of income - wage income and profit income. Total wage income is the fraction $1-\alpha$ of final output:

$$W_t = L \times \partial Y_t \partial / L = (1-\alpha) Y_t$$

Profits are earned only by the local monopolists who sell intermediate products to the final sector (the final good sector is perfectly competitive and under constant returns to scale). Since each monopolist charges a price equal to $1/\alpha$ and has a cost per unit equal to 1, therefore a profit margin on each unit sold of $(1-\alpha) p_{it}$, such that that total profits equal:

$$\begin{aligned} \Pi_t &= \int_0^1 (p_{it} - 1) x_{it} dt = (1-\alpha) \int_0^1 p_{it} x_{it} dt \\ &= (1-\alpha) \int_0^1 (\partial Y_t / \partial x_{it}) x_{it} dt (1-\alpha) \alpha Y_t \end{aligned}$$

Hence national income is:

$$N_t = W_t + \Pi_t = \left(1-\alpha^2\right) Y_t = \left(1-\alpha^2\right) \zeta A_t L. \tag{5}$$

which is strictly proportional to average productivity and to population.

Productivity growth comes from innovations. In each sector, at each date there is a unique entrepreneur with the possibility of innovating in that sector. She is the incumbent monopolist, and an innovation would enable her to produce with a productivity (quality) parameter $A_{it} = \gamma A_{i,t-1}$ that is superior to that of the previous monopolist, by the factor $\gamma > 1$. Otherwise her productivity parameter stays the same: $A_{it} = A_{i,t-1}$. Innovation with any given probability μ entails the cost $c_{it}(\mu) = (1-\tau) \cdot \phi(\mu) \cdot A_{i,t-1}$, of the final good in research, where $\tau > 0$ is a parameter that represents the extent to which national policies (institutions) encourage innovation, and ϕ is a standard convex cost function. Thus the local entrepreneur's expected net profit is:

$$\begin{aligned} V_{it} &= E\pi_{it} - c_{it}(\mu) \\ &= \mu \delta L \gamma A_{i,t-1} + (1-\mu) \delta L A_{i,t-1} - (1-\tau) \phi(\mu) A_{i,t-1} \end{aligned}$$

Each local entrepreneur will choose a frequency of innovations μ^* that maximizes V_{it}. The first-order condition for an interior maximum $\partial V_{it} / \partial \mu = 0$, can be expressed as the research arbitrage equation:

$$\phi'(\mu) = \delta L (\gamma - 1) / (1-\tau). \tag{6}$$

If the research environment is favorable enough (τ is large enough), or the population large enough, so that:

$$\phi'(0) > \delta L (\gamma - 1) / (1-\tau)$$

then the unique solution μ to (6) is positive, so in each sector the probability of an innovation is that solution ($\widehat{\mu} = \mu$), otherwise the local entrepreneur chooses never to innovate ($\widehat{\mu} = 0$). Since each A_{it} grows at the rate $\gamma - 1$ with probability $\widehat{\mu}$, and at the rate 0 with probability $1 - \widehat{\mu}$, the expected growth rate of the economy is:

$$g = \widehat{\mu} (\gamma - 1)$$

So we see that countries with a larger population and more favorable innovation conditions will be more likely to grow, and grow faster.

2.2 Opening the Economy

Now open trade in goods (both intermediate and final) between the domestic country and the rest of the world. For simplicity, assume two countries, "home" and "foreign," with an identical range of intermediate and final product, and no transportation costs. Within each intermediate sector the world market can then be monopolized by the lowest cost producer. Asterisks denote foreign-country variables.

The immediate effect of this opening up is to allow each country to take advantage of more productive efficiency. In the home country, final good production will equal

$$Y_t = \int_0^1 Y_{it} di = L^{1-\alpha} \int_0^1 \widehat{A}_{it}^{1-\alpha} x_{it}^{\alpha} di, \; 0 < \alpha < 1 \tag{7}$$

where $\widehat{A}_{it}$ is the higher of the two initial productivity parameters $\widehat{A}_{it} = \max\{A_{it}, A_{it}^*\}$. Symmetrically for the foreign country.

Monopolists' profit will now be higher than under autarky, because of increased market size. For price p_{it}, final good producers will buy good i up to the point where marginal product equals p_{it}:

$$x_{it} = \widehat{A}_{it} L \left(p_{it}/\alpha\right)^{\frac{1}{\alpha-1}} \text{ and } x_{it}^* = \widehat{A}_{it} L^* \left(p_{it}/\alpha\right)^{\frac{1}{\alpha-1}} \tag{8}$$

so that price will depend on global sales relative to global population:

$$p_{it} = \alpha \left(\frac{X_{it}}{(L + L^*) \widehat{A}_{it}} \right)^{\alpha-1} \tag{9}$$

Accordingly the monopolist's profit π_{it} will equal revenue $p_{it}X_{it}$ minus cost X_{it}, and profit maximization requires that:

$$X_{it} = \widehat{A}_{it} \left(L + L^*\right) \alpha^{2/(1-\alpha)}$$

with price $p_{it} = 1/\alpha$ and profit level:

$$\pi_{it} = \delta \widehat{A}_{it} \left(L + L^*\right) \tag{10}$$

Substitution of prices $p_{it} = 1/\alpha$ into the demand functions (8) yields

$$x_{it} = \widehat{A}_{it} L \alpha^{2/(1-\alpha)} \text{ and } x_{it}^* = \widehat{A}_{it} L^* \alpha^{2/(1-\alpha)}$$

and substituting these into the production functions, final good production in the two countries will be proportional to their populations:

$$Y_t = \zeta \widehat{A}_t L \text{ and } Y_t^* = \zeta \widehat{A}_t L^* \tag{11}$$

and cross-sectoral average of the $\widehat{A}_{it}$'s, $\widehat{A}_t = \int_0^1 \widehat{A}_{it} di$.

Predictions for the impact of opening the economy to trade now follow.

2.3 The Impact of Trade Liberalization

2.3.1 On National Income

The impact of trade liberalization on national income operates through three distinct channels in the model:

- Through the *selection effect* of increased competition,[7] such that firms buy intermediate products from the most efficient producer leading to exit of less efficient producers, increasing efficiency and hence raising aggregate incomes. In the present model this arises since total world income of the world economy under openness is given by:

  $$N_t + N_t^* = \left(1 - \alpha^2\right) \zeta \left(L\widehat{A}_t + L^* \widehat{A}_t\right)$$

  whereas under closure it is:

  $$N_t + N_t^* = \left(1 - \alpha^2\right) \zeta \left(LA_t + L^* A_t^*\right)$$

[7] See Melitz (2003).

Total world income is raised by international trade since the average productivity parameter $\widehat{A}_t$ is generally larger than either A_t or A_t^*. Given that each county's pre-trade average productivity includes some sectors in which trade provides access to a higher productivity ($\widehat{A}_{it} > A_{it}$), while in sectors where the home country obtains the monopoly there is no productivity loss ($\widehat{A}_{it} = A_{it}$). Hence average $\widehat{A}_{it}$ is larger than average A_{it}, necessarily. Symmetrically for the A_{it}^*'s. Note therefore that international trade raises total world income through the selection effect.

- Through the *scale effect* of increased market size. The home country's national income under closure is:

$$N_t = \left(1 - \alpha^2\right) A_t L \zeta$$

while under trade liberalization it changes to:

$$N_t^{'} = \left[(1-\alpha)\,\widehat{A}_t L + \alpha\,(1-\alpha)\int_0^1 \lambda_{it}\widehat{A}_{it}\,(L + L^*)\,di\right]\zeta$$

To isolate the impact of scale (population size) for any given level of technological development, assume home and foreign countries to start at equal levels of technological development, such that in half of the sectors the home country starts with higher productivity and captures the monopoly, while in the other half the foreign country captures the monopoly, with both countries realizing average global productivity, $\widehat{A}_t$. Then the home country's national income after opening up to trade would be:

$$N_t' = \left(1-\alpha^2\right)\widehat{A}_t L \zeta + \alpha\,(1-\alpha)\,(1/2)\,(L^* - L)\,\widehat{A}_t \zeta$$

so the proportional gain from openness is:

$$\frac{N_t^{'}}{N_t} = \frac{\widehat{A}_t}{A_t}\left(1 + \frac{\alpha}{2\,(1+\alpha)}\frac{L^* - L}{L}\right)$$

It follows directly that the smaller the country, as measured by L, the larger the proportional gain from liberalization. By opening up to international trade, technologically advanced intermediate producers can now sell their products to a larger market. The smaller was the market before opening up the bigger this gain will be.

- Through the *backwardness effect*, by which technologically less advanced countries seemed to gain more from openness. Repeating the analysis for the scale effect, but setting both countries to be of equal size, ($L = L^*$), the corresponding relative gain from openness is:

$$\frac{N_t^{'}}{N_t} = \frac{1}{1+\alpha}\frac{\widehat{A}_t}{A_t} + \frac{2\alpha\int_0^1 \lambda_{it}\widehat{A}_{it}di}{(1+\alpha)\,A_t}$$

where the first term represents wage income and the second profit income, both relative to pre-trade national income. Now while opening up to trade will definitely raise wage income, since workers will be working with more advanced intermediate inputs and hence will be more productive, it might not raise the home country's profit income. Where the home country lags behind the foreign country in every sector, $\lambda_{it} = 0$ in all sectors i, hence the profit component of national income would vanish as a result of openness, such that the gain in wage income might not be enough to compensate for the loss of profit income. Even in this extreme case, however, if the country starts far enough behind the rest of the world, i.e. $A_t < \widehat{A}/\left(1+\alpha\right)$, then $N_t'/N_t > 1$, such that the country will definitely gain from international trade, and gain more in relative terms the further behind it starts. Nonetheless, the net effect of backwardness is not quite as clear cut as in the case of the scale effect, and we should be aware that although international trade raises total world income through the selection effect, there is no guarantee that it will raise national income in every country.

2.3.2 On Innovation

The impact of trade liberalization on innovation is analogous to that of competition on innovation.[8] Here the stylization is that the competitor comes from the foreign country. Three possibilities must be considered:

A Case A is the case in which the lead in sector i resides in the home country, while the foreign country lags behind. In this case the open economy research arbitrage equation governing μ_A:

$$(1-\tau)\,\phi'\left(\mu_A\right)/\delta = (\gamma-1)\left(L+L^*\right)+\mu_A^* L^* \tag{12}$$

makes clear that for the technology leader innovation will be greater than under the closed economy (compare equation 6). This arises because of:

- Scale effects realized because the successful innovator gets enhanced profits from both markets $(L+L^*)$, not just the domestic market, L, thus giving a stronger incentive to innovate.
- Escape entry effects arising because the unsuccessful innovator in the open economy is at risk of losing the foreign market to the foreign rival, avoidable by innovation $(\mu_A^* L^*)$. The unsuccessful innovator in the closed economy loses nothing to a foreign rival and thus does not have this extra incentive to innovate.

B Case B is the case in which the domestic and foreign sectors are neck-and-neck. In this case the open economy research arbitrage equation governing μ_B:

$$(1-\tau)\,\phi'\left(\mu_B\right)/\delta = (\gamma-1)\,L+\mu_B^* L+\left(1-\mu_B^*\right)\gamma L^*$$

again has scale $(\left(1-\mu_B^*\right)\gamma L^*)$ and escape competition $(\mu_B^* L)$ effects, with symmetrical intuition as for μ_A above.

C Case C is the case in which the foreign country starts with the lead. Here the open economy research arbitrage equation governing μ_C:

$$(1-\tau)\,\phi'\left(\mu_C\right)/\delta = \left(1-\mu_C^*\right)L$$

shows that sectors behind the world technology frontier may be discouraged from innovating by the threat of entry because even if it innovates it might lose out to a superior entrant. Provided that the foreign country's innovation rate is large enough when it has the lead, then the right-hand side of this research arbitrage equation will be strictly less than that of the closed economy (compare equation 6), so we will have $\mu_C < \mu$.

It follows that $\mu_A > \mu$, $\mu_B > \mu$, and $\mu_C^* > \mu^*$, $\mu_B^* > \mu^*$, with μ_C and μ_A^* indeterminate. It therefore follows that a sufficient (not necessary) condition for the innovation of the domestic economy to be higher under openness is that $|\mu_A+\mu_B| > |\mu_C|$, and symmetrically for the foreign country that $|\mu_B^*+\mu_C^*| > |\mu_A^*|$.

2.4 Taking Stock

Where does the preceding leave us in terms of a set of priors for purposes of empirical testing of the theory? We summarize briefly as follows:

- Selection effects predict a positive effect of measures of openness on income. In addition, trade will increase the productivity of the final sector everywhere.
- Scale effects predict:
  - A negative impact from the interaction of openness and size on income; i.e. smaller countries should gain proportionately more from openness than large countries.

[8] See Aghion et al (2005), Aghion and Griffith (2005), and Aghion et al (2006).

- A negative impact from the interaction of openness and size on growth; i.e. smaller countries should gain proportionately more from openness than large countries.

- Backwardness effects predict:
  - An ambiguous effect from the interaction of openness and distance from the technological frontier on income. As long as the distance is not excessive, the impact should be positive; the greater the distance, the greater the proportionate gain from openness. However, where the distance from the frontier is too great, the impact can be reversed.
  - An ambiguous effect from the interaction of openness and distance from the technological frontier on growth. While firms that are the technological leader, or that are at level pegging with the technological leader should increase innovation under trade liberalization, firms that lag behind the technological leader may decrease productivity growth if the lag is large enough. The net effect is ambiguous.

Given that the impact of openness on income captures steady state effects, we note that in the general case of countries still subject to development, the distinction between income and growth effects will be difficult to identify empirically. Thus particularly the backwardness effect will be subject to empirical validation.

3 The South African Experience of Trade Liberalization and Growth

South Africa represents an interesting natural experiment where the process of liberalization of trade can be well located in time and at the sectoral level.

Fedderke and Vaze (2001) examine the extent to which South Africa's trade regime has opened up since the implementation of trade liberalization measures (i.e., during the course of the 1990s). They consider 38 sectors of the South African economy. They find that the hype about "significant trade liberalization" is not borne out by the data. In particular, in terms of the effective rates of protection (ERP), trade liberalization has had a limited effect on effective protection of South African industries. South African industries are still heavily protected. In some industries, protection appears to have increased (Fedderke and Vaze (2001).[9] Fedderke and Vaze qualify their findings by pointing out that ERP may not be a good measure of the extent of trade liberalization in the context of South Africa's trade regime (p. 471).[10]

Edwards (2005) provides the most recent re-evaluation of the extent to which South Africa has liberalized its trade since the late 1980s. He finds that significant progress has been made in terms of reducing tariff protection. In particular, between 1994 and 2004, the "effective protection in manufacturing fell from 48% to 12.7%" (p. 774).[11] Moreover, the pace at which liberalization has taken place is in line with the pace in other lower-middle income countries. Edwards's findings appear to support the conclusion of Fedderke and Vaze (2001, 2004) that liberalization has been incomplete. In particular, Edwards notes that further progress (in the simplification of tariff structures and reduction of protection) can be made since effective protection still remains high in some sectors.[12]

[9] This finding is in line with the findings of Fedderke et al (2003) and Aghion et al (2007) of high mark-ups in South African manufacturing sectors. As Fedderke and Vaze (2001) point out, ERP measures the shelter that a sector has from international prices and is thus a proxy for excess returns a sector can realize due to protective trade (p. 437).

[10] This is because a significant feature of SA's trade liberalization has been the movement from quantitative restrictions (quotas) to tariff lines. In this case, effective protections rates may understate the extent of trade liberalization (Fedderke and Vaze (2001: 471)). Rangasamy and Harmse (2003) have also challenged the findings of Fedderke and Vaze (2001) – in particular their conclusion that protection appears to have increased over the period under study. They conclude that, based on ERP analysis, tariff protection has largely decreased. Fedderke and Vaze (2004), in their response to Rangasamy and Harmse, note that their main finding of the original study, that more of South Africa's output is protected in 1998 than in 1988 (i.e. once GDP weighted protection measures are used), is in principle actually confirmed by the Rangasamy and Harmse study (Fedderke and Vaze (2004; 411)).

[11] These percentages are unweighted averages. Fedderke and Vaze (2001) use GDP weighted EPRs.

[12] Ibid.

4 Empirical Strategy

4.1 The Data Sets

For this study we employ three distinct data sources. Confronted with gaps in firm-level data over the past ten years, we use:

1. Industry-level panel data for South Africa and for more than 100 countries since the mid 1960s, obtained from UNIDO's International Industry Statistics 2004. This data set contains yearly information on output, value added, total wages, and employment, gross capital formation and the distribution of value added between factor inputs for 28 different manufacturing industries in more than 100 countries from 1963-2002. From the gross capital formation data we compute capital stock data on the basis of the perpetual inventory methodology.[13] Chief use of the UNIDO database is to compute USA total factor productivity, in order to establish the distance from the international productivity frontier of South African 3-digit manufacturing industry.

2. Industry-level panel data for South Africa from the Trade and Industry Policy Strategies (TIPS) database. The data employed for this study focus on the three digit manufacturing industries, over the 1970-2004 period. Variables for the manufacturing sector include the output, capital stock, and labour force variables their associated growth rates, the distribution of value added between factor inputs, and the skills composition of the South African manufacturing labour force by manufacturing sector. Data are obtained from the Trade and Industrial Strategies (TIPS) data base.

3. For our openness indicators, we employ data on effective rates of protection, scheduled tariff rates, export taxes and a measure of anti-export bias, obtained from Edwards (2005).

4. For measures of industry pricing power, we employ the estimated values of the mark-up of price over marginal cost of production obtained from the Roeger (1995) methodology, of Fedderke and Hill (2007) and Aghion et al (2006).

5. For measures of market structure, we reply on the industry concentration measures of Fedderke and Szalontai (2005) and Fedderke and Naumann (2005).

INSERT TABLE 1 ABOUT HERE.

While most indicators employed for this study are available over the 1970-2004 or 1970-2002 period, the trade measures are restricted to the 1988-2003 period. In addition, data comparability issues between the US and SA reduced the total number of comparable sectors from 28 to 23 sectors. The list of sectors included in the panel is that specified in Table 1. This generated a panel of dimension $23 \times 15 = 345$ observations.

There are questions over the reliability of South African industry data post-1996. Since the last South African manufacturing survey was undertaken in 1996, data post-1996 have been disaggregated from the 2-digit sector level on the basis of a single input-output table. The large sample manufacturing survey of 2001 does not appear to have been incorporated into the data (at least not reliably so), and moreover the 2001 survey has not released the labour component of the survey. The reliability of the data has suffered as a result of this data collection strategy. See the discussion in Aghion et al (2006) for more detail.

4.2 The Distance From Frontier Measures

Following Aghion et al (2005) and Aghion and Griffith (2005), we generate and industry and time specific measure of distance from the technological frontier, under the assumption that the USA constitutes the technological leader for South African industry. The measure we employ is given by

$$M_{i,t} = tfp_{SA,i,t}/tfp_{US,i,t}$$

where the measure of distance from the frontier, M, for industry i in year t, in country $X = [SA, US]$, is the difference between total factor productivity (TFP) in the US from that in SA for that industry and

[13] Since the comparison of distance from the frontier is conducted over the 1970-2002 period, and data for the US is available from 1963, implementation employed a seven year lead, under an assumption of 15% depreciation rates.

year. TFP is computed by means of the primal decomposition, with factor shares given by the share of labour remuneration in value added.[14] We compute the distance measure both by comparing US TFP with Rand-denominated and Dollar-denominated South African TFP.

INSERT TABLE 2 ABOUT HERE.

Table 2 summarizes the evidence.

We find three broad patterns in the data.

One grouping of thirteen sectors sees a steady widening of the technological gap between South African and US TFP. While for six sectors the widening gap occurs from a base that is already very low (defined as less than 10% of US TFP productivity levels),[15] for two sectors there is a collapse of TFP productivity off relatively high levels (defined as greater than 50% of US TFP productivity levels),[16] and for four sectors the growing productivity gap occurs for mid-range productivity sectors (defined as between 10% and 50% of US TFP productivity levels).[17] Figure 1 illustrates the rising gap for two representative sectors with a high initial, and a mid-level initial productivity level.

A second grouping of 5 sectors sees a narrowing of the TFP productivity gap between South Africa and the US - though for a number of these sectors the final few years sees a reversal in the trend. Again, there is a distinction between one sector for which the productivity gain has been substantial (to the point of rising to TFP productivity levels that exceed that of the US),[18] and four sectors for which the gain has been moderate.[19] Figure 2 illustrates for two representative cases of moderate productivity gain (Wood & wood products) and substantial productivity gain (Plastics & plastic products).

The third grouping of five sectors sees a catch-up of South African TFP productivity levels with the US from 1988 through the mid-1990s, but with a subsequent reversal in the catch-up. In the case of one sector this decline is both dramatic and off a relatively high base,[20] for two sectors the decline occurs off a mid-level plateau,[21] one sector experiences both substantial catch-up but equivalent decline toward the end of our sample period,[22] and for one sector the movements are small leaving the sector at moderate US TFP productivity levels throughout.[23]

What is particularly noteworthy is that productivity catch-up for South African manufacturing sectors does not in general occur in sectors that are obviously natural resource extractive. Non-metallic minerals, Basic iron & steel, Basic non-ferrous metals, Metal products, and Paper & paper products all consistently lose ground relative to US productivity levels, and in the case of virtually all of these sectors South African TFP productivity is never close to US levels - the only possible exception is Paper & paper products.

INSERT FIGURE 1 ABOUT HERE.

INSERT TABLE 3 ABOUT HERE.

INSERT FIGURE 2 ABOUT HERE.

INSERT FIGURE 3 ABOUT HERE.

However, given the findings of Aghion et al (2007) on the impact of market structure on productivity growth, and of Fedderke (2006) on the impact of poor human capital endowments and low R&D investment by South African manufacturing on productivity growth, these findings are not surprising.

4.3 The Measure of Scale

Earlier studies employed the total labour force of countries as a measure of scale While measures of sectoral employment might constitute a comparable measure for our study, for South Africa there is considerable evidence that technological change has been labour saving.[24] We therefore use an alternative measure of

[14] Thus $tfp_{it} = \dot{Y}/Y - (1 - s_L)\dot{K}/K - s_L\dot{L}/L$, where Y denotes value added, K capital, L employment, and s_L labour remuneration as a proportion of value added.

[15] Beverages, Tobacco, Leather & leather products, Industrial chemicals, Basic non-ferrous metals, Other manufacturing equipment.

[16] Footwear and Paper & paper products.

[17] Food, Non-metallic mineral products, Basic iron & steel, Metal products.

[18] Plastics & plastic products.

[19] Wearing apparel, Wood & wood products, Furniture, Rubber & rubber products.

[20] Television, radio & communication equipment.

[21] Textiles and Professional & scientific equipment.

[22] Glass & glass products.

[23] Machinery & equipment.

[24] See for instance the discussion in Banerjee et al (2007), Fedderke, Shin and Vaze (2005) and Rodrick (2006).

scale, designed to capture not only the absolute size of the South African manufacturing sectors, but their size relative to world markets. Specifically we employ:

$$S_{i,t} = \frac{VA_{SA,i,t}}{VA_{US,i,t}}$$

where $VA_{X,i,t}$ denotes value added of industry i in year t, in country $X = [SA, US]$. Our scale measure is thus a measure of the size of South African manufacturing industries relative to comparable industries of the USA, where the latter serves as proxy for world market size.

Advantage of the measure is that it will not overstate gains in scale simply due to growth in South African sectors which lies below the growth in world markets. The obvious disadvantage of the measure is that a gain in scale may not reflect growth in the South African sector, but rather a relative decline in the corresponding sector in the USA.

Table 4 reports summary results of the measure over the 1970-2002 period. There is strong sectoral variation in performance. Two sectors gained in scale relative to the USA by more than 20 percentage points,[25] four by between 10 and 20 percentage points,[26] 10 sectors posted marginal gains (0-10 percentage points), but 6 sectors also actively lost scale relative to the USA.[27]

INSERT TABLE 4 ABOUT HERE.

4.4 The Empirical Specification to be Tested

We briefly summarize the empirical predictions of the preceding theoretical analysis highlighted in section 2.4. First, trade liberalization increases aggregate productivity (and wages). Second, whereas scale of production should have a direct positive impact on growth, smaller sectors should respond more strongly to trade liberalization. Third, whereas sectors with firms at considerable distance from the technological frontier grow more slowly (since firms do not innovate), the impact of trade liberalization is ambiguous. Innovation in sectors in which firms are closer to the technological frontier reacts positively to an increase in product market competition due to trade liberalization - but where they lag considerably behind the frontier, the impact of the liberalization reverses.

To test these predictions of the theoretical framework, we examine productivity dynamics in South African manufacturing sectors for the period 1988-2002. The basic specification relates productivity dynamics to trade policy and distance from the technological leader. Formally:

$$\Delta A_{it} = a_0 + a_1 M_{i,t} + a_2 P_{i,t} + a_3 M_{i,t} P_{i,t} + a_4 S_{i,t} + a_5 S_{i,t} P_{i,t} + a_6 M_{i,t} S_{i,t} + \alpha_i + \beta_t + u_{it} \quad (13)$$

where ΔA_{it} is productivity growth in sector i in year t, $M_{i,t}$ is the distance from the technological frontier defined above, P_{it} is a measure of effective trade barriers as obtained form Edwards (2005) - see the discussion in the data section above. The P measure is given by measures of nominal tariffs, of effective protection rates, of export taxes and of anti-export bias. The measure is thus an inverse of openness. The term $M_{it} P_{i,t}$ represents an interaction term that captures the relationship between openness and technological innovation. The $S_{i,t}$ measure denotes the scale variable defined in section 4.3, while $S_{i,t} P_{i,t}$ is an interaction term capturing the relationship between openness and scale of production. Finally, α_i and β_t represent fixed and time effects respectively.

Priors are that $a_1 > 0$, i.e. the larger is the distance from the technological frontier the lower is the productivity growth (there is no incentive to innovate as catching up is less likely), $a_2 < 0$, i.e. either by preventing an increase of technological innovation by more advanced firms or by preventing the import of new technology protection (as an inverse of openness) induces a decrease in the level of productivity, and $a_3 \lesseqgtr 0$, where if distance from the frontier is not too large, the maximum effect of trade liberalization occurs in sectors that are closer to the technological frontier, but with the reverse impact under conditions where distance is substantial. Note therefore that isolation of a statistically significant impact of the interaction across sectors that are heterogeneous in their distance from the frontier may be difficult (positive and negative

[25] Footwear and Other manufacturing.

[26] Beverages, Leather & leather products, Basic iron & steel and Basic non-ferrous metals.

[27] Tobacco (strongly), Non-metallic minerals, Metal products excluding machinery, Machinery & equipment, Transport equipment, Professional & scientific equipment.

associations may cancel). Finally, our theoretical framework anticipates that $a_4 > 0$, such that sectors that operate under larger scale realize higher productivity growth, but smaller sectors realize larger gains in scale of production from trade liberalization, such that $a_5 < 0$. In terms of the interaction of the scale and distance dimensions, the benefits of both scale and closeness to the frontier suggest a prior of $a_6 > 0$.

We note from the outset that the distance measure, $M_{i,t}$, is is correlated with u_{it} by definition, necessitating an instrumentation strategy in estimation. The scale measure, $S_{i,t}$, may be similarly subject to endogeneity bias, as may be the measures of trade protection, $P_{i,t}$.

Specification (13) ignores a number of additional factors known to be relevant to productivity growth in the context of trade liberalization. First, Aghion et al (2006) demonstrated both that product market competition has strong predictive power for productivity growth in South African manufacturing, and that pricing power of domestic producers in manufacturing appears to be substantial. Rodrick (2006) however has argued that the relative price of manufacturing in the South African economy has declined, due in considerable measure to the rising import penetration associated with the liberalization of the economy, placing domestic producers under a profit squeeze. For this reason we also test for the impact both of a Lerner index of pricing power,[28] and of the Rosenbluth index of industry concentration[29] while controlling for trade openness effects, to test for the robustness of the product market competition effect in the presence of controls for trade liberalization.[30]

In the South African context it is also often argued that depreciation of the exchange rate is an underutilized instrument in promoting growth,[31] by raising the export competitiveness of domestic producers. In presenting evidence on the distance measure to be employed in section 4.2, we have seen that the exchange rate may well be important in determining international rates of return. On the other hand, in the context of the significant potential impact of pricing power in South African manufacturing, we note from the outset that the impact of the exchange rate may not be unambiguous. Depreciation of the domestic currency may promote the international competitiveness of domestic producers - but it also effectively serves to protect them from import competition. The substantial depreciation of the currency noted in Figure 4 suggests that this effect may not have been inconsiderable during the 1990s. The impact of the nominal exchange rate on productivity growth is thus ambiguous, and a matter of empirical determination.

INSERT FIGURE 4 ABOUT HERE.

Finally, given the frequent suggestions that skills shortages constrain growth in South Africa, we also control for the skills composition of the manufacturing sectors. The variable is defined as the ratio of highly skilled and skilled workers to the total workforce.

5 Results

Estimation proceeds for the panel of South African manufacturing sectors listed in Table 1, controlling for industry and time fixed effects. Results of estimation are reported in Tables 5 for estimations controlling for fixed and time effects, and Table 6 for estimations under GMM in order to control for the endogeneity of the distance and scale variables.

INSERT TABLES 5 AND 6 ABOUT HERE.

Results from estimation are as follows. Consider the baseline estimations of Table 5 which do not allow for the endogeneity of the distance and scale measures through GMM estimation. We note from the outset that our results are robust to controlling for endogeneity through GMM estimation. For this reason we begin with the discussion of the baseline results, noting modulations to emerge from the GMM estimations where appropriate.

[28] Mark-ups are obtained following the contributions by Hall (1990) and Roeger (1995) by means of:

$$\begin{aligned} NSR &= \Delta(p+q) - \alpha \cdot \Delta(w+l) - (1-\alpha) \cdot \Delta(r+k) \\ &= (\mu - 1) \cdot \alpha \cdot [\Delta(w+l) - \Delta(r+k)] \end{aligned}$$

where $\mu = P/MC$, with P denoting price, and MC denoting marginal cost. Under perfect competition $\mu = 1$, while imperfectly competitive markets allow $\mu > 1$. Δ denotes the difference operator, lower case denotes the natural log transform, q, l, and k denote real value-added, labour, and capital inputs, and α is the labour share in value-added. See the additional discussion in Fedderke et al (2007).

[29] Obtained from Fedderke and Naumann (2005).

[30] Note that as in Aghion et al (2006), lagged values of the two regressors are employed in estimation.

[31] See again Rodrick (2006), as well as Frankel, Smit and Sturzennegger (2006).

First, distance from the technological frontier has a positive direct effect on productivity growth - with greater distance from the frontier assocaited with accelerated productivity growth. However, the finding is generally not statistically significant (the one exception is the specification that utilizes the export tax specification of protection, where the distance measure is significant at the 10% level), invariant across the four distinct measures of trade protection employed in estimation, to industry and time fixed effects, of considerable economic strength, and with estimated coefficients tightly clustered in the range from -0.07 through -0.13. Specifically, the implication is that a one percentage point decrease in the distance from the technological frontier, would be associated with a 7 to 13 percentage point efficiency gain in South African manufacturing, estimated at sample means of South African manufacturing productivity growth and distance from the frontier.

Second, theoretical priors that scale of production is positively related to productivity growth are also strongly ratified, and again the result is statistically as well as economically significant, invariant to the openness measure employed as well as to whether time and industry effects are controlled for in estimation. The estimated coefficient range from 0.45 through 0.70 implies that if the ratio of South African to US value added production rises by one percentage point, productivity growth in South African manufacturing would rise by approximately half a percentage point.

Third, we also note that the impact of scale is not invariant to distance to the technological frontier. The interaction term between the scale and distance measure is again invariably positively statistically significant across all estimations, regardless of the trade liberalization measure, or whether industry or time effects are controlled for. The inference is that it is large sectors that are closer to the technological frontier that experience the most rapid productivity growth, while small sectors far from the frontier grow relatively slowly. What is more, the range of estimated coefficients from 0.43 through 0.86, again suggesting an economically strong impact of the scale dimension of production.

Fourth, estimations both confirm and extend the earlier results of Aghion et al (2006). We find both that the proxy for the Lerner index that captures pricing power of South African manufacturing industry, as well as the Rosenbluth measure of industry concentration are strongly associated with productivity growth, in the case of the markup variable irrespective of whether industry and/or time effects are controlled for, and in the case of the market structure variable statistically significantly so only in the presence of both time and industry effects. We also note specifically that the finding is invariant to controlling for a wide range of trade related measures, specifically the four distinct measures of protection, as well as the exchange rate. The implication is that the negative association between pricing power, and the associated lack of competitive pressure in South African manufacturing and productivity growth reported in the earlier study, is *not* eroded by the liberalization of the South African trade regime - as suggested by Rodrick (2006). What is more, once the measures of trade protection are controlled for, the economic impact of pricing power *rises*, rather than falls. While Aghion et al (2006) found that a 0.1 unit increase in the Lerner index resulted in the loss of approximately one percentage point in productivity growth. Estimated coefficients in the presence of trade effects are again tightly clustered in the -0.20 through -0.35 range. The implication is that a 0.1 unit increase in the Lerner index now results in a 2 to 3.5 percentage point loss in productivity growth, considerably stronger than in the absence of controlling for the trade regime. The inference is that sectors not impacted by trade liberalization, have a larger pricing power impact.

While Rodrick (2006) was therefore correct to caution that the trade context is important to the quantification of the impact of pricing power on productivity growth, the impact of trade liberalization is not such as to eliminate the impact of pricing power - instead it enhances its importance. Not controlling for the reduction in trade protection biases the impact of pricing power downward. Further, and crucially for the policy context we also note that liberalization of the South African economy is incomplete at present.[32]

We also note that both pricing power and the index of industry concentration have independent impacts on productivity growth. The economic magnitude of the concentration index impact is more difficult to determine, since the Rosenbluth index is distributed across the scale from $1/n$ to 1, where the lower bound obtains when firms are of equal size. Given the estimated coefficient range of -0.77 to -0.88, the inference is then that a 0.01 unit increase in the concentration index reduces productivity growth in South African manufacturing by between 0.77 and 0.88 percentage points,[33] thus again suggesting a powerful impact of

[32] There is extensive evidence and debate on this question. For two recent contributions see Edwards (2005) and Edwards and Lawrence (2006).

[33] The impact may appear implausibly large. But given that South African manufacturing sectors over the sample period

market structure on growth.

Note that for the purpose of policy inference, the implication of this finding is that both pricing power as well as market structure are important to productivity growth, strengthening the earlier findings by Aghion et al (2006) by rendering them robust to the inclusion of additional regressors. The significance of competition policy as a means of promoting productivity growth is thereby strengthened.

The skills ratio of the labour force enters estimations significantly only in the presence of both industry and time effects, irrespective of which openness measure we employ, and provides a downward correction to the TFP productivity measure which is appropriate given the inability to control for the improvement in the quality of the labour input into production under the standard primal growth decomposition that underlies the computation of TFP.

Crucially and as the main focus of this paper, we consider the evidence to emerge concerning the openness and trade related measures employed by the study.

In terms of the theoretical framework proposed by this paper, the real impact of the measure of trade liberalization emerges through the indirect impacts captured by the interaction terms of the estimation. Most importantly, from the interaction term between our scale measure and the trade protection measures, we find that a reduction in trade protection statistically significantly raises productivity growth more in smaller manufacturing sectors than in large manufacturing sectors. This finding is consistent with the expectation that smaller sectors stand to gain more from an opening of the trade regime in scale of production terms than do large sectors. The finding that trade liberalization favours smaller sectors is invariant across the four measures of trade protection, and to allowing for the possibility of endogeneity.

The theoretical discussion indicated that trade liberalization would have a differential impact on industrial sectors, depending on how close to the frontier they were located. Sectors close to or at the frontier would realize a gain in productivity growth, while sectors that lag the frontier by a sufficiently significant margin, would experience a reduction in productivity growth. The net effect is thus a matter for empirical determination. For the estimations that utilize the effective protection rate and nominal tariff rate measures of trade liberalization, the interaction term between our distance measure and the openness measures consistently proves to be statistically significant, and negatively signed. Thus that sector further from the technological frontier, are more likely to benefit from trade liberalization, than sectors close to the frontier. Note however, that for the specifications controlling for anti export bias and export tax as the measures of trade orientation, do not report a statistically significant finding on the interaction between the distance and trade measure. This pattern of findings is invariant to controlling for the endogeneity of distance, scale and protection - see the results of Table 6. The implication of these findings given the theoretical framework we consider in this paper is that South African manufacturing firms are not sufficiently far from the technological frontier, for trade liberalization to exercise a negative impact on productivity growth.

The direct impact of the measures of the extent of trade liberalization of the South African manufacturing sectors are statistically significant for all trade liberalization measures but the export tax measure, irrespective of whether endogeneity is controlled for by GMM estimation. The inference from the estimated positive signs on the trade protection measures is that an increase in trade protection raises productivity growth in South African manufacturing. Two considerations qualify this finding, however, First, the *net* effect across the direct and indirect impacts of trade protection for the effective protection rate, the nominal tariff rate, the export tax and the anti-export bias computed at the mean values of the protection measures and the respective interaction terms, is 0.01, -0.01, -0.07 and -0.05 respectively.

It is also worth noting that we also tested extensively more parsimonious specifications of the empirical model given by equation (13), isolating explicitly the impacts of trade liberalization to emerge from our theoretical exposition. Again, estimation controlled extensively for fixed and time effects, as well as for the endogeneity of the distance and scale measures through GMM estimation, and using all four measures of trade protection. Estimation results are reported in Appendix 1, in Tables A1 through A4. What is striking about the results that exclude the range of additional estimators controlling for pricing power, market structure, the exchange rate, skills composition of the labour force, or that include these measures individually, is that the direct impact of the measures of the trade dispensation are generally statistically significant, robust to the inclusion of industry and/or time fixed effects, and find a negative direct effect of the trade protection measure on productivity growth - with the sole exception of the anti export bias measure, for which the

have Rosenbluth indexes that span the 0.001 to 0.213 range, a 0.01 unit increase represents a fairly large proportional increase in concentration.

positive sign of the fuller specification persists, though with vanishingly small economic magnitudes. Thus higher levels of trade protection are associated with significant direct reductions in productivity growth in South African manufacturing sectors.

These findings, and the established negative association between the measure of pricing power used for this study and import penetration,[34] suggest that while greater openness is associated with higher productivity growth, the most important aspects of the impact of trade reform is through the differential impact on small and large industries, and industries close or far from the technological frontier. The direct impact of liberalization hides the significant action.

Nominal exchange rate movements have only limited impact on productivity growth, which is statistically significant provided that time effects are not controlled for. The impact is the generally anticipated finding of productivity growth associated with a nominal depreciation of the currency, and the result is robust to alternative measures of trade protection, as well as controlling for endogeneity by means of GMM estimation. However, note that for a 1 Rand to the Dollar depreciation, the gain in productivity growth amounts to 0.01 percentage points - not a particularly strong association in economic terms. Moreover, controlling for time effects also serves to lower the statistical significance of the exchange rate effect.

We conclude the results section by noting that the results reported above are robust to controlling for the endogeneity of the scale and distance measures through GMM estimation. Results are reported in Table 6. as expected, under the GMM instrumentation strategy both economic and statistical significance is diminished for most dimensions controlled for in estimation. However, the substantive and econometric conclusions identified above continue to hold under GMM.

6 Conclusion and Evaluation

This paper has provided a new approach for the examination of the linkage between trade liberalization and productivity growth.

The theoretical framework employed in the paper, while acknowledging a direct impact of openness on growth, also serves to highlight that the impact of trade liberalization on growth may also operate through indirect channels. Specifically, the prediction is that smaller sectors should benefit more from trade liberalization, since they stand to realize greater proportional gains in their scale of production than large sectors. In addition, while distance from the technological frontier *per sê* is negatively associated with productivity growth, innovation in sectors in which firms are closer to the technological frontier reacts positively to an increase in product market competition due to trade liberalization, but where they lag considerably behind the frontier, the impact of the liberalization reverses.

We report empirical results from panel estimations for the South African manufacturing sector.

Results confirm that the greatest positive impact of trade liberalization will be on small rather than large sectors of the manufacturing sector. While distance from the technological frontier *per sê* is positively (though statistically insignificantly) associated with productivity growth, South African manufacturing firms are not sufficiently far from the technological frontier, for trade liberalization to exercise a negative impact on productivity growth. Importantly, while the direct impact of trade liberalization on productivity growth appears to be negative, the net effect of liberalization accounting for scale distribution and distance from technological frontier of South African manufacturing industry is positive. Where only the direct effect of trade liberalization is controlled for, the impact is unambiguously positive.

Given the strengthening of the impact of product market competition on productivity growth when trade liberalization is controlled for, results suggests that trade liberalization lowers the pricing power of domestic producers, thereby limiting the negative impacts of insufficient product market competition on long run economic growth. While Rodrick (2006) was therefore correct to caution that the trade context is important to the quantification of the impact of pricing power on productivity growth, the impact of trade liberalization is not such as to eliminate the impact of pricing power - instead it enhances its importance. Not controlling for the reduction in trade protection biases the impact of pricing power downward. Further, and crucially for the policy context we also note that liberalization of the South African economy is incomplete at present.

Further results confirm the positive impact of scale of production on productivity growth, while pricing power as well as industry concentration in the manufacturing sector are strongly negatively associated with

[34] See the analysis in Fedderke et al (2007).

productivity growth. By contrast, the skills composition of the labour force is not significantly associated with productivity growth.

Finally, nominal depreciation of the exchange rate is associated with increased productivity growth in South African manufacturing - though the effect is economically small, and of limited statistical robustness.

Policy implications to follow from the analysis affirms the importance of trade liberalization as a means of raising productivity growth. Impact of the liberalization may be direct, but will also stand to benefit small sectors of the economy disproportionately, and serve to discipline the pricing power of domestic producers. By contrast, depreciation of the domestic currency is vastly inferior as a means of promoting productivity growth.

7 Appendix 1

INSERT TABLES A1 THROUGH A4 ABOUT HERE.

References

[1] Aghion, P., Bloom, N., Blundell, R., Griffith, R., and Howitt, P., 2005, Competition and Innovation: An Inverted-U Relationship, *Quarterly Journal of Economics*, 120(2), 701-728.

[2] Aghion, P., Braun, M., and Fedderke, J.W., 2006, Competition and Productivity Growth in South Africa, *Center for International Development at Harvard Working Paper No. 132.*

[3] Aghion, P. and Griffith, R., 2005, *Competition and Growth: Reconciling Theory and Evidence*, Cambridge Mass.: MIT Press.

[4] Aghion, P. and Howitt, P., 1992, A Model of Growth through Creative Destruction, *Econometrica*, 60(2), 323-351.

[5] Aghion, P. and Howitt, P., 2007, International Trade and Growth, in Aghion, P. and Howitt, P., *Understanding Economic Growth*, MIT Press forthcoming.

[6] Alesina, Spolaore and Wacziarg, 2005, Trade, Growth and the Size of Countries, in P.Aghion and S.N.Durlauf (eds.) *Handbook of Economic Growth 1B*, Chapter 23, 1499-1542.

[7] Banerjee, A., Galiani, S., Levinsohn, J., and Woolard, I., 2007, Why Has Unemployment Risen in the New South Africa? *Center for International Development at Harvard Working Paper No. 134.*

[8] Coe, D.T., and Helpman, E., 1995, International R&D Spillovers, *European Economic Review*, 39(5), 859-87.

[9] Edwards, L., 2005, Has South Africa Liberalised its Trade? *South African Journal of Economics*, 73(4), 754-75.

[10] Edwards, L., and Lawrence, R., 2006, South African Trade Policy Matters: Trade Performance and Trade Policy, *Center for International Development at Harvard Working Paper No. 135.*

[11] Fedderke J.W., Kularatne, C., and Mariotti, M., 2007, Mark-up Pricing in South African Industry, *Journal of African Economies*, 16(1), 28-69.

[12] Fedderke, J.W., and Naumann, D., 2005, An Analysis of Industry Concentration in South African Manufacturing, 1972-2001, *ERSA Working Paper No. 27.*

[13] Fedderke, J.W., and Szalontai, G., 2005, Industry Concentration in South African Manufacturing: Trends and Consequences, *World Bank Africa Region Working Paper Series Number 96.*

[14] Fedderke, J.W., and Vaze, P., 2001, The Nature of South Africa's Trade Patterns, *South African Journal of Economics*, 69(3), 436-73.

[15] Fedderke, J.W., and Vaze, P., 2004, Response to Rangasamy and Harmse: Trade Liberalisation in the 1990's, *South African Journal of Economics*, 72(2), 408-13.

[16] Frankel, J. and Romer, D., 1999, Does Trade Cause Growth?, American Economic Review, 89(3), 379-99.

[17] Frankel, J., Smit, B., and Sturzennegger, F., 2006, South Africa: Macroeconomic Challenges after a Decade of Success, *Center for International Development at Harvard Working Paper No. 133.*

[18] Hall, R.E., 1988, The Relation between Price and Marginal Cost in US Industry, *Journal of Political Economy*, 96(5), 921-47.

[19] Hall, R.E., 1990, The Invariance Properties of Solow's Productivity Residual, in P. Diamond (Ed..) *Growth, Productivity, Unemployment*, Cambridge MA: MIT Press.

[20] Harding, T. and Ratso, J., 2005, The barrier Model of Productivity Growth: South Africa, *NUST Working Paper N.1/2005*, Trondheim.

[21] Keller, W., 2002, Geographic Localization of International Technological Diffusion, *American Economic Review*, 92(1), 170-92.

[22] Melitz, M.J., 2003, The impact of trade on intra-industry reallocations and aggregate industry productivity, *Econometrica*, 71, 1695-1725.

[23] Rangasamy, L. and Harmse, C., 2003,. The Extent of Trade Liberalisation in the 1990s: Revisited. *South African Journal of Economics*, 71(4): 705-728.

[24] Rodrick, D., 2006, Understanding South Africa's Economic Puzzles, *Center for International Development at Harvard Working Paper No. 130.*

[25] Roeger, W., 1995, Can Imperfect Competition explain the Difference between Primal and Dual Productivity Measures? Estimates for US Manufacturing, *Journal of Political Economy*, 103, 316-30.

[26] Sachs, J.D., and Warner, A., 1995, Economic Reform and the Process of Global Integration, *Brookings Papers on Economic Activity*, The Brookings Institution.

[27] Trefler, D. 2004, The Long and Short of the Canada-US Free Trade Agreement, *American Economic Review*, 94(4), 870-95.

Table 1: List of 3-Digit Manufacturing Sectors included in the Study

Sector	Sector	Sector	Sector
Food	Footwear	Plastic products	Machinery & equip.
Beverages	Wood & wood products	Glass & glass products	TV, radio & comm equip.
Tobacco	Furniture	Non-metallic minerals	Transport equip
Textiles	Paper & paper products	Basic iron & steel	Prof.& scien. equip.
Wearing apparel	Industrial Chemicals	Basic non-ferrous metals	Other manuf.
Leather & leather products	Rubber products	Metal products excl. mach.	

Table 2: Distance of South African 3 Digit Manufacturing Sectors from the US Technological Frontier

Sector	1988-2004	1988-1993	1994-1999	2000-2004
Food (301-304)	0.18	0.24	0.15	0.11
Beverages (305)	0.06	0.08	0.04	0.04
Tobacco (306)	0.01	0.02	0.01	0.01
Textiles (311-312)	0.21	0.16	0.28	0.16
Wearing apparel (313-315)	0.28	0.21	0.33	0.34
Leather & leather products (316)	0.11	0.17	0.08	0.06
Footwear (317)	0.46	0.92	0.21	0.05
Wood & wood products (321-322)	0.15	0.07	0.17	0.26
Furniture (391)	0.17	0.15	0.13	0.26
Paper & paper products (323)	0.31	0.57	0.17	0.08
Industrial Chemicals	0.04	0.04	0.02	n/a
Rubber products (337)	0.15	0.16	0.11	0.24
Plastic products (338)	0.68	0.23	0.80	1.33
Glass & glass products (341)	0.20	0.12	0.31	0.15
Non-metallic minerals (342)	0.09	0.19	0.04	0.01
Basic iron & steel (351)	0.25	0.39	0.22	0.03
Basic non-ferrous metals (352)	0.02	0.03	0.01	0.00
Metal products excluding machinery (353-355)	0.21	0.28	0.15	0.18
Machinery & equipment (356-359)	0.44	0.44	0.46	0.43
Television, radio & communication equipment (371-373)	0.65	0.65	0.77	0.39
Transport equipment (381-387)	0.13	0.16	0.13	0.10
Professional & scientific equipment (374-376)	0.32	0.35	0.38	0.12
Other manufacturing (392-393)	0.01	0.01	0.01	0.01

Table 3: Broad Patterns to Emerge From Distance From Technological Frontier Measurement, 1970-2002

Sectors with Growing Productivity Gap	Sectors with Narrowing Productivity Gap	Sectors with Falling, then Rising Productivity Gap
Food (301-304)	Wearing apparel (313-315)	Textiles (311-312)
Beverages (305)	Wood & wood products (321-322)	Glass & glass products (341)
Tobacco (306)	Furniture (391)	Machinery & equipment (356-359)
Leather & leather products (316)	Rubber products (337)	Television, radio & communication equipment (371-373)
Footwear (317)	Plastic products (338)	Professional & scientific equipment (374-376)
Wood & wood products (321-322)		
Paper & paper products (323)		
Industrial Chemicals		
Non-metallic minerals (342)		
Basic iron & steel (351)		
Basic non-ferrous metals (352)		
Metal products excluding machinery (353-355)		
Transport equipment (381-387)		
Other manufacturing (392-393)		

Table 4: Scale Measure of South African Manufacturing Industry Size

	1970-2002	1970s	1980-1993	1994-2002
Food (301-304)	0.078	0.069	0.084	0.079
Beverages (305)	0.215	0.136	0.253	0.243
Tobacco (306)	0.188	0.255	0.206	0.087
Textiles (311-312)	0.079	0.066	0.093	0.071
Wearing apparel (313-315)	0.091	0.049	0.091	0.138
Leather & leather products (316)	0.112	0.068	0.110	0.164
Footwear (317)	0.345	0.186	0.375	0.475
Wood & wood products (321-322)	0.105	0.084	0.113	0.117
Furniture (391)	0.046	0.036	0.051	0.048
Paper & paper products (323)	0.079	0.063	0.082	0.091
Industrial Chemicals	0.039	0.039	0.078	-
Rubber products (337)	0.076	0.051	0.085	0.089
Plastic products (338)	0.055	0.038	0.061	0.064
Glass & glass products (341)	0.056	0.037	0.058	0.073
Non-metallic minerals (342)	0.124	0.116	0.141	0.105
Basic iron & steel (351)	0.160	0.098	0.173	0.208
Basic non-ferrous metals (352)	0.126	0.051	0.124	0.213
Metal products excluding machinery (353-355)	0.099	0.099	0.114	0.073
Machinery & equipment (356-359)	0.043	0.043	0.048	0.036
Electrical machinery_TV_Communication	0.029	0.024	0.033	0.030
Transport equipment (381-387)	0.062	0.061	0.065	0.058
Professional & scientific equipment (374-376)	0.011	0.011	0.013	0.007
Other manufacturing (392-393)	0.306	0.154	0.342	0.421

Table 5: Determinants of Productivity Growth in South African Manufacturing Sectors

* denotes significance at the 1% level; ** denotes significance at the 5% level; *** denotes significance at the 10% level

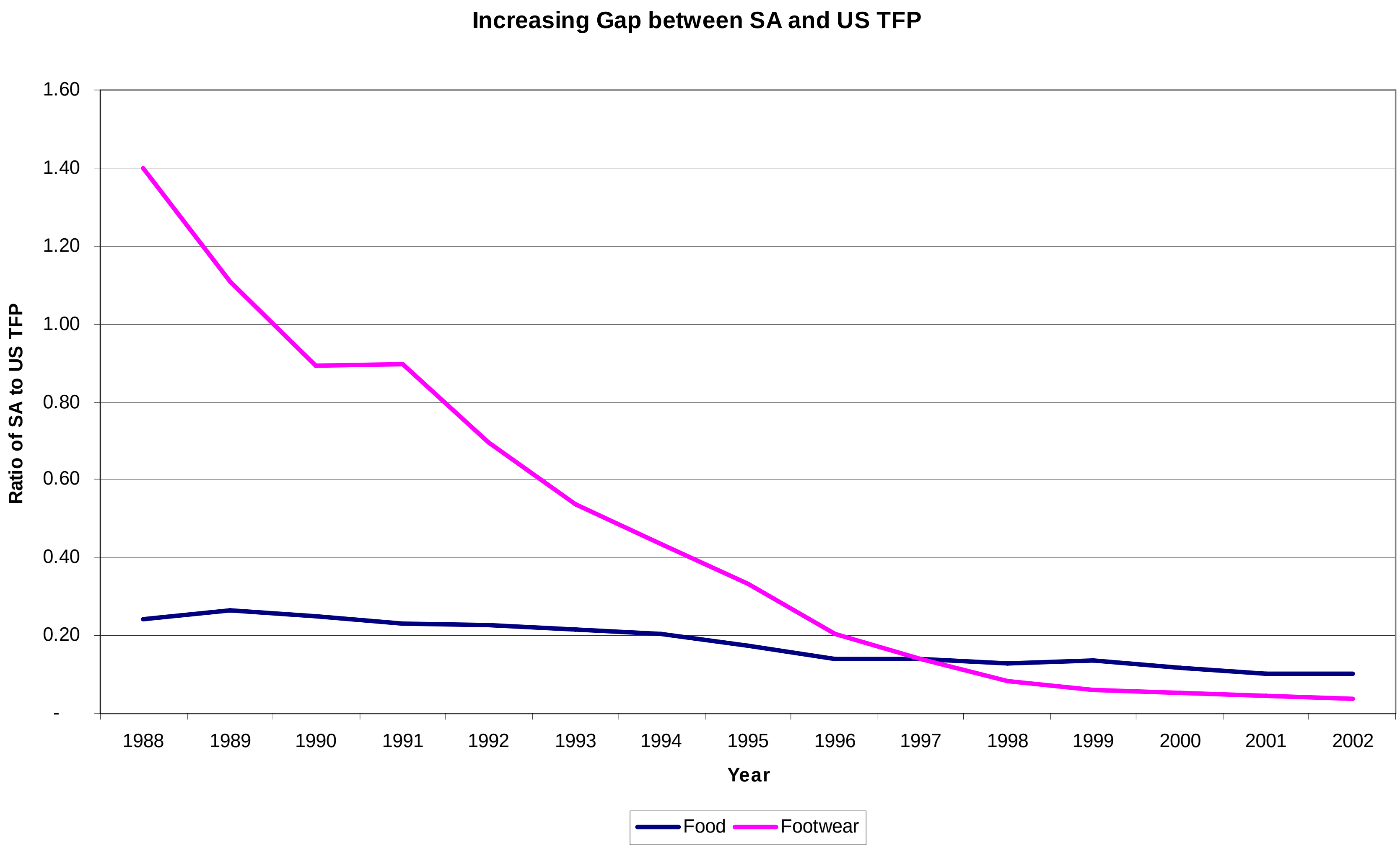
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
P-meas:	ERP	ERP	Nom Tariff	Nom Tariff	Export Tax	Export Tax	Anti Exp Bias	Anti Exp Bias
M	-0.10 (0.08)	-0.07 (0.06)	-0.10 (0.09)	-0.07 (0.06)	-0.13 (0.09)	-0.11*** (0.07)	-0.13 (0.09)	-0.11 (0.07)
M x P	-0.002** (0.001)	-0.002* (0.001)	-0.004 (0.003)	-0.005** (0.002)	-0.0003 (0.002)	-0.0004 (0.002)	-0.002 (0.01)	-0.01 (0.01)
P	0.001** (0.0004)	0.001** (0.0003)	0.002 (0.001)	0.002*** (0.0003)	0.0001 (0.001)	7.2e-005 (0.001)	0.01* (0.002)	0.01* (0.001)
S	0.48* (0.17)	0.63* (0.19)	0.51* (0.19)	0.70* (0.21)	0.45** (0.17)	0.66* (0.19)	0.50* (0.17)	0.59* (0.19)
S x P	-0.003* (0.001)	-0.003* (0.001)	-0.01** (0.004)	-0.01* (0.003)	-0.003 (0.003)	-0.01** (0.003)	-0.06** (0.02)	-0.06* (0.02)
M x S	0.63* (0.16)	0.73* (0.14)	0.70* (0.17)	0.86* (0.17)	0.43*** (0.25)	0.60** (0.26)	0.43** (0.18)	0.54* (0.13)
R/$	0.01* (0.004)	0.01 (0.004)	0.01* (0.004)	0.01 (0.004)	0.01* (0.004)	0.005 (0.005)	0.01* (0.004)	0.01** (0.003)
Markup	-0.34* (0.07)	-0.21* (0.08)	-0.33* (0.07)	-0.20* (0.08)	-0.33* (0.07)	-0.21** (0.09)	-0.35* (0.07)	-0.22** (0.09)
Rosen	-0.17 (0.39)	-0.88** (0.37)	-0.19 (0.39)	-0.88** (0.37)	-0.20 (0.38)	-0.85** (0.39)	-0.20 (0.39)	-0.77** (0.35)
Skills Ratio	-0.17 (0.17)	-0.37* (0.06)	-0.19 (0.17)	-0.39* (0.06)	-0.17 (0.17)	-0.33* (0.06)	-0.18 (0.16)	-0.32* (0.07)
Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time Effects	No	Yes	No	Yes	No	Yes	No	Yes
N	200	200	200	200	200	200	200	200
Adj-R^2	0.23	0.40	0.23	0.40	0.22	0.38	0.24	0.40

Table 6: Determinants of Productivity Growth in South African Manufacturing Sectors Under Instrumentation Strategy

* denotes significance at the 1% level; ** denotes significance at the 5% level; *** denotes significance at the 10% level

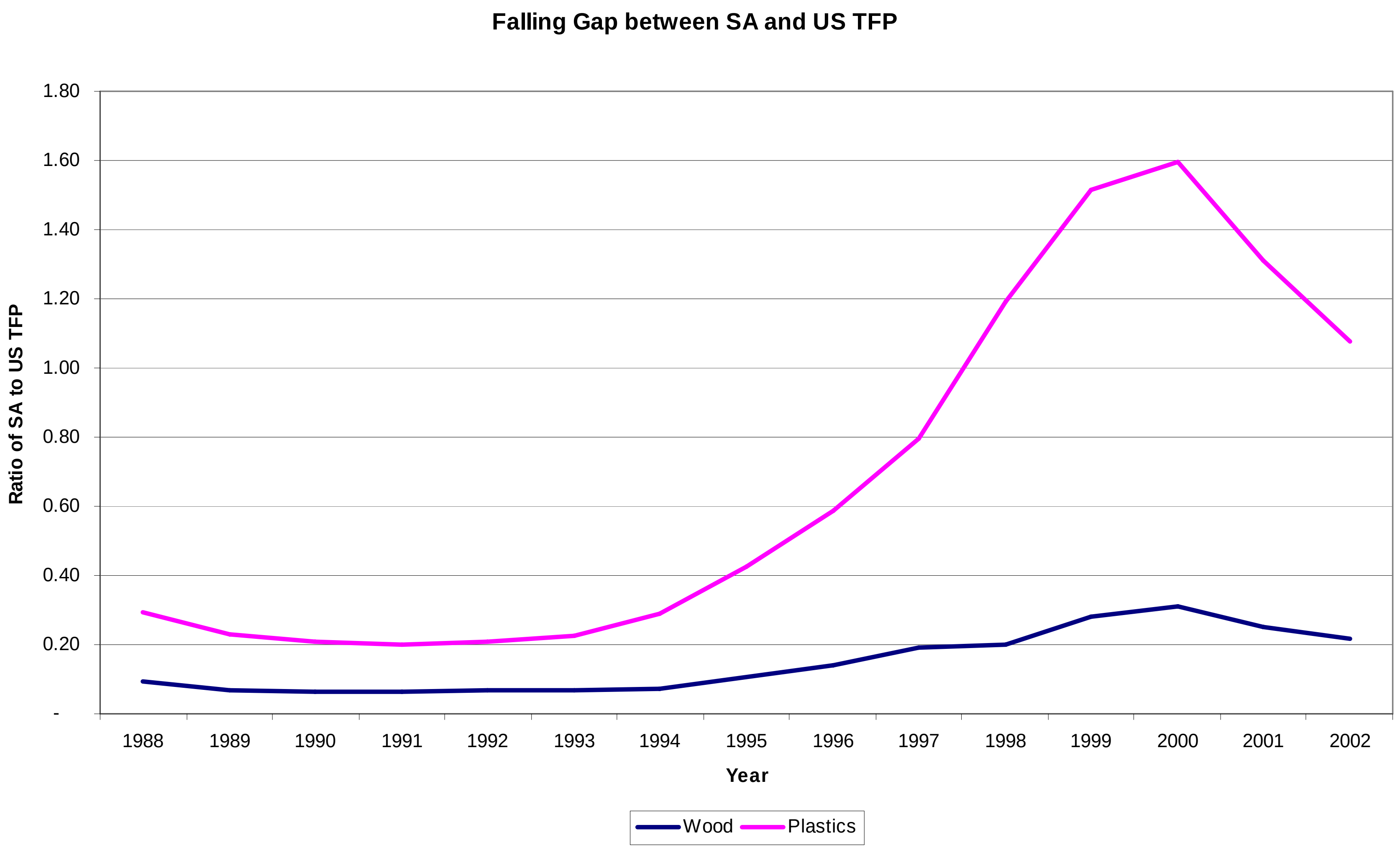
	(1)	(2)	(3)	(4)
P-meas:	ERP	Nom Tariff	Export Tax	Anti Exp Bias
M	-0.09 (0.06)	-0.09 (0.06)	-0.12*** (0.03)	-0.11 (0.07)
M x P	-0.002* (0.001)	-0.01* (0.002)	-0.001 (0.002)	-0.01 (0.01)
P	0.001** (0.0003)	0.002** (0.001)	2.7e-005 (0.001)	0.01* (0.001)
S	0.48** (0.20)	0.61* (0.20)	0.61* (0.19)	0.53* (0.18)
S x P	-0.003* (0.001)	-0.01* (0.003)	-0.01** (0.003)	-0.05** (0.02)
M x S	0.82* (0.15)	0.95* (0.18)	0.60** (0.27)	0.54* (0.14)
R/$	0.01** (0.005)	0.01* (0.004)	0.01** (0.004)	0.01* (0.004)
Markup	-0.14*** (0.08)	-0.18** (0.08)	-0.24* (0.09)	-0.23* (0.08)
Rosen	-1.10** (0.53)	-0.92*** (0.48)	-0.80*** (0.48)	-0.69*** (0.41)
Skills Ratio	-0.30 (0.18)	-0.28*** (0.15)	-0.19 (0.15)	-0.18 (0.14)
Industry Effects	Yes	Yes	Yes	Yes
Time Effects	Yes	Yes	Yes	Yes
GMM	Yes	Yes	Yes	Yes
N	200	200	200	200
RSS/TSS	0.53	0.53	0.55	0.53
Wald (joint)	137.9*	86.2*	63.84*	119.4*
Wald (dumies)	1593*	3501*	719.3*	2.6e+004*
Wald (Time)	89.42*	91.46*	57.98*	61.81*
Sargan	122.9	119.7	120.8	120.9
AR(1)	-1.73***	-1.74***	-1.62	-1.58
AR(2)	0.16	0.02	0.17	-0.06

Figure 1:



Increasing Gap between SA and US TFP
Ratio of SA to US TFP
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
-
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Year
Food
Footwear

Figure 2:



Falling Gap between SA and US TFP
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
-
Ratio of SA to US TFP
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Year
Wood
Plastics

Figure 3:

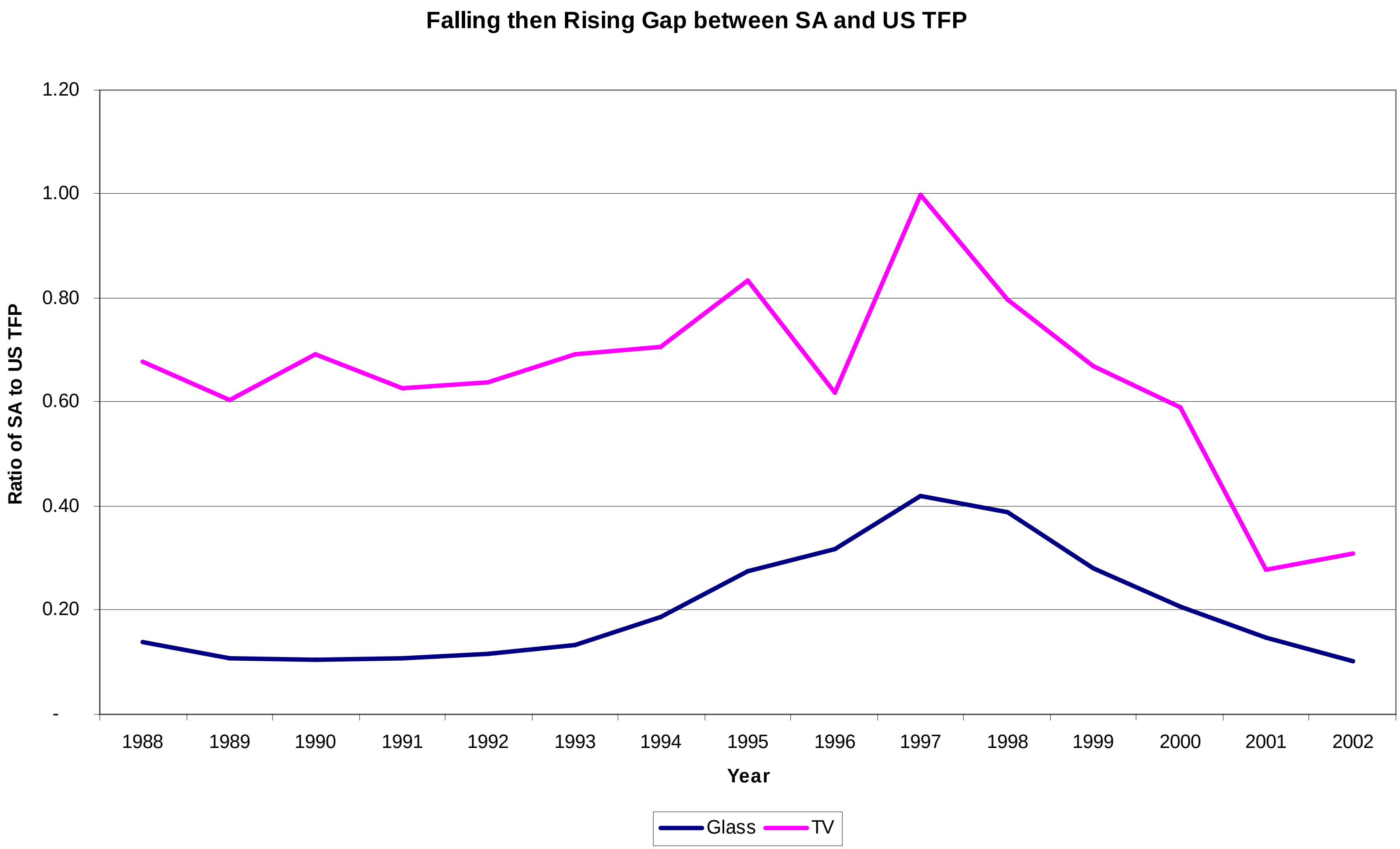

Falling then Rising Gap between SA and US TFP
1.20
1.00
0.80
0.60
0.40
0.20
-
Ratio of SA to US TFP
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
Year
Glass
TV

Figure 4: Rand – Dollar Nominal Exchange Rate

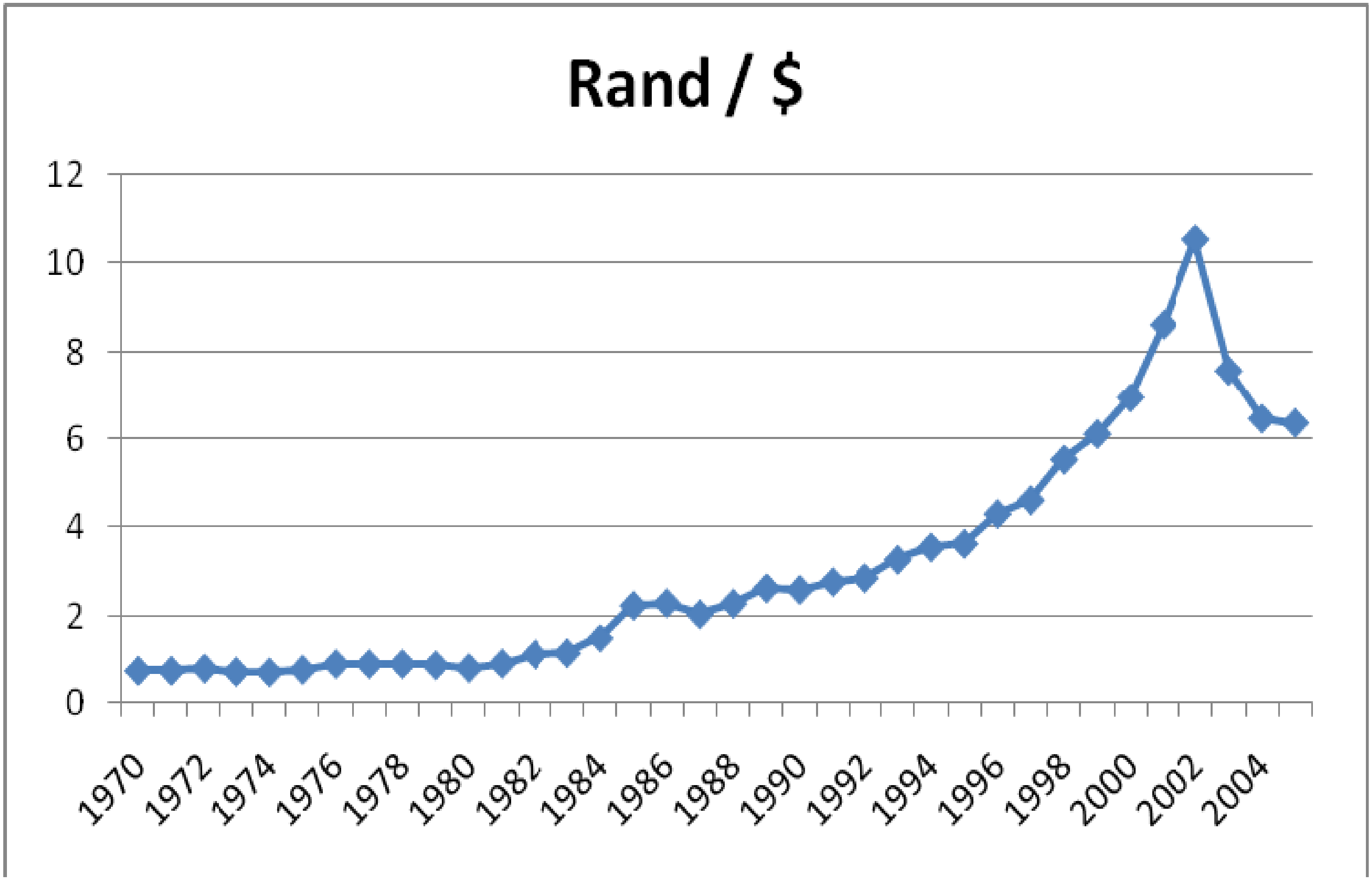


Table A1: Productivity Impact of Openness – Effective Protection Rates

* denotes significance at the 1% level; ** denotes significance at the 5% level; *** denotes significance at the 10% level

	(1)	(2)	(4)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth
M	0.004 (0.03)	0.02 (0.02)	0.01 (0.02)	-0.002 (0.03)	-0.02 (0.03)	0.01 (0.02)	0.01 (0.02)	-0.01 (0.03)	0.0004 (0.07)	0.01 (0.02)
M x Open	-0.0001 (0.0005)	-0.001 (0.0004)	-0.0002 (0.0003)	0.0002 (0.0004)	0.0002 (0.0004)	-0.0004 (0.001)	-0.0002 (0.0003)	3.4e-005 (0.0004)	7.5e-005 (0.001)	-0.0001 (0.0003)
Open: ERP	-0.001* (1.9e-005)	-0.0004* (5.7e-005)	-0.0002* (5.7e-005)	-6.3e-005* (1.9e-005)	-6.7e-005* (2.1e-005)	-0.0003* (6.3e-005)	-0.0002* (5.7e-005)	-0.0003* (4.1e-005)	-0.0003 (0.0003)	-0.0002* (5.6e-005)
Scale					-0.08*** (0.04)	0.26 (0.16)				
Scale x Open					0.10 (0.08)	0.07 (0.13)				
R/$							0.01*** (0.004)			
Markup								-0.09 (0.06)		
Concentration									-0.69*** (0.39)	
Skills Ratio										-0.11 (0.11)
Industry Effects	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Time Effects	No	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
GMM	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes
N	338	338	338	338	338	338	338	338	200	338
Adj-R^2	0.02	0.05	0.25			0.26	0.25	0.28	0.29	0.26
RSS/TSS				0.78	0.78					
Wald (joint)				14.04 *	16.98*					
Wald (dummies)				467*	469*					
Wald (time)				466*	427*					
Sargan				107.3	159.5					
AR(1)				1.57	-1.40					
AR(2)				0.15	0.06					

Table A2: Productivity Impact of Openness – Nominal Tariffs

* denotes significance at the 1% level; ** denotes significance at the 5% level; *** denotes significance at the 10% level

	(1)	(2)	(4)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth
M	0.001 (0.03)	0.002 (0.02)	0.01 (0.02)	0.0001 (0.03)	-0.02 (0.03)	0.003 (0.02)	0.01 (0.02)	-0.03 (0.03)	-0.03 (0.07)	0.005 (0.02)
M x Open	0.0002 (0.001)	0.0003 (0.001)	0.0001 (0.001)	0.0003 (0.001)	0.0003 (0.002)	0.0001 (0.002)	0.0002 (0.001)	0.001 (0.001)	0.002 (0.002)	0.0002 (0.001)
Open: Nominal Tariff	-0.001** (0.0004)	-0.003* (0.0001)	0.001 (0.001)	-0.0002 (0.0003)	-0.0002 (0.001)	-0.002 (0.001)	-0.001 (0.001)	-0.002** (0.001)	-0.001 (0.002)	-0.001 (0.001)
Scale					-0.08*** (0.05)	0.25 (0.16)				
Scale x Open					0.11 (0.12)	0.02 (0.17)				
R/$							0.01 (0.004)			
Markup								-0.09 (0.06)		
Concentration									-0.69*** (0.40)	
Skills Ratio										-0.08 (0.12)
Industry Effects	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Time Effects	No	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
GMM	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes
N	338	338	338	338	338	338	338	315	200	338
Adj-R^2	0.02	0.07	0.25			0.26	0.24	0.28	0.29	0.25
RSS/TSS				0.78	0.79					
Wald (joint)				0.50	4.03					
Wald (dummies)				491*	503*					
Wald (time)				489*	401*					
Sargan				107.6	157.7					
AR(1)				1.59	1.44					
AR(2)				0.20	0.12					

Table A3: Productivity Impact of Openness – Export Taxes

* denotes significance at the 1% level; ** denotes significance at the 5% level; *** denotes significance at the 10% level

	(1)	(2)	(4)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth
M	0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)	0.005 (0.02)	-0.01 (0.02)	-0.01 (0.02)	-0.01 (0.02)	-0.03 (0.02)	-0.05 (0.06)	-0.01 (0.02)
M x Open	-0.0004 (0.001)	0.001 (0.001)	0.001 (0.001)	4.19 (0.001)	-0.0004 (0.001)	0.002 (0.002)	0.001 (0.001)	0.001*** (0.001)	0.002 (0.001)	0.001 (0.001)
Open: Export Tax	-0.0003 (0.0002)	-0.002* (0.0005)	-0.001 (0.001)	-4.7e-005 (0.0002)	-6.5e-006 (0.0003)	-0.001 (0.001)	-0.001 (0.001)	-0.001** (0.001)	-0.001 (0.001)	-0.001 (0.001)
Scale					-0.08*** (0.05)	0.23 (0.16)				
Scale x Open					0.17 (0.16)	-0.18 (0.20)				
R/$							0.01*** (0.004)			
Markup								-0.08 (0.07)		
Concentration									-0.62 (0.40)	
Skills Ratio										-0.07 (0.12)
Industry Effects	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Time Effects	No	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
GMM	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes
N	338	338	338	338	338	338	338	315	200	338
Adj-R^2	0.01	0.06	0.25			0.25	0.25	0.27	0.29	0.25
RSS/TSS				0.79	0.79					
Wald (joint)				0.13	4.52					
Wald (dummies)				450*	507.5*					
Wald (time)				450*	410.9*					
Sargan				122	158.2					
AR(1)				1.63	1.47					
AR(2)				0.22	0.11					

Table A4: Productivity Impact of Openness – Anti Export Bias

* denotes significance at the 1% level; ** denotes significance at the 5% level; *** denotes significance at the 10% level

	(1)	(2)	(4)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth	Prod. Growth
M	0.03 (0.02)	0.05** (0.02)	-0.01 (0.02)	0.01 (0.02)	-0.005 (0.02)	-0.004 (0.02)	-0.01 (0.02)	-0.02 (0.02)	-0.04 (0.07)	-0.01 (0.02)
M x Open	-0.001** (0.0004)	-0.002** (0.001)	0.001 (0.001)	-0.0002 (0.001)	-0.001*** (0.001)	0.001 (0.002)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
Open: Anti Export Bias	9.5e-005* (1.7e-005)	9.1e-005* (1.4e-005)	8.4e-005* (1.5e-005)	9.8e-005* (2.1e-005)	0.0001* (1.9e-005)	8.4e-005* (1.6e-005)	8.4e-005* (1.5e-005)	8.4e-005* (1.5e-005)	7.1e-005* (1.7e-005)	8.5e-005* (1.6e-005)
Scale					-0.09** (0.04)	0.22 (0.17)				
Scale x Open					0.25*** (0.14)	-0.08 (0.18)				
R/$							0.01** (0.004)			
Markup								-0.06 (0.07)		
Concentration									-0.54 (0.41)	
Skills Ratio										-0.05 (0.13)
Industry Effects	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Yes
Time Effects	No	No	Yes	No	No	Yes	Yes	Yes	Yes	Yes
GMM	No	No	No	Yes	Yes	No	Yes	Yes	Yes	Yes
N	338	338	338	338	338	338	338	315	200	338
Adj-R^2	0.01	0.01	0.25			0.25	0.25	0.27	0.29	0.25
RSS/TSS				0.78	0.79					
Wald (joint)				25.43*	44.4*					
Wald (dummies)				375*	491*					
Wald (time)				372*	404*					
Sargan				107.0	157.2					
AR(1)				1.61	1.48					
AR(2)				0.17	0.07					