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

Philippe Aghion,* Johannes Fedderke,† Peter Howitt,‡ and Nicola Viegi§

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Abstract

This paper analyses the relationship between trade liberalization and economic growth using a Schumpeterian framework of technological innovation. The framework illustrates direct and indirect effects of trade libaralization on productivity growth. Indirect impacts operate through a differential impact on firms conditional on their distance from the international technological frontier. Estimation results confirm positive direct impacts of trade liberalization. In addition, results confirm that the greatest positive impact of trade liberalization will be on sectors close to the international technological frontier. Sectors with low product market competition and smaller scale of production benefit most significantly from trade liberalization. Results also confirm that sectors close to the technological frontier and that have greater product market competition, and sectors of greater scale and high product market competition experience higher productivity growth. Finally, the paper confirms the positive impact of product market competition on productivity growth under an open economy setting.

Keywords: productivity growth, trade liberalization, South African manufacturing
JELCodes: F1, L1, L6, O1, O3.

1 Introduction

What policy intervention does a small, less developed economy far from the international technological frontier use in order to promote growth? One intervention that has frequently been posed in the literature is trade liberalization. Openness of the economy is posited as growth enhancing. In this paper we outline recent theoretical advances that render the link between trade liberalization and endogenous growth processes more precise. The paper details a set of direct and indirect impacts of trade liberalization, and tests their validity on a ~~developing~~ country data set. We find support for both the direct and indirect impacts of liberalization.

Empirical results on the impact of openness and economic growth have steadily accumulated in the literature. Aghion and Howitt (2007) represents a first attempt to provide a clear set of theoretical priors on the mechanisms though which liberalization might exercise an impact on economic development. Aghion and Howitt (2007) report three core results from a cross-country panel regression which involves 98 countries over the period 1960-2000. First, the study confirms a result often found in the empirical growth literature that openness has a positive and significant effect on growth. Second, through interaction effects estimations support 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. Third, again from interaction effects, it emerges that growth is less enhanced by openness in more advanced countries, interpreted as a *knowledge spillover effect* whereby trade induces

*Harvard University
†Economic Research Southern Africa and University of Cape Town
‡Brown University
§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.

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 is not captured in these results: 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, 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 the theoretical model of Aghion and Howitt (2007) in a middle income country context, using South African manufacturing sector data, using three digit SIC industrial sector data. 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. Moreover the South African experience with trade liberalization and economic growth has been extensively analyzed in the literature, which provide an useful set of results to use as comparative check of our analysis. 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 [7] 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

The theoretical model of this study is provided by the Schumpeterian framework of Aghion and Howitt (2007). The Schumpeterian paradigm has proved to be useful in considering extensions of models of economic growth beyond the impact of innovation on economic development. Since the endogenization of innovation requires an explicit treatment of the source of efficiency gains, the Schumpeterian framework, such as originally advanced by Aghion and Howitt (1992) is useful in analyzing the interaction between institutions and economic growth.

This proves the case in the current context. Institutions determine the set of incentives faced by the firm in its decisions of investing in technological innovation. Trade policies are just another set of institutions that define the dimension of the market and the level of competition that national firms face. On the one hand trade liberalization increases the size of the potential market, thus increasing the expected profits from successful innovation. On the other hand trade liberalization increases the level of market competition and the ability of the national firm to successfully expand and innovate depends critically on their ability to "compete."

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:

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

[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).

[3] For instnace Trefler (2004) shows that trade liberalization in Canada resulted in a 6% increase in average productivity.

[4] See Aghion, Braun and Fedderke (2008).

[5] See Fedderke and Szalontai (2009) and Fedderke and Naumann (2009).

[6] See Fedderke (2006).

[7] See Fedderke (2006).

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

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 goods 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}:

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

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:

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

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

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

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,[8] 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:

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

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:

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

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:

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

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

[8] See Melitz (2003).

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. $A_t < \widehat{A}/(1+\alpha)$, 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.[9] 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:

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

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:

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

again has scale $((1-\mu_B^*)\,\gamma L^*)$ 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:

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

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 $|\mu_B^* + \mu_C^*| > |\mu_A^*|$.

To recapitulate, the theory gives a rich set of empirical predictions. First there is a set of static effects of trade liberalization. After a reduction in trade barriers, any sector in the economy should experience an increase in productivity, either because the final sector adopts more advanced foreign technology or because only the more productive intermediate good firms survive international competition (selection effects). At

[9] See Aghion et al (2005), Aghion and Griffith (2005), and Aghion et al (2008).

the same time the positive effect of trade liberalization on productivity would be limited by the extent that national firms can maintain anticompetitive bahaviour. This limits the extent of penetration of more productive foreign firms and technology. Even in a non competitive national environment, trade liberalization increases the size of the potential market for each national firm, thus changing the scale of production and the incentive for innovation. The furthest away from the technological frontier a country is, the greatest the productivity gain that can be achieved via trade liberalization, because of the jump in technological adoption that trade openness allows. On the other hand, the adoption of more advanced foreign technology in the final good sector will reduce the variety of national production of intermediate goods, with the exit of the least productive firms.

A second set of results refer to the dynamic effect of an increase in competition on the incentives to invest and innovate. For this the most important variable is the distance from the technological frontier of national firms and the size of the potential market for successful innovators. Thus firms closer to the technological frontier will have an incentive to increase investment in technological innovation as a defensive measure against foreign competitors and as an instrument to gain access to a much larger potential market. This should be particularly true for firms located in small countries. Instead, if a firm is far away from the technological frontier, trade liberalization will discourage further investment in innovation. This, coupled with the selection effect, should induce significant exit from the market of inefficient firms.

The rest of the paper will take these theoretical observations to the data, looking at the experience of trade liberalization in South Africa from the end of the 1980s to the present.

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. Although in the literature there is some disagreement about the extent of effective trade liberalization[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). 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.

4 Empirical Strategy

4.1 The Data Sets

For this study we employ industry level data from a number of distinct sources:

1. 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 1988-2003 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.

2. Industry-level panel data for South Africa and the USA and 28 manufacturing industries from 1963-2003, 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 . From the gross capital formation data we compute

[10] See for example Fedderke and Vaze (2001) for a sceptical view on the real extent of trade libaralization in South Africa, and Rangasamy and Harmse (2003) for a more postive assesment

capital stock data on the basis of the perpetual inventory methodology.[11] 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.

3. 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 (2008).

4. Given the focus of the present study on the impact of trade liberalization on productivity growth, accurate measures of openness or protection are crucial. For our openness indicators, we employ data on effective rates of protection and scheduled nominal tariff rates obtained from Edwards (2005).[12]

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 ~~for the industry level data base~~. 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.

[INSERT TABLE 1 ABOUT HERE]

Note that 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[13].

4.2 The Distance From Frontier Measures

Following Aghion et al (2005) and Aghion and Griffith (2005), we generate an 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

$$M_{i,t} = tfp_{SA,i,t}/tfp_{US,i,t} \tag{13}$$

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 year. TFP is computed by means of the primal decomposition, with factor shares given by the share of labour remuneration in value added. We compute the distance measure both by comparing US TFP with Rand-denominated and Dollar-denominated South African TFP. Table 2 summarizes the evidence.

[INSERT TABLE 2 ABOUT HERE]

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),[14] for two sectors there is a ~~collapse~~ of TFP productivity off relatively ~~high~~ levels (defined as greater than 50% of US TFP productivity levels),[15] and for four sectors the growing productivity gap occurs for mid-range productivity sectors (defined as between 10% and 50% of

[11] 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.

[12] Note that Edwards (2005) also contain measures of export taxes and anti-export bias. We also used both these measures in estimation, with symmetrical results. In the case of the anti export bias measure, however, strong sectoral outliers render the measure less reliable in the sense of raising standard errors. Full results available from the authors on request.

[13] See the discussion in Aghion et al (2008) for more detail.

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

[15] Footwear and Paper & paper products.

US TFP productivity levels).[16] 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),[17] and four sectors for which the gain has been moderate.[18] 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,[19] for two sectors the decline occurs off a mid-level plateau,[20] one sector experiences both substantial catch-up but equivalent decline toward the end of our sample period,[21] and for one sector the movements are small leaving the sector at moderate US TFP productivity levels throughout.[22]

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.]

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 Empirical Specification to be Tested

We briefly summarize the empirical predictions of the preceding theoretical analysis. First, trade liberalization increases aggregate productivity (and wages) through selection effects and increase in competition. Second, the positive effect of openness on productivity depends of the size of the potential market for the winning firm, and thus is related to the relative size of markets. Thus although scale of production should have a direct positive impact on growth, smaller sectors (relative to the world) should respond more strongly to trade liberalization. Third, innovation in sectors in which firms are sufficiently close 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. Thus distance from the technological frontier have an ambiguous effect on productivity in the intermediate sector.

To test these predictions of the theoretical framework, we examine productivity dynamics in South African manufacturing sectors for the period 1988-2002 for the three digit SIC level data. The baseline specification tests for a direct linear impact of the trade protection measure on productivity growth:

$$\Delta A_{it} = a_1 P_{i,t} + \alpha_i + u_{it} \tag{14}$$

where ΔA_{it} denotes productivity growth in sector i in year t, measured by TFP growth or growth in output per worker. P_{it} is a measure of effective trade barriers as detailed in the data section above. The P measure is given by measures of nominal tariffs and of effective protection rates. The measure is thus an inverse of

[16] Food, Non-metallic mineral products, Basic iron & steel, Metal products.
[17] Plastics & plastic products.
[18] Wearing apparel, Wood & wood products, Furniture, Rubber & rubber products.
[19] Television, radio & communication equipment.
[20] Textiles and Professional & scientific equipment.
[21] Glass & glass products.
[22] Machinery & equipment.

openness. Finally, α_i represent fixed effects.[23] The theoretical prior is that $a_1 < 0$, since protection (as an inverse of openness), ~~either by preventing an increase of technological innovation by more advanced firms or by preventing the import of new technology,~~ induces a decrease in the level of productivity growth. In order to capture some of the entry-exit flows that are central to the theoretical analysis, we also use the sectoral change in the output to labour ratio $\Delta\left(Y_{it}/L_{it}\right)$ as an alternative measure of productivity growth for all specifications we estimate.

Since the theoretical framework outlined above also identifies an indirect impact of trade liberalization, that differentiates the impact of liberalization conditional on the distance of the industrial sector from the technological frontier, we supplement the baseline specification by incorporating the impact of distance from the technological leader into the productivity growth dynamics. Formally, for the three digit SIC level data we specify:

$$\Delta A_{it} = a_0 + a_1 P_{i,t} + a_2 M_{i,t} P_{i,t} + \alpha_i + u_{it} \tag{15}$$

where terms are defined as before, $M_{i,t}$ denotes the distance from the technological frontier defined in equation (13), and the term $M_{it}P_{i,t}$ represents an interaction term that captures the relationship between openness and technological innovation. Additional priors are that $a_2 < 0$, such that the maximum effect of trade liberalization occurs in sectors that are closer to the technological frontier.

Specification (15) ignores one important additional factor known to be relevant to productivity growth in South African manufacturing. Aghion et al (2008) 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 (2008) 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 robustness of our findings on a_1 and a_2, by controlling for the impact of a Lerner index of pricing power.[24] We also allow for the possibility of interaction between product market competition and trade protection and distance from technological frontier, providing us with:

$$\Delta A_{it} = a_0 + a_1 P_{i,t} + a_2 M_{i,t} P_{i,t} + a_3 \mathcal{L}_{it} + a_4 \mathcal{L}_{it} P_{i,t} + a_5 \mathcal{L}_{it} M_{i,t} + \alpha_i + u_{it} \tag{16}$$

with all terms defined as before, and with $\mathcal{L}$ denoting the measure of pricing power.

Additional priors are that $a_3 < 0$, given that lower product market competition hampers the escape competition effect. $a_4 < 0$, since a decrease in trade protection should have greater productivity growth effects for sectors with low rather than high product market competition. We do not have explicit theoretical priors for a_5. Nonetheless, we posit $a_5 < 0$ on the grounds that sectors with strong competitive pressure far from the technological frontier would be vulnerable to entry without the possibility of recourse to an escape competition response by incumbent producers.

An additional concern is that the level of protection of manufacturing sectors may simply reflect the bargaining power of the sector when lobbying policy makers, and bargaining power in turn may simply be a reflection of the size of the sector. As a final robustness check for our findings on trade liberalization, we also control for the impact of scale of production~~,~~ on productivity growth. Specifically, we allow for a differential impact of trade liberalization on sectors of different size,[25] and of a differential impact of product market

[23] One question concerns whether time effects should be included in estimation. Given that our specifications are isolating determinants of productivity growth, inclusion of time effects would imply a steady growth acceleration or deceleration which does not match South African manufacturing data. For this reason we do not report results incorporating time effects. We note however that all specifications were estimated under inclusion of time effects, with symmetrical results.

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

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

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).

[25] Readers should note that this is not the same as the scale effect identified by the theoretical discussion. In the latter, the scale effect is the gain in market size by efficient producers that survive liberalization, and capture foreign markets. Our data does not allow us to capture this dynamic impact. Instead, we capture only a possible static effect of scale, with large and small sectors responding differently to liberalization.

competition under different scales of production. Our final full specification is then:

$$\Delta A_{it} = a_0 + a_1 P_{i,t} + a_2 M_{i,t} P_{i,t} + a_3 \mathcal{L}_{it} + a_4 \mathcal{L}_{it} P_{i,t} + a_5 \mathcal{L}_{it} M_{i,t} + a_6 S_{i,t} P_{i,t} + a_7 \mathcal{L}_{it} S_{i,t} + \alpha_i + u_{it} \quad (17)$$

with all terms defined as before, and with S denoting the scale variable.

For our scale measure we employ $S_{i,t} = VA_{SA,i,t}/VA_{US,i,t}$, 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,[26] where the latter serves as proxy for world market size.[27] Table 4 reports summary results of the measure over the 1970-2002 period.

[INSERT TABLE 4 ABOUT HERE].

Additional priors are that $a_6 > 0$, since smaller sectors should realize larger gains in scale of production from trade liberalization. While we again do not have explicit theoretical priors for a_7, we posit that $a_7 < 0$, since sectors that produce with scale and under high product market competition should realize the greatest productivity growth.[28]

5 Results

In our empirical estimation results we consider the direct effects of trade protection on industry and firm productivity growth as specified in equation (14), and the non-linear specification given by equation (15) under the two alternative productivity measures, and for the two measures of trade protection given by effective protection rates and nominal tariff rates.

Robustness checks on the results proceed by allowing for the possibility that the protection measures we use are not exogenous to productivity growth. Sectors that are subject to low productivity growth, have an incentive to lobby for protection. We allow for this possibility by estimating (14) and (15) under the systems GMM methodology. A further concern under the use of panel estimation methodology might be that the underlying assumption of homogeneity across the manufacturing sectors required for the pooling of the data is not appropriate, resulting in bias and inconsistency of estimation results. For this reason we employ the pooled mean group (PMG) estimation methodology,[29] to both test and control for manufacturing group heterogeneity.

[26] 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. See for instance the discussion in Banerjee et al (2008), Fedderke, Shin and Vaze (2005) and Rodrick (2008).

[27] 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.

[28] The correlation between the pricing power proxy and the technological distance measure is -0.35, with the scale of production measure 0.33.

[29] See Pesaran et al (1999) for the derivation of the estimator. PMGE proceeds under the unrestricted error correction ARDL(p, q) representation:

$$\Delta y_{it} = \phi_i y_{i,t-1} + \boldsymbol{\beta}_i' \mathbf{x}_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \boldsymbol{\delta}_{ij}' \Delta \mathbf{x}_{i,t-j} + \mu_i + \varepsilon_{it}, \quad (18)$$

where $i = 1, 2, ..., N$, $t = 1, 2, ..., T$, denote the cross section units and time periods respectively. Here y_{it} is a scalar dependent variable, $\mathbf{x}_{it}$ $(k \times 1)$ a vector of (weakly exogenous) regressors for group i, and μ_i represents fixed effects. We allow the disturbances ε_{it}'s to be independently distributed across i and t, with zero means and variances $\sigma_i^2 > 0$, and assume that $\phi_i < 0$ for all i. Then, there exists a long-run relationship between y_{it} and $\mathbf{x}_{it}$:

$$y_{it} = \boldsymbol{\theta}_i' \mathbf{x}_{it} + \eta_{it}, \ i = 1, 2, ..., N, \ t = 1, 2, ..., T, \quad (19)$$

where $\boldsymbol{\theta}_i = -\boldsymbol{\beta}_i'/\phi_i$ is the $k \times 1$ vector of the long-run coefficients, and η_{it}'s are stationary with possibly non-zero means. This allows (18) to be written as the error correction model:

$$\Delta y_{it} = \phi_i \eta_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \boldsymbol{\delta}_{ij}' \Delta \mathbf{x}_{i,t-j} + \mu_i + \varepsilon_{it}, \quad (20)$$

Further robustness checks follow by allowing for the impact of product market competition, and for the impact of scale of production under specifications (16) and (17) respectively.

5.1 The Direct Productivity Effect of Trade Protection

Estimation proceeds on the specification provided by (14). For the panel of South African manufacturing sectors listed in Table 2, we control for industry fixed effects. Results are reported in Table 5A for the TFP productivity growth measure, and Table 5B for growth in the output labour ratio, and in columns 1 and 2 for effective protection rates, and 8 and 9 for nominal tariff rates respectively.

[INSERT TABLE 5A AND 5B ABOUT HERE]

Estimation results consistently confirm the negative direct impact of trade protection on productivity growth ($a_1 < 0$) both for the TFP growth measure and the growth in output per worker. We note that for both effective rate of protection and nominal tariff rate measures the negative impact is robust to industry fixed effects.

Both sets of results imply an economically significant marginal impact. A 10 percentage point decrease in effective protection increases TFP growth by $0.2 - 0.4$ percentage points and growth of output per worker by $0.1 - 0.3$ percentage points. A reduction in nominal tariffs by 10 percentage points increases TFP growth by $1 - 2$ percentage points and growth of output per worker between 0.5 and 1 percentage points.

Our results prove to be robust to controlling for the possibility of endogeneity of the trade protection measure under systems GMM, as reported in columns (4) for effective protection rates, and (11) for nominal tariffs, of Tables 5A (for the TFP growth) and 5B (for $\Delta\left(Y_{it}/L_{it}\right)$) respectively. The negative impact and both economic and statistical significance of trade protection on productivity growth is maintained under the GMM estimator.[30]

Allowing for the possibility of heterogeneity across manufacturing sectors by means of the PMG estimator, in columns (6) for effective protection rates and (13) for nominal tariffs, of Tables 5A (TFP growth) and 5B ($\Delta\left(Y_{it}/L_{it}\right)$) respectively, further confirms the robustness of the finding of the negative impact of trade protection on productivity growth.[31] Indeed, under the ARDL specification of the PMGE estimator, the strength of the long run impact of trade protection if anything increases from that obtained under the static fixed effects estimation.

Results for the TFP and output per worker productivity growth results are symmetrical throughout.

The empirical results are thus encouraging for our posited theoretical framework. That the impact of trade protection should be pervasively negative, even without controlling for the indirect effects identified by the theory, and under alternative estimation methodologies that control both for potential endogeneity and panel group heterogeneity, suggests some robustness of the link between trade dispensations and growth. It remains to be seen whether controlling for the nonlinearities implied by our theory adds additional insight.

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where ϕ_i is then the error correction coefficient measuring the speed of adjustment towards the long-run equilibrium.

This general framework gives the formulation of the PMG estimation, which allows the short-run coefficients and error variances to differ freely across groups, but the long-run coefficients to be homogenous; *i.e.* $\boldsymbol{\theta}_i = \boldsymbol{\theta}\ \forall\ i$. Group-specific short-run coefficients and the common long-run coefficients are computed by pooled maximum likelihood estimation. Denoting these PMG estimators by $\tilde{\phi}_i$, $\tilde{\boldsymbol{\beta}}_i$, $\tilde{\lambda}_{ij}$, $\tilde{\boldsymbol{\delta}}_{ij}$ and $\tilde{\boldsymbol{\theta}}$, we obtain them by $\hat{\phi}_{PMG} = \frac{\sum_{i=1}^{N}\tilde{\phi}_i}{N}$, $\hat{\boldsymbol{\beta}}_{PMG} = \frac{\sum_{i=1}^{N}\tilde{\boldsymbol{\beta}}_i}{N}$, $\hat{\lambda}_{jPMG} = \frac{\sum_{i=1}^{N}\tilde{\lambda}_{ij}}{N}$, $j = 1, ..., p-1$, and $\hat{\boldsymbol{\delta}}_{jPMG} = \frac{\sum_{i=1}^{N}\tilde{\boldsymbol{\delta}}_{ij}}{N}$, $j = 0, ..., q-1$, $\hat{\boldsymbol{\theta}}_{PMG} = \tilde{\boldsymbol{\theta}}$. PMGE provides an intermediate case between the dynamic fixed effects (DFE) estimator which imposes the homogeneity assumption for all parameters except for the fixed effects, and the mean group estimator (MGE) proposed by Pesaran and Smith (1995), which allows for heterogeneity of all parameters. It exploits the statistical power offered by the panel through long-run homogeneity, while admitting short-run heterogeneity. To test the validity of long-run homogeneity we employ a Hausman (1978) test (hereafter h test) on the difference between MG and PMG estimates of long-run coefficients, under the null of homogeneity.

[30] While in general the economic magnitude of the impact of trade protection is not weaker under GMM estiamtion, for the impact of effective protection rates on TFP growth the impact is approximately halved.

[31] The PMG estimator confirms the homogeneity of the impact of the trade protection measure in the long-run specification (see the Hausman test statistic), as well as adjustment to long-run equilibirum by virtue of the negative PHI coefficient.

5.2 Testing for the Productivity Effect of Trade Protection under Nonlinear Specifications

Under the non-linear specification given by (15) we explicitly control for the differential impact predicted by our theory of trade liberalization on productivity growth for sectors that differ in terms of their distance from the technological frontier. To determine robustness of our results we again estimate under both productivity growth measures, for both measures of trade protection, and under fixed effects, GMM (to control for endogeneity), and PMG (to control for sector heterogeneity) estimation methodologies.

Results are reported in Tables 5A and 5B for the TFP and output-labour ratio productivity growth measures respectively. Columns (3) and (10) report results under fixed effects estimation for effective protection rates and nominal tariff rates respectively. Columns (5) and (12) report GMM, and (7) and (14) the PMGE estimations.

Note immediately that the negative of trade protection on productivity growth is confirmed for all specifications that control for the impact of distance from the technological frontier. What is more, both the statistical and the magnitude of the economic significance of the protection measure is maintained under the specification controlling for the non-linear impact of protection.

More importantly in the present context, our results also confirm our prior that sectors that are closer to the technological frontier benefit more from trade liberalization in productivity growth terms ($a_2 < 0$), than do sectors far from the technological frontier. What is more, the result is again robust across the alternative productivity growth measures, the alternative trade protection measures, as well as the estimation methodologies that control for sectoral heterogeneity by means of fixed effects or the more elaborate dynamic PMGE methodology,[32] as well as the GMM approach that allows for endogeneity of the protection measure.

What is more, note that the indirect impact of trade liberalization conditional on distance from technological frontier is of significant magnitude in economic terms. For a 10 percentage point decrease in trade protection, each percentage point increase in distance from the technological frontier lowers productivity growth by between 0.1 and 0.2 percentage points under the TFP productivity growth measure, and 0.13 and 0.44 percentage points under the output-labour ratio measure.

Trade liberalization thus stands to benefit sectors closer to the technological frontier considerably more, than those that lag the frontier.

5.3 Controlling for the Impact of Product Market Competition

In Table 6 we report the results of estimations under the specification given by (16). We allow for the impact of our measure of pricing power evident in South African manufacturing sectors, and for different levels of pricing power for a differential impact of both trade liberalization and distance from the technological frontier. Columns (1-3) and (4-6) report results for TFP growth under the effective rate and nominal tariff protection measures respectively, while columns (7-9) and (10-12) repeat for the output-labour productivity growth rate. Given the robustness of our findings to the GMM and PMGE methodologies, we do not repeat the robustness check with respect to endogeneity and dynamic sectoral heterogeneity.

[INSERT TABLE 6 ABOUT HERE]

Again, we note that our finding of both the direct negative impact of trade protection, and the greater positive impact of trade liberalization for sectors closer to the technological frontier is robust to the additional controls for product market competition.

The impact of pricing power continues to have the statistically significant negative impact on productivity growth ($a_3 < 0$) noted in Aghion et al (2008). Indeed, the economic size of the impact is approximately double that found for the closed economy model of the earlier study. Aghion et al (2008) found that a 0.1 unit increase in the Lerner index resulted in the loss of approximately one percentage point in productivity growth as measured by TFP. Under the present open economy specifications the implication is that a 0.1 unit increase in the Lerner index now results in a 1 to 2 percentage point loss in productivity growth under

[32] Only for the PMGE methodology under the nominal tariff measure does the interaction term report coefficients of the wrong sign (for both productivity growth measures) - but under this specification the coefficients is statistically insignificant.

the TFP productivity growth measure (see columns 1 and 4), and a loss of between 2 and 3 percentage points under output-labour ratio productivity growth (see columns 7 and 10).[33]

For the pricing power interaction terms, our results suggest that trade liberalization has greater productivity growth effects for sectors with low rather than high product market competition ($a_4 < 0$).

Further, results also support the inference that sectors with strong competitive pressure far from the technological frontier experience lower productivity growth ($a_5 < 0$).

Our findings on the impact of trade liberalization (direct and indirect) are therefore robust to the inclusion of the measure for pricing power in the form of the proxy of the Lerner index.

5.4 Controlling for the Impact of Scale of Production

Finally, we also test for the robustness of our results by controlling for the impact of the scale of production, to control for the possibility that the level of trade protection is simply a reflection of lobbying power as determined by the size of the sector. We report the results of the estimation of specification (17) in Tables 7A and 7B for the TFP and $\Delta(Y_{it}/L_{it})$ productivity growth measures respectively.

[INSERT TABLE 7A AND 7B ABOUT HERE]

Once again we confirm that the negative direct impact of trade protection, as well as the finding that the positive impact of trade liberalization is greater for sectors closer to the technological frontier, is robust to the additional controls for the scale of production. The magnitude of the economic impact is similarly preserved, though statistical precision of the direct impact of trade protection is weaker under the $\Delta(Y_{it}/L_{it})$ productivity growth measure and effective protection rate specification. Else the findings are robust.

As for the impact of our scale variable, we find that our prior that manufacturing sectors operating at smaller scales of production benefit more from trade liberalization ($a_6 > 0$) is confirmed across all specifications. Moreover, sectors of smaller scale and low product market competition experience lower productivity growth ($a_7 < 0$). In both instances this finding is robust to the inclusion of controls of pricing power in manufacturing sectors.

Core implication of these findings is that the negative impact of trade protection, and of the deleterious impact of distance from the technological frontier under trade liberalization, is robust to the inclusion of controls both for pricing power, as well as scale of production in order to account for the possibility that trade protection is correlated with the size of the manufacturing sector. The priors of our theoretical framework thus obtain supporting empirical evidence.

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 sectors that are closer to the world technological frontier should benefit more from trade liberalization.

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

Our results confirm that the productivity growth impact of trade liberalization is positive, both in terms of its direct and in terms of its indirect impacts. Trade protection has a direct negative impact on productivity growth. Sectors closer to the international technological frontier benefit most significantly from trade liberalization. These findings are robust to controlling for potential endogeneity of the trade protection

[33] While Rodrick (2008) 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 not only incomplete at present, but that the regulatory framework on output markets in South Africa is more stringent than even for the OECD (see OECD, 2008: 65), thus creating non-tariff barriers to entry that contuinue to protect incumbent firms even under trade liberalization.

measure by means of GMM estimation, and manufacturing sector heterogeneity by means of fixed effects and pooled mean group estimation, as well as to controlling for the impact of product market competition, and the possibility that trade protection is correlated with the scale of production.

Additional findings indicate that sectors with low product market competition and smaller scale of production benefit most significantly from trade liberalization. Further, we report results that indicate that sectors close to the technological frontier, that have greater product market competition experience higher productivity growth. Finally, sectors of greater scale and high product market competition experience higher productivity growth.

Our results also strengthen findings of a positive impact of product market competition on productivity growth. Under our open economy specifications, controlling for trade liberalization serves to verify the positive impact of competitive pressure on productivity growth, and suggests that the impact of competition is in fact greater than suggested by specifications that do not control for the extent of trade protection. Our findings indicate a productivity growth impact of double the magnitude obtained from estimations that do not control for trade protection measures.

Policy implications to follow from the analysis affirm the importance of trade liberalization and competition policy 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. Addressing the restrictiveness of the regulatory environment is a further policy target.

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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.	

Table2: Distance of South African 3 Digit Manufacturing Sectors from the US Technological Frontier

		TFP Distance				TFP Distance				TFP Distance				TFP Distance	
Sector	**Period**	**$-R**	**$-$**	**Sector**		**$-R**	**$-$**	**Sector**		**$-R**	**$-$**	**Sector**		**$-R**	**$-$**
Food	1970-79:	7.58	7.41	Footwear	1970-79:	9.83	9.59	Plastic products	1970-79:	7.93	7.76	Machinery	1970-79:	8.56	8.35
	1980-93:	6.78	7.16		1980-93:	9.16	9.69		1980-93:	7.35	7.74	& equip.	1980-93:	8.20	8.65
	1994-2002:	6.19	7.14		1994-2002:	8.20	9.29		1994-2002:	6.98	8.31		1994-2002:	7.59	8.88
	1970-2002:	6.86	7.23		1970-2002:	9.10	9.55		1970-2002:	7.43	7.90		1970-2002:	8.14	8.62
Beverages	1970-79:	6.66	6.53	Wood & wood	1970-79:	8.90	8.70	Glass & glass	1970-79:	8.73	8.52	TV, radio &	1970-79:	8.81	8.60
	1980-93:	5.65	5.93	products	1980-93:	8.45	8.82	products	1980-93:	7.97	8.34	comm equip.	1980-93:	7.56	7.98
	1994-2002:	4.86	5.53		1994-2002:	7.70	8.87		1994-2002:	6.77	7.87		1994-2002:	6.34	7.55
	1970-2002:	5.74	6.00		1970-2002:	8.38	8.80		1970-2002:	7.87	8.26		1970-2002:	7.61	8.05
Tobacco	1970-79:	3.62	3.59	Furniture	1970-79:	10.12	9.92	Non-metallic	1970-79:	8.17	7.98	Transport	1970-79:	8.80	8.60
	1980-93:	3.24	3.35		1980-93:	9.56	10.02	minerals	1980-93:	8.10	8.52	equip	1980-93:	8.49	8.91
	1994-2002:	3.72	3.96		1994-2002:	8.47	9.73		1994-2002:	7.11	7.90		1994-2002:	7.34	8.40
	1970-2002:	3.49	3.59		1970-2002:	9.44	9.91		1970-2002:	7.85	8.19		1970-2002:	8.27	8.68
Textiles	1970-79:	9.59	9.41	Paper & paper	1970-79:	7.36	7.17	Basic iron	1970-79:	9.15	8.95	Prof.&scien.	1970-79:	7.30	7.10
	1980-93:	8.83	9.27	products	1980-93:	6.65	7.08	& steel	1980-93:	8.84	9.29	equip.	1980-93:	6.69	7.07
	1994-2002:	8.54	9.84		1994-2002:	6.04	6.92		1994-2002:	7.34	8.34		1994-2002:	7.10	8.24
	1970-2002:	8.98	9.47		1970-2002:	6.70	7.07		1970-2002:	8.52	8.93		1970-2002:	6.98	7.40
Wearing apparel	1970-79:	10.38	10.16	Industrial	1970-79:	6.34	6.20	Basic non-ferrous	1970-79:	8.67	8.48	Other manuf.	1970-79:	6.57	6.48
	1980-93:	9.70	10.18	Chemicals	1980-93:	6.53	6.81	metals	1980-93:	8.17	8.48		1980-93:	5.60	5.74
	1994-2002:	8.87	10.29		1994-2002:	6.45	7.02		1994-2002:	6.81	7.31		1994-2002:	5.15	5.51
	1970-2002:	9.68	10.21		1970-2002:	6.45	6.59		1970-2002:	7.95	8.16		1970-2002:	5.77	5.90
Leather & leather	1970-79:	10.52	10.28	Rubber	1970-79:	8.33	8.15	Metal products	1970-79:	8.64	8.43				
products	1980-93:	9.55	10.01	products	1980-93:	8.05	8.45	excl. mach.	1980-93:	8.35	8.79				
	1994-2002:	7.70	8.72		1994-2002:	7.58	8.70		1994-2002:	7.84	9.00				
	1970-2002:	9.34	9.74		1970-2002:	8.01	8.43		1970-2002:	8.30	8.74				

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

Sectors with Productivity Gap Constant with SA TFP Measured in $ Terms, Narrowing in R Terms	Sectors with Productivity Gap Narrowing in Both Rand and $ Terms
Food	Beverages
Textiles	Leather & leather products
Wearing apparel	Paper & paper products
Footwear	Glass & glass products
Wood & wood products	Non-metallic minerals
Furniture	Basic iron & steel
Rubber products	Basic non-ferrous metals
Plastic products	TV, radio & comm equip.
Metal products excl. mach.	Other manuf.
Machinery & equip.	
Transport equip	
Prof.& scien. equip.	

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: Productivity Growth in TFP and Output/Labour (Y/L) Ratio
(Standard deviation in parenthesis * sig at 5%, ** at 10% level; PHI denotes the error correction coefficient under the PMGE methodology)

Table 5A	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Productivity Growth	TFP	TFP	TFP	TFP	TFP	TFP	TFP	TFP	TFP	TFP	TFP	TFP	TFP	TFP
Measure of Trade Liberalization	ERP	ERP	ERP	ERP	ERP	ERP	ERP	Nom Tar	Nom Tar	Nom Tar	Nom Tar	Nom Tar	Nom Tar	Nom Tar
P	-0.001* (3.4e-005)	-0.0004 * (6.9e-005)	-0.0004* (5.6e-005)	-0.0002* (5.7e-005)	-0.0002* (4.9e-005)	-0.0004* (0.0001)	-0.0004* (0.0001)	-0.001** (0.004)	-0.0022* (0.0006)	-0.0021* (0.0007)	-0.0020* (0.0005)	-0.0016* (0.0007)	-0.0030* (0.0004)	-0.0030* (0.0004)
M (-1)x P(-1)			-0.0009* (0.0003)		-0.0017* (0.0005)		-0.0002 (0.0003)			-0.0013** (0.0007)		-0.0018 (0.0011)		0.0010 (0.0007)
TFP(-1)				0.12 (0.12)	-0.002 (0.010)						-0.006 (0.11)	0.0290 (0.1387)		
PHI						-1.03* (0.05)	-1.003* (0.05)						-1.004* (0.05)	-1.02* (0.05)
Ind. Effs	No	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes
GMM	No	No	No	Systems	Systems	No	No	No	No	No	Systems	Systems	No	No
PMGE	-	-	-	-	-	AIC(1)	AIC(1)	-	-	-	-	-	AIC(1)	AIC(1)
N	368	368	338	345	338	391	391	368	368	338	345	338	-	-
Adj-R^2	0.01	0.04	0.06	-	-	-	-	0.02	0.05	0.07	-	-	-	-
Wald (joint)	10.76*	37.72 *	71.10*	27.53*	42.09*	-	-	3.17	13.51*	37.80*	15.29*	20.27*	-	-
Wald (dummy)	-	-	-	4.61*	6.51*	-	-	-	-	-	9.81*	4.51*	-	-
Sargan	-	-	-	21.93	19.14	-	-	-	-	-	21.77	20.39	-	-
AR(1)	1.87	-0.37	-1.17	-3.13*	-3.13*	-	-	1.78	-0.78	-1.60	-2.92*	-2.89*	-	-
AR(2)	1.12	-2.21 *	-2.11*	0.42	-0.49	-	-	1.00	-2.60*	-2.43*	-0.55	-0.25	-	-
h-test (Hausman Test for homogeneity)	-	-	-	-	-	1.61 [0.20]	3.26 [0.20]	-	-	-	-	-	0.78 [0.38]	1.87 [0.39]
RLL	-	-	-	-	-	-1135	-1003	-	-	-	-	-	-1129	-1004
ULL	-	-	-	-	-	-1117	-953	-	-	-	-	-	-1116	-956

Table 5B	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Productivity Growth	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L
Measure of Trade Liberalization	ERP	ERP	ERP	ERP	ERP	ERP	ERP	Nom Tar	Nom Tar	Nom Tar	Nom Tar	Nom Tar	Nom Tar	Nom Tar
P	-0.0127* (0.005)	-0.0298* (0.011)	-0.0207* (0.0077)	-0.0229* (0.0047)	-0.0148* (0.0057)	-0.025* (0.008)	-0.024* (0.009)	-0.1019* (0.045)	-0.2192* (0.0673)	-0.1755* (0.0641)	-0.2339* (0.0726)	-0.1224 (0.0748)	-0.202* (0.045)	-0.217* (0.054)
M (-1)x P(-1)			-0.1280* (0.0436)		-0.2087* (0.0557)		-0.035 (0.056)			-0.2305* (0.1135)		-0.4378* (0.1801)		0.045 (0.126)
[d(Y/L)/dt](-1)				-0.1187 (0.1280)	-0.1646 (0.1396)						-0.1837 (0.1704)	-0.1167 (0.1775)		
PHI						-1.05* (0.04)	-1.01* (0.05)						-1.12* (0.08)	-1.01* (0.05)
Ind. Effs	No	Yes	Yes	No	No	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes
GMM	No	No	No	Systems	Systems	No	No	No	No	No	Systems	Systems	No	No
PMGE	-	-	-	-	-	AIC(1)	AIC(1)	-	-	-	-	-	AIC(2)	AIC(1)
N	368	368	338	345	338	-	-	368	368	338	345	338	-	-
Adj-R^2	0.01	0.012	0.02	-	-	-	-	0.02	0.03	0.04	-	-	-	-
Wald (joint)	7.21*	7.92*	20.06*	27.72*	23.02*	-	-	5.04*	10.61*	20.67*	11.40*	13.57*	-	-
Wald (dummy)	-	-	-	9.61*	6.35*	-	-	-	-	-	12.96*	10.23*	-	-
Sargan	-	-	-	19.69	18.48	-	-	-	-	-	21.34	20.31	-	-
AR(1)	1.07	-0.79	-1.22	-2.37*	-2.18*	-	-	0.94	-1.12	-1.47	-1.95	-2.02*	-	-
AR(2)	1.45	-2.06*	-2.26*	-1.19	-1.52	-	-	1.18	-2.52*	-2.58*	-1.25	-1.09	-	-
h-test (Hausman Test for homogeneity)	-	-	-	-	-	1.04 [0.31]	2.94 [0.23]	-	-	-	-	-	2.21 [0.14]	2.04 [0.36]
RLL	-	-	-	-	-	-1212	-1071	-	-	-	-	-	-1186	-1071
ULL	-	-	-	-	-	-1195	-1024	-	-	-	-	-	-1171	-1035

Table 6: Robustness Under Controls for Product Market Competition
(Standard deviation in parenthesis * sig at 5%, ** at 10% level)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Productivity Growth	TFP	TFP	TFP	TFP	TFP	TFP	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L
Protection Measure	ERP	ERP	ERP	Nom Tar	Nom Tar	Nom Tar	ERP	ERP	ERP	Nom Tar	Nom Tar	Nom Tar
P	-0.0003*	-0.0002*	-0.0003*	-0.0018*	-0.0009	-0.0011	-0.0160*	-0.0131	-0.0044	-0.1187**	-0.0315	-0.0609
	(5.9e-005)	(9.6e-005)	(9.3e-005)	(0.0007)	(0.0008)	(0.0008)	(0.0072)	(0.0117)	(0.0102)	(0.0709)	(0.0786)	(0.0779)
M (-1)x P(-1)	-0.0015*	-0.0019*	-0.0012*	-0.0024*	-0.0040*	-0.0023*	-0.2208*	-0.1513*	-0.1642*	-0.4261*	-0.5995*	-0.3508*
	(0.0003)	(0.0003)	(0.0003)	(0.0010)	(0.0010)	(0.0010)	(0.0538)	(0.0646)	(0.0476)	(0.1448)	(0.1483)	(0.1422)
L(-1)	-0.1835*	-0.1818*	-0.1265*	-0.1532*	-0.1433*	-0.0916**	-30.95*	-30.95*	-22.9763*	-28.6*	-28.446*	-21.1838*
	(0.0456)	(0.0473)	(0.0513)	(0.0448)	(0.0472)	(-1.81)	(7.13)	(7.13)	(7.998)	(7.15)	(7.608)	(8.348)
L(-1) x P(-2)		-0.0002*	-0.0002*		-0.0019*	-0.00156**		-0.0187*	-0.0163*		-0.1399**	-0.0943
		(7.0e-005)	(6.2e-005)		(0.0009)	(0.0009)		(0.0081)	(0.0065)		(0.0721)	(0.0731)
L(-1) x M(-1)			-0.4426*			-0.4203*			-63.38*			-59.1185*
			(0.1110)			(0.1020)			(16.14)			(16.90)
Ind. Effs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	338	315	315	338	315	315	338	292	315	338	315	315
Adj-R^2	0.10	0.10	0.13	0.09	0.11	0.13	0.09	0.05	0.12	0.09	0.0981	0.12
Wald (joint)	75.70*	331.5*	357.4*	43.76*	58.45*	90.73*	30.53*	87.81*	202.0*	28,04*	49.53*	66.46*
AR(1)	-0.87	-0.70	-1.41	-1.13	-0.95	-1.63	-1.10	-0.59	-1.67	-1.28	-1.376	-1.77
AR(2)	-2.21*	-2.50*	-2.55*	-2.36*	-2.58*	-2.63*	-2.50*	-2.48*	-2.81*	-2.65	-2.876*	-2.87*

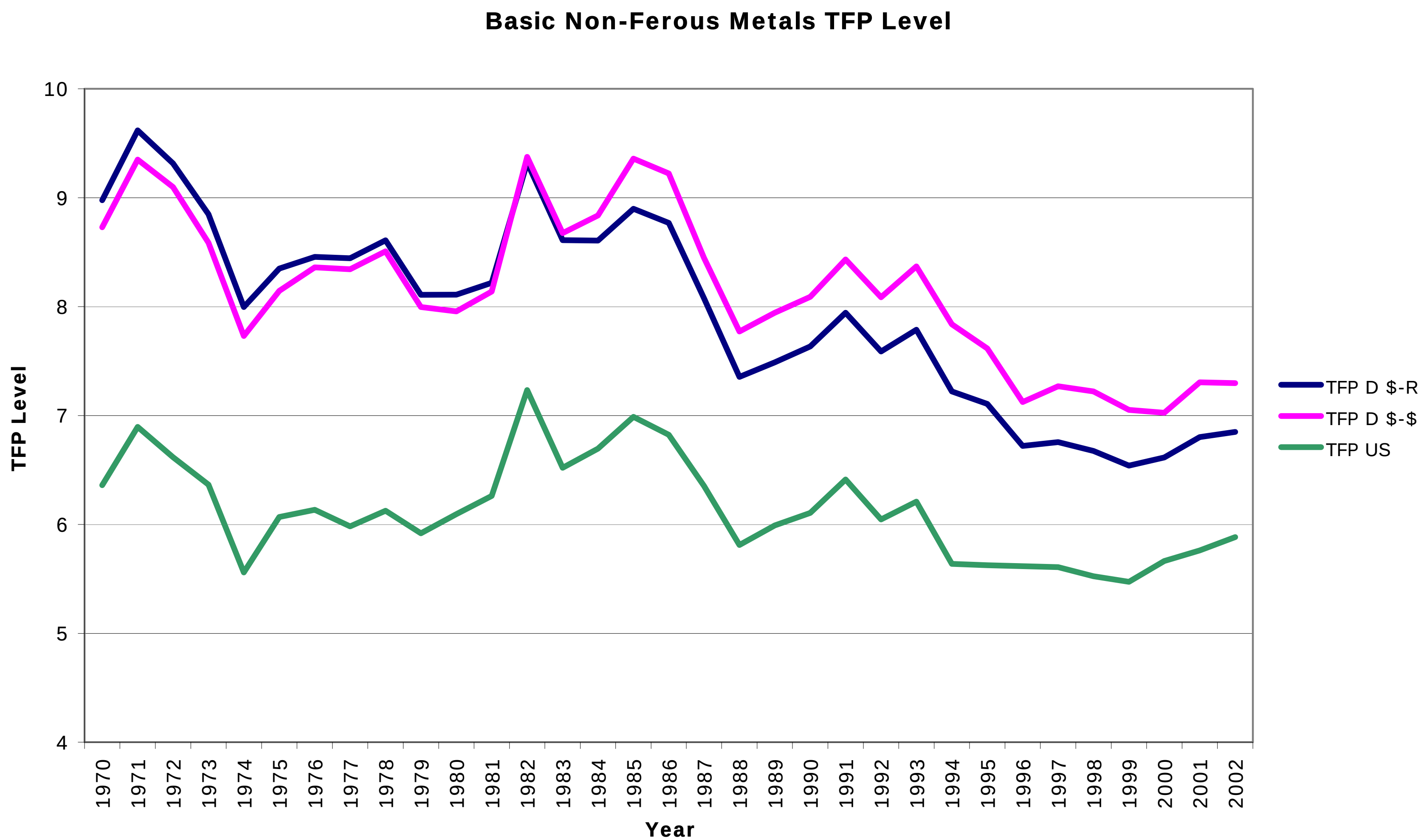
Table 7: Robustness under Controls for Scale of Production

(Standard deviation in parenthesis, * sig at 5%, ** at 10% level)

Table 7A	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Productivity Growth	TFP	TFP	TFP	TFP	TFP	TFP	TFP	TFP	TFP	TFP
Protection Measure	ERP	ERP	ERP	ERP	ERP	Nom Tar	Nom Tar	Nom Tar	Nom Tar	Nom Tar
P	-0.0003*	-0.0003*	-0.0002*	-0.0002*	-0.0002*	-0.0037*	-0.0032*	-0.0020	-0.0023**	-0.0029*
	(3.9e-005)	(4.1e-005)	(7.98e-005)	(7.6e-005)	(7.4e-005)	(0.0011)	(0.0012)	(0.0013)	(0.0013)	(0.0013)
M (-1)x P(-1)	-0.0027*	-0.0032*	-0.0030*	-0.0025*	-0.0025*	-0.0019*	-0.0027*	-0.0046*	-0.0023*	-0.0032*
	(0.0008)	(0.0007)	(0.0008)	(0.0007)	(0.0007)	(0.0007)	(0.0009)	(0.0010)	(0.0011)	(0.0009)
L(-1)		-0.2006*	-0.1995*	-0.0917	-0.0536		-0.1442*	-0.12780*	-0.0360	0.0601
		(0.0459)	(0.0491)	(0.0604)	(0.0659)		(0.0508)	(0.0546)	(0.0633)	(0.0667)
L(-1) x P(-2)			-0.0002*	-0.0002*	-0.0002*			-0.0028*	-0.0025*	-0.0016
			(6.99e-005)	(6.2e-005)	(6.1e-005)			(0.0009)	(0.0009)	(0.0010)
L(-1) x M(-1)				-0.6169*	-0.6352*				-0.5389*	-0.5881*
				(0.1538)	(0.1561)				(0.1258)	(0.1227)
SxP	0.5328*	0.5114*	0.3640*	0.5406*	0.5150*	0.0080*	0.0072*	0.0074**	0.0076*	0.0112*
	(0.1605)	(0.1530)	(0.1757)	(0.1487)	(0.1625)	(0.0034)	(0.0036)	(0.0038)	(0.0036)	(0.0031)
L(-1) x S(-1)					-0.2923*					-0.7965*
					(0.2342)					(0.2517)
Industry Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	315	315	292	292	292	316	316	293	293	293
Adj-R^2	0.10	0.13	0.12	0.16	0.17	0.11	0.13	0.14	0.17	0.18
Wald (joint)	80.77*	79.73*	754.5*	636.2*	448.2*	48.42*	51.90*	127.1*	164.5*	216.6*
AR(1)	0.58	0.39	0.43	0.15	0.35	-0.07	0.03	0.31	-0.01	0.57
AR(2)	-2.18*	-2.26*	-2.31*	-2.45*	-2.41*	-2.56*	-2.37*	-2.57*	-2.64*	-2.66*

Table 7B	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Productivity Growth	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L	Y/L
Protection Measure	ERP	ERP	ERP	ERP	ERP	Nom Tar	Nom Tar	Nom Tar	Nom Tar	Nom Tar
P	-0.0627*	-0.0520	-0.0298	-0.0331	-0.0483*	-0.4146*	-0.3279*	-0.1902	-0.2285**	-0.3151*
	(0.0276)	(0.0246)	(0.0226)	(0.0228)	(0.0221)	(0.1196)	(0.1329)	(0.1384)	(0.1375)	(0.1348)
M (-1)x P(-1)	-0.1516*	-0.2301*	-0.1564*	-0.1552*	-0.1973*	-0.3266*	-0.4712*	-0.6635*	-0.3619*	-0.4913*
	(0.0431)	(0.0502)	(0.0697)	(0.0492)	(0.0562)	(0.0927)	(0.1154)	(0.1217)	(0.1329)	(0.1579)
L(-1)		-30.86*	-25.2019*	-18.2146**	-4.4384		-25.2816*	-24.22*	-11.77	2.5343
		(8.00)	(8.614)	(9.593)	(9.636)		(8.343)	(9.284)	(11.06)	(9.469)
L(-1) x P(-2)			-0.0212*	-0.0209*	-0.0113*			-0.2564*	-0.2238**	-0.0829
			(0.0092)	(0.0100)	(0.0065)			(0.1117)	(0.1180)	(0.1118)
L(-1) x M(-1)				-74.93*	-82.88*				-73.08*	-80.4092*
				(15.98)	(16.63)				(18.66)	(19.25)
SxP	0.2325*	0.2015**	0.1240	0.1838**	0.3350*	1.2842*	1.1327*	1.1069*	1.13*	1.6637*
	(0.1147)	(0.1109)	(0.1002)	(0.0980)	(0.1158)	(0.4383)	(0.4663)	(0.4973)	(0.49)	(0.5631)
L(-1) x S(-1)					-100.34					-118.609*
					(61.38)					(61.79)
Ind. Effs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	316	316	292	293	293	316	316	293	293	293
Adj-R^2	0.05	0.10	0.06	0.13	0.14	0.08	0.12	0.11	0.15	0.17
Wald (joint)	25.35*	40.51*	40.91*	81.61*	152.5*	41.01*	40.24*	51.17*	72.47*	175.5*
AR(1)	-0.30	-0.46	-0.55	-0.53	-0.30	-0.54	-0.57	-0.63	-0.63	-0.41
AR(2)	-2.19*	-2.38*	-2.50*	-2.68*	-2.68*	-2.72*	-2.70	-2.82	-2.80*	-2.82*

Figure 1:


Basic Non-Ferous Metals TFP Level
TFP Level
10
9
8
7
6
5
4
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
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1987
1988
1989
1990
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1992
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1994
1995
1996
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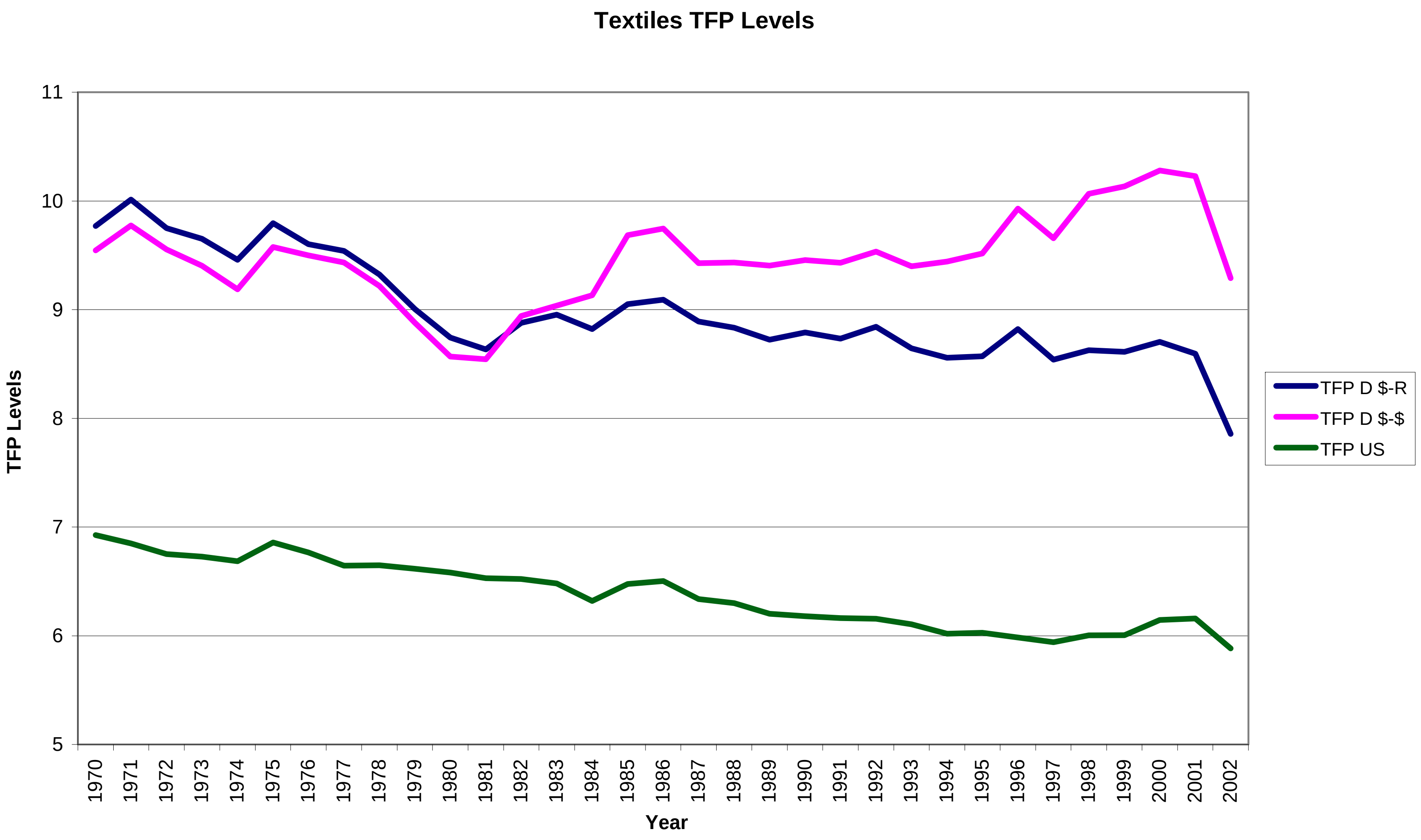
1998
1999
2000
2001
2002
Year
TFP D $-R
TFP D $-$
TFP US

Figure 2:


Textiles TFP Levels
11
10
9
8
7
6
5
TFP Levels
1970
1971
1972
1973
1974
1975
1976
1977
1978
1979
1980
1981
1982
1983
1984
1985
1986
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1988
1989
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1995
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1997
1998
1999
2000
2001
2002
Year
TFP D $-R
TFP D $-$
TFP US