

Industrial labour productivities and tariffs in South Africa

Identification based on multilateral liberalization reform¹

Torfinn Harding* and Jørn Rattsø**

*University of Oxford, Oxford, UK; and Statistics, Norway, Oslo, Norway.

E-mail: torfinn.harding@economics.ox.ac.uk

**Norwegian University of Science and Technology, Trondheim, Norway.

E-mail: jorn.rattso@svt.ntnu.no

Abstract

The analysis of the effect of tariffs for labour productivity faces the challenge of tariff policy endogeneity. Tariff policy is designed to promote economic development and the industrial sector tariff structure may reflect characteristics of the industries protected. We seek to identify the effect of tariffs by taking advantage of multilateral tariff liberalization using reductions in industrial sector tariffs in other world regions as instruments for sectoral tariff reductions in South Africa. The data cover 28 manufacturing sectors over the period 1988–2003. We find that tariff reductions have stimulated labour productivity when instrumented by multilateral tariffs. The ordinary least-squares estimates show downward bias and this confirms the endogeneity of tariffs. Investigation of channels of effects shows some support for the importance of competitive pressure and technology spillover from trade liberalization.

Received: April 16, 2009; Acceptance: October 7, 2009

¹ We appreciate discussions at the TIPS South Africa Forum, seminars at the NTNU, Statistics Norway, University of Oslo, Oxford University and comments in particular from Ådne Cappelen, Xinshen Diao, Karolina Ekholm, Steinar Holden, Beata Smarzynska Javorcik, Terje Skjerpén, Hildegunn Stokke, Kjetil Storesletten, Fredrik Wulfsberg, and a referee of this journal. The project is financed by the Norwegian Research Council.

© 2010 The Authors

Journal compilation © 2010 The European Bank for Reconstruction and Development.

Published by Blackwell Publishing Ltd, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main St, Malden, MA 02148, USA

JEL classifications: F13, F43, O11, O33, O55.

Keywords: Trade policy, policy evaluation, barriers to growth, technology adoption, South Africa, labour productivity.

1. Introduction

Do tariffs affect labour productivity? We investigate this relationship using data for industrial sector development and tariffs for South Africa. The main challenge for any policy evaluation is to take into account the endogeneity of policy. Trade policy is usually part of industrial policy and the sectoral tariff rates are designed to promote sectoral policy goals. Correlations between tariffs and productivity may reflect political responses to sectoral productivity development. We take advantage of multilateral tariff reform and use industrial sector tariffs of countries in other world regions as instruments for tariff reductions in South Africa. Identification of the tariff effect is based on predictions from tariff reform elsewhere, controlling for possible direct effects of foreign tariffs on domestic productivity.

We apply the Trade and Industry Policy Studies (TIPS, 2004) industrial sector panel data for the period 1988–2003 covering 28 manufacturing industries in South Africa. The panel data allow for the calculation of labour productivity and this is related to sectoral tariff rates. The tariff rates are instrumented using sectoral tariff rates for similar countries in three world regions: Latin America, the Middle East and South Asia. Various model specifications are investigated to check the robustness of the results and reveal the dynamics of adjustment. The results consistently show that reduced industrial sector tariffs have contributed to higher labour productivities.

Tariffs may influence productivity through various channels, and international technology spillovers and increased competition have been particularly addressed in the literature. The understanding of international spillover and ‘catching up’ has historical roots in Gerschenkron’s (1962) analysis of development out of backwardness and was formalized by Nelson and Phelps (1966) as technology adoption. They assume that individual country productivity growth is determined by the distance to the world technology frontier and factors affecting the technology adoption. Caselli and Coleman (2006) offer an application of the world technology frontier in a cross-country analysis with aggregate data. Recent theoretical advances are discussed by Klenow and Rodriguez-Clare (2005) in an overview of the literature on international externalities and economic growth. Aghion and Howitt (2005) elaborate on appropriate growth frameworks and their ‘Schumpeter meets Gerschenkron’ covers catching up to the world frontier. In this context, tariffs affect the international spillover of technologies. Our analysis includes the world technology frontier described by sectoral labour productivities in the US. The results indicate that the links to the world technology frontier are weak in South Africa.

Aghion *et al.* (2008a) analyse the relationship between competition and productivity growth in South Africa and a broad set of countries. Their results indicate that competitive pressure has been important for productivity growth. This is consistent with the study of Aghion *et al.* (2008b) investigating the economic mechanisms involved in the relationship between trade and growth in South Africa based on nominal tariffs, effective protection rates and export taxes. Their estimates show that competition may be important for total factor productivity spillover. We have analysed whether the price–cost margin, the variable used by Aghion *et al.* (2008a), influences productivity in our sample. We find that including the price–cost margin as a control variable does not change the effect of tariffs, and that the price–cost margin only affects labour productivity when year dummies are excluded. Furthermore, we have analysed whether tariffs influence the price–cost margin and find that tariff reductions have contributed to lower price–cost margins. These results are consistent with Aghion *et al.* (2008a) and confirm that competitive pressure may be a channel for tariff liberalization effects.

The effect of trade policy for productivity and growth is a classic issue in policy evaluation and has been analysed in an enormous literature including case studies, country time series and cross-country econometric analysis. The literature has exploited data at the plant/firm level, industrial sector level and country aggregates. The industrial sector level has the advantage of long panel data. Recent country studies with the ambition of identifying causal effects of trade policy in sector data include Ferreira and Rossi (2003) and Muendler (2004) for Brazil, Fernandes (2007) and Karacaovali (2006) for Colombia, and Amiti and Konings (2007) for Indonesia. All these authors apply instruments to represent changes in tariffs, but the instruments are typically constructed from industrial sector characteristics other than productivity.² For example, Amiti and Konings (2007) use historical tariffs as instruments in an analysis of Indonesia. While this approach certainly represents an improvement compared to the earlier literature, there is potential endogeneity involved in using historical and sectoral characteristics to predict sectoral tariff policies. Alternative approaches are offered by Trebler (2004) and Romalis (2007). Trebler studies trade policy reform in the context of the Canada–US free trade agreement. Romalis uses US tariff barriers to predict the openness of developing countries, in a cross-country study. We suggest using other countries' sectoral tariffs to predict tariffs in South Africa and thereby avoid dependence on internal industrial characteristics.

The econometric challenges are discussed in Section 2, and Section 3 offers a first look at the data. The econometric analysis is presented in Section 4, and Section 5 provides concluding remarks.

² A related literature addresses tariffs and productivity at the firm level (Pavcnik, 2002).

2. Econometric challenges

Trade liberalization may or may not improve labour productivity. Trade policy is controversial not only because strong economic interests and ideological views are involved, but also because the effects of trade policy are unclear. Protecting industries while they are fostered and made ready for international competition has for long been the main argument for import substitution policies – the infant industry argument. Such trade policy easily ends up protecting low-productivity industries, but can stimulate high-productivity sectors when successful. The opposite outward orientation strategy attempts to promote reallocation, competition and learning from international technological spillovers in an open economy. Theoretically, there are many potential linkages between trade policy and productivity. Empirical analyses have not solved the controversy, as case studies are always open to interpretation and econometric studies have run into serious methodological problems of policy endogeneity. Rodrik (1995) offers a good overview of the literature on the political economy of tariff protection, and his discussion shows how trade policy is part of industrial policy.

The endogeneity of policy in policy evaluation can be understood as an omitted variable problem. Besley and Case (2000) elaborate the biases involved in estimating policy effects. In our setting, policy output is measured as labour productivity, the policy is tariffs, and a set of economic variables explain labour productivity. The tariff policy is a function of economic and political variables normally not controlled for in the estimation of labour productivity equations. Political preferences for industrial sector production and employment may influence sectoral tariffs over time. Controlling for politics is in practice hard to do, especially because policies endogenously respond to economic conditions. For instance, if governments protect industries with high-productivity growth, high sectoral tariffs will be associated with relatively high sectoral productivity growth. A simple econometric analysis assuming tariffs to affect productivity growth is likely to conclude that high tariffs do not hamper productivity growth. Ordinary least squares (OLS) will underestimate a negative effect of tariffs.

The relationship between industrial characteristics and trade policy has been investigated recently. Ferreira and Facchini (2005) show that more concentrated industries are more protected. Karacaovali (2006) offers a two-way analysis of tariffs and productivity for Colombia. He finds that sectors with high productivity are liberalized less. Trade liberalization is used to increase foreign exposure for low-productivity industries. These studies support the understanding that the design of trade policy takes into account industrial characteristics. The endogeneity of policy is a serious challenge for policy evaluation.

The recent analyses of trade policy and productivity instrumenting trade policy represent an attempt at correcting for the endogeneity. Ferreira and Rossi (2003) discuss the endogeneity, but conclude that 'endogeneity is not a problem with

respect to tariff determination' in Brazil. They base this conclusion on the observation that tariffs were reduced proportionally across industries. Muendler (2004) applies domestic and foreign price and exchange rate components as instruments. Fernandes (2007) controls for endogeneity by using lagged tariff rates in Colombia. Karacaovali (2006) uses, among other variables, capital to output ratios and material prices to instrument the import ratio as a determinant of tariffs in his analysis of Colombia. Amiti and Konings (2007) use former tariffs to instrument for present tariffs in a study of Indonesia. All the studies referred to above use instruments that are unlikely to be independent of productivity and therefore not well suited to identification of the tariff effect.

An alternative approach is to look for tariff reform. Trefler (2004) makes use of the Canada-US free trade agreement as an experiment of trade policy shift. We study a more continuous trade liberalization process and must look for exogenous background factors driving trade reform. In the broader literature of applied political economy, characteristics of the political system are typically used to instrument policies. This is hard to do properly in a disaggregated analysis of industrial sectors. If disaggregated political factors relevant at the sectoral level are observed, such as lobbying, they are themselves endogenous to sectoral productivity. Romalis (2007) uses US tariff barriers as instruments for the openness of developing countries. Our use of other countries' tariff liberalization as instruments shares the view that good instruments can be found abroad. Overseas tariff changes are correlated with South African ones and are expected to be uncorrelated with South African industry productivity.

South Africa is one of many countries participating in the multilateral liberalization of import tariffs under the coordination of GATT (General Agreement on Tariffs and Trade) and later World Trade Organization (WTO). We use the fact that the lowering of tariffs was the result of international negotiations and therefore harmonized across countries. It should be noticed that the tariff negotiations have affected the bound tariffs, but actual tariffs that we use have broadly followed the course set by the bound tariffs. It is an empirical question whether actual South African tariffs have followed the harmonized pattern of actual tariffs and we show that they have. As will become clear, most of the worldwide tariff reductions, including those in South Africa, came during the 1990s. International shocks may have driven industry tariffs and productivity across countries and will be a concern for the validity of the instrument. We use time dummies and the sector-specific international labour productivity frontier to control for general and sector-specific global shocks, respectively. Change of tariffs in other world regions can affect productivity in South African industries directly via exports. We control for exports to account for this possibility. The analysis below shows that OLS underestimates the effect of tariffs. Underestimation indicates that the trade liberalization process may have given more protection to industries with high-productivity growth. Instrumenting, which identifies the effects of the international component of the tariff policy, leads to larger and more significant negative effects of tariffs on labour productivity growth.

3. A first look at the data

The analysis is based on the three-digit panel dataset of manufacturing industries in South Africa provided by TIPS (2004).³ Labour productivity, y , is simply sector value added, measured in 1995 Rand, divided by the number of people employed (including casual and seasonal workers) in the sector. Table A1 in Appendix A documents the data, and the average South Africa labour productivity in our sample is 140,000 Rand per worker. The average logarithmic growth rate of labour productivity is 4 percent. The TIPS panel also provides us with a sector-specific annual measure of percentage capacity utilization.

We use applied tariffs, rather than applied and most favoured nation tariffs. As explained by Nicita and Olarreaga (2006), applied rates take into consideration the available data for preferential schemes.⁴ Tariff data are at the level of three-digit ISIC Rev. 2.⁵ Table A2 in Appendix A shows the matching of the sectors. We apply sectoral tariff changes in countries in other world regions as instruments for tariff changes in South Africa and focus on similar middle-income countries and look at three regions – Latin America and Caribbean (LAC), Middle East and North Africa (MENA) and South Asia (SA).⁶ The regions are selected since they represent similar semi-industrialized countries, and the empirical analysis below shows that the sectoral tariff rates of the countries involved do work well as instruments for the tariff rates in South Africa. We have investigated alternative sets of regions representing semi-industrialized middle-income countries. The selection of countries/regions is not very important as the WTO-driven change in the tariff structure among these countries has been similar.

The development of selected sectoral tariffs in South Africa is shown in Figure 1. The sectors shown are basic chemicals, basic iron and steel, basic non-ferrous metals, motor vehicles parts and accessories, other transport equipment, and textiles. The tariffs have been reduced for almost all industrial sectors during the period studied. The size of the full period reduction varies, but is about 50 percent on average. Tariffs have been reduced over the whole period, but with particular sharp reductions around 1995–1996, consistent with the multilateral reform promoted by the Uruguay round. The sharp reduction for 1995–1996 in particular is pronounced for basic chemicals and basic metals.⁷ In the context of productivity growth, it is of interest

³ The data are now available at: <http://www.quantec.co.za/>.

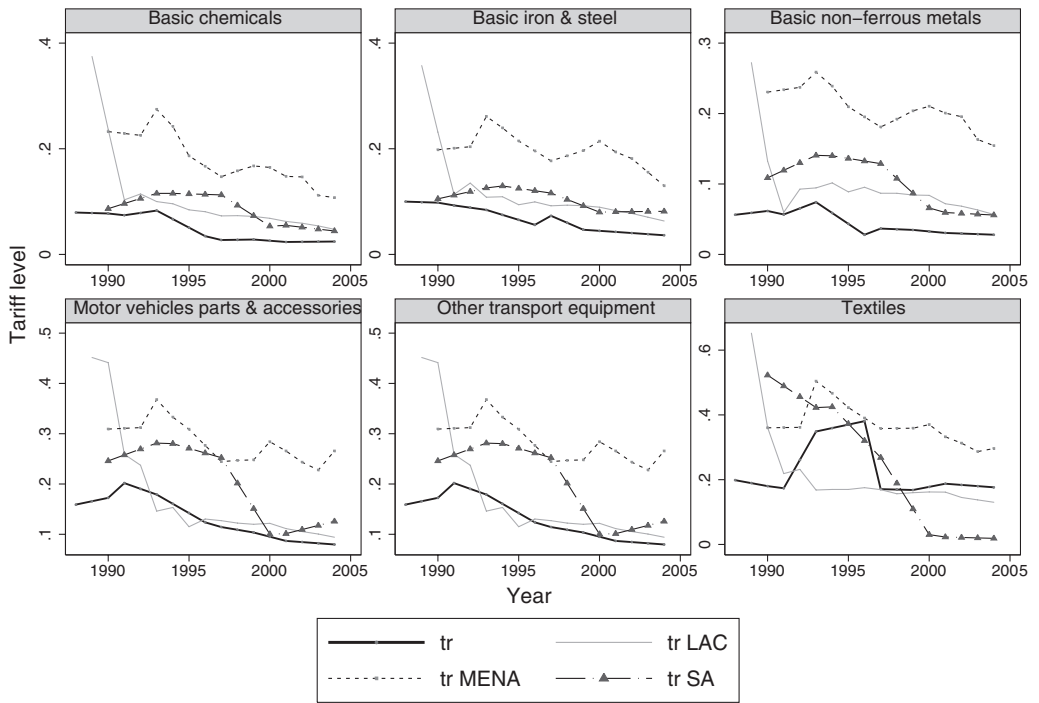
⁴ Most favoured nation rates are those granted to all WTO members to whom no preferential access is granted.

⁵ The data are available at: <http://go.worldbank.org/EQW3W5UTP0>.

⁶ The relevant countries in these regions with tariff data that are included in the analysis: nine countries in LAC (Bolivia, Brazil, Colombia, Ecuador, El Salvador, Guatemala, Honduras, Peru and Suriname), six countries in MENA (Algeria, Arab Rep. Egypt, Islamic Rep. Iran, Jordan, Morocco and Tunisia) and one country in SA (Sri Lanka).

⁷ Also electrical machinery, metal products, non-metallic minerals, plastic products and other industries experienced such sharp reductions (not shown).

Figure 1. Tariffs in South Africa, Latin America and Caribbean (LAC), Middle East and North Africa (MENA) and South Asia (SA)



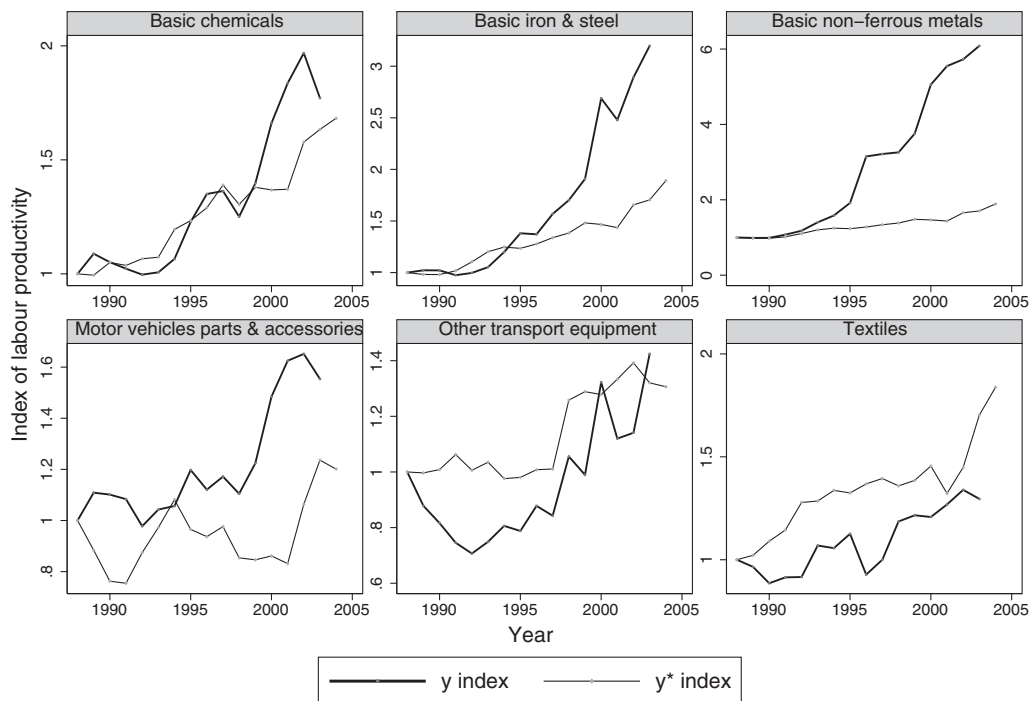
Graphs by selected sectors

Notes: tr and tr Z measure interpolated tariffs in South Africa and region Z respectively. The regional measures are simple averages of the specific sectors' tariff level in year t, across the countries in region Z.

whether the trade liberalization has been concentrated on low- or high-productivity growth sectors. The data indicate that tariff reductions in South Africa have followed similar countries and have primarily been dictated by the WTO process. The development of tariffs for the same selected industries in the three regions (LAC, SA and MENA) is also shown in Figure 1. Broadly, tariff reductions in South Africa and the three mentioned regions moved in tandem during the 1990s. Tariff developments in these regions may predict the path of South African tariffs. For further analysis of the tariff policy of South Africa, we refer to Edwards (2005), and Edwards and Lawrence (2008) offer a broader investigation of the effects of trade policy.

Beyond the analysis of tariffs and labour productivity, we add the world frontier labour productivity represented by industrial sectors in the US. Consistent with the above South African data, we apply three-digit US data to calculate

Figure 2. Labour productivity in South Africa and in the US



Graphs by selected sectors

Notes: y and y^* measure sectoral labour productivities in South Africa and the US, respectively. The indexes are scaled relative to the level of 1988.

manufacturing sector labour productivities. The US data are published by the Bureau of Economic Analysis (BEA) and are classified according to SIC 87.⁸ Labour productivity for the US, y^* , is defined as value added in fixed USD, and is found by deflating value added measured in millions of current USD with the corresponding price indices. These indices are 100 in 2000. The number of workers per sector is measured by the published full- and part-time employees in thousands of employees. As shown in Table A1 in Appendix A, mean US labour productivity is 95,000 USD per worker in our sample. The average logarithmic growth rate of labour productivity in the US is 2 percent, and consequently the raw data indicate catching up productivity growth in South Africa.

⁸ The classification has been changed over time from SIC72 to SIC87 to NAICS97. We first merge the US data according to SIC87 and then merge the US data with the South African data. For access to and description of the data, see: <http://www.bea.gov/industry/index.htm>

The development of labour productivities for the same selected industries in South Africa and in the US during 1988–2003 are shown in Figure 2. Overall, South Africa has had positive labour productivity growth in manufacturing industries, but across industries the performance is quite heterogeneous. The diagrams broadly confirm a relationship between labour productivities in South Africa and in the US. Productivity growth in South Africa has been higher in basic iron and steel, basic non-ferrous metals and motor vehicles parts and accessories, similar to the US in basic chemicals and other transport equipment, and below in textiles. The time paths differ, but many of the growth sectors have a take off around 1996–1997.

Graphical observation of the raw data supports the understanding that the development of labour productivity in South Africa and in the US is linked and that a period of rising labour productivity has been associated with reduced tariff levels. The interaction between the three factors needs to be investigated econometrically.

In an extension of the analysis, we investigate the competition channel of the tariff liberalization effect. Following Aghion *et al.* (2008a) we calculate the price–cost margin from the TIPS dataset (all variables in 1995 prices). The variable is measured as value added less total wages divided by gross output and is similar to their PCM1. As shown in Table A1 of Appendix A, the average price–cost margin is about 16 percent, a realistic number. We are able to reproduce their negative relationship between tariffs and the price–cost margin, and we use the price–cost margin as a control variable in regression models of the relationship between tariffs and labour productivity. As analysed below, the price–cost margin clearly reacts to the trade liberalization process and consequently may be an important channel of effect.

4. Econometric analysis

The econometric analysis seeks to reveal any relationship between sectoral labour productivities and tariffs. The dataset covers 28 industrial sectors during the period 1988–2003 and we use about 300 observations. The two basic variables of the analysis are the growth rate of sectoral labour productivity $\Delta \ln y_{it}$ (sector i , year t) and tariff rate tr_{it} . The econometric specification investigates alternative dynamics of the response of labour productivity to tariffs. The adjustment process towards long-run equilibrium is expected to be much longer than the observation period. In this case, we are primarily able to identify the transition effect of tariff reform. This motivates estimation of the effects of tariffs on labour productivity growth. Sectoral fixed effects take into account time-invariant variation in labour productivity across sectors. Year fixed effects control for common shocks and trends over time. Many different specifications of the lag structure have been investigated and the negative effect of tariffs on labour productivity consistently shows up. To limit the reporting, we concentrate on a 1-year lag of the tariff effect and a 2-year lag of the world technology frontier effect.

The benchmark relationship between labour productivity growth and tariffs is:

$$\Delta \ln y_{it} = \alpha_i + \alpha_t + \beta \text{tr}_{it-1}. \quad (1)$$

The extension of the benchmark model includes the world technology frontier on the level form and with interaction:

$$\Delta \ln y_{it} = \alpha_i + \alpha_t + \beta \text{tr}_{it-1} + \gamma \ln y_{it-2}^* + \delta \text{tr}_{it-1} \ln y_{it-2}^*. \quad (2)$$

We start out by reporting standard OLS estimates in Table 1. Column 1 is the benchmark model of the growth rate effect with sectoral and year fixed effects. The coefficient is negative, but not statistically significant. As stated above, we expect the OLS estimates to be biased downwards because of the endogeneity of tariffs. Neither tariffs nor the frontier has a statistically significant effect when the world technology frontier is entered in the level form. In column 3, the full model (2) is estimated including the interaction term. Now both the frontier and interaction coefficients are statistically significant, but the quantitative effects are small. When year effects are left out, the statistical significance disappears.

The main econometric challenge in estimating the relationship is the endogeneity of tariffs with respect to labour productivity. To handle the endogeneity, we apply a standard two-stage least-square method with instrument variables to predict the sectoral tariff levels. In the first stage, sectoral tariffs are predicted by sectoral tariff levels in three world regions assumed to capture the multilateral liberalization that South Africa was part of. In the second stage, the predicted sectoral tariffs are included as independent variables in the analysis of sectoral labour productivities.

Table 1. First difference of log of labour productivity – OLS estimation

	1	2	3	4
	<i>d ln y</i>	<i>d ln y</i>	<i>d ln y</i>	<i>d ln y</i>
tr-1	-0.073 (0.129)	-0.075 (0.129)	-0.228 (0.153)	-0.119 (0.119)
ln <i>y</i> *-2		0.008 (0.021)	0.068* (0.039)	0.043 (0.033)
tr-1 × ln <i>y</i> *-2			-0.169* (0.092)	-0.124 (0.081)
Year FE	Yes	Yes	Yes	No
Sector FE	Yes	Yes	Yes	Yes
Observations	305	305	305	305
Number of group (code sector)	28	28	28	28
<i>R</i> ²	0.07	0.07	0.08	0.01
<i>R</i> ² overall	0.08	0.08	0.06	0.02

Notes: Standard errors in brackets. *Significant at 10%. All estimations include contemporary capacity utilization as control variable.

In the first stage, the one-year lagged South African sectoral tariff rates $tr-1$ are related to the two- and three-year lagged sectoral tariff rates of the three regions LAC, MENA and SA. The choice of lag structure is based on the predictive power of the instruments. The first-stage estimation also includes sector and year fixed effects. Column 1 in Table 2 shows the first-stage regression for the basic model of Equation (1). The sectoral tariff developments in all three regions seem to have predictive power for the sectoral tariff developments in South Africa. Columns 2–5 report first-stage estimates of the extended models.

Shea R^2 and the F -test, reported in the second-stage tables, indicate the predictive power of the instruments. Shea R^2 above 0.10 and P -values of the F -test below 0.10 are generally regarded as support of predictive power.⁹ We also report P -values of a Sargan test in the second-stage tables. An insignificant Sargan test, Sargan P -value above 0.10, is taken as the indication of valid exclusion of the instruments from the second stage. Our Sargan tests are generally insignificant and this supports our intuition: the South African productivity level in sector i in year t is unlikely to be endogenous to the average tariff level in the corresponding sectors in these geographically distant regions in year $t-2$ or $t-3$.

The first column in Table 3 presents the second-stage estimation of Equation (1) and suggests a negative and, at the 5 percent level, statistically significant relationship between tariffs and labour productivity growth. The estimated coefficient of -0.8 implies that a 10 percent higher tariff level reduces productivity growth about 1 percentage point. The quantitative effect is quite large and the economic interpretation is that tariff reductions stimulate the transition growth of labour productivity. The size of the effect is comparable with the analysis of Indonesia by Amity and Konings (2007). They find that the labour productivity level increases by about 5.5 percent in response to a 10 percentage point output tariff reduction.

The negative association between tariffs and productivity across industrial sectors is clearly more robust than in the OLS estimates. The tariff effects are in general much larger in the instrument variable estimation. First, it should be noticed that bias confirms the need for instruments to control for endogenous determination of tariffs. The downward bias of the OLS estimates supports the understanding that the government has given priority to tariff reductions in sectors with slow productivity growth. The government has attempted to open up for international competition and spillovers in sectors that needed it the most. When we control for this endogeneity, we increase the productivity enhancing effect of tariff reductions.

A basic relationship between tariffs and productivity growth using year and sector fixed effects and instrumentation of tariffs represents the core of our analysis. Two specification issues are worth pursuing: the relationship between domestic and international productivity growth and dynamics. Discussions of the methodology and alternative specifications are offered by Griffith *et al.* (2004), Harding and Rattsø (2009) and Rattsø and Stokke (2003).

⁹ See Shea (1996) for an explanation of Shea R^2 .

Table 2. First-stage estimation of sectoral tariffs – corresponding to Table 3

Dependent variable	1	2	3	4	5
	tr-1	tr-1	tr-1 \times ln y^{*-2}	tr-1	tr-1 \times ln y^{*-2}
tr-2 LAC	-0.132 (0.194)	-0.156 (0.194)	-0.013 (0.315)	0.367*** (0.130)	0.044 (0.207)
tr-2 MENA	0.120** (0.057)	0.121** (0.057)	-0.106 0.092	0.168*** (0.045)	-0.092 (0.072)
tr-2 SA	0.131** (0.063)	0.258*** (0.097)	0.758*** (0.157)	0.375*** (0.081)	0.717*** (0.130)
tr-3 LAC	0.303*** (0.103)	0.295*** (0.103)	0.124 (0.167)	0.015 (0.052)	0.141* (0.082)
tr-3 MENA	0.007 (0.056)	-0.007 (0.056)	0.045 (0.092)	-0.085* (0.045)	0.004 (0.072)
tr-3 SA	-0.017 (0.073)	-0.112 (0.091)	-0.870*** (0.148)	-0.219** (0.085)	-0.762*** 0.135
ln y^{*-2}		-0.027* (0.016)	0.277*** (0.026)	-0.041*** (0.014)	0.274*** (0.022)
Year FE	Yes	Yes	Yes	No	No
Sector FE	Yes	Yes	Yes	Yes	Yes
Observations	305	305	305	305	305
Number of group code sector	28	28	28	28	28
R^2	0.36	0.37	0.70	0.31	0.68
R^2 overall	0.56	0.62	0.57	0.67	0.64

Notes: Column 1 corresponds to column 1 in Table 3, column 2 to column 2 and 3 in Table 2, column 3 to column 3 in Table 2 and column 4 and 5 to column 4 in Table 2. tr-XZ means average applied tariffs among lower middle-income countries in region Z, lagged X periods. The regions, defined as World Bank regions as of July 2006, are: LAC Latin America and the Caribbean, MENA Middle East and North Africa and SA South Asia. All models include contemporaneous capacity utilization. *Significant at 10%; **significant at 5%; ***significant at 1%.

Productivity growth in the open economy is often understood as ‘catching up’ to the world technology frontier and involving international productivity spillover. The barriers to growth model originated by Nelson and Phelps (1966) assume a long-run equilibrium where individual country productivity is proportional to the world technology frontier. The proportionality factor is affected by barriers such as tariffs, and tariff-reduction may allow catching up to world technology. Benhabib and Spiegel (2005) have made alternative econometric tests of the relationship. This

Table 3. First difference of log of labour productivity – IV estimation

Dependent variable	1	2	3	4
	$d \ln y$	$d \ln y$	$d \ln y$	$d \ln y$
Second stage				
tr-1	-0.840** (0.419)	-0.948** (0.411)	-0.830** (0.412)	0.087 (0.263)
$\ln y^{*-2}$		0.015 (0.022)	0.082 (0.077)	0.158* (0.085)
$\text{tr-1} \times \ln y^{*-2}$			-0.194 (0.214)	-0.458* (0.238)
Year FE	Yes	Yes	Yes	No
Sector FE	Yes	Yes	Yes	Yes
First-stage tr-1				
Shea partial R^2	0.10	0.11	0.14	0.22
Partial R^2	0.10	0.11	0.11	0.30
F	4.95	5.38	5.38	19.54
$F, P\text{-value}$	0.00	0.00	0.00	0.00
First-stage $\text{tr-1} \times \ln y^{*-2}$				
Shea partial R^2			0.19	0.13
Partial R^2			0.15	0.17
F			7.52	9.35
$F, P\text{-value}$			0.00	0.00
df	6	6	6	6
df_r	260	259	259	269
Observations	305	305	305	305
Number of group code sector	28	28	28	28
Sargan statistics	1.85	1.65	1	3.96
Sargan $P\text{-value}$	0.87	0.89	0.91	0.41
$F\text{-value}$	4.95	5.38	2.57	3.13
$Fdf1$	260	259	259	269
$Fdf2$	6	6	6	6

Notes: Instruments are as shown in Table 1. Standard errors in brackets. *Significant at 10%; **significant at 5%. All estimations include contemporary capacity utilization as control variable. df and df_r give the degrees of freedom in the F -test for the instruments' prediction power in the first stage. These numbers are the same for all first stages within the same column.

is investigated in relationships expanded to take into account the role of the world sectoral labour productivity frontier, y_{it}^* , measured as the labour productivities in corresponding US industrial sectors. This variable takes out all global time-varying sector-specific shocks. Alternative dynamic formulations are investigated, first expanding the benchmark model with the world frontier and interaction with

tariffs, then in an error-correction formulation and finally using the productivity gap as the dependent variable.

Column 2 in Table 3 adds the world frontier sectoral labour productivity level. The world frontier has no independent effect on the labour productivity growth in South Africa in this specification. This is still true when we in column 3 add interaction between the tariff level and the world frontier. Our understanding of the lack of a world frontier effect is that time dummies already take care of the trend growth represented by the world frontier. The exclusion of time dummies does not provide robust and stable results. The world frontier is statistically significant when time dummies are excluded in column 4. We have also included the world frontier on growth form (results not reported) and again the frontier has no separate effect on productivity growth with time dummies. The result is fairly consistent with other analyses of the role of the world technology frontier in South Africa. Harding and Rattsø (2009) find a weak long-run relationship between the frontier represented by the US industries and productivity measured by technology shocks. They conclude that the estimates reject catching up and indicate divergence. Aghion *et al.* (2008b) find that distance to the frontier has a positive but weak effect on total factor productivity growth. Distance to the frontier is shown to be important for total factor productivity in a panel of OECD countries by Vandebussche *et al.* (2006).

To investigate the validity of the instruments, we have estimated the relationship between South African industrial productivity growth and the tariff rates of the three regions. The econometric formulation reported in Table 4 includes sector and year fixed effects and we study both 1-year lead, contemporary and 1-year lagged effects. The effect of the productivity growth rates is reported with and without the world frontier variable. As seen from the table, there is no statistically significant relation between sectoral productivity growth in South Africa and the tariffs used as instruments. We have also investigated 2-year leads and lags (not reported) and found no statistical association.

Following Aghion *et al.* (2008a), we analyse whether competitive pressure may be a channel for the effects of trade liberalization. We have computed the price–cost margin as gross profits (value added less taxes) relative to gross output, the same definition as their PCM1 variable. Table 5 reports estimation of the relationship between tariffs and labour productivity when the price–cost margin is included as the control variable. The table presents models similar to Table 3. The effect of the tariffs on labour productivity is not much affected, and the price–cost margin is not statistically significant in models including time dummies. The result is similar to the analysis of the world technology frontier in Table 3, the price–cost margin is only important when the common trends represented by the time dummies are excluded. In this case, the price–cost margin has a negative effect on labour productivity, consistent with Aghion *et al.* (2008a). We have investigated alternative specifications with interaction effects between tariffs and price–cost margin and with and without the world technology frontier with similar results (not reported).

Table 4. Instrument validity, the effect of productivity growth for instrument tariffs

	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
	LAC	LAC	MENA	MENA	SA	SA
$d \ln y_{+1}$	0.002 (0.031)	0.002 (0.031)	-0.045 (0.041)	-0.042 (0.041)	0.009 (0.054)	-0.004 (0.044)
$\ln y^{*-2}$		0.003 (0.011)		-0.037** (0.014)		0.201*** (0.015)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	386	386	359	359	359	359
Number of group code sector	28	28	28	28	28	28
R^2	0.82	0.82	0.29	0.31	0.45	0.65
	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>	<u>11</u>	<u>12</u>
	LAC	LAC	MENA	MENA	SA	SA
$d \ln y$	0.044 (0.029)	0.044 (0.029)	-0.016 (0.039)	-0.015 (0.039)	0.016 (0.053)	0.008 (0.042)
$\ln y^{*-2}$		0.005 (0.009)		-0.032** (0.013)		0.192*** (0.014)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	413	413	386	386	386	386
Number of group code sector	28	28	28	28	28	28
R^2	0.82	0.82	0.31	0.33	0.46	0.66
	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>	<u>17</u>	<u>18</u>
	LAC	LAC	MENA	MENA	SA	SA
$d \ln y_{-1}$	0.021 (0.031)	0.020 (0.031)	0.005 (0.042)	0.009 (0.042)	0.047 (0.057)	0.023 (0.046)
$\ln y^{*-2}$		0.005 (0.009)		-0.032** (0.013)		0.192*** (0.014)
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Sector FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	413	413	386	386	386	386

Table 4. (cont) Instrument validity, the effect of productivity growth for instrument tariffs

	<u>13</u>	<u>14</u>	<u>15</u>	<u>16</u>	<u>17</u>	<u>18</u>
	LAC	LAC	MENA	MENA	SA	SA
Number of group code sector	28	28	28	28	28	28
R ²	0.82	0.82	0.31	0.33	0.46	0.66

Notes: Standard errors in brackets. *Significant at 10%; **significant at 5%; ***significant at 1%. Dependent variable is average applied tariffs among lower middle-income countries in the region indicated. The regions, defined as World Bank regions as of July 2006, are: LAC Latin America and the Caribbean, MENA Middle East and North Africa and SA South Asia. All models include contemporaneous capacity utilization.

The price–cost margin can clearly be endogenous with respect to labour productivity, and Aghion *et al.* (2008a) study instrument estimation using tariffs among other variables as instruments. The effects of tariffs are under study here, and we have analysed whether tariffs influence the price–cost margin. The results shown in Table 6 show that tariffs have a statistically significant positive effect on the price–cost margin of South African industries. The result holds both using OLS and when we use our instruments for tariffs. We conclude that competitive pressure may be a channel for trade liberalization effects.

A concern with the instruments chosen is that tariffs in other world regions may affect productivity in South Africa directly via exports. We investigate the exclusion restriction of the instruments by introducing exports as a separate control variable in Table 7. The exports have no statistically significant effect on labour productivity in any of the specifications and the tariff effect is unchanged. The export channel seems not to be important for our results.

To check for the robustness of the relationship, we investigate alternative dynamic specifications. The error-correction model separates between short- and long-run adjustments and excludes time dummies. The length of the time series allows for specification with lagged endogenous variable and sector fixed effects. The dependent variable is still the growth rate of sectoral labour productivity, and the full model is:

$$\Delta \ln y_{it} = \alpha_i + \alpha_1 \ln y_{it-1} + \beta_1 \Delta \text{tr}_{it-1} + \beta_2 \text{tr}_{it-2} + \gamma_1 \Delta \ln y_{it-2}^* + \gamma_2 \ln y_{it-3}^* + \gamma_2 \text{tr}_{it-2} \ln y_{it-3}^*.$$

We start out in the first column of Table 8 with only the tariffs on level and first difference form. The coefficient of the tariff level effect is basically the same as the results in Table 3 above, about -0.8 , and with the same statistical significance. The coefficient of the lagged endogenous variable is statistically significant at the

Table 5. First difference of log of labour productivity, controlling for price–cost margin (PCM1 – IV estimation)

Dependent variable	1	2	3	4
	$d \ln y$	$d \ln y$	$d \ln y$	$d \ln y$
Second stage				
tr-1	-0.771* (0.454)	-0.900** (0.444)	-0.707 (0.464)	0.186 (0.272)
PCM1-1	-0.181 (0.248)	-0.145 (0.250)	-0.289 (0.279)	-0.737*** (0.263)
$\ln y^{*-2}$		0.014 (0.022)	0.086 (0.078)	0.167** (0.084)
tr-1 $\times \ln y^{*-2}$			-0.211 (0.219)	-0.478** (0.233)
Year FE	Yes	Yes	Yes	No
Sector FE	Yes	Yes	Yes	Yes
First-stage tr-1				
Shea partial R^2	0.09	0.10	0.11	0.21
Partial R^2	0.09	0.10	0.10	0.30
F	4.16	4.54	4.54	18.80
F, P -value	0.00	0.00	0.00	0.00
First-stage tr-1 $\times \ln y^{*-2}$				
Shea partial R^2			0.18	0.13
Partial R^2			0.15	0.19
F			7.86	10.53
F, P -value			0.00	0.00
df	6	6	6	6
df_r	259	258	258	268
Observations	305	305	305	305
Number of group code sector	28	28	28	28
Sargan statistics	1.94	1.78	1.07	2.44
Sargan P -value	0.86	0.88	0.90	0.65
F -value	4.16	4.54	1.97	3.16
$Fdf1$	259	258	258	268
$Fdf2$	6	6	6	6

Notes: Instruments are as shown in Table 1. Standard errors in brackets. *Significant at 10%; **significant at 5%; ***significant at 1%. All estimations include contemporary capacity utilization as control variable. df and df_r give the degrees of freedom in the F -test for the instruments' prediction power in the first stage. These numbers are the same for all first stages within the same column.

1 percent level and shows slow adjustment of labour productivity over time. The implied long-run negative tariff effect on labour productivity is quite high, and our understanding is that the data sample is too short to identify the long-run effect. The strong transition effect of tariffs is translated into an even stronger long-run

Table 6. Price–cost margin (PCM1) and tariffs

Dependent variable	1	2
	IV	OLS
	PCM1	PCM1
tr-1	0.238* (0.143)	0.096** (0.046)
Year FE	Yes	Yes
Sector FE	Yes	Yes
First-stage tr-1		
Shea partial R^2	0.10	
Partial R^2	0.10	
F	4.95	
F, P -value	0.00	
df	6	
df_r	260	
Observations	305	305
Number of group (code sector)	28	28
Sargan statistics	2.97	
Sargan P -value	0.70	
F -value	4.95	
Fdf1	260	
Fdf2	6	

Notes: Standard errors in brackets. *Significant at 10%; **significant at 5%; ***significant at 1%. Both estimations include contemporary capacity utilization as a control variable. In column 1, tariffs are instrumented with the instruments shown in Table 1. Column 2 shows OLS estimation. df and df_r give the degrees of freedom in the F -test for the instruments' prediction power in the first stage.

effect, but in a dataset that cannot show the true long-run implications. The extension of the error correction specification to include the world frontier on level and first difference form in column 2 does not add new effects. When interaction between tariffs and the frontier is added in the full error correction model, column 3 in Table 8, the world frontier emerges with statistically significant effect. The quantitative effect of the tariff rate is similar to that above, and is again understood as a transition effect. An increase in the world frontier labour productivity level raises labour productivity growth in South Africa.

An alternative specification sets the focus directly on catching up towards the world frontier. The effect of tariffs on the productivity gap y/y^* is investigated directly. In Table 9, different lags of the tariff effect on the productivity gap are shown. The results show a consistent negative effect of tariffs on the productivity gap. Higher tariffs increase the distance to the world frontier labour productivity, and 10 percent higher tariffs increase the gap by about 2 percent. Columns 1 and 2

Table 7. First difference of log of labour productivity, controlling for exports – IV estimation

	1	2	3	4
	$d \ln y$	$d \ln y$	$d \ln y$	$d \ln y$
Second stage				
tr-1	-0.863** (0.419)	-0.940** (0.402)	-0.844** (0.413)	0.054 (0.255)
$\ln y^{*-2}$		0.010 (0.022)	0.066 (0.087)	0.174* (0.096)
tr-1 $\times \ln y^{*-2}$			-0.156 (0.236)	-0.495* (0.262)
$\ln x$	0.026 (0.022)	0.025 (0.023)	0.016 (0.026)	-0.013 (0.024)
Year FE	Yes	Yes	Yes	No
Sector FE	Yes	Yes	Yes	Yes
First-stage tr-1				
Shea partial R^2	0.10	0.11	0.14	0.26
Partial R^2	0.10	0.11	0.11	0.28
F	4.98	5.58	5.58	17.36
F, P-value	0.00	0.00	0.00	0.00
First-stage tr-1 $\times \ln y^{*-2}$				
Shea partial R^2			0.16	0.12
Partial R^2			0.13	0.13
F			6.51	6.53
F, P-value			0.00	0.00
Observations	305	305	305	305
Number of group code sector	28	28	28	28
Sargan statistics	1.27	1.2	0.86	3.83
Sargan P-value	0.94	0.94	0.93	0.43
F-value	4.98	5.58	2.34	3.05
Fdf1	259	258	258	268
Fdf2	6	6	6	6

Notes: This table corresponds to Table 2, but log sectoral exports, $\ln x$, is now included as control variable. Instruments are as shown in Table 1. Standard errors in brackets. *Significant at 10%; **significant at 5%; ***significant at 1%. All estimations include contemporary capacity utilization as control variable. df and df_r give the degrees of freedom in the F -test for the instruments' prediction power in the first stage. These numbers are the same for all first stages within the same column.

Table 8. First difference of log of labour productivity, error correction model – IV estimation

Dependent variable	1	2	3
	$d \ln y$	$d \ln y$	$d \ln y$
Second stage			
$\ln y_{-1}$	-0.162*** (0.033)	-0.171*** (0.033)	-0.250*** (0.051)
dtr_{-1}	-0.333 (0.387)	-0.309 (0.393)	0.280 (0.485)
tr_{-2}	-0.746*** (0.264)	-0.824*** (0.247)	-0.677*** (0.251)
$d \ln y^{*-2}$		-0.001 (0.036)	0.038 (0.040)
$\ln y^{*-3}$		0.016 (0.023)	0.241** (0.116)
$tr_{-2} \times \ln y^{*-3}$			-0.629** (0.319)
Year FE	No	No	No
Sector FE	Yes	Yes	Yes
First-stage dtr_{-1}			
Shea partial R^2	0.16	0.16	0.10
Partial R^2	0.13	0.13	0.13
F	6.45	6.40	6.40
F, P -value	0.00	0.00	0.00
First-stage tr_{-2}			
Shea partial R^2	0.21	0.24	0.28
Partial R^2	0.17	0.19	0.19
F	8.81	10.67	10.67
F, P -value	0.00	0.00	0.00
First-stage $tr_{-2} \times \ln y^{*-1}$			
Shea partial R^2			0.08
Partial R^2			0.10
F			4.94
F, P -value			0.00
df	6	6	6
df_r	267	265	265
Observations	304	304	304
Number of group (code sector)	28	28	28
Sargan statistics	4.78	5.05	1.48
Sargan P -value	0.31	0.28	0.69
F -value	4.98	5.35	2.38
Fdf1	267	265	265

Table 8. (cont) First difference of log of labour productivity, error correction model – IV estimation

Dependent variable	<u>1</u>	<u>2</u>	<u>3</u>
	$d \ln y$	$d \ln y$	$d \ln y$
Fdf2	6	6	6
R^2 centred	0.02	-0.01	0.05

Notes: Instruments are as shown in Table 1. All are included in second and third lag. Standard errors in brackets. *Significant at 10%; **significant at 5%; ***significant at 1%. All estimations include one period lagged and contemporary first differenced capacity utilization as control variables. df and df_r give the degrees of freedom in the *F*-test for the instruments' prediction power in the first stage. These numbers are the same for all first stages within the same column.

include different lags with both sectoral and year fixed effects. Exclusion of time dummies, shown in column 3 and 4, does not change the results.¹⁰

5. Conclusion

We have evaluated the effect of tariff policy on labour productivity in industrial sectors in South Africa using the sectoral tariffs of other countries as instruments. Tariff liberalization in South Africa has been part of a multilateral process, and other countries' sectoral tariff developments work as good predictors of tariffs in South Africa. In this way, we circumvent the methodological challenge of tariff policy endogeneity in estimating the tariff effect on productivity.

The industrial sectors in South Africa have generally experienced increasing labour productivities during the period investigated, 1988–2003. Our analysis confirms that productivity growth has been linked to tariff reductions. Instrumented tariff changes are significantly related to industrial labour productivity growth. It should be noticed that the dataset covers both increases and decreases of sectoral tariffs and both improvements and setbacks in sectoral labour productivities.

In extensions of the analysis, we have investigated whether the trade liberalization effects are related to international technology spillover and competitive pressure. We find some support for the importance of the world technology frontier (represented by labour productivity in US industries) and we estimate a positive

¹⁰ In Table 5, the Sargan test is significant and it may point to invalid exclusion of the instruments from the second stage. Given our other results, a strict interpretation could be that labour productivity in the US is affected by the tariff levels in these countries. We are interested in South Africa's catch up to the frontier and we interpret the results of Table 5 to be consistent with our overall findings.

Table 9. Relative productivity – IV estimation

Dependent variable	1	2	3	4
	y/y^*	y/y^*	y/y^*	y/y^*
Second stage				
tr-1	-1.242*** (0.403)	0.386 (0.783)	-0.771*** (0.186)	-0.006 (0.378)
tr-2		-1.881** (0.743)		-1.030** (0.438)
Year FE	Yes	Yes	No	No
Sector FE	Yes	Yes	Yes	Yes
First-stage tr-1				
Shea partial R^2	0.10	0.06	0.29	0.15
Partial R^2	0.10	0.10	0.29	0.29
F	4.95	4.95	18.15	18.15
F, P -value	0.00	0.00	0.00	0.00
First-stage tr-2				
Shea partial R^2		0.05		0.10
Partial R^2		0.10		0.20
F		4.71		11.02
F, P -value		0.00		0.00
df	6	6	6	6
df_r	260	260	270	270
Observations	305	305	305	305
Number of group (code sector)	28	28	28	28
Sargan statistics	65.78	46.77	77.33	65.51
Sargan P -value	0.00	0.00	0.00	0.00
F -value	4.95	2.28	18.15	5.04
$Fdf1$	260	260	270	270
$Fdf2$	6	6	6	6

Notes: Instruments are as shown in Table 1. All are included in second and third lag. Standard errors in parentheses. *Significant at 10%; **significant at 5%; ***significant at 1%. All estimations include contemporary capacity utilization as control variable. df and df_r give the degrees of freedom in the F -test for the instruments' prediction power in the first stage. These numbers are the same for all first stages within the same column.

relationship between tariffs and the price–cost margin of South African industries. The results indicate that both spillover and competition may be at work. It is challenging to identify channels through which the effects of trade liberalization and domestic factors affect the consequences of reduced tariffs because of endogeneity. Future research should develop the understanding of the interplay between international and domestic factors in productivity growth.

References

- Aghion, P. and Howitt, P. (2005). 'Joseph Schumpeter Lecture Appropriate Growth Policy: A unifying framework', *Journal of the European Economic Association*, 4(2–3), pp. 269–314.
- Aghion, P., Braun, M. and Fedderke, J. (2008a). 'Competition and productivity growth in South Africa', *Economics of Transition*, 16(4), pp. 741–768.
- Aghion, P., Fedderke, J., Howitt, P., Kularatne, C. and Vieg, N. (2008b). *Testing Creative Destruction in an Opening Economy: The Case of South African Industries*, Mimeo, Cambridge, MA: Department of Economics, Harvard University.
- Amiti, M. and Konings, J. (2007). 'Trade liberalization, intermediate inputs, and productivity: Evidence from Indonesia', *American Economic Review*, 97(5), pp. 1611–1638.
- Benhabib, J. and Spiegel, M. M. (2005). 'Human capital and technology diffusion', in: Aghion, P. and Durlauf, S. (eds), *Handbook of Economic Growth, Edition 1, Vol. 1A*, Amsterdam: North-Holland, pp. 935–966.
- Besley, T. and Case, A. (2000). 'Unnatural experiments? Estimating the incidence of endogenous policies', *Economic Journal*, 110, pp. F672–F694.
- Caselli, F. and Coleman, W. (2006). 'The world technology frontier', *American Economic Review*, 96(3), pp. 499–522.
- Edwards, L. (2005). 'Has South Africa liberalized its trade?' *South African Journal of Economics*, 73(4), pp. 754–775.
- Edwards, L. and Lawrence, R. (2008). 'South African trade policy matters: Trade performance and trade policy', *Economics of Transition*, 16(4), pp. 585–608.
- Fernandes, A. (2007). 'Trade policy, trade volumes, and plant-level productivity in Colombian manufacturing industries', *Journal of International Economics*, 71(1), pp. 52–71.
- Ferreira, P. and Facchini, G. (2005). 'Trade liberalization and industrial concentration: Evidence from Brazil', *Quarterly Review of Economics and Finance*, 45, pp. 432–446.
- Ferreira, P. C. and Rossi, J. L. (2003). 'New evidence from Brazil on trade liberalization and productivity growth', *International Economic Review*, 44(4), pp. 1383–1405.
- Gerschenkron, A. (1962). *Economic Backwardness in Historical Perspective*, Cambridge, MA: Belknap Press of Harvard University Press.
- Griffith, R., Redding, S. and Van Reenen, J. (2004). 'Mapping the two faces of R&D productivity growth in a panel of OECD industries', *Review of Economics and Statistics*, 86(4), pp. 883–895.
- Harding, T. and Rattso, J. (2009). *Learning Abroad, but Lagging Behind: How the World Technology Frontier Affects South Africa*, mimeo, Oxford: University of Oxford and NTNU.
- Karacaovali, B. (2006). 'Productivity matters for trade policy: Theory and evidence', *World Bank Research Working Paper 3925*, Washington, DC: The World Bank.
- Klenow, P. and Rodriguez-Clare, A. (2005). 'Externalities and growth', Ch. 11 in Aghion, P. and Durlauf, S. (eds), *Handbook of Economic Growth*, Ed. 1, Vol. 1A, Amsterdam: North Holland, pp. 817–861.
- Muendler, N. (2004). *Trade, Technology and Productivity: A Study of Brazilian Manufacturers 1986–1998*, mimeo, San Diego: University of California at San Diego.
- Nelson, R. and Phelps, E. (1966). 'Investment in humans, technology diffusion and economic growth', *American Economic Review*, Papers and Proceedings, 56, pp. 69–75.
- Nicita, A. and Olarreaga, M. (2006). 'Trade, production and protection 1976–2004', *World Bank Economic Review*, 21(1), pp. 165–171.
- Pavcnik, N. (2002). 'Trade liberalization, exit, and productivity improvements: Evidence from Chilean plants', *Review of Economic Studies*, 69, pp. 245–276.

- Rattso, J. and Stokke, H. E. (2003). 'Learning and foreign technology spillovers in Thailand', *Nordic Journal of Political Economy*, 29(1), pp. 47–66.
- Rodrik, D. (1995). 'Political economy of trade policy', in Grossman, G. and Rogoff, K. (eds), *Handbook of International Economics*, Vol. 3, Amsterdam: Elsevier, pp. 1457–1494.
- Romalis, J. (2007). 'Market access, openness and growth', *NBER Working Paper 13048*, Cambridge, MA: National Bureau of Economic Research.
- Shea, J. S. (1996). 'Instrument relevance in multivariate linear models: A simple measure', *NBER Working Paper, T0193*, Cambridge, MA: NBER.
- TIPS (2004). 'SA standard industry database'. Tech. Rep., Trade and Industrial Policy Strategies. Last accessed: August 2004.
- Trefler, D. (2004). 'The long and short run of the Canada – U.S. free trade agreement', *American Economic Review*, 94(4), pp. 870–895.
- Vandenbussche, J., Aghion, P. and Meghir, C. (2006). 'Growth, distance to the frontier and composition of human capital', *Journal of Economic Growth*, 11, pp. 97–127.

Appendix A

Table A1. Descriptive statistics

Variable	No. of observations	Mean	SD	Min	Max
y	305	0.14	0.15	0.02	0.83
$\ln y$	305	-2.39	0.83	-3.88	-0.19
$d \ln y$	305	0.04	0.10	-0.40	0.50
y^{*-2}	305	0.95	1.42	0.23	12.46
$\ln y^{*-2}$	305	-0.34	0.59	-1.47	2.52
$d \ln y^{*-2}$	305	0.02	0.17	-2.59	0.43
tr-1	305	0.14	0.12	0.00	0.74
tr-1 $\times \ln y^{*-2}$	305	-0.05	0.21	-0.91	1.21
tr-2 LAC	305	0.14	0.05	0.06	0.38
tr-2 MENA	305	0.34	0.15	0.13	1.21
tr-2 SA	305	0.27	0.32	0.03	2.28
tr-3 LAC	305	0.17	0.10	0.06	0.85
tr-3 MENA	305	0.34	0.15	0.13	1.21
tr-3 SA	305	0.29	0.33	0.05	2.28
x	305	2,523.38	2,999.00	22.16	16,090.77
$\ln x$	305	7.16	1.27	3.10	9.69
PCM1	305	0.16	0.09	-0.07	0.42

Notes: The sample corresponds to Table 2. tr-X means average applied tariffs among lower middle-income countries in the particular region. The regions, defined as World Bank regions as of July 2006, are: LAC (Latin America and the Caribbean), MENA (Middle East and North Africa) and SA (South Asia). X denotes the number of lags. Scale: average tr-1 is 14%, average y is 140,000 1995 Rands per worker, average y^* is 95,000 2000 USD per worker.

Table A2. Sector concordances

SA code	SA name	ISIC Rev. 2 code	ISIC Rev. 2 name	SIC87 code	SIC87 name
12101	Food (301–304)	311	Food products	20	Food and kindred products
12102	Beverages (305)	313	Beverages	20	Food and kindred products
12103	Tobacco (306)	314	Tobacco	21	Tobacco products
12111	Textiles (311–312)	321	Textiles	22	Textile mill products
12112	Wearing apparel (313–315)	322	Wearing apparel except footwear	23	Apparel and other textile products
12113	Leather & leather products (316)	323	Leather products	31	Leather and leather products
12114	Footwear (317)	324	Footwear except rubber or plastic	31	Leather and leather products
12121	Wood & wood products (321–322)	331	Wood products except furniture	24	Lumber and wood products
12122	Paper & paper products (323)	341	Paper and products	26	Paper and allied products
12123	Printing, publishing & recorded media (324–326)	342	Printing and publishing	27	Printing and publishing
12131	Coke & refined petroleum products (331–333)*	353	Petroleum refineries	29	Petroleum and coal products
12132	Basic chemicals (334)	351	Industrial chemicals	28	Chemicals and allied products
12133	Other chemicals & man-made fibres (335–336)	352	Other chemicals	28	Chemicals and allied products
12134	Rubber products (337)	355	Rubber products	30	Rubber and miscellaneous plastics products
12135	Plastic products (338)	356	Plastic products	30	Rubber and miscellaneous plastics products

Table A2. (cont) Sector concordances

SA code	SA name	ISIC Rev. 2 code	ISIC Rev. 2 name	SIC87 code	SIC87 name
12141	Glass & glass products (341)	362	Glass and products	32	Stone, clay, and glass products
12142	Non-metallic minerals (342)†	369	Other non-metallic mineral products	32	Stone, clay, and glass products
12151	Basic iron & steel (351)	371	Iron and steel	33	Primary metal industries
12152	Basic non-ferrous metals (352)	372	Non-ferrous metals	33	Primary metal industries
12153	Metal products excluding machinery (353–355)	381	Fabricated metal products	34	Fabricated metal products
12154	Machinery & equipment (356–359)	382	Machinery except electrical	35	Machinery, except electrical
12160	Electrical machinery (361–366)	383	Machinery electric	36	Electric and electronic equipment
12171	Television, radio & communication equipment (371–373)	383	Machinery electric	36	Electric and electronic equipment
12172	Professional & scientific equipment (374–376)	385	Professional and scientific equipment	38	Instruments and related products
12181	Motor vehicles, parts and accessories (381–383)	384	Transport equipment	37	Motor vehicles and equipment
12182	Other transport equipment (384–387)	384	Transport equipment	37	Other transportation equipment

Table A2. (cont) Sector concordances

SA code	SA name	ISIC Rev. 2 code	ISIC Rev. 2 name	SIC87 code	SIC87 name
12191	Furniture (391)	332	Furniture except metal	25	Furniture and fixtures
12193	Other industries (392)	390	Other manufactured products	39	Miscellaneous manufacturing industries

Notes: Data on tariffs are classified according to ISIC Rev. 2, while Bureau of Economic Analysis data necessary for calculating labour productivity in the US were merged in according to the SIC87 classification.

*Represented by 353 rather than 354, since 353 is the largest (more than ten times the output).

†Represented by 369 rather than 361 since 369 is the largest (more than six times the number of employees).