

Trade, Technology and Wage Inequality: A Dynamic Panel Data Approach to the South African Manufacturing Sectors*

Johannes Fedderke, ERSA, University of the Witwatersrand
Yongcheol Shin, Department of Economics, University of Edinburgh
Prabhat Vaze, ERSA, University of the Witwatersrand

This Version: September, 2001

Abstract

ABSTRACT: This paper advances on previous works on the effects of trade and technical change on labour markets within the framework of Heckscher-Ohlin trade theory. *First*, we employ dynamic heterogeneous panel estimation techniques not previously used in this context. *Second*, we consider evidence from a middle income country with abundant unskilled labor. For South African manufacturing we find that output prices increase most strongly in sectors that are labor intensive; that trade has mandated positive earnings increases for both labor and capital, though increases are greater for labour; and that technology has mandated negative earnings increases for both labor and capital. Given these results, growth of real wage rates are a plausible explanation of the high and sustained levels of unemployment in South African labor markets.

JEL Classification: C23, C33, F16.

Key Words: Trade, Total Factor Productivity, Stolper-Samuelson Theorem, Mandated Factor Earnings Changes, Dynamic Heterogeneous Panel

*We would like to thank the Trade & Industry Policy Secretariat for making available the data that made this project possible. The South African National Treasury, and USAID provided financial assistance for the project. The second author also gratefully acknowledges partial financial support from the ESRC (grant No. R000223399). We are grateful to an editor and two anonymous referees, Stephen Hall, David Hendry, Merle Holden, Ravi Kanbur, Richard Ketley, Chris Loewald, Marc Nerlove, Adrian Wood and Robert Wright for valuable and helpful comments. Views expressed in the paper should not be taken to reflect the views of the institutions that provided data and financial assistance for the project. The usual disclaimer applies.

1 Introduction

Recent experience in many industrialized countries has seen a large fall in the level of employment amongst the unskilled at the same time as employment of skilled labor has risen. Wage levels for the skilled workers have also risen in relation to those of the unskilled. Both factors have resulted in rising wage inequality. Two considerations have been given for this phenomenon: skill-biased technological improvement and increased international competition. The rapidly expanding interest in examining the impact of trade on labor markets has focused predominantly on developed country contexts. Trade with less developed countries endowed with an abundance of unskilled labor has been advanced as one possible explanation for rising wage inequality, consistent with the Stolper-Samuelson theorem. See for example Borjas and Freeman (1992), Wood (1994), Baldwin and Cain (1997), Leamer (1998), Feenstra and Hanson (1999), Slaughter (2000) and Haskel and Slaughter (2001).

In recent years many developing countries have liberalized their trade regime. One expectation of Heckscher-Ohlin trade theory is that strongest product price changes should occur in sectors using the abundant factor of production. Empirical validity of this impact would potentially carry important welfare implications for the developing world since in terms of the Stolper-Samuelson theorem the corollary of output price changes is that they come to be translated into changes in the earnings of abundant factors of production. Empirical evidence on developing country contexts is currently more limited than for developed countries (though see Wood (1994)). This paper redresses this imbalance and examines the impact of trade liberalization on South Africa's labor markets.

We note two qualifications that might apply to the empirical application of the Stolper-Samuelson theorem. *First*, the theorem is less conclusive about the effect of increased trade openness on middle income countries, which are likely to share characteristics with both developed and with less developed countries. Perhaps one implication is that the impact of trade liberalization is likely to be sectorally specific: depending on whether trade of the middle income country is dominated by exchange with developed or less developed economies. Ready predictions of changing factor usage patterns for middle income countries thus remain more ambiguous than for the more extreme examples afforded by a comparison of the industrialized and less developed countries. *Second*, while trade liberalization can be plausibly linked to a labor market impact, it is not the only possible reason for price and demand changes in labor markets. Changes in the pattern of wages and employment may also reflect the impact of skill-biased technological change. See Leamer (1998) and Feenstra and Hanson (1999) for further discussion.

The paper represents an advance on the previous debate in at least two senses. *First*, while some earlier studies employed panel data techniques (*e.g.*, Sachs and Shatz, 1994, and Hine and Wright, 1998), estimation allowed neither for dynamics nor for the possibility of panel heterogeneity beyond fixed effects. In the present paper we use dynamic heterogeneous panel estimation techniques proposed by Pesaran, Shin and Smith (1999) that allow for both dynamics across time periods and a reasonable amount of heterogeneity across cross-sectional units. In particular, this approach allows us to investigate both (possibly homogenous) long-run relationship and (possibly heterogenous) short-run dynamic adjustment towards equilibrium simultaneously. Considering that the Stolper-Samuelson theorem tends to hold

in the long-run but may deviate from its equilibrium path over the short-run, our suggested approach is likely to address the theoretical underpinning more clearly than the earlier approach based on a static model.

The *second* sense in which this paper represents a departure is that the choice of South African labor markets introduces a middle-income country into the debate on the validity of the Stolper-Samuelson theorem. Indeed, a number of considerations make South Africa an interesting test case in the context of debates surrounding trade impacts on labor markets. In the first instance relatively detailed sectoral data on the tradeable sector of the economy (manufacturing) is available over a protracted time run (1970-97). In the second instance South Africa offers an interesting opportunity to study the impact of trade liberalization on a less developed country precisely because its international isolation meant trade with the North dominated any trade with other developing countries, see Fedderke and Vaze (2001) for details. Although in general we might expect trade effects on middle income countries to be ambiguous, in the case of South Africa we are offered a natural experiment allowing us to establish the effect of trade liberalization on a country with a relative abundance of unskilled labor relative to its trading partners.¹

For South African manufacturing we find that output prices increase most strongly in sectors that are labor intensive and unskilled labor intensive, consistent with the prediction of the Stolper-Samuelson theorem and Heckscher-Ohlin trade theory. Therefore, our results are consistent with those reported for developed countries which have suggested that trade has contributed toward widening wage inequality in the North. But, in the South African context, consistent with its developing country status relative to the North, the implication is of narrowing wage and factor return inequality. Our results further suggest that trade-mandated earnings increases are positive for both labor and capital, though the increase is stronger for the former. By contrast technology has mandated negative earnings increases for both factors. In general, the identification problem associated with establishing the reason for product price changes makes it impossible to suggest that our evidence provides conclusive proof that trade liberalization in South Africa has had a positive impact on domestic labor markets. Evidence in favor of technology pass-through seems to be weak in South African manufacturing. This is a plausible finding for a small open economy such as South Africa. Since such economies are effectively world price takers the impact of technological progress would be absorbed by producers and not translated into price changes. Hence all our results are consistent with declining inequality in the labor market. To this extent therefore the current study provides support to developed country studies suggesting that the impact of trade has been to shift unskilled labor intensive production to the developing world.

The layout of the paper is as follows. Section 2 provides a brief overview of previous studies into the link between trade and labor markets, and summarizes some of the findings relevant to the present study. Section 3 provides the dynamic panel data estimation methodology used in the paper. Section 4 presents an empirical examination of trade effects on South African labor markets, using annual sectoral manufacturing data over 1970-1997. Subsection

¹Wood (1997, 2000) points out that five countries in East and South Asia contribute more than 50% of the world supply of unskilled labour. The implication for other developing countries is that they may in fact be relatively skills abundant. If so trade liberalization may widen wage inequality. The focus of South African trade on developed countries is thus fortunate in ameliorating this impact.

4.1 describes the data (further details are presented in a Data Appendix). Subsections 4.2 and 4.3 provide the detailed estimation results. Section 5 concludes.

2 Overview of the Trade and Labor Debate

The empirical work on the impact of trade on labor markets has concentrated on developed countries. In Europe and the US, growing unemployment amongst the unskilled and rising wage inequality between the skilled and the unskilled led some to attribute the phenomenon to increased trade liberalization. The fear was that unskilled jobs were going to low-wage economies as a result of the lifting of trade barriers. Such an argument is plausible in terms of Heckscher-Ohlin (henceforth HO) trade theory. In the simplest case, skilled and unskilled labor are two factors of production, with developed countries showing a comparative advantage in skills-intensive goods due to greater relative supplies of skilled labor, while developing countries have a comparative advantage in labor-intensive goods due to greater relative supply of unskilled labor. Removal of trade barriers would strengthen the impact of comparative advantage, with developed countries experiencing contraction in unskilled labor intensive sectors, and expansion in skilled labor intensive sectors, leading to widening inequality in the labor market.² This migration of jobs thesis would have quite different implications for a less developed country. For poorer countries, the situation for unskilled labor should be reversed, with the position of the unskilled laborer improving with liberalization. By contrast for skilled labor in developing countries, the premium extracted by their scarcity is put at risk as developing countries increasingly import skilled labor intensive products from the developed countries, thus lowering wage inequality. A useful summary of the state of the debate within developed countries can be found in Slaughter (2000).

However, testing these implications of HO trade theory is not a trivial task. As a consequence empirical modeling has provided checks on whether changes in labor markets are *consistent* with the predictions of trade theory, rather than proof that the changes in labor markets are the consequence of trade liberalization. At the heart of the HO story lies an interaction of the Heckscher-Ohlin and the Stolper-Samuelson theorems (hereafter SST), providing the comparative advantage induced relative shift in demand and the change in relative factor price components of the tale respectively. Yet as Deardorff (1994) has pointed out the SST has assumed at least six different formulations. Only two of these mention international trade at all, which Deardorff terms the *general* and the *restrictive* versions. The reason for this is that the essence of the SST is the existence of a link between product and factor price changes. This makes clear the difficulty of directly testing HO trade theory, since domestic product price changes can be brought about by many factors, and cannot be exclusively attributed to international trade. Isolating the impact of international trade is thus difficult, particularly so since international trade is likely to be an endogenous outcome of differences in tastes, technology, endowments, domestic and international barriers to trade.

²An alternative Heckscher-Ohlin story would not rely on the lowering of protection, but instead posit a strong expansion of world production of unskilled-labour intensive goods, driving down world prices in unskilled labour intensive sectors and hence the factor reward for unskilled labour.

A further difficulty in testing the validity of HO trade theory concerns dimensionality. The predicted impact of trade liberalization on skilled and unskilled labor is couched in a two-factor-two-product world. While an instructive simplification, the result does not generalize unambiguously to multi-factor and multi-product contexts (see the discussion in Jones and Schenkman (1977), Ethier (1984) and Leamer (1998)). For this reason the most prevalent test of the trade impact on labor markets has adopted what Deardorff terms the *correlation version* of the SST, which relates any vector of relative product price changes to relative factor price changes. It predicts that *on average* factors used intensively in rising (falling) price industries will experience relative price increases (declines).³

But again, the correlation version of the SST provides no more than a consistency check of the trade theory since the source of product price changes remains difficult to unambiguously associate with trade effects. Moreover, empirical application has frequently linked product price changes to factor proportions rather than relative factor price changes. Thus for industrialized countries, a common check is whether observed price changes of unskilled labor intensive goods after liberalization are consistent with factor scarcity, *i.e.* whether unskilled labor intensive product prices fell. A typical regression specification is given by⁴

$$\hat{p}_i = \alpha_i + \theta_i \left(\frac{NPW_i}{PW_i} \right) + \varepsilon_i, \quad i = 1, 2, \dots, N, \quad (2.1)$$

where \hat{p}_i denotes the percentage change in product prices of sector i ,⁵ NPW non-production workers (a proxy for skilled workers), PW production workers (a proxy for unskilled workers), α_i intercept(s) and ε_i underlying errors. For example, Lawrence and Slaughter (1993) have found non-positive estimates of θ_i and interpreted this result as evidence against the prediction of SST for developed countries.

The first difficulty with this simple consistency check is that in order to be interpreted as a test of the impact of international trade, it must assume all domestic prices to be exogenously set internationally. Only by arguing that for a small economy domestic industries are international price takers can all domestic price changes be argued to be the outcome of trade-induced changes. The assumption is legitimate only if tariff changes are not altering the wedge between domestic and international prices, and only as long as we ignore the impact of technological progress, particularly its industry and factor specific impacts.⁶ Yet there is no *a priori* reason to suppose that technological progress will be factor-neutral. Where technological progress is not so neutral, the prior expectation must be that relative factor productivity and hence factor prices would reflect its shift.

One response to the ambiguity introduced by technological change has been to control directly for some readily identifiable technological changes, see Sachs and Shatz (1994).

³The *friends and enemies* version of SST would generalize into multi-dimensional contexts. It has found less favour in empirical application since it focuses on price changes of a single factor of production only.

⁴As argued by Haskel and Slaughter (2001), however, this specification does not follow from the HO model as closely as the mandated regression specification discussed below.

⁵Throughout this section we employ the notation, $\hat{x} = \frac{dx}{x}$.

⁶Some authors abandon the HO framework entirely. Feenstra and Hanson (1995) employ a Ricardian framework instead, allowing them to drop the assumption that all countries are in the same cone of diversification. Others extend the HO framework to incorporate the process of technological know-how, see Wood (1997), Wood and Riddo-Cano (1999) and Tang and Wood (2000).

Applying similar arguments to (2.1) we can also specify the *TFP* augmented consistency check specification as follows:

$$\widehat{p}_i = \alpha_i + \theta_i \left(\frac{NPW_i}{PW_i} \right) - \widehat{TFP}_i + \varepsilon_i \quad i = 1, 2, \dots, N. \quad (2.2)$$

A more informative method would allow for the impact of technological change on sounder theoretical foundations, as proposed by Leamer (1998). Recall that typically the Stolper-Samuelson result is founded on the set of sectoral zero profit conditions,

$$\mathbf{p} = \mathbf{A}\mathbf{w}, \quad (2.3)$$

where \mathbf{p} denotes the $N \times 1$ vector of (domestic) product prices, \mathbf{w} the $J \times 1$ vector of (domestic) factor prices, and $\mathbf{A} = \{A_{ij}\}_{i=1, \dots, N; j=1, \dots, J}$ the $N \times J$ matrix of input intensities.⁷ The input intensity of factor j in sector i is given by $A_{ij} = v_{ij}/Q_i$, where v_{ij} denotes j -th factor input quantity in sector i and Q_i output in sector i . Typically, we might have the following relationship:

$$\widehat{p}_i = \mathbf{s}'_i \widehat{\mathbf{w}}, \quad i = 1, 2, \dots, N, \quad (2.4)$$

where $\mathbf{s}_i = (s_{i1}, \dots, s_{iJ})'$ is the $J \times 1$ vector of factor cost shares of sector i and $s_{ij} = \frac{A_{ij}w_j}{p_i}$ is the share of factor j in the average unit cost of product i . (2.4) allows for estimation of changes in factor prices $\widehat{\mathbf{w}}$ that are deemed *mandated* (*viz.* required to maintain the zero profit condition) as the factor share coefficient. This allows for a comparison of mandated with actual factor price changes. Where mandated changes adequately conform to actual factor price changes, the SST is deemed to provide an accurate explanation of factor price trends.⁸

However, in both specification (2.1) and (2.4) no attempt is made to control explicitly for the impact of technological change.⁹ Leamer (1998) demonstrates the importance of explicitly introducing technological improvements in mandated factor share estimations. Differentiation of the zero profit condition (2.3) combined with the standard measurement of growth in total factor productivity (hereafter *TFP*) results in¹⁰

$$\widehat{p}_i = \mathbf{s}'_i \widehat{\mathbf{w}} - \widehat{TFP}_i, \quad i = 1, 2, \dots, N. \quad (2.5)$$

⁷The zero profit conditions imply a systematic relationship between the set of product prices facing producers, and the set of factor prices paid by producers. One means of ensuring this is by assuming perfectly competitive product markets. Under these conditions, price would be equal to average cost. But a systematic link is also possible under conditions of imperfect competition, as long as a fixed positive price-cost markup applies. A third option is monopolistic competition, in which sufficient entry ensures zero equilibrium profits.

⁸This approach, called the mandated regression or the price regression, has been used by Baldwin and Hilton (1984), Baldwin and Cain (1997), Krueger (1997) and Leamer (1998). The mandated wage regressions are odd in the sense that the explanatory variable serves as the regressand rather than regressor. This is because the dimensionality of the data prevents inversion of the $N \times J$ matrix of factor cost shares, \mathbf{S} .

⁹Sachs and Shatz (1994) found the factor usage changes predicted by the SST once the impact of technological change was controlled for. But they use a very simple device to control for the impact of technological progress, adding a dummy for computer technology in (2.1).

¹⁰The assumption of HO theory that technology is an international public good is potentially questionable for developing countries. However, the assumption may be reasonable for South Africa, since it has available not only a relatively large stock of know-how, but the flow of skilled people passing on know-how is also likely to have increased with the end of Apartheid.

Notice, however, that (2.5) implicitly contains two potentially serious limitations. *First*, it carries the implication that factor-biased technological change is entirely irrelevant, and that instead only the sectoral distribution of \widehat{TFP}_i matters.¹¹ *Second*, it entails an under-identification problem, because it does not allow for the separation of factor price changes due to trade (and other) factors, and those due to TFP growth. In effect we have:

$$\widehat{p}_i(t) = \mathbf{s}'_i \widehat{\mathbf{w}}(t) - \widehat{TFP}_i \quad \text{and} \quad \widehat{p}_i(g) = \mathbf{s}'_i \widehat{\mathbf{w}}(g), \quad (2.6)$$

where $\widehat{p}_i(t)$ captures the technology effect and $\widehat{p}_i(g)$ the globalization (trade) effect.¹² Therefore,

$$\widehat{p}_i = \widehat{p}_i(t) + \widehat{p}_i(g) = \mathbf{s}'_i \widehat{\mathbf{w}}(t) + \mathbf{s}'_i \widehat{\mathbf{w}}(g) - \widehat{TFP}_i, \quad i = 1, 2, \dots, N, \quad (2.7)$$

The underidentification problem arises due to the fact that many possible trade effects are consistent with (2.7). The only complete resolution requires the provision of a model of demand and supply conditions for the world. A more manageable alternative would be to assume that all sectors have a single common pass-through rate of technological progress to product prices, such that $\widehat{p}_i(t) = -\lambda \widehat{TFP}_i$, with λ the common pass-through rate. This also implies that factor biased technological change does not induce sectorally biased factor price changes.¹³ Another complication is that output price reduction would be particularly strong in sectors using the technology-improving sectors' outputs as inputs, which requires the separation of pass-through to final goods prices and the indirect effect on intermediate inputs - requiring a consideration of the full input-output linkages in a strict sense. An alternative is once again to invoke a simplifying assumption that TFP improvements not only have a common pass-through, but that they apply to value-added prices. Then we have

$$\widehat{p}_i(t) - \boldsymbol{\gamma}' \widehat{\mathbf{p}}(t) = -\lambda \widehat{TFP}_i, \quad (2.8)$$

with $\boldsymbol{\gamma}$ and $\widehat{\mathbf{p}}(t)$ denoting respectively a vector of intermediate input shares and a vector of product price changes (due to the technology effect), such that $\widehat{p}_i(t) - \boldsymbol{\gamma}' \widehat{\mathbf{p}}(t)$ denotes value-added product price change of sector i . Factor price changes can now be separated into those due to technology:

$$(1 - \lambda) \widehat{TFP}_i = \mathbf{s}'_i \widehat{\mathbf{w}}(t), \quad (2.9)$$

and those due to trade liberalization:

$$\widehat{p}_i + \lambda \widehat{TFP}_i = \mathbf{s}'_i \widehat{\mathbf{w}}(g) + \boldsymbol{\gamma}'_i \widehat{\mathbf{p}}. \quad (2.10)$$

Thus, the identification problem can be resolved under the assumption of common pass-through applying to value-added prices. Note that the changes mandated by trade liberalization are the factor price changes required to maintain the zero-profit condition after

¹¹Where factor-biased TFP growth induces sector-biased price changes, second-order effects allowing for the interaction of factor intensity and factor price become relevant. The difficulty is that the second order effects introduce endogeneity of the factor intensities. The approach outlined assumes these effects away.

¹²In what follows we separate product price changes into those mandated by technology, and those mandated by what Leamer termed *globalization*. Globalization-related changes should be seen as the endogenous outcome of international differences in tastes, endowments, and barriers to trade amongst others. Thus both trade and product price changes are simultaneously brought about.

¹³One circumstance in which this is justified, would be where nontradeable demand is elastic, and capable of absorbing factors released due to technological change without necessitating change in the prices of tradeables.

accounting for the impact of technology. Hence the identification problem of associating product price changes with trade liberalization effects remains, and the Leamer specification remains a *consistency check* rather than a direct empirical test of the SST.¹⁴

Most of the empirical results based on the product price effects do not clearly support SST (*e.g.*, Bhagwati (1991), Lawrence and Slaughter (1993)), though explicit incorporation of technological progress through TFP improvements lead to results consistent with SST, see Baldwin and Cain (1997), Krueger (1997), Leamer (1998), and Haskel and Slaughter (2001).¹⁵

Also outlined is an approach which attempts to isolate the direct labor requirements effect of trade liberalization on labor usage. Hine and Wright (1998) examine whether the source of imports into the UK explains sectoral labor demand shift. Their findings cannot support a hypothesis of job migration to less developed countries. A more detailed study of how trade with poor countries affects the developed countries is Wood (1994). This study uses a factor content of trade methodology, improving on previous similar studies by modelling the technology available to developing countries more realistically. Migration of labor is very high in Wood's results such that trade with developing countries implies a large loss of employment for the developed countries amongst their unskilled work force.

3 Econometric Methodology: Dynamic Heterogeneous Panel Data Approach

In this section we describe the main econometric tool used in the paper. *First of all*, it must be noted that the SST or its consistency versions described in the previous section tends to hold in the long-run but may deviate from its equilibrium path over the short-run. Even though the underlying economic theory is entirely silent on these issues, there is still a need for a detailed exploration of dynamics. Slaughter (2000) has pointed out the importance of this line of enquiry.

In this regard we express (2.1) or (2.4) as the following long-run equilibrium relationship:¹⁶

$$y_{it} = \boldsymbol{\theta}' \mathbf{x}_{it} + \varepsilon_{it}, \quad i = 1, 2, \dots, N, \quad t = 1, 2, \dots, T, \quad (3.1)$$

where y_{it} is a scalar dependent variable for sector i at time t , \mathbf{x}_{it} is the $k \times 1$ vector of regressors for sector i at time t , and ε_{it} is the underlying random disturbance. For example, y_{it} is product price change, and \mathbf{x}_{it} includes the ratio of skilled to unskilled labor or the factor shares for labor and capital or the growth of total factor productivity. The ε_{it} 's of

¹⁴Recently, some progress has been made to deal with issues of endogeneity. See Feenstra and Hanson (1999) and Haskel and Slaughter (2001).

¹⁵However, the findings are mixed considering different time periods investigated. Baldwin and Cain (1997) and Leamer (1998) found that the SST consistent results for the US were stronger during the 1970's than during the 1980's. Krueger (1997) extends this finding to the 1990's. Haskel and Slaughter (2001) find similar results for the UK in the 1980s.

¹⁶The long-run parameter vector $\boldsymbol{\theta}$ is more likely to be homogenous across sectors in the context of the mandated regression (2.4), because these parameters are interpreted as the economy-wide mandated changes in factor costs. See Haskel and Slaughter (2001). But, $\boldsymbol{\theta}$ would possibly be heterogenous in the consistency check specification (2.1).

(3.1) are likely to be subject to serial correlation, but the pattern of serial correlation is not necessarily homogenous across different sectors. The possibility of both serial correlation and heterogeneity raises further econometric issues, which will be dealt with explicitly below.¹⁷

Most empirical applications in the literature so far have been carried out by using the cross-section regression specification based on¹⁸

$$\bar{y}_i = \boldsymbol{\theta}' \bar{\mathbf{x}}_i + \bar{\varepsilon}_i, \quad i = 1, 2, \dots, N, \quad (3.2)$$

where $\bar{y}_i = T^{-1} \sum y_{it}$ and $\bar{\mathbf{x}}_i = T^{-1} \sum \mathbf{x}_{it}$. Alternatively, the static panel data technique based on either pooling or fixed effects has been applied to (3.1). Both approaches are unsatisfactory in the sense that no attempt has been made to accommodate heterogeneous dynamic adjustment of the long-run equilibrium relationship as described above.

We now provide an estimation approach that deals with these issues explicitly in the context of panel data, with which we hope to address the theoretical underpinnings more clearly than earlier approaches. The approach suggested here has the advantage of being able to accommodate both the long run equilibrium character of the SST results and its possibly heterogeneous dynamic adjustment process due to information and adjustment costs that may allow deviations to persist for some time. Another advantage of the proposed estimation approach is that theoretically congruent results are possible despite the estimation problems that have traditionally beset this literature.¹⁹

Embodying the long-run equilibrium relationship (3.1) in an otherwise unrestricted autoregressive distributed lag (ARDL) model for the levels of y and \mathbf{x} , and following Pesaran, Shin and Smith (1999), we base our panel analysis on the unrestricted error correction ARDL(p, q) representation:²⁰

$$\Delta y_{it} = \phi_i y_{i,t-1} + \boldsymbol{\beta}'_i \mathbf{x}_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \boldsymbol{\delta}'_{ij} \Delta \mathbf{x}_{i,t-j} + \mu_i + u_{it}, \quad (3.3)$$

$i = 1, 2, \dots, N$, and $t = 1, 2, \dots, T$. Here y_{it} is a scalar dependent variable, \mathbf{x}_{it} is the $k \times 1$ vector of (weakly exogenous) regressors for group i , μ_i represent the fixed effects, ϕ_i is a scalar coefficient on the lagged dependent variable, $\boldsymbol{\beta}'_i$'s is the $k \times 1$ vector of coefficients on explanatory variables, λ_{ij} 's are scalar coefficients on lagged first-differences of dependent variables, and $\boldsymbol{\delta}'_{ij}$'s are $k \times 1$ coefficient vectors on first-difference of explanatory variables and their lagged values. We assume that the disturbances u_{it} 's are independently distributed across i and t , with zero means and variances $\sigma_i^2 > 0$. Further assuming that $\phi_i < 0$ for all

¹⁷Economic theory is not likely to be informative in modelling the short-run dynamic as well as heterogeneous sectoral behavior. Thus, as is usually the case in the related empirical work, we do not formally derive dynamics.

¹⁸Alternative specifications are also suggested. For example, Leamer (1996) uses the following cross-section regression: $\bar{y}_i = \boldsymbol{\theta}' \mathbf{x}_{i1} + \bar{\varepsilon}_i$, $i = 1, 2, \dots, N$, where \mathbf{x}_{i1} 's are beginning-of-period observations.

¹⁹We recognize that much is left to be done if we are to fully understand the dynamic processes here. As mentioned in Leamer (1998), "we make two important mistakes when we analyze data, taking the theory too seriously and not taking the theory seriously enough." We hope that our current modelling approach provides a useful compromise and intermediate link between theory and estimation.

²⁰This is simply a transformed model of the ARDL for the levels of the variables. For details see Pesaran, Shin and Smith (2001).

i and thus there exists a long-run relationship between y_{it} and \mathbf{x}_{it} :

$$y_{it} = \boldsymbol{\theta}'_i \mathbf{x}_{it} + \eta_{it}, \quad i = 1, 2, \dots, N, \quad t = 1, 2, \dots, T, \quad (3.4)$$

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 (including fixed effects). Since (3.3) can be rewritten as

$$\Delta y_{it} = \phi_i \eta_{i,t-1} + \sum_{j=1}^{p-1} \lambda_{ij} \Delta y_{i,t-j} + \sum_{j=0}^{q-1} \boldsymbol{\delta}'_{ij} \Delta \mathbf{x}_{i,t-j} + \mu_i + u_{it}, \quad (3.5)$$

where $\eta_{i,t-1}$ is the error correction term given by (3.4), hence ϕ_i is the error correction coefficient measuring the speed of adjustment towards the long-run equilibrium.

Under this general framework Pesaran, Shin and Smith (1999) have advanced the Pooled Mean Group (PMG) estimator. This estimator allows the intercepts, short-run coefficients and error variances to differ freely across groups, but the long-run coefficients are constrained to be the same; that is, $\boldsymbol{\theta}_i = \boldsymbol{\theta}$ for all i . The group-specific short-run coefficients and the common long-run coefficients are computed by the pooled maximum likelihood estimation. These estimators are denoted by $\tilde{\phi}_i$, $\tilde{\boldsymbol{\beta}}_i$, $\tilde{\lambda}_{ij}$, $\tilde{\boldsymbol{\delta}}_{ij}$ and $\tilde{\boldsymbol{\theta}}$. We then obtain the PMG estimators by

$$\begin{aligned} \hat{\phi}_{PMG} &= \frac{\sum_{i=1}^N \tilde{\phi}_i}{N}, \quad \hat{\boldsymbol{\beta}}_{PMG} = \frac{\sum_{i=1}^N \tilde{\boldsymbol{\beta}}_i}{N}, \quad \hat{\lambda}_{jPMG} = \frac{\sum_{i=1}^N \tilde{\lambda}_{ij}}{N}, \quad j = 1, \dots, p-1, \\ \hat{\boldsymbol{\delta}}_{jPMG} &= \frac{\sum_{i=1}^N \tilde{\boldsymbol{\delta}}_{ij}}{N}, \quad j = 0, \dots, q-1, \quad \hat{\boldsymbol{\theta}}_{PMG} = \tilde{\boldsymbol{\theta}}. \end{aligned} \quad (3.6)$$

We also consider the two other dynamic panel estimation techniques. *First*, the dynamic fixed effects (DFE) model which imposes the homogeneity assumption for all of the parameters except for the fixed effects. The DFE estimates of all the short-run parameters are obtained by pooling and denoted by $\hat{\phi}_{DFE}$, $\hat{\boldsymbol{\beta}}_{DFE}$, $\hat{\lambda}_{jDFE}$, $\hat{\boldsymbol{\delta}}_{jDFE}$, and $\hat{\sigma}_{DFE}^2$. The estimate of the long-run coefficient is then obtained by

$$\hat{\boldsymbol{\theta}}_{DFE} = -(\hat{\boldsymbol{\beta}}_{DFE}/\hat{\phi}_{DFE}). \quad (3.7)$$

Secondly, the mean group (MG) estimates proposed by Pesaran and Smith (1995), which allows for heterogeneity of all the parameters and gives the following estimates of short-run and long-run parameters:

$$\begin{aligned} \hat{\phi}_{MG} &= \frac{\sum_{i=1}^N \hat{\phi}_i}{N}, \quad \hat{\boldsymbol{\beta}}_{MG} = \frac{\sum_{i=1}^N \hat{\boldsymbol{\beta}}_i}{N}, \quad \hat{\lambda}_{jMG} = \frac{\sum_{i=1}^N \hat{\lambda}_{ij}}{N}, \quad j = 1, \dots, p-1, \\ \hat{\boldsymbol{\delta}}_{jMG} &= \frac{\sum_{i=1}^N \hat{\boldsymbol{\delta}}_{ij}}{N}, \quad j = 0, \dots, q-1, \quad \hat{\boldsymbol{\theta}}_{MG} = N^{-1} \sum_{i=1}^N -(\hat{\boldsymbol{\beta}}_i/\hat{\phi}_i), \end{aligned} \quad (3.8)$$

where $\hat{\phi}_i$, $\hat{\boldsymbol{\beta}}_i$, $\hat{\lambda}_{ij}$ and $\hat{\boldsymbol{\delta}}_{ij}$ are the OLS estimates obtained individually from (3.3). We note in passing that the PMG estimation provides an intermediate case between the above two extreme cases, but also its modelling approach matches precisely with the underlying nature of the long-run equilibrium relationship described above.

We briefly discuss one additional important modelling issue. In principle, we need to choose between the alternative specifications. Tests of homogeneity of error variances and/or short- or long-run slope coefficients can be easily carried out using the Log-Likelihood Ratio tests, since the PMG and DFE estimators are restricted versions of all heterogeneous individual group equations. It is worth noting, however, that for most cross-country studies the Likelihood Ratio tests usually reject equality of error variances and/or slopes at conventional significance levels, though the finite sample performance of such tests are generally unknown and thus unreliable. An alternative would be to use Hausman (1978) type tests. The MG estimator provides consistent estimates of the mean of the long-run coefficients, though these will be inefficient if slope homogeneity holds. Under long-run slope homogeneity the PMG estimators are consistent and efficient. Therefore, the effect of both long-run and short-run heterogeneity on the means of the coefficients can be determined by the Hausman test (hereafter h test) applied to the difference between MG and PMG or DFE estimators. In this paper we will examine the extent of panel heterogeneity mainly in terms of the difference between MG and PMG estimates of long-run coefficients using the Hausman test.²¹

4 Empirical Results

The review of the existing literature outlined earlier points to a gap in current knowledge. In particular, research has been relatively quiet about trade effects on labor markets in developing countries. To analyze this, some reframing of the model specification is required. In a middle income or developing country, we argue that the skilled labor and unskilled labor dichotomy, while relevant, may be complemented by the capital-labor divide.²²

There is one practical issue in modelling and interpreting the empirical results: that is, the theory and the data analysis are entirely silent on the issues of timing over which the long-run equilibrium relationship is likely to hold. In fact, it could be argued that the mandated changes in factor returns may not be constant over time such that the product price changes favor labour in some periods and capital in others. This has been handled in the cross-section regression approach by simply splitting the samples into sub-time periods. For example, Leamer (1998) has applied the cross-section regression to the sub-period samples of 1960's, 1970's and 1980's, and found qualitatively different estimation results. See also Feenstra and Hanson (1999) and Haskel and Slaughter (2001). Although this is an empirically plausible approach, the selection of sub-period samples is clearly *ad hoc*. We take the stance that we are primarily interested in exploring both the long-run equilibrium character and the associated short-run dynamics. Hence, our suggestion here is that we require consideration

²¹A significant test result may suggest the adoption of a more pragmatic approach of dividing the total group of samples into sub-group samples, which differ in the strength of the relationship being estimated. Then, each sub-group's behavior can be compared with expectations of theory, and thus we would draw qualitatively different results for heterogenous sub-groups.

²²This is a minor adjustment in terms of the formal model and the empirical analysis can proceed with little modification. Usually we might argue that the mobility of capital would preclude anything but the world price of capital from applying. However, in South Africa the presence of capital controls has meant that this is unlikely to have been the case. On the nature and determinants of capital flows in South Africa see Fedderke (2001) and Fedderke and Liu (2001).

of as long a time run as is feasible instead of using only the arbitrary decade-long time runs employed by other studies.

4.1 The data

The original data set used in this paper is composed of a panel of the 28 three-digit SIC version 5 manufacturing sectors in the South African economy observed annually over the period 1970-97. Focus on the manufacturing sector rather than the whole industry sectors (48 three-digit SIC version 5 sectors) is mainly for two reasons. *Firstly*, manufacturing sectors are more likely to be appropriately understood as engaged in the production of tradeables. By contrast, at least some of the sectors included in the full economy panel - particularly services and the building and construction sectors - are unlikely to be engaged in the production of tradeables. *Secondly*, the reliability of consistent data definitions across manufacturing and other sectors is less assured than within manufacturing sectors, and with respect to some variables data is available only for the manufacturing sectors. For further details see Fedderke and Vaze (2001), and Fedderke *et al.* (2000, 2001).

This is a macro-type panel where both $T = 28$ and $N = 28$ are sufficiently large, which allows the use of dynamic panel techniques to estimate a long-run equilibrium relationship while at the same time modeling the short-run dynamics. The list of sectors included in the panel is specified in Table 1. For more details about the data employed see the data appendix.

Table 1 about here

4.2 Product price changes and factor proportions

In this first set of estimations, the change in the product price changes of each sector is modeled in accordance with specifications based on either (2.1) or (2.2). We investigate the link between product price changes and factor intensity with reference to two factor ratios. The first is the capital-labor ratio (KL) defined in terms of the machinery and equipment capital stock series per employment available for South African economic sectors. Labor usage can be further analyzed by using the breakdown of labor by skill level. A skills ratio (SR) is calculated as the sum of highly skilled and skilled workers divided by the number of unskilled workers in a sector.²³

Using the dynamic panel data technique we thus attempt to estimate the following long-run relationship (see also (3.4)):²⁴

$$\Delta p_{it} = \theta_{FR} FR_{it} + \eta_{it}, \quad i = 1, \dots, N, \quad t = 1, \dots, T, \quad (4.1)$$

²³The use of the skills ratio makes the result of the present study comparable to those reported for developed countries. Since skills breakdowns were not available for Tobacco, Plastics, TV, Radio & Communications Equipment, and Other Transport Equipment sectors, the number of sectors available for this analysis falls to 24, see Fedderke *et al.* (2000).

²⁴Notice that η_{it} can be decomposed as $\eta_{it} = \alpha_i + \varepsilon_{it}$, where α_i 's are fixed effects and ε_{it} is the zero-mean stationary process. θ_{FR} might be heterogeneous. Also without loss of generality we use the common notation in the long-run relationship equations that follow.

where Δp_{it} and FR_{it} denote the percentage change in output price, and the relevant factor ratio for sector i . The prior is that under the consistency check of the correlation version of the Stolper-Samuelson theorem, for South Africa we should expect $\theta_{FR} < 0$.

In order to control for the potential impact of technological progress in the factor intensity equations (4.1), we also estimate,

$$\Delta p_{it} = \theta_{FR}FR_{it} + \theta_{TFP}\Delta TFP_{it} + \eta_{it}, \quad i = 1, \dots, N, \quad t = 1, \dots, T, \quad (4.2)$$

where the growth rate of TFP has been obtained by the standard computation:

$$\Delta TFP_{it} = \Delta \log(Y_{it}) - \ell_{it}\Delta \log(L_{it}) - k_{it}\Delta \log(K_{it}), \quad (4.3)$$

where Y_{it} is the sectoral (value-added) output, L_{it} the sectoral labor employed, K_{it} the constant prices value of sectoral machinery and equipment, and ℓ_{it} and k_{it} denote the labor and capital value-added factor shares for sector i . We do not hold firm priors on the sign of θ_{TFP} , though $\theta_{TFP} < 0$ implies that technological progress is passed on to consumers in the form of falling prices.

In estimating (4.1) or (4.2) it may be more appropriate to use the natural logarithmic transform of the factor ratio, since the use of a ratio of levels may generate strong non-linearities over time in the capital-labor ratio and the skills ratio. In what follows we will provide estimation results only with a logged factor ratio.²⁵

4.2.1 Estimation results with the capital-labor ratio

Results for the consistency check approach to examining the impact of trade employing manufacturing sector capital-labor ratios as the factor proportions are presented in Table 2.

Table 2 about here

The three estimates of the long-run parameter (θ_{KL}) are similar, and are significantly negative, despite the different manner in which the long-run relationship and short-run dynamics are modeled. The Hausman h test also suggests that there is no significant difference between MG and PMG estimates of θ_{KL} . The results for South Africa manufacturing sectors with respect to the capital labor ratio are thus consistent with the implication derived from the correlation version of the SST. The implication of the test throughout is that the strongest price increases have occurred in labor-intensive sectors. Thus to the extent that trade effects are responsible for product price changes the findings are consistent with strengthening demand for labor relative to capital in South Africa.²⁶

²⁵The literature has estimated the factor intensity equations (4.1) using the ratio of levels (and only the skills ratio) as the factor ratio variable. We have also estimated (4.1) and (4.2) in levels form (detailed results are available from the authors). These are congruent to what follows. One difference is that we find more significance when using logged data.

²⁶To take account of the possible heterogenous behavior of individual sectors, we have also attempted to divide the sample into one group of sectors (including Food, Beverage, Wood, Rubber, Non-ferrous metals, Metal, Motor and Other Transport) with significantly negative long-run coefficients of θ_{KL} and another group with insignificant zero coefficients. We find that the negative association is stronger in the case of the sub-group with significantly negative long-run coefficients, *i.e.* MG, PMG and DFE estimates are -0.13, -0.08 and -0.07, respectively. On the other hand, for the rest of the sectors the decline in the capital-labor ratio is insignificantly different from zero. Also, we do not find that the estimates of θ_{KL} are positive for any sector. Detailed estimation results are available from the authors.

Estimation results for the case including the TFP measure are provided in Table 3. The impact of technological progress is shown to be insignificant, indicating that technological change does not appear to be passed through into product price reductions. This is a plausible finding for a small open economy such as South Africa. Since such economies are effectively world price takers, the impact of technological progress would be absorbed by producers and not translated into price changes.²⁷ But the main point to highlight here is the small change in the θ_{KL} long-run coefficients between specifications which include or exclude total factor productivity.

Table 3 about here

Estimation results reported in the present section thus conform to the expectation generated by the correlation version of the SST. The correlation between product price changes and factor ratios indicates the strongest product price changes in sectors intensive in the abundant factor of production (irrespective of technology impacts). To the extent that output price changes are due to trade effects, therefore, the implication of these findings is thus that any trade impact on factor employment favored labor rather than capital. Finally, we note in passing that a consistent feature of estimation results from Tables 3 and 4 is that the speed of adjustment towards the long-run equilibrium is fairly high, as indicated by the estimates of the error correction coefficient ϕ with more than 80% of the adjustment to equilibrium occurring within a year.

4.2.2 Estimation results with the skills ratio

Table 4 presents estimation results employing the skills ratio as the factor proportions variable without modeling the impact of technological progress. As in the case of the capital-labor ratio, the presence of significant negative coefficients of θ_{SR} is consistent with the correlation version of the SST, suggesting that product price changes were strongest in sectors using unskilled labor intensively. The Hausman h statistic is again insignificant, supporting that the long-run relationship is common across the panel.

Table 4 about here

The results of estimation with technological progress included in the model are presented in Table 5.²⁸ The effect of the inclusion of the total factor productivity measure on the

²⁷The impact of sanctions and any protection applied to South Africa's markets would merely impose a mark-up over world prices, with any price changes continuing to track changes in world prices.

²⁸Throughout all of empirical experiments we have used the fixed lag specification for the underlying sectoral ARDL regression, mostly using two lag orders. The ensuing estimation results are not very sensitive to the different choice of the lag orders, though the more parsimonious version based on model selection criteria such as Akaike Information Criteria (AIC) or Schwarz Bayesian Criteria (SBC) would be desirable, *ceteris paribus*. The cost is that the *DFE* estimation cannot be computed. But, here the estimation result based on the ARDL(2,2,2) model seems to be nonsensical in the sense that the estimates of θ_{TFP} are significantly positive (though other coefficients remain of the expected sign and significant). For ARDL(1,1,1), by contrast, estimates of θ_{TFP} are insignificant once more. Since positive θ_{TFP} estimates are difficult to justify on theoretical grounds, and given the instability of the results based on fixed lag-length estimation, for this case only we have reported the estimation results based on AIC with maximum lag order 2.

skills ratio coefficient again seems to be insubstantial in the sense that the coefficient of θ_{SR} remains statistically significantly negative, and the introduction of technology does not alter our estimates of θ_{SR} .²⁹ As for the capital labor ratio, the coefficient of θ_{TFP} is statistically insignificant. The reasons explaining the poor rate of technology pass-through based on the small open economy argument continue to apply. We also find in both cases that the estimate of error correction coefficient ϕ is significantly negative around -0.8, again indicating that the dynamic adjustment towards the long-run equilibrium is reasonably rapid.

Table 5 about here

4.3 The mandated regression specification

In the second set of estimations the change in the product price of each sector is modeled in accordance with a specification based on (2.8) through (2.10). We investigate the impact of product price changes on factor earnings, now explicitly decomposing the change in factor earnings into those mandated by technology and those mandated by globalization effects.³⁰

First, the price change equation under the assumption of zero technology pass-through (*i.e.* $\lambda = 0$ in (2.10)) is given by

$$\Delta p_{it} = \theta_l \ell_{it} + \theta_k k_{it} + \eta_{it}, \quad i = 1, \dots, N, \quad t = 1, \dots, T, \quad (4.4)$$

where Δp denotes the percentage change in product price, $\ell \equiv (W/P)L/Y$ is the share of labor in value added with W/P the real wage, L labor input, and Y real value added, and $k = GOS/Y$ is the share of capital in value added with GOS gross operating surplus. Given the accounting identity $\ell_{it} + k_{it} = 1$, we face a perfect multicollinearity problem in estimation. Thus, for purposes of estimation we attempt to estimate³¹

$$\Delta p_{it} = \theta_l \ell_{it} + \theta_k k_{it}^* + \eta_{it}, \quad i = 1, \dots, N, \quad t = 1, \dots, T, \quad (4.5)$$

where $k^* = NOS/Y$ and NOS is net operating surplus. *Second*, the price change equation under the assumption of perfect technology pass-through becomes:

$$\Delta p_{it} + \Delta TFP_{it} = \theta_l \ell_{it} + \theta_k k_{it}^* + \eta_{it}, \quad i = 1, \dots, N, \quad t = 1, \dots, T, \quad (4.6)$$

where ΔTFP denotes the growth rate of total factor productivity already defined by (4.3). *Finally*, we estimate the technology equation (see (2.9)):

$$\Delta TFP_{it} = \theta_l \ell_{it} + \theta_k k_{it}^* + \eta_{it}, \quad i = 1, \dots, N, \quad t = 1, \dots, T. \quad (4.7)$$

²⁹Again, there are no sectors with a significant positive parameter estimate on the skills ratio.

³⁰Note that all empirical specifications are in terms of price changes for output in value added terms. Thus we may ignore the $\gamma' \hat{\mathbf{p}}$ term in estimation.

³¹Since GOS is the sum of NOS and $Depreciation$, this constitutes an errors in variables problem. But, this bias ($Depreciation/Y$) is known, and thus computable. For the correction method see Griliches (1974). In most instances, however, the change in the implied mandated factor earnings seems to be negligible.

An alternative approach might be to replace k_{it} by $1 - \ell_{it}$ in (4.4) and estimate, $\Delta p_{it} = \theta_k + (\theta_l - \theta_k) \ell_{it} + \eta_{it}$. While there is an identification problem in separating θ_k and θ_l from $\theta_l - \theta_k$, we can still consistently estimate $\theta_l - \theta_k$. For SST-consistent results to hold for labor abundant economies, what is required is that $\theta_l > \theta_k$. We have also carried out the estimations based on the above specification, and consistently found $\theta_l - \theta_k > 0$. Nevertheless, we persist with the Leamer-estimations, in order to be able to decompose technology- and trade-mandated factor earnings changes.

Results from the estimation of (4.5) through (4.7) are reported in Tables 6-8.

Table 6 about here

Tables 7 about here

Tables 8 about here

One notable feature here is that there is non-negligible variation across MG, PMG and DFE estimates of the long-run parameters unlike the estimation results employing factor ratios in the previous subsection. This is also confirmed by the significance of the Hausman test results. We note at the outset that the results based on the assumption of perfect technology pass-through are unlikely to hold for South Africa, for the now standard small open economy argument. There are thus grounds to treat the results obtained for (4.6) with some degree of caution.

These results place us in a position to identify factor earnings growth mandated by technological change, and those mandated by *globalization*, which was not possible on the first set of price effects estimations reported above.³²

Here we report only the results obtained by the PMG methodology in Table 9. The main justification for the use of the PMG estimation is as follows: *First*, the PMG approach is consistent with the underlying theory of homogenous long-run relationship and the possibly heterogeneous dynamic time series nature of the data (see the discussion in Section 3). *Second and similarly*, it offers an intermediate option in which the opportunities offered by panel estimation continue to be realized in terms of the long-run homogeneity, while the short-run heterogeneity embodied in the mandated equilibrium relationship is also admitted into estimation.³³

Table 9 about here

The top panel of Table 9 contains the information given by the preceding regression results. Thus the price change equation estimated on a zero pass-through assumption implies an annualized earnings increase of 0.33%. Given the aggregate output price inflation of 0.12% per annum, this provides the mandated annual earnings growth unrelated to technology of 0.21%. Technology by contrast mandates a 0.57% decrease in labor earnings, suggesting that the total mandated change in labor earnings is -0.36% per annum. Symmetrically for the full technology pass-through column.

Given our lack of confidence in the estimations based on (4.6), we focus on the computations assuming zero pass-through of technology (the Δp column in Table 9). *First*, both labor and capital demonstrate positive average annual growth rates in earnings due to the impact of globalization, though the impact on the abundant factor of production labor is

³²The temptation is to identify this directly with trade effects. However, recall that this continues to be a composite effect of all demand-related factors, of which trade is only one. Recently, some attempts have been made to address these issues. In particular, Haskel and Slaughter (2001) have attempted to account for the endogeneity, assuming that the technology pass rate is zero (relevant only for small open economy) and that the prices (and technology) are caused by a set of underlying forces, *e.g.*, changes in trade barriers. See also Feenstra and Hanson (1999).

³³Note however that the final mandated results from other estimation methods carry qualitatively similar import.

stronger than that on capital stock. Moreover, the globalization related earnings changes are greater for labor than capital, as is consistent with the SST. *Second*, the impact of technology on mandated factor earnings is negative for both factors of production, though in this instance the impact on capital is stronger than it is on labor.³⁴

The overall results thus are consistent with the findings obtained from the factor intensity estimations of the previous subsection. They confirm the positive impact of globalization on mandated labor earnings, with the magnitude of the impact exceeding that on capital. Moreover, evidence in favor of technology pass-through continues to be weak. However, a new piece of evidence points that total mandated earnings growth particularly for labor in South Africa was negative over the 1972-97 period. Given the strength and persistence of real wage increases in South Africa over this period, however, the evidence thus suggests that an important possible source of the persistent and high levels of unemployment in South Africa's labor markets may well lie with relative factor prices.³⁵

5 Conclusion

In this paper, we investigate the impact of trade on labor markets by examining two operational correlation versions of the Stolper-Samuelson theorem. The paper innovates both by obtaining estimation results by means of dynamic heterogeneous panel estimation, and by employing developing country data.

Estimation results suggest that technological progress appears to have had negative consequences for both labor relative to capital, and unskilled labor relative to skilled labor in South African manufacturing industry. By contrast, results are consistent with a positive impact of trade on the use of labor relative to capital stock, and unskilled relative to skilled labor. We find that while globalization effects have mandated positive growth in labor earnings which exceeds that of capital, technological progress has mandated negative growth in labor earnings.

Finally, one important implication of the mandated regression estimations suggests that factor prices are likely to be crucial in determining factor demand in South African labor markets. In particular, labor remuneration has not followed mandated patterns, and recognition of this fact is vital if South Africa's poor job creation is to be reversed.

³⁴Even the results based on the full technological pass-through assumption suggest that any negative impact of globalization on mandated labor (and capital) earnings is very much weaker than the change mandated by technology.

³⁵This finding is confirmed by estimation of the inverted production function employed by Hine and Wright (1998). We find that relative factor prices dominate any impact of openness or reductions in the effective rate of protection of South African manufacturing sectors.

Data Appendix: List of Variables and their Descriptions

WEFA South Africa, based in Pretoria, provided data for the present study. The panel includes 28 sectors for the years 1970 to 1997. WEFA have brought together data from a number of sources published by Statistics South Africa and South Africa Reserve Bank. The full dataset is available with documentation from the Trade and Industry Policy Secretariat, Johannesburg (see <http://www.tips.org.za/>). Variables used are:

p : the natural logarithm of the value added deflator

KL : the natural logarithm of the ratio of the value of machinery and equipment to labor remuneration at constant prices

SR : the natural logarithm of the number of skilled and highly skilled workers divided by the number of unskilled workers

Y : the sectoral value added GDP at constant prices

K : the rand value of machinery and equipment at constant prices

L : the total sectoral labor employed

W : the nominal wage level

GOS : the gross operating surplus

NOS : net operating surplus calculated as GOS less depreciation

ℓ : the share of labor in value added, calculated as $(W/P)L/Y$

k : the share of capital in value added, calculated as GOS/Y

k^* : the share of capital less depreciation in value added, calculated as NOS/Y

$OPEN$: the ratio of imports and exports to output

$RPRICE$: the ratio of the user cost of capital to real per laborer remuneration

Table 1. Manufacturing Sectors of South Africa included in Panel.		
Food	Petroleum Refining	Fabricated Metals
Beverages	Basic Chemicals	Machinery & Apparatus
Textiles & Knitting	Other Chemicals & Fibres	Electrical Machinery
Wearing Apparel	Rubber	Radio, TV & Comms. Equipment
Leather & Tanning	Plastics	Instruments
Footwear	Glass & Glass Products	Motor Vehicles & Accessories
Wood	Other Non-metallic Minerals	Transport Equipment
Paper	Basic Iron & Steel	Furniture
Publishing & Printing	Basic Non-ferrous Metals	Other Manufacturing & Recycling

Table 2. Alternative Panel Data Estimates for ARDL(2,2)-based Factor Intensity Functions (4.1) for Manufacturing Sectors over 1972-97 Using the Capital-Labor Ratio			
	Mean Group	Pooled Mean Group	Dynamic Fixed Effect
Long-run Coefficient, θ_{KL}	-.03 (.02)	-.05* (.01)	-.03* (.01)
Speed of Adjustment, ϕ	-.88* (.07)	-.81* (.07)	-.79* (.04)
h Test for Long-run Homogeneity	1.06 [.34]		

Note to the Tables: Standard errors are given in (.), “*” indicates significance at the 5% level, and the p-value of the h-test is given in [.]

Table 3. Alternative Panel Data Estimates for ARDL(2,2,2)-based Factor Intensity Functions (4.2) for Manufacturing Sectors over 1972-97 Using the Capital-Labor Ratio			
	Mean Group	Pooled Mean Group	Dynamic Fixed Effect
Long-run Coefficient, θ_{KL}	-.02 (.02)	-.05* (.01)	-.02* (.01)
Long-run Coefficient, θ_{TFP}	.07 (.10)	.01 (.04)	.05 (.04)
Speed of Adjustment, ϕ	-.89* (.07)	-.77* (.06)	-.79* (.07)
h Test for Long-run Homogeneity	2.22 [.33]		

Table 4. Alternative Panel Data Estimates for ARDL(2,2)-based Factor Intensity Functions (4.1) for Manufacturing Sectors over 1972-97 Using the Skills Ratio			
	Mean Group	Pooled Mean Group	Dynamic Fixed Effect
Long-run Coefficient, θ_{SR}	-.06* (.03)	-.03* (.01)	-.03* (.01)
Speed of Adjustment, ϕ	-.81* (.06)	-.76* (.05)	-.80* (.05)
h Test for Long-run Homogeneity	1.36 [.24]		

Table 5. Alternative Panel Data Estimates for ARDL-AIC based Factor Intensity Functions (4.2) for Manufacturing Sectors over 1972-97 Using the Skills Ratio		
	Mean Group	Pooled Mean Group
Long-run Coefficient, θ_{SR}	-.06* (.02)	-.03* (.01)
Long-run Coefficient, θ_{TFP}	.15 (.08)	.03 (.02)
Speed of Adjustment, ϕ	-.78* (.04)	-.79* (.04)
h Test for Long-run Homogeneity	4.95 [.08]	

Table 6. Alternative Panel Data Estimates for ARDL(1,1,1)-based Price Change Function (4.5) with Zero Technology Pass-through for Manufacturing Sectors over 1972-97

	Mean Group	Pooled Mean Group	Dynamic Fixed Effect
Long-run Coefficient, θ_l	1.61* (.58)	.33* (.12)	.24 (.13)
Long-run Coefficient, θ_k	1.50* (.56)	.18* (.10)	.16 (.11)
Speed of Adjustment, ϕ	-.71* (.05)	-.63* (.04)	-.71* (.06)
h Test for Long-run Homogeneity	6.03* [.05]		

Table 7. Alternative Panel Data Estimates for ARDL(1,1,1)-based price change function (4.6) with full technology pass-through for manufacturing sectors over 1972-97

	Mean Group	Pooled Mean Group	Dynamic Fixed Effect
Long-run Coefficient, θ_l	-.63* (.27)	-.24* (.13)	-.03 (.11)
Long-run Coefficient, θ_k	-.72* (.25)	-.40* (.12)	-.21* (.09)
Speed of Adjustment, ϕ	-.86* (.02)	-.86* (.02)	-.85* (.03)
h Test for Long-run Homogeneity	2.70 [.26]		

Table 8. Alternative Panel Data Estimates for ARDL(1,1,1) Technology Equation (4.7) for Manufacturing Sectors over 1972-97

	Mean Group	Pooled Mean Group	Dynamic Fixed Effect
Long-run Coefficient, θ_l	-1.74* (.50)	-.57* (.11)	-.10 (.15)
Long-run Coefficient, θ_k	-1.90* (.47)	-.68* (.11)	-.22 (.14)
Speed of Adjustment, ϕ	-.93* (.02)	-.94* (.02)	-.94* (.03)
h Test for Long-run Homogeneity	7.21* [.03]		

Table 9. Mandated Price Changes Based on PMG Estimates of Long-run Coefficients for Manufacturing Sectors over 1972-97

	Δp	$\Delta p + \Delta TFP$	ΔTFP
θ_l	.33	-.24	-.57
θ_k	.18	-.40	-.68
Mean Dependent Variable	.12	.12	.01
Mandated Earning Growth Unrelated to Technology			
Labour	.21	-.36	
Capital	.06	-.52	
Mandated Earning Growth Related to Technology			
Labour	-.57	-.57	
Capital	-.69	-.68	
Total Mandated Earnings Growth			
Labour	-.36	-.93	
Capital	-.63	-1.20	

References

- [1] Baldwin, R.E. and G.G. Cain (1997): "Shifts in US Relative Wages: The Role of Trade, Technology, and Factor Coefficients," *Working Paper 5934, National Bureau of Economic Research*.
- [2] Baldwin, R.E. and R.S. Hilton (1984): "A Technique for Indicating Comparative Costs and Predicting Changes in Trade Ratios," *Review of Economics and Statistics*, 105-110.
- [3] Bhagwati, J. (1991): *Free Traders and Free Immigrationists: Strangers or Friends?* Washington D.C., AEI Press.
- [4] Borjas, G.J. and R.B. Freeman (1992): "On Labor Market Effects of Immigration and Trade," in *Immigration and the Workforce*, eds. by G.J. Borjas and R.B. Freeman. Chicago, Chicago University Press.
- [5] Deardorff, A.V. (1994): "Overview of the Stolper-Samuelson Theorem," in *The Stolper Samuelson Theorem: A Golden Jubilee*, eds. by A.V. Deardorff and R.M. Stern. Ann Arbor: The University of Michigan Press, 7-34.
- [6] Ethier, W. (1984): "Higher Dimensional Issues in Trade Theory," in *Handbook of International Economics*, Vol. 1 eds. by R.W. Jones and P.B. Kenen. Elsevier Science Publishers.
- [7] Fedderke, J.W. (2001): The Virtuous Imperative: Modelling Capital Flows in the Presence of Nonlinearity, forthcoming in *Economic Modelling*. Available at www.wits.ac.za/economics/ersa.
- [8] Fedderke, J.W., S. Henderson, J. Kayemba, M. Mariotti and P. Vaze (2001): "Changing Factor Market Conditions in South Africa: The Capital Market - A Sectoral Description of the Period 1970-1997," forthcoming in *Development Southern Africa*. Available at www.wits.ac.za/economics/ersa.
- [9] Fedderke, J.W., S. Henderson, M. Mariotti and P. Vaze (2000): "Changing Factor Market Conditions in South Africa: The Labor Market - A Sectoral Description of the Period 1970-1997," *Econometric Research Southern Africa Policy Paper No. 5*, University of the Witwatersrand, www.wits.ac.za/economics/ersa.
- [10] Fedderke, J.W. and W. Liu (2001): "Modelling the Determinants of Capital Flows and Capital Flight: with an Application to South African Data from 1960-95," forthcoming in *Economic Modelling*. Available at www.wits.ac.za/economics/ersa.
- [11] Fedderke, J.W. and P. Vaze (2001): "The Nature of South Africa's Trade Patterns by Economic Sector and the Extent of Trade Liberalization during the Course of the 1990's," forthcoming in *South African Journal of Economics*. Available at www.wits.ac.za/economics/ersa.

- [12] Feenstra, R.C. and G. Hanson (1995): "Productivity Measurement and the Impact of Trade and Technology on Wages: Estimates for the U.S., 1972-1990," *Working Paper 6052, National Bureau of Economic Research*.
- [13] Feenstra, R.C. and G. Hanson (1999): "The Impact of Outsourcing and High-Technology on Wages: Estimated for the United States, 1979-1990," *Quarterly Journal of Economics*, 114, 907-940.
- [14] Griliches, Z (1974). "Errors in Variables and other Unobservables," *Econometrica*, 48, 971-990.
- [15] Hausman, J. (1978): "Specification Tests in Econometrics," *Econometrica*, 46, 1251-1271.
- [16] Haskel, J. and M.J. Slaughter (2001): "Trade, Technology and U.K. Wage Inequality," *Economic Journal*, 111, 163-187.
- [17] Hine, R.C. and P.W. Wright (1998): "Trade with Low Wage Economies, Employment and Productivity in UK Manufacturing," *Economic Journal*, 108, 1500-1510.
- [18] Jones, R.W. and J. Schenkman (1977): "The Relevance of the Two-sector Production Model in Trade Theory," *Journal of Political Economy*, 85, 905-35.
- [19] Krueger, A.B. (1997): "Labor Market Shifts and the Price Puzzle Revisited," *Working Paper 5924, National Bureau of Economic Research*.
- [20] Lawrence, R.Z. and M.J. Slaughter (1993): "International Trade and American Wages in the 1980s: Giant Sucking Sound or a Small Hiccup?" *Brookings Papers Economic Activity: Microeconomics*, 2, 161-211.
- [21] Leamer, E.E. (1998): "In Search of Stolper-Samuelson Linkages between International Trade and Lower Wages," in *Imports, Exports and the American Worker*, ed. by S. Collins. Washington D.C., Brookings Institution, 141-214.
- [22] Pesaran, M.H. and R.P. Smith (1995): "Estimating Long-Run Relationships from Dynamic Heterogeneous Panels," *Journal of Econometrics*, 68, 79-113.
- [23] Pesaran M.H., Y. Shin and R.P. Smith (1999): "Pooled Mean Group Estimation of Dynamic Heterogenous Panels," *Journal of the American Statistical Association*, 94, 621-634.
- [24] Pesaran M.H., Y. Shin and R.J. Smith (2001): "Bounds Testing Approaches to the Analysis of Level Relationships," *Journal of Applied Econometrics*, 16, 289-326.
- [25] Sachs, J.D. and H. Shatz (1994): "Trade and Jobs in US Manufacturing," *Brookings Papers on Economic Activity*, 1-84.

- [26] Slaughter, M.J. (2000): "What Are the Results of Product-Price Studies and What Can We Learn from Their Differences?" in *The Impact of International Trade on Wages* ed. by R.C. Feenstra. Cambridge, MA: National Bureau of Economic Research Conference Volume, 129-170.
- [27] Tang, P.J.G. and A. Wood (2000): "Globalization, Co-Operation Costs and Wage Inequalities," unpublished manuscript. University of Sussex: Institute for Development Studies.
- [28] Wood, A. (1994): *North-South Trade, Employment and Inequality: Changing Fortunes in a Skill-Driven World*. Oxford, Clarendon.
- [29] Wood, A. (1997): "Openness and Wage Inequality in Developing Countries: The Latin American Challenge to East Asian Conventional Wisdom," *The World Bank Economic Review*, 11, 33-58.
- [30] Wood, A. (2000): "When and Why Does Globalization Increase Rather Than Reduce Labor Market Inequalities in Developing Countries?" Keynote Address, *Trade and Industrial Policy Secretariat Forum 2000*, Johannesburg, South Africa.
- [31] Wood, A. and C. Ridao-Cano (1999): "Skill, Trade, and International Inequality," *Oxford Economic Papers*, 51, 89-119.