University of Stellenbosch

Department of Economics

**Does Technical Efficiency Dominate Resource Reallocation in Aggregate Productivity Growth? Firm-Level Evidence from the Manufacturing Sector in Swaziland**

Samuel V. Mhlanga

University of Swaziland

Administration

and

Neil A. Rankin

University of Stellenbosch

Department of Economics

We are grateful to the Private Enterprise Development for Low-Income Countries (PEDL) research initiative of the Centre for Economic Policy Research (CEPR) and the Department for International Development (DFID) for the Exploratory Research Grant (Ref. 1670) covering the cost of buyout, data collection, digitising of records, data analysis and travel between the University of Swaziland and the University of Stellenbosch. We owe a great deal of gratitude to the Micro Finance Unit in Swaziland for research assistance funding. We are also indebted to the Central Statistical Office (CSO) of Swaziland for making the firm-level dataset available for research. All views expressed in this paper are those of the authors and do not necessarily represent those of, and should not be attributed to, the financier of the project, the (CSO), the University of Stellenbosch or the University of Swaziland.

© 2015 by the Department of Economics, University of Stellenbosch. All rights reserved. Short sections of text, not to exceed two paragraphs, may be quoted without explicit permission provided that full credit, including © notice, is given to the source.

**Abstract**

Is the effect of input reallocation on aggregate productivity growth (APG) *less* than that of technical efficiency? A robust finding in two influential meta-analyses by Bartelsman *et al*. (2004) and Paǵes *et al.* (2008) is that within-plant productivity dominates input reallocation across plants in the 25 countries studied. The method used to derive these patterns of growth is based on the Baily *et al*. (1992) and Foster *et al*. (2001) approaches which decompose aggregate labour productivity into real productivity and reallocation. This paper applies the Baily *et al*. (1992)/Foster *et al*. (2001) and Nishida *et al*. (2013) approaches to answer this question using the Swaziland manufacturing plant-level dataset covering a trade liberalization period of 1994-2003. In terms of the traditional approach, growth from within-firm activity (-4.88%) is subordinate to the Baily *et al*. (1992) reallocation growth (0.38%) and to the Foster *et al*. (2001) reallocation growth (3.53%). The Nishida *et al*. (2013) method generates similar results. For instance, the component of APG associated with technical efficiency/within-firm growth (-3.61%) compares with input reallocation growth (0.15%). The results from both approaches remain unchanged regardless of deflation criterion applied to value-added, capital and material input quantities. Therefore, the Swaziland manufacturing sector experienced robust contribution of input reallocation to APG relative to technical efficiency during the trade reform period. This suggests that firms were not investing more on improving production efficiency through innovation and adoption of new technologies than they moved inputs to higher activity producers.

--------------------------------------------------

**Does Technical Efficiency Dominate Resource Reallocation in Aggregate Productivity Growth? Firm-Level Evidence from the Manufacturing Sector in Swaziland**

1. **Introduction**

Recent research spurred by the increasing availability of longitudinal plant-level data links microeconomic dynamics to aggregate outcomes. One area of focus for this literature is the identification of establishment-level drivers and relative dominance of sources of aggregate productivity growth. A robust finding is that structural change effects of resource reallocation across plants are subordinate to within-plant productivity arising from learning-by-doing and learning-by-watching. For example, in nine of the 25 countries studied by Bartelsman *et al.* (2004) (or BHS) and Paǵes *et al.* (2008) (or PPS), resource reallocation between plants was negative and weakly positive in only four countries. Similarly, in the analysis of job creation and productivity growth for the Slovenian manufacturing sector, De Loecker and Konings (2006) find dominance of technical efficiency over the reallocation of market-share of labour from low to high-productivity incumbents as well as over firm turnover in driving aggregate productivity. In a comprehensive survey of the literature, Isaksson (2010) confirms for several countries at different stages of development that within-firm effects contribute more than inter-sectoral reallocation effects to aggregate labour productivity growth.

Another strand of the literature using enterprise-level micro-data also finds overwhelming evidence that within-industry reallocation of resources shape changes in industry aggregates; see Foster *et al*. (2008). This churning process and its effects on aggregate productivity have received special theoretical and empirical attention. First, as observed by Foster *et al*. (2008), models of selection mechanisms depict industries as assortments of producers characterized by heterogeneous productivity which link a firm’s productivity level to its performance and survival in the industry. Key contributions in this area include Jovanovic (1982), Ericson and Pakes (1995), Melitz (2003), and Asplund and Nocke (2006). The main mechanism that causes change in these models is the reallocation of market-shares from either inefficient to efficient incumbent producers or from entry and exit of firms. Low productivity establishments are less likely to survive and prosper relative to high productivity incumbents, which creates selection-driven increases in industry productivity, Foster *et al*. (2008).

The common approach used to generate these results is largely based on Baily *et al.* (1992) and its derivatives such as Foster *et al.* (2001), Griliches and Regev (1995) and Olley and Pakes (1996). The Baily *et al.* (1992) method defines industry productivity growth as resource-share weighted changes in the distribution of the Solow-type technical efficiency. It derives its foundations from the decomposition and aggregation of plant-level residuals into productivity growth components. The sources of this growth include changes in plant’s continuous innovation and adaptation to technological advances in the sense of learning-by-doing/watching as in Jovanovic (1982) and Pakes and Ericson (1998), movement in resource-share changes from low to high activity plants and turnover of firms. One question this method seeks to answer relates to the height of barriers to input reallocation in an economy as in Bartelsman *et al.* (2004) and Pages *et al.* (2008).

The Petrin and Levinsohn (2012) method presents an alternative framework which introduces an environment with imperfect competition that creates a wedge in the marginal productreward mix of inputs. It also creates a friction that induces heterogeneity in production technology and productivity levels, entry and exit of goods, costs of adjusting outputs and inputs, sunk and fixed costs, and markup-pricing. This is consistent with the recent work by Hsieh and Klenow (2009) and Petrin and Sivadasan (2013) who find significant heterogeneity between inputs’ marginal products across establishments suggesting the presence of prohibitive distortions in input reallocation. Restuccia and Rogerson (2008) also calibrate a growth model with establishment-level heterogeneity arising from idiosyncratic policies and regulations, and institutional behaviour. This allows them to analyse the distortionary effects of such idiosyncrasies on the reallocation of resources across producers. Policies creating price heterogeneity among producers are found to reduce output and aggregate productivity by a range of 30 to 50 percent (see Restuccia and Rogerson (2008)).

The proposition by Petrin and Levinsohn (2012) has been applied by Nishida *et al.* (2013) to Chile, Columbia, and Slovenia; Ho *et al*. (2014) to Ecuador, Petrin *et al.* (2011) to the USA, and Kwon *et al.* (2009) to Japan. This measurement approach defines aggregate productivity growth (hereafter referred to as APG) “as the change in aggregate final demand *minus* the change in aggregate expenditure on capital and labour” in the presence of imperfect competition and other distortions or frictions. Crucially, the APG decomposition has a term per establishment linked to technical efficiency and one for each primary input at each plant[[1]](#footnote-1). The term associated with either capital or labour is a function of the wedge between the value of the marginal product (VMP) and the relevant input price.

The purpose of this chapter is two-fold. *First*, it seeks to compare the individual drivers of aggregate labour productivity for the Swazi manufacturing sector with similar drivers for other countries. This exercise has never been done before for a Southern African country using a relatively long panel dataset compiled by a state agency[[2]](#footnote-2). *Second*, it estimates the components of industry productivity over time using both the Baily *et al.* (1992)/Foster *et al.* (2001) and Petrin and Levinsohn (2012) methods. In essence, the chapter examines the robustness of the overwhelming findings of the meta-analyses that productivity arising from learning-by-doing and learning-by-watching *dominates* productivity from market-share reallocation across incumbent firms from net-entry of firms?[[3]](#footnote-3),[[4]](#footnote-4) This question is examined across several dimensions using a rich and unique dataset for the manufacturing sector in a small developing African country- Swaziland.

This chapter makes three contributions to the literature. *First*, it applies the Baily *et al.* (1992)/Foster *et al.* (2001) approach to compare the drivers of industry productivity in Swazi manufacturing with similar growth drivers in Sub-Saharan economies, economies in transition and developed countries. *Second*, it uses the traditional approach and Petrin and Levinsohn (2012)/Nishida *et al*. (2013) to estimate ALP and APG over time. *Third*, it estimates the impact of confounding effects of plant turnover on the Baily *et al*. (1992) reallocation in the Swazi manufacturing data.

In the next section, we present an overview of the manufacturing sector in Swaziland for a period which coincides with trade liberalization and the political transition in South Africa. Section 3 undertakes descriptive analyses of key indicators and the behaviour of aggregate productivity for capital and labour. This is followed by a formal presentation of the Baily *et al.* (1992)/Foster *et al.* (2001) methodology for ALP decomposition in Section 4. Section 5 calculates ALP growth and its component drivers using the traditional method. In Section 6, we recast the Petrin and Levinsohn (2012)/Nishida *et al*. (2013) framework of APG decomposition, demonstrating how the Wooldridge (2009) modification of Levinsohn and Petrin (2003) is implemented in the dataset. Finally, we perform a direct estimation of APG and its component parts to determine the differential roles of technical efficiency and input reallocation on growth.

1. **Overview of the Manufacturing Sector in Swaziland**

The latter part of the 1980s was a period of unprecedented economic growth in the Swazi manufacturing sector. This was in response to economic sanctions on South Africa imposed by influential world economies (Edward *et al*. (2013)) and the relocation of some South African firms to neighbouring countries like Swaziland to circumvent these sanctions. The relocation decision enabled them to access foreign markets and/or to export intermediate inputs back to the home country. These foreign affiliates gained access to relatively cheap labour and material inputs in Swaziland which reduced production costs. The domestic effect of this foreign presence in the sector came in the form of transfer of technical knowledge to local labour and to upstream suppliers. The resulting learning-by-doing increased both the efficiency of primary inputs and the quality of intermediate inputs from suppliers. Consequently, Hammouda *et al* (2010) found that Swaziland experienced 11.15% growth in real gross domestic product during the period 19851990 in which capital and total factor productivity accounted for 3.13% and 6.34%, respectively.

However, the period spanning 1990s and 2000s was characterized by marked deterioration in economic growth. This was due largely to the lifting of sanctions and re-integration of South Africa back into the world economy (Hammouda *et al* (2010)). In particular, trade liberalization that took place in the second half of the 1990s made South Africa appear as a more attractive investment destination. The response of South African multinational enterprises was to recall their foreign affiliates to improve their own scale economies, see Jonsson and Subramanian (2001). As international competition intensified, domestic industries that were characterized by oligopolistic markup pricing behaviour were forced to behave competitively. The consequence of a freer market environment was the exit of some of the inefficient firms which, in turn, reallocated market shares to continuing ones and also to industry entrants. Despite the presence of such import discipline mechanism, the limited domestic market size still enabled a portion of inefficient plants to survive and also allow new low-productivity manufacturers to enter the market.

During this period the Swaziland Government responded with an attempt to address the issue of missing markets in the economy. One critical area for industrial policy intervention involved institutional reforms and infrastructure development to attract FDI, see Masuku and Dlamini (2009). As a result, the Swaziland Industrial Development Corporation (SIDC) was commissioned to design and implement a factory shell development programme to reduce sunk investment costs for producers, particularly in the textile and apparel industries. The Swaziland Investment Promotion Authority (SIPA) was also established in 1998 as a one-stop shop to serve mainly foreign investors. The objective of SIPA’s existence was to market the country abroad as an investment destination and also to serve as an information desk when the foreign firm was ready to invest in Swaziland. In addition to these efforts to lure foreign investment, the state was also an active participant in the domestic economy. Direct state presence through Tibiyo TakaNgwane sought, *inter alia*, to increase formal sector employment and earn foreign exchange[[5]](#footnote-5). The presence of this state-owned enterprise is found in key sectors of the economy, and is perceived by the Federation of Swaziland Employers and Chamber of Commerce as having undesirable crowding-out effects on private investment, see Tibiyo TakaNgwane’s Annual Report (2010).

1. **Descriptive Analysis of the Panel Data Series** 
   1. **Data Description and Summary Statistics**

Although a detailed account of the source and structure of the dataset are presented in the overview chapter, the investigation of aggregate productivity growth requires a more direct description of relevant data series. Firm dynamics in the 1990s and early 2000s were driven by an average entry rate of 9.72% and exit rate of 8.03% per year. In the same period, the aggregate labour series oscillated around an average of 21 500 employees, see Table 1. In particular, aggregate labour changes exhibit relatively erratic patterns of weakening over the entire period. At the same time, the real value-added series in column four was largely static, except for a sharp drop in 1997.

**Table 1: Summary Statistics**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Year** | **No. of Firms** | **Employment** |  | **Total Amount in E’ Million\*** | | |
|  | **Real Value-Added** | **Real Capital** | **Real Wages** |
| **1994** | 100 | 17 260 |  | 1 241.28 | 2.2218 | 2.2672 |
| **1995** | 109 | 18 216 |  | 1 033.25 | 1.4457 | 2.1444 |
| **1996** | 117 | 17 837 |  | 1 132.92 | 1.0857 | 2.2710 |
| **1997** | 130 | 18 513 |  | 664.43 | 1.2872 | 1.4333 |
| **1998** | 150 | 20 296 |  | 1 087.23 | 2.9282 | 1.6056 |
| **1999** | 153 | 19 760 |  | 2 568.00 | 5.3443 | 2.0425 |
| **2000** | 164 | 19 036 |  | 2 291.59 | 5.4776 | 2.7058 |
| **2001** | 177 | 28 861 |  | 2 697.51 | 5.4822 | 2.6857 |
| **2002** | 188 | 32 219 |  | 2 143.96 | 6.8795 | 2.8307 |
| **2003** | 160 | 23 499 |  | 1 919.77 | 6.5572 | 2.8529 |

Notes: The asterisk \* symbolizes double-deflation of value-added, capital and the wage series as required by Bruno (1978) and applied by Nishida *et al*. (2013) for the case of Chile, Columbia and Slovenia.

The events that characterize the churning process of firms included the deepening pressure for higher wage increases by unions, and the resulting worker unrest necessitated restructuring of businesses through retrenchments[[6]](#footnote-6). Industrial action was however more visible in some sectors than in others. Moreover, the increase in aggregate capital was rather rapid from 1996 and levelled off somewhat in 1999. Since capital measurement is based on the plant, machinery and equipment (PME) series, which excludes the cost of repairs and replacement, its years of upward trend is a reflection of generally lumpy investment in fixed capital by a few large firms[[7]](#footnote-7).

* 1. **Aggregate Input Productivity Movements**

Aggregate input productivity changes in manufacturing during the trade liberalization period show a general decline as shown in Figure 2(a). The aggregate labour productivity index mimics aggregate labour input trends examined above. This suggests a high level of comovement between value-added output and aggregate labour productivity. It is therefore not surprising to see a rapid decline in aggregate capital productivity from a point in time when the capital series begins an increase. Furthermore, the capital-labour ratio shows an increase after the first three years. This reflects a general increase in capital-intensity in production during the period under analysis without corresponding growth in real value-added.

**Figure 2(a): Output-Input and Capital-Labour Ratios by Year**

**Figure 2(b): Output-Input and Capital-Labour Ratios by Industry (1994-2003)**

In general, the descriptive analysis is consistent with an explanation where a significant proportion of larger firms shed labour and keeps capital adjustment levels largely unchanged. This pattern of firm behaviour aligns with an economic environment which favours shifting most of the production by South African affiliates in Swaziland back to South Africa. Given that capital is mostly irreversible in nature, these firms could not recoup the fixed costs of capital but simply operated to cover their variable costs to remain in business.

This evidence sheds light about average patterns of aggregate factor input productivity across time and industry but cannot reveal much, if at all, about its cross-sectional distribution at a given point in time. Looking at aggregate labour productivity (ALP), Figure 3 shows a persistent shift of ALP towards the left with growing fat-tails in both directions. These patterns remain unaltered even when the value-added series is subject just to single deflation, except that the whole distribution moves more to the left, see Appendix A.2. This is in sharp contrast to conventional wisdom where market reforms increase productivity within and across firms to drive aggregate growth[[8]](#footnote-8). Normally, trade liberalization has been shown to increase firms’ incentives to invest in innovative technologies and weak firms to shed off market share to efficient ones, thereby boosting productivity, see Lileeva (2008).

**Figure 3: ALP Distribution for Selected Years (1994, 1997, 2000, 2003)**



Notes: ALP is measured as a ratio of double-deflated value-added to aggregate employment in a year; see Appendix A.2 in the Appendix for a single-deflated ratio of real value-added to annual total employment.

In Table 3, we report patterns of productivity index movements by industry, and measure their central tendencies and dispersion. This allows us to document the relative performance of industries in relation to the chosen base year. Our first year of the sample period 1994 is normalized to one and the productivity index for the subsequent years is measured relative to this base year. On average, there is at best stagnation in 1998-1999 and at worst a loss of about 3% in productivity by 2003.This is contrary to De Loecker and Konings (2006) who use Olley and Pakes (1996) to find an average increase of 63% in the productivity index for Slovenia covering the period 1994-2000. The presence of heterogeneity is starkly reflected by a 2% growth in the ‘Wearing Apparel’ industry, while the ‘Basic Metals’ industry decline by the 9% in the final year. Again, De Loecker and Konings (2006) found increases of 7% and 77% in the respective industries. However, the Pulp and Paper industry remains the dominant driver of ALP growth in the trade reform period in Swaziland.

Table 3: Evolution of the Average ALP by Industry (1994-2003)

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Industry | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
| Food and Food Products | 1.00 | 0.97 | 0.97 | 0.98 | 0.99 | 0.98 | 0.98 | 0.98 | 0.97 | 0.96 |
| Textile | 1.00 | 0.98 | 0.98 | 0.98 | 1.00 | 1.00 | 0.97 | 1.00 | 0.97 | 0.96 |
| Wearing Apparel | 1.00 | 0.99 | 1.03 | 1.01 | 1.03 | 1.01 | 1.01 | 0.88 | 1.00 | 1.02 |
| Wood and Wood Products | 1.00 | 0.97 | 0.96 | 0.96 | 0.99 | 0.98 | 1.00 | 0.97 | 0.98 | 0.95 |
| Pulp and Paper Products | 1.00 | 1.01 | 1.03 | 1.05 | 1.05 | 1.05 | 1.05 | 1.01 | 1.02 | 0.97 |
| Printing, Publishing | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 1.00 | 1.00 | 0.99 | 0.99 |
| Chemicals Products | 1.00 | 0.99 | 1.00 | 1.01 | 0.98 | 0.99 | 1.00 | 1.01 | 1.00 | 0.98 |
| Rubber and Plastic Products | 1.00 | 0.99 | 0.99 | 0.97 | 0.99 | 0.98 | 0.97 | 0.98 | 0.96 | 0.94 |
| Other non-metallic Minerals | 1.00 | 0.99 | 0.96 | 0.94 | 0.96 | 0.97 | 0.98 | 0.96 | 0.98 | 0.97 |
| Basic Metals | 1.00 | 0.99 | 1.01 | 1.02 | 1.01 | 1.02 | 0.98 | 0.98 | 0.99 | 0.91 |
| Fabricated Metal Products | 1.00 | 0.99 | 1.01 | 0.98 | 0.99 | 0.99 | 0.97 | 0.97 | 0.98 | 0.99 |
| Machinery and Equipment | 1.00 | 0.99 | 0.99 | 0.99 | 0.99 | 0.99 | 0.97 | 0.99 | 1.00 | 0.99 |
| Furniture | 1.00 | 1.02 | 1.00 | 0.98 | 0.98 | 1.02 | 0.98 | 0.99 | 0.98 | 0.98 |
| **Sector Mean** | **1.00** | **0.99** | **0.99** | **0.99** | **1.00** | **1.00** | **0.99** | **0.98** | **0.99** | **0.97** |
| **Sector Median** | **1.00** | **0.99** | **0.99** | **0.98** | **0.99** | **0.99** | **0.98** | **0.98** | **0.98** | **0.97** |
| **Std Dev (** | **0.00** | **0.01** | **0.02** | **0.03** | **0.02** | **0.02** | **0.02** | **0.03** | **0.02** | **0.03** |

*Source*: Author’s calculations.

It also seems natural to perform an analysis of ALP behavioural patterns at the tails of its distribution. For example, the 25th percentile in the ALP distribution shows more volatility than either the average situation or the upper 75th tail. That is, the standard deviation of the first-quartile was whereas the top quartile was characterized by as shown in Appendices A.3 and A.4, respectively. This suggests that a firm belonging to the first-quartile ALP distribution was more sensitive to productivity shocks than either an average or a third-quartile firm. As a result of these industrial productivity swings, the low and top quartile firms experienced an ALP decline of 8% and 5%, respectively.

The emerging ALP trends and heterogeneity suggest the need for a deeper understanding of microeconomic causes and foundations for productivity growth, or in Swaziland’s case stagnation and decline. It is therefore necessary to disentangle the roles of real productivity, intensive margins of share-shift effects, and extensive margins of turnover in productivity growth across industries. We achieve this in the next section by formally presenting a framework that outlines the relationship between resource shares and the productivity index in calculating each component of the ALP decomposition.

1. **Measurement and Decomposition of Aggregate Labour Productivity** 
   1. **Definition and Measurement of ALP Growth**

The quantity of labour as a primary input in production at firm *i* is measured by the head-count of paid workers and working proprietors[[9]](#footnote-9). Nominal value-added output is measured as gross-output *minus* intermediate inputs; that is, material and energy. Following Nishida *et al.* (2013) and Petrin *et al.* (2011), the quantity index of real value-added is then constructed by using the double-deflation approach to nominal value-added proposed by Bruno (1978) as

(1)

where and are nominal gross-output and inputs of material and energy with their respective price indices, approximated with a common industry price deflator. The denominator in each of the quotients represents the relevant price index for gross-output and intermediate input quantities.

Armed with and it is straightforward to calculate the aggregate labour productivity (ALP) index. Thus, plant *i*'s labour productivity at time *t* is represented by =, aggregate labour productivity at time *t* can then be expressed as = and the employment share of plant *i* at time *t* is. Movements in may reflect changes in embodied and disembodied technology as well as changes in technical efficiency[[10]](#footnote-10). These changes may also reflect shifts in scale economies and degrees of capacity utilization. For the decomposition of aggregate labour productivity growth, , the literature relies largely on the tradition of Baily *et al.* (1992)/Foster *et al.* (2001) in defining the effects of its sources. Specifically,

(2)

Eq.2 means that aggregate labour productivity growth, increases when firms use innovative production methods to produce more output through the ‘Within-Firm’ effects term holding factor inputs constant. The index can also increase when inefficient incumbent firms reallocate resources to more efficient ones through the term. Haltiwanger (1997) adds a component that allows for the interaction between the change in resources and the change in ALP growth, and calls it the ‘cross’ or the ‘covariance’ term. The cross term increases when the changes in both components move in the same direction; that is, when the market share and ALP growth jointly increase and vice versa. Lastly, if new business methods including capital deepening that lead to improvements in industry productivity can only be adopted by new plants, then the net-entry term, should dominate.

Motivated by PPS and BHS, Nishida *et al*. (2013) perform a theoretical and empirical analysis of ALP and APG using traditional methods and Petrin and Levinsohn (2012), respectively. We replicate Nishida *et al*. (2013) for the case of manufacturing sector Swaziland by decomposing ALP on the basis of Baily et al. (1992)/Foster et al. (2001) and APG using the marginal product of factor inputs.

* 1. **The ALP Growth Decomposition Using the Baily *et al.* (1992) Method**

The traditional method of decomposition is associated with the Baily *et al.* (1992) approach and its derivatives such as Griliches and Regev (1995), Foster *et al.* (2001) and Olley and Pakes (1996). In this context, is traditionally defined as input-share weighted changes in the distribution of plant-level technical efficiency, covariance and resource reallocation by incumbents and net entrants into the market. The Baily *et al.* (1992) decomposition additively isolates gains arising only from technical efficiency and resource reallocation. The Baily *et al.* (1992) (or) procedure decomposes as

(3)

where and andand represent firm entry and exit at time *t*, respectively. The different sources of are defined as

**Within-plant effects**: is the sum of changes in plant-level labour productivity weighted by *t1* base-period labour share for continuing plants. It measures a plant’s gains in productivity induced by continuous improvement in production methods without an increase in its labour share. This growth component is referred to as real-productivity effects in Levinsohn and Petrin (1999).

**Between-plant effects**: in Baily *et al.* (1992) is the sum of changes in plant-level employment-shares multiplied by the *t1* labour productivity for continuing plants. This growth effect measures the extent of labour share reshuffling across plants where the labour input is reallocated to more efficient plants. This term is also viewed as ‘clean’ because it hold real-productivity constant, see Nishida *et al.* (2013).

**Covariance effects**: is the sum of plant-level contemporaneous changes in the labour share and labour productivity. As Nishida *et al*. (2013) point out, this term increases when plants with increasing labour productivity are also plants with increasing labour shares.

**Net entry effects**: An entering plant is identified when it first appears at time *t*, and an exiting plant is identified when it last appeared at time *t1*. Thus, for, ALP growth contributions associated with entrants are measured by the plant-level sum of the current share-weighted labour productivity. In the case of exiting plants, the contributions are measured by the plant-level sum of the base-period share-weights *multiplied* by *t1* firm-level labour productivity. Net entry effects therefore refer to the difference between contributions by entering and exiting plants.

In the formulation of resource movement between plants in Eq.2, as Forster *et al*. (2001) and Nishida *et al*. (2013) point out, even if all plants have the same level of productivity for both the beginning and end period, the between component and net entry component will in general be nonzero. Moreover, previous studies such as Syverson (2004) have estimated high dispersion in measured productivity, which translates to large and volatile Baily *et al.* (1992) ‘Between’ effects. The standard remedy for this is to ‘normalize’ each industry’s ‘Between’ and ‘Within’ terms by the industry’s ALP and use the industry’s revenue shares as weights to aggregate across industries, see Petrin and Levinsohn (2012). As in Petrin and Levinsohn (2012) and Nishida *et al*. (2013), no normalization is carried out here in order to avoid losing the potential link between the actual ALP and, although the nature of such a link prior to normalization is unknown.

* 1. **The ALP Growth Decomposition Using the Foster *et al.* (2001) Method**

The decomposition of ALP using Foster *et al.* (2001) (or) is given as

, (4)

where the ‘Within’ and ‘Covariance’ terms are identical to those calculated using the Baily *et al*. (1992) method. The rest of the other ALP growth components calculated using Foster *et al*. (2001) are described as

**Between-plant effects**: is the sum of the changing labour shares weighted by the deviation of initial plant-level productivity from initial industry productivity index. An increase in a continuing plant’s labour share makes a positive contribution to the ‘Between’ component only if its initial productivity exceeds the average initial industry productivity.

**Net entry effects**: The ‘Entry’ term, reflects the deviation of current firm-level productivity from average initial industry productivity index weighted by current labour shares. First, a new firm contributes positively to growth if its productivity level exceeds the average initial industry productivity index; i.e., Second, the ‘Exit’ component is calculated similarly to the ‘Between’ term, except that it is weighted by the un-differenced labour shares. Thus, a shutting down plant contributes positively to ALP growth only if it has lower productivity than the average initial industry productivity index; i.e.,

Finally, by construction.

* 1. **Evidence on Drivers of ALP Growth**

Empirical decompositions of into its component sources of growth are common. Two meta-analyses by Bartelsman *et al.* (2004) (BHS) and by Paǵes *et al.* (2008) (PPS) together analyse 25 countries across Europe, the Americas and East Asia. Isaksson (2010) also surveys sources of in 33 advanced and developing countries as well as economies in transition, which includes many of the countries covered in the BHS/PPS meta-analyses. A number of these countries have undergone economic reforms to facilitate freer movement of inputs across firms in order to trigger productivity growth from resource reallocation. A consistent finding is that there has been significant ALP growth, measured as growth in =, for these economies.

In order to examine the sources of ALP growth, the BHS/PPS meta-studies decompose this index into real-productivity and reallocation terms using the Baily *et al*. (1992) and Foster *et al*. (2001) methods. The survey by Isaksson (2010) adds Haltiwanger (1997) in its arsenal of techniques of productivity decomposition[[11]](#footnote-11). A key finding is that most of the growth in aggregate labour productivity comes from real-productivity. Specifically, nine of the 25 countries experienced negative growth from resource reallocation and four more had a weak ‘Between’ term. Furthermore, 23 of the 25 countries had a negative covariance term.

Table 4 presents empirical decompositions of for the manufacturing sector covering a sample of 13 countries from the survey by Isaksson (2010), *plus* Swaziland, based on either the Foster *et al.* (2001) or Haltiwanger (1997) methods. This allows us to compare the results from Swaziland with evidence from market economies, economies in transition and Sub-Saharan Africa. Following the example of Van Biesebroeck (2005) for the Sub-Saharan results, we estimate a value-added production function which enables comparison of our results with those of other Sub-Saharan economies. Unlike Van Biesebroeck (2005), however, we also calculate productivity contributions coming from entry and exit of firms, which now enables comparison with results from advanced nations and economies in transition[[12]](#footnote-12).

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 4: ALP Growth Decomposition for the Manufacturing Sector in Industrialized Countries, Economies in Transition and in Developing Countries (Percentage) using Eq.4.** | | | | | | | | | |
| Method | Country | Period | Output/Share/  Productivity | Within | Between | Cross | Entry | Exit | Total |
| FHK (2001) | USA | 1992 & 1997 | GO/Labour/LP | 109.00 | -3.00 | -24.00 | -29.00 | 49.00 | 102.00 |
| FHK (2001) | UK | 2000-2001 | GO/Labour/LP | 48.00 | 19.00 | -17.00 | 35.00 | 12.00 | 97.00 |
| FHK (2001) | Germany | 1993-2003 | GO/Labour/LP | 118.60 | 11.50 | -30.10 |  |  | 100.00 |
| FHK (2001) | Russia | 1992-2004 | GO/Labour/LP | -590.40 | 359.60 | 61.61 | -223.70 | 292.93 | -99.96 |
| FHK (2001) | Slovenia | 1997-2001 | GO/Labour/LP | 68.00 | 18.00 | -2.00 | 15.00 | 13.00 | 112.00 |
| FHK (2001) | Chile | 1985-1999 | GO/Labour/LP | 95.00 | 25.00 | -50.00 | -35.00 | 65.00 | 100.00 |
| FHK (2001) | Columbia | 1987-1998 | GO/Labour/LP | 105.00 | 20.00 | -45.00 | -20.00 | 40.00 | 100.00 |
| **FHK (2001)** | **Swaziland** | **1994-2003** | **VA/Labour/LP** | **-4.88** | **3.53** | **-3.24** | **16.86** | **2.37** | **14.64** |
| Halti (1997) | Cameron | 1990-1995 | VA/Labour/LP | 144.94 | -25.84 | -13.48 |  |  | 105.62 |
| Halti (1997) | Ghana | 1990-1995 | VA/Labour/LP | 78.97 | 66.15 | -43.59 |  |  | 101.53 |
| Halti (1997) | Kenya | 1990-1995 | VA/Labour/LP | 445.45 | 282.80 | -629.09 |  |  | 99.16 |
| Halti (1997) | Tanzania | 1990-1995 | VA/Labour/LP | 122.00 | 13.00 | -36.00 |  |  | 99.00 |
| Halti (1997) | Zambia | 1990-1995 | VA/Labour/LP | 357.14 | 28.57 | -278.57 |  |  | 107.14 |
| Halti (1997) | Zimbabwe | 1990-1995 | VA/Labour/LP | 163.33 | 33.33 | -96.67 |  |  | 99.99 |
| *Notes*: Methods are described in the text. LP = Labour Productivity, GO = Gross Output, VA= Value Added, and Halti (1997) = Haltiwanger (1997). Information sources include Isaksson (2010), “Structural Change and Productivity Growth: A Review with Implications for Developing Countries”, *United Nations Industrial Development Organization,* Tables 1-3; Van Biesebroeck (2005), “Firm Size Matters: Growth and Productivity Growth in African Manufacturing”, *Economic Development and Cultural Change*, Vol. 53(3), pp. 543-83; and the author’s calculation of ALP growth components for Swaziland. | | | | | | | | | |

The average industry productivity for non-SSA countries, excluding Russia, is 101.83% and for SSA excluding Swaziland is 102.07%. This compares with 14.64% for Swazi manufacturing. The ‘Within’ effects generate more growth than ‘Between’ effects across all countries except Swaziland. In 12 of 14 countries, results show dominance of real-productivity over both resource reallocation among incumbents and turnover effects. Sub-Saharan ‘Within’ effects also dominate share-shift effects in the rest of the other economies surveyed in the table. This suggests that the Sub-Saharan manufacturing sectors generate incredibly more productivity growth from innovation and technological progress than do the more technologically advanced economies. The highest beneficiary from technological advancement is, for example, Kenya with 445% ‘Within’ effects followed by Zambia with 357%. On the other hand, looking at the ‘Between’ term alone shows that only the USA and Cameron had negative growth. Contrary to normally functioning market economies, this suggests that the USA manufacturing sector reallocated resources from high to lowproductivity plants between 1992 and 1997; and Cameron did the same in the period 1990 to 1995.

Finally, while all countries reporting on turnover have positive growth from firm exit, only Swaziland, Slovenia and the UK report positive entry contributions to growth. The 2.37% for Swaziland means that the country experienced the exit of lower productivity firms than the average initial industry productivity index. At the same time, Swaziland also experienced firm entry with higher average productivity of 16.86% than the average initial industry productivity. The entryexit rationalization effect of firms has a pronounced impact of 19.23% on ALP growth in Swaziland.

Moreover, the stylized fact from BHS/PPS and Isaksson (2010) is that real-productivity dominates both the share-shift effects and turnover terms in studies that use Baily *et al.* (1992) or its derivatives such as Foster *et al.* (2001) and Haltiwanger (1997)[[13]](#footnote-13). Contrary to conventional wisdom; however, the Swazi results show superiority of resource reallocation among incumbents and firm entry-exit dynamics over real-productivity. This suggests that the Swazi manufacturing sector is unique in delivering dominance of reallocation and rationalization effects over innovation and technological advancement during a period of trade reforms.

1. **A Detailed ALP Decomposition for the Swazi Manufacturing Sector**

This section is concerned with detailed analysis of the Swazi manufacturing sector to gain insight into the annual patterns of productivity variation represented by cross-plant movement of resources and technical change. It achieves this by using an unbalanced dataset of heterogeneous producers across 13 two-digit ISIC industries in the period 19942003. The estimation of ALP and its component parts is based on the Baily *et al.* (1992)/Foster *et al.* (2001) decomposition in Eqs.3 and 4 and reported in Table 5.

**Table 5: ALP growth rate in Swazi manufacturing 1994–2003: Baily *et al.* (1992)/Foster *et al.* (2001) Decomposition Using Eq.3 andEq.4 for Columns 37.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **year** | **Value-Added Growth** | **Labour productivity growth (0)** | **Baily *et al.* (1992) and Foster *et al.* (2001) ALP decomposition: (0) = (1) + (2) + (3) + (4)** | | | | | |
| **Within (1)** | **Between (2)** | | **Cross (3)** | **Net Entry (4)** | |
| **BHC-RE** | **FHK-RE** | **BHC** | **FHK** |
| 1995 | 7.76 | -26.03 | -12.34 | -27.06 | 0.67 | 3.60 | 9.51 | -17.83 |
| 1996 | 23.10 | -1.33 | -7.93 | -6.92 | 0.08 | 0.23 | 13.37 | 6.28 |
| 1997 | -44.35 | -2.79 | 2.93 | 32.90 | -8.51 | 4.09 | -42.71 | -1.31 |
| 1998 | 265.55 | 119.30 | 1.32 | -36.46 | 0.40 | -0.90 | 155.33 | 118.47 |
| 1999 | 275.57 | 102.21 | 9.89 | -35.03 | 5.11 | -3.86 | 134.79 | 91.46 |
| 2000 | -16.28 | -17.27 | -17.10 | -1.39 | -3.20 | 0.11 | 0.05 | 3.67 |
| 2001 | 37.42 | -1.02 | 31.79 | -28.89 | -0.42 | -8.90 | 4.97 | -23.50 |
| 2002 | -20.74 | -39.18 | -25.93 | -21.55 | -3.62 | 5.60 | 2.71 | -15.22 |
| 2003 | -36.71 | -3.33 | -26.55 | 73.21 | 41.25 | -29.12 | -20.88 | 11.09 |
| **Mean** | **54.59** | **14.51** | **-4.88** | **-5.69** | **3.53** | **-3.24** | **28.57** | **19.23** |
| **Median** | **7.76** | **-2.79** | **-7.93** | **-21.55** | **0.08** | **0.11** | **4.97** | **3.67** |
| **Std Dev** | **125.32** | **56.26** | **18.67** | **36.72** | **14.63** | **10.66** | **68.48** | **50.43** |

**Notes**: The ‘‘Labour productivity growth” column depicts the ALP growth with entry and exit, and the ‘‘Value added growth’’ column represents the aggregate real value added growth rate. The plant-level real value added is summed and annualized across plants. As in Nishida *et al.* (2013), numbers are percentage growth rates. We define labour productivity as the amount of real value added relative to unit labour. is decomposed into four components: (1) within, (2) between, (3) cross, and (4) net entry term, using Eq.1 in text for Baily *et al.* (1992) and Eq.2 in text for Foster *et al*. (2001). We use employment share for the share weights, and both “within” and “between” terms use the base-period share for the weights.

*Source*: Author’s own calculations.

The second and third columns report annualized growth rates in real value-added and ALP, respectively. The annual average (median) growth rate in real value-added is 54.59% (7.76%) with the measured standard deviation of 125.32%. Although real value-added growth is largely positive, particularly in 1998 and 1999, the incidence of negative growth is non-negligible. ALP, on the other hand, had an annual average (median) growth rate of 14.51% (2.79%). Again, the years 1998 and 1999 stand out as outliers[[14]](#footnote-14). In seven out of nine years, we observe negative ALP values in column three.

In columns four through nine, we present the Baily *et al.* (1992) and Foster *et al.* (2001) decompositions. On average, the annual average ‘within-effects' in column four is 4.88% compared to the Baily *et al.* (1992) between-plants term of 5.69% and Foster *et al.* (2001) between-plants term of 3.53%. Clearly, real-productivity dominates the Baily *et al.* (1992) share-shift component of aggregate productivity, yet it is subordinate to the Foster *et al.* (2001) between-plants term. Thus; *ceteris paribus*, it remains inconclusive at this point whether it is the “Within” or the “Between” term that generates more growth for ALP in the period under study. However, if the potentially profound confounding effects of entryexit dynamics in the measured “Between” term calculated using the Baily *et al.* (1992) approach is accounted for, then net-entry and the “Between” effects dominate the measured “Within” effects. Furthermore, both Baily *et al.* (1992) and Foster *et al.* (2001) decompositions make significant net entry contributions to ALP growth by contributing 28.57% and 19.23%, respectively. That is, the entry of more productive firms than the average initial industry productivity and the exit of low productivity firms than the average initial industry productivity are the main drivers of ALP.

Looking at firm-level production efficiency in isolation, we find evidence of progressive weakening of technical change in manufacturing potentially induced by increasing competition in the customs union, save for the 31.79% productivity increase in 2001 which was consistent with the start of AGOA. Judging from the size of the standard deviation, there was marked heterogeneity in plant-level technical efficiency around a declining average productivity trend.

In a closer examination of incumbents, entrants and exiting firms, we find evidence of significant heterogeneity as in Liu and Tybout (1996) represented by the standard deviations of 68.48% and 50.43% in the Baily *et al*. (1992 and the Foster *et al*. (2001) approaches, respectively. We also find that, on average, exiting plants are 28.97% and 19.23% lower than incumbents in terms of productivity contribution to ALP when using the respective methods. Hence, their disappearance improves sectoral productivity. However, the occasional exit of relatively more efficient firms has the consequence of inducing a negative turnover effect on aggregate labour productivity. In this context, Liu and Tybout (1996) note that while productivity of exiting firms may drop; surviving entrants may raise their productivity such that the snowballing effects of this cleansing process are probably substantial over a longer time horizon. According to Caballero and Hammour (1994), it is this continuous process of creation and destruction of business units that results from product and process innovation that is essential for understanding growth.

A further isolation of incumbents shows that productivity heterogeneity remains important, regardless of the approach used. Using the Forster *et al*. (2001), the portion of change in sectoral productivity that is due to the labour market share reallocation accounts for 3.53%, on average. As in Nishida *et al*. (2013), it is instructive to determine the impact of an expanding or shrinking economy on the Baily *et al.* (1992) share-shift component. The direction of change in the number of firms can work to reduce or increase this component of productivity as shown in the next section.

* 1. **Confounding Effects of Firm Turnover on the Baily *et al*. (1992) Reallocation**

The Baily *et al.* (1992) reallocation component can be further decomposed into two more constituent parts: one related to reallocation and another related to the number of plants as in Nishida *et al.* (2013). Suppose there are plants in manufacturing at time *t* and the plant-level average share of employment is. Then, the relative labour share in the ith plant is defined as and the change in the relative labour share from time *t-1* to *t* is. Hence, the “Between” term for incumbent firms can be decomposed as follows:

(5)

where refers to continuing plants at time *t*. The first component represents labour reallocation and the second component is related to patterns of creative destruction. An increase in the number of firms over time confounds the first component by in the negative direction since can never be negative. The reverse effect obtains in case of a persistent fall in the number of firms. The second component also gets smaller and smaller as the number of firms gets smaller and smaller, which happens if firm exit rate is persistently higher than the entry rate. If the there is no change in the number of firms in the adjacent periods, the second component falls away. That is, the entry-exit dynamics have a spurious influence on the Baily *et al*. (1992) labour reallocation effect. Table 6 presents a quantitative decomposition of for Swazi manufacturing sector.

**Table 6: The ALP Growth Rate for the Swazi Manufacturing Sector (1994–2003): Baily *et al*. (1992) Between Term Decomposition.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Year | BHC (0): Between | Baily *et al*. (1992) between term decomposition: (0) = (1) + (2) | | Percentage Growth of firms |
| (1) First component | (2) Second component |
| 1995 | -27.06 | -16.93 | -10.13 | 11.11 |
| 1996 | -6.92 | 4.71 | -11.63 | 13.75 |
| 1997 | 32.90 | 30.89 | 2.00 | -2.20 |
| 1998 | -36.46 | -13.21 | -23.25 | 25.84 |
| 1999 | -35.03 | -24.83 | -10.20 | 23.21 |
| 2000 | -1.39 | 4.08 | -5.47 | 7.97 |
| 2001 | -28.89 | -21.39 | -7.50 | 10.07 |
| 2002 | -21.55 | -14.49 | -7.06 | 8.54 |
| 2003 | 73.21 | 54.59 | 18.62 | -15.17 |
| **Mean** | **-5.69** | **0.38** | **-6.07** | **9.24** |
| **Median** | **-21.55** | **-13.21** | **-7.50** | **10.07** |
| **Std Dev** | **36.72** | **26.73** | **11.39** | **12.37** |
| *Notes:* Percentage growth rates. The Baily *et al*. (1992) ‘between’ term is decomposed into two terms using Eq.5 in the text. | | | | |

*Source*: Author’s own calculations.

The second column is identical to the column in table 6. The third and fourth columns are the respective first and second components of Eq. 5, and the last column is the percentage growth of firms per year. In seven out of nine years, the manufacturing sector experienced 9.24% average growth in the number of firms, and in these years the confounding effect of plant expansion was negative on the first component. Consequently, the comparison of the first term to the overall average of the Baily *et al*. (1992)-‘between’ term shows that on average it is 6.07 % higher over the sample period due to the downward confounding effects of plant turnover to the first component. These results mimic the findings by Nishida *et al.* (2013) for Chile and Slovenia, and they cast doubt on the validity of the share-shifting effects of the Baily *et al.* (1992) approach. This confirms the conclusion by Nishida et al. (2013) that the Baily *et al*. (1992) reallocation can be negatively correlated, positively correlated or simply uncorrelated with the actual reallocation of inputs. A crucial argument in that paper, also corroborated by our results, is that the Baily *et al.* (1992) indices can erroneously equate reallocation growth to productivity growth, yet output per labour ratio is neither a perfect proxy for marginal products nor plant-level productivity.

This dilemma opens a door to the application of one of the promising approaches to estimating the decomposition of APG based on parametric aggregation of plant-level productivity. In his study of robustness of productivity estimates, Van Biesebroeck (2007) demonstrates with Monte Carlo techniques the circumstances in which each of the methodologies works well. Among the six approaches analysed, two parametric methods appear suited to investigating productivity growth; namely, the systems generalized method of moments’ estimator (SYS-GMM) and the semiparametric Olley and Pakes (1996)/Levinsohn and Petrin (2003)-type of models.

The next sections draw heavily from the theoretical foundations of Petrin and Levinsohn (2012) as applied in Nishida *et al.* (2013) for measuring APG using plant-level data. Our purpose is to estimate and contrast the APG sources with those found when using traditional methods. It begins by determining a suitable proxy for the unobserved firm-level productivity. The actual semiparametric model estimation follows immediately.

1. **The Petrin-Levinsohn (2012) Approach to Aggregate Productivity Growth Decomposition**
   1. **Production Function Specification**

The semiparametric method of estimating production functions initiated by Olley and Pakes (1996) addresses problems of endogeneity in inputs and the unobserved productivity shocks. Instead of using lumpy investment as a proxy for productivity like Olley and Pakes (1996), the Levinsohn and Petrin (2003) approach uses the intermediate input to estimate the gross output production function[[15]](#footnote-15)

, (6)

where all variables are in natural logarithms. The variable is real output, is the constant term, the coefficients are elasticities with respect to labour and capital inputs[[16]](#footnote-16). is variable labour input for firm i at time t, is fixed and/or quasi-fixed capital input. The last two components are the unobservable productivity, which is known to the firm but unknown to the econometrician and is a sequence of independent and identically distributed (i.i.d) shocks. Demand for intermediate inputs, is a function of state variables and and is assumed monotonically increasing in Therefore, this function is invertible to express as a function of and In turn, is governed by a first-order Markov process with an additional innovation that is uncorrelated with but not necessarily with

In the first stage, Levinsohn and Petrin (2003) transform (6) into a function of labour input and an unknown function where is approximated with a third-degree polynomial in and, and is estimated using O.L.S., see Eqs.1.61.8 in Appendix A.1. Ackerberg *et al.* (2008) demonstrate how is unidentified because is correlated with, and propose an alternative but still two-stage approach. The second stage in Levinsohn and Petrin (2003) involves nonparametric estimation of the value of, and estimating the productivity series using. A consistent nonparametric approximation to is then given by predicted values from a nonlinear regression shown by Eq.1.21 in Appendix A.1. Given and, the estimate of solves the minimization of the squared regression residuals

. (7)

Instead of a two-step approach, Wooldridge (2009) proposes to simultaneously estimate by making Conditional Mean Independence (CMI) assumption about the error term in respect of current and past values of. This allows him to express the third-degree polynomial in single-period lags of capital and intermediate inputs as in (8)

(8)

or

. (9)

Following Petrin and Levinsohn (2012), Petrin *et al*. (2011) and Nishida *et al*. (2013), Eq. 9 can be estimated using a pooled IV, with and third order polynomial approximation of with as instruments for. CMI IIin the Appendix renders this approach robust to the Ackerberg *et al.* (2008) critique and it does not require bootstrapping to obtain robust standard errors for.

* 1. **Parametric Estimation of the Production Function**

It is essential to show in a practical sense how to efficiently estimate the parameters using firm-level datasets. Eq.9 can be estimated either by gross output production functions as in Petrin *et al*. (2011) or a value-added production technology as in Nishida *et al*. (2013). The latter is adopted here. Table 7 presents the characteristics of the empirical model.

Table 7: Specification of the Empirical Model

|  |  |
| --- | --- |
| **Panel A: Variables for the Levinsohn and Petrin (2003) or the LP Model** | |
| *Dependent variable*: | Double-deflated value-added () |
| *Freely variable inputs*: |  |
| *Proxy*: Intermediate Inputs |  |
| *Capital*: |  |
| *value-added*: |  |
| *Reps (#)*: | Number of bootstrap replications to be performed |
| **Panel B: Variables for the Wooldridge (2009) and Levinsohn and Petrin (2003) or the WLP Model** | |
| *Dependent variable*: | Double-deflated real value-added () |
| *Included Instruments*: |  |
| *Endogenous variables*: |  |
| *Excluded Instruments:* |  |

Panel A is the LP Model which includes freely variable inputs and excludes the proxy variable. In order to estimate the parameters, we regress the empirical LP Model as

levpet free () proxy () capital () reps(***$nreps***). (10)

Acherberg *et al* (2008) have however shown that the LP Model suffers from parametric identification problems arising from firms’ optimization of variable labour, yet labour is also a deterministic function of unobservable productivity and capital. In Panel B, Wooldridge (2009) therefore modifies Levinsohn and Petrin (2003) to correct for this endogeneity problem. In this Model, endogenous variables are instrumented with capital and the polynomial approximation of the unknown expression and specified as[[17]](#footnote-17)

ivreg2 ***$exoreg*** (***$endoreg = $instr***), gmm2s cluster(***id***) (11)

Table 8 presents estimation results from the WLP Model, Levinsohn and Petrin (2003), Fixed Effects and O.L.S. methods with and without interaction. Our preferred production function specification, the WLP, is well-behaved[[18]](#footnote-18).

**Table 8: Estimates of Production Functions with Third Order Polynomial[[19]](#footnote-19)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Variable | WLP | LP | FEa | FE-Intb | O.L.S. | O.L.S.lab |
|  | -0.162 | -0.118 | -0.069 | -0.028 | -0.070 |  |
|  | 0.892\*\*\* | 0.794\*\*\* | 0.796\*\*\* | 0.793\*\*\* | 0.811\*\*\* |  |
|  |  |  |  |  |  | 0.863\*\*\* |
|  | 0.224\*\*\* | 0.181\*\*\* | 0.216\*\*\* | 0.222\*\*\* | 0.193\*\*\* | 0.158\*\*\* |
|  |  |  | 0.325\*\*\* | 0.321\*\*\* | 0.306\*\*\* | 0.356\*\*\* |
|  | 7.074\* |  |  |  |  |  |
|  | 0.663 |  |  |  |  |  |
|  | -0.682\*\* |  |  |  |  |  |
|  | -0.162 |  |  |  |  |  |
|  | 0.293\*\* |  |  |  |  |  |
|  | 0.010 |  |  |  |  |  |
|  | 0.014\* |  |  |  |  |  |
|  | 0.001 |  |  |  |  |  |
|  | -0.011\*\*\* |  |  |  |  |  |
| cons | -25.021 |  | 8.413\*\*\* | 8.397\*\*\* | 8.810\*\*\* | 8.367\*\*\* |
| N | 757 | 1021 | 1021 | 1021 | 1021 | 1257 |
| r2 | 0.839 |  | 0.811 | 0.827 | 0.796 | 824 |
| r2\_a | 0.837 |  | 0.806 | 0.803 | 0.795 | 824 |

Legend: \* p<0.05; \*\* p<0.01; \*\*\* p<0.001.

*Notes*: The core model estimated in this table is Eq.9 and outlined in Appendix A.5. Endogenous variable is instrumented with contemporaneous capital and the polynomial function. The two-step GMM framework in the WLP model produced estimates that are efficient for arbitrary heteroskedasticity and clustering on a firm, and the model is exactly identified. The symbol ‘a’ represents a fixed effects model that controls for both time and industry effects; ‘b’ is a fixed effects model that interacts time with industry effects.

The over-identification test of all instruments shows that the model is exactly identified. Whileis negative and insignificant across specifications, and are consistently positive and highly significant.

One important finding from the IVGMM estimator is that the primary inputs in manufacturing deliver increasing returns to scale. This is potentially associated with import-competing industries whose output is likely to decline due to intensified foreign competition during the trade liberalization episode in the customs union[[20]](#footnote-20). The low value of the capital coefficient is typical in the literature and the cited cause for this is measurement error; see Levinsohn and Petrin (2003)[[21]](#footnote-21). The IVGMM labour coefficient shows an improvement of 10 percentage points compared to the other estimation methods. This can be attributed to efficiency gains in the GMM routine induced by the removal of selection and simultaneity biases. Industry effects on real value-added movements show a significant degree of heterogeneity whereby five of the 13 industries made insignificant contributions to output and the Apparel industry suffered a marked decline, particularly in 2001. Furthermore, there is no evidence of time effects in the first seven years and a significant decline began persistently in 2000 with marked negative effects in 2001 and 2003. The economic performance in the latter years coincides with heightened firm exit and the near-conclusion of progressive tariff-cuts in SACU.

* 1. **General Set-Up, APG Decomposition and Estimation**

There is already a growing view noted by Barnerjee and Moll (2010), among others, that countries’ underdevelopment may not only be an outcome of resource inadequacy, such as capital, skilled labour, entrepreneurship, or ideas, but also a result of the misuse or misallocation of available resources. Specifically, Banerjee and Duflo (2005); Jeong and Townsend (2007); Restuccia and Rogerson (2008, 2012); Hsieh and Klenow (2009); Bartelsman, Haltiwanger, and Scarpetta (2008); and Alfaro, Charlton, and Kanczuk (2008) all argue that the scope of resource misallocation in developing economies is large enough to explain a significant gap in the aggregate productivity growth between advanced and poor countries. A similar argument is relevant if trade reforms identify industries that still need protection while trade liberalization in other industries deepens as demonstrated by Edwards (2006) in the case of South Africa and, by extension, the rest of SACU.

Furthermore, there are also factors that move an economy away from the perfect competition setting such as input adjustment costs, hiring, firing and search costs, holdup and other contracting problems, taxes and subsidies, and markups. Examples of empirical evidence include Kambourov (2009) for firing costs in the case of Chile and Mexico, Aghion *et al.* (2007) and Fedderke *et al*. (2005) for markups in South Africa, and Petrin and Sivadasan (2013) for marginal product-marginal cost gaps in Chile. The finding of input misallocation suggests the presence of barriers to the movement of resources across heterogeneous production units. Similarly, firm-level heterogeneity in marginal products of inputs within industries in a country is also pronounced; see, for example Hsieh and Klenow (2009) for the case of India and China, Petrin and Sivadasan (2013) for Chile and Ho *et al.* (2014) for Ecuador. Ho *et al.* (2014), Petrin *et al*. (2011) and Nishida *et al*. (2013) rely on Levinsohn and Petrin (2010, 2012) to identify the relative role of technical efficiency improvement, the intensive and extensive margins. In response to the non-neoclassical frictions in developing economies, we also implement the Petrin and Levinsohn (2012) approach to estimate the extent of technical efficiency improvement and both margins of reallocation.

* + 1. **The General Set-Up**

In this section we focus on the reallocation of primary inputs across, and the patterns of technical efficiency within, firms. The characterization of aggregate productivity growth in the absence of intermediate inputs takes the form

(12)

where is the partial derivative of output with respect to capital. We denote the price of output in establishment i as, and denotes the cost of labour. The change in the use of kth input quantity by firm i is. The ‘net output’ remaining after deducting contributions by factor inputs to is. Therefore, represents gains from total technical efficiency changes, given. In Petrin and Levinsohn (2012, Lemma 1) and Petrin *et al*. (2011, Eq.7), the impact of a change in the kth input on a change in output is normalized as to transform the total technical efficiency changes into .

Thus, Eq.12 shows that the primary input reallocation is zero if =0. This occurs if distortions or adjustment costs are prohibitively high that inputs do not adjust and consequently do not reallocate across firms. Furthermore, under a perfectly operating factor input market, the VMP of each input is equal to its reward. This means that factor inputs are continuously reallocated across plants in response to changes in economic conditions to maintain the VMP-price equality and no extra output gains can be realized from this reallocation; see Petrin and Levinsohn (2012).

* + 1. **APG Decomposition and Estimation**

The decomposition of APG based on a double-deflation procedure for the value-added function, if it exists, is shown by Petrin and Levinsohn (2012) to be

APG (13)

where the Domar-weight is plant i's real value-added share. The two classes of labour are defined as and where refers to Paid Employees and refers to Working Proprietors (or Nonproduction Workers in Levinsohn and Petrin (2003)). The real value-added production function can then be written as

(14)

Eq.12 can be translated into APG as

(15)

where the first-difference operator is and is the input revenue ratio to the plant’s real value-added. The real value-added elasticity with respect to the input is. The gaps in Eq.13 are measured by the difference between the plant-level value-added elasticities and its input revenue share to value-added. The aggregate input reallocation is therefore given by and aggregate technical efficiency is The APG approach has been applied to the US manufacturing data by Petrin *et al*. (2011), to Chile, Columbia and Slovenia by Nishida *et al*. (2013), to Chile by Petrin and Sivadasan (2013) and to Ecuador by Ho *et al.* (2014).

Using index number theory, it is possible to estimate Eq.10 directly from the discrete data using the TörnqvistDivisia methods. As in Nishida *et al*. (2013), the prices in the Domar-weights are annually chain-weighted and updated. The TörnqvistDivisia method can be used in Eq.12 for each of the two APG components; namely, the reallocation of primary inputs and technical efficiency - the respective analogues to the ‘Between’ and ‘Within’ terms from ALP in the traditional approach. The *estimated* aggregate productivity growth can then be expressed as

, (16)

which translates to

(17)

The denotes plant i’s average value-added share weight from year *t1* to *t,*  the first difference operator as before, and is the two-period average of plant i's expenditure for the kth primary input as a share of firm-level value-added. In summary, the definitions of the APG components are

**Technical Efficiency**: is the value-added production function sum of the Domar-weighted changes in the Solow residuals, the APG analogue of the ALP “Within” term in Baily *et al*. (1992)/Foster *et al*. (2001). Technical efficiency increases when a plant continuously innovates and adapts to technological advances through learning-by-doing/watching and other means.

**Reallocation**: According to Petrin and Levinsohn (2012), Petrin *et al*. (2011), Petrin and Sivadasan (2013, p.288) and Nishida *et al*. (2013, Eqs.6 and 8), plants produce at the output level where, under imperfect factor market conditions. Therefore, there are three potential instances for input reallocation growth. *First*, if is the change in the kth factor input that was previously idle, but now reallocates to plant i, then the value of aggregate output changes by. *Second*, when a small amount of primary inputs reallocates from j to i so that then aggregate output changes by. *Third*, in the event factor inputs reallocate across firms but the total amount of these inputs is held constant, the change in aggregate output induced by reallocation is given by.

**Entry and Exit**: Entry in this set up includes the development of a new product, the replication of an existing product by a new firm or a reintroduction of a good back into the market after exiting previously, (see Petrin and Levinsohn (2012, Appendix)).

In order to separately estimate firm-level technical efficiency in Eq.12 for each ISIC2-digit industry code in Swazi manufacturing, Eq.6 can be re-written as

(18)

and estimated using the proxy method by Wooldridge (2009) that modifies Levinsohn and Petrin (2003) to address the simultaneity problem in the determination of inputs and productivity. In Eq.14, we use three factor inputs as regressors: non-production (Working Proprietors), production (Paid Employees) and capital Unlike Nishida *et al*. (2013), we do not report only aggregate labour reallocation in our results but we also report reallocation of and separately.

Table 9 quantitatively decomposes APG into technical efficiency, primary input reallocation and net entry estimated using Eq. 14. The second and third columns show changes in real value-added and aggregate productivity, respectively. It is striking to observe such a high correlation between aggregate productivity growth and the growth of value added. This reflects the fact that most of the fluctuations in aggregate productivity are predominantly linked to fluctuations in value-added. Similar results are found in the case of Chile, Columbia or Slovenia in Nishida *et al.* (2013) or for the case of Japan in Kwon *et al.* (2009). For example, the Swazi manufacturing sector reports an estimated average real value-added of 54.59% and average APG of 54.54%, or the median real value-added of 7.76% and the median APG of 7.71% per year, respectively.

**Table 9: Aggregate multifactor productivity growth rate, Swaziland manufacturing 1994–2003: APG decomposition, manufacturing value-added index double-deflator.**

**Estimates of**  and ***+*.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Value-Added Growth | APG (0) | APG Decomposition: (0)= (1) + (2) + (3) | | | | | |
| Technical Efficiency (1) | Reallocation | | | | Net Entry (3) |
| Total Reallocation (2) | Labour Reallocation | Working Proprietors’ Reallocation | Paid Employees’ Reallocation |
| 1995 | 7.76 | 7.71 | -4.43 | -4.31 | 8.76 | 5.61 | 3.15 | 16.45 |
| 1996 | 23.10 | 23.03 | 2.27 | -6.98 | 1.21 | -0.30 | 1.51 | 27.75 |
| 1997 | -44.35 | -44.25 | -2.69 | 18.13 | 9.84 | -0.08 | 9.92 | -59.69 |
| 1998 | 265.55 | 265.30 | 2.31 | -2.38 | 0.10 | 0.02 | 0.07 | 265.37 |
| 1999 | 275.57 | 275.42 | 0.64 | 9.81 | 3.01 | -0.01 | 3.03 | 264.97 |
| 2000 | -16.28 | -16.27 | -15.30 | -5.16 | 0.61 | -0.13 | 0.74 | 4.18 |
| 2001 | 37.42 | 37.39 | 9.03 | 20.10 | -0.08 | -0.11 | 0.03 | 8.25 |
| 2002 | -20.74 | -20.75 | -3.56 | -29.01 | -1.36 | -1.66 | 0.30 | 11.82 |
| 2003 | -36.71 | -36.67 | -20.74 | 1.12 | 7.14 | -2.61 | 9.75 | -17.05 |
| **Mean** | **54.59** | **54.54** | **-3.61** | **0.15** | **3.25** | **0.08** | **3.17** | **58.01** |
| **Median** | **7.76** | **7.71** | **-2.69** | **-2.38** | **1.21** | **-0.11** | **1.51** | **11.82** |
| **Std Dev** | **125.32** | **125.23** | **9.21** | **14.88** | **4.22** | **2.27** | **3.96** | **120.14** |
| *Notes*: As in Nishida *et al.* (2013), numbers are percentage growth rates. The plant-level multifactor productivity is calculated by using production function parameters that vary across 2-digit ISIC. We obtain the estimates by using Wooldridge (2009). APG represents the aggregate productivity growth with entry and exit, which is defined as aggregate change in final demand *minus* aggregate change in expenditure in inputs, holding input constant. We use value-added share (Domar) for weights. APG is decomposed into four components: (1) technical efficiency, (2) reallocation, and (3) net entry term, using Eq. 17 in text. | | | | | | | | |

These trends are characterized by high firm-level heterogeneity in the change of value-added and APG. For example, the measure of dispersion for APG is over twice its average size. One channel explaining this is found in Syverson (2004) which states that trade liberalization creates a competitive market environment and snowballing of product variety. This enables consumers to switch between products and/or producers such that high-cost producers’ profitability is diminished. Thus, a high substitutability industry is likely to have less productivity dispersion and high aggregate productivity level.

The contribution of technical efficiency to APG is on average (median) 3.61% (2.69%) per year, compared to an average of 0.95% for Chile, 0.25% for Columbia and 2.17% for Slovenia (see Nishida *et al.* (2013)). This component of APG is positive in only four out of nine years. However, the most interesting case is the combined input reallocation in the fourth column reflecting simultaneous cross-plant movements in capital and components of labour inputs. The average total reallocation is 0.15% per year and consists of input reallocation from low to high productivity plants, from idle state to productive uses and reallocation that is not accompanied by changes in input amounts. Clearly, the average reallocation compares with 1.60% for Chile, 3.63% for Columbia and 3.42% for Slovenia reported in Nishida *et al.* (2013).

However, our penultimate focus is the behaviour of the paid labour resource in response to shifts in economic factors that cause movements in the manufacturing sector. We first isolate labour reallocation from the contribution of all inputs put together. This produces 3.25% as the average annual rate of labour reallocation, and we report only two instances of negative reallocation out of the nine years studied. A further decomposition of labour reallocation into that which is accounted for by the reshuffling of working proprietors and paid employees produces sharper results. Paid employment shows positive growth in every year and accounts for an average of about 98% [3.17%3.25%] of all labour reallocated per year. Again, paid labour reallocated from low to high VMP plants, new paid labour entered the labour market and some paid labour reallocated without increasing the number of workers. This is consistent with the wave of downsizing in the manufacturing sector during the period of trade liberalization. Our results are robust to the use of ‘single-deflation’ by the manufacturing value-added deflator in Appendix A.3 and ‘double-deflation’ by the consumer price index in Appendix A.4. Another robustness check applied, but not reported here, involved ‘single-deflation’ by the consumer price index which also sustained the basic results.

Thus, the analysis reveals that the contribution by the labour reallocation growth to APG decisively *dominates* technical efficiency in the manufacturing sector in Swaziland. Firms were not investing more on improving production efficiency through innovation and adoption of new technologies than they moved labour to higher activity producers. This conclusion remains robust regardless of the deflation procedure used in the estimation of the value-added production function. However, based on our robustness checks, the combined input reallocation *versus* technical efficiency is inconclusive because the outcome depends on whether we use the mean or the median as a standard for comparison.

On the other hand, the extensive margin accounts for most of the change in APG. The annual average of net entry contribution to APG is 58.01% and is driven by the dramatic increase of APG in 1998 and 1999. This pattern of high contribution by net entry is consistent with extensive margin effects of trade liberalization which increases opportunities for mergers and acquisitions as well as business restructuring and retrenchments.

* + 1. **The Nature of Aggregate Productivity Growth from Net-Entry the 19981999 Period**

In a case like Swaziland with relatively few larger companies, entry and exit and mergers and acquisitions amongst these types of companies can have a large effect on APG. For example, in 1998 a division of a large company was taken over by another firm in the same sector but this was recorded as entry of a new firm. In the following year the acquiring firm took over the rest of the company and engaged in extensive retrenchments which raised labour productivity in this sector. This behaviour accounted for approximately 265% productivity growth in these two years.

1. **Summary and Conclusion**

This chapter investigates primary input trends, aggregate productivity and factor-intensities in Swazi manufacturing firms over a period of trade liberalisation in the Southern African Customs’ Union. It begins with descriptive analyses and then investigates the drivers of aggregate productivity growth over time and across industries. A cross-country comparison of drivers of aggregate labour productivity growth with those of the Swazi manufacturing sector is also undertaken. The chapter then deepens the analysis to focus on Swaziland by decomposing aggregate labour productivity growth over time using traditional methods and also relying on Levinsohn and Petrin (2012) as applied by Nishida *et al*. (2013). It concludes with an analysis of seemingly outlying aggregate labour productivity growth in 1998 and 1999 to determine the characteristics of entrants associated with it.

The descriptive evidence shows a decline in both aggregate labour and capital productivities and an increase in the capitallabour ratio. It also shows a leftward distribution of ALP and increasing heaviness of both tails. There are three potential explanations for this. First, firms shed more labour relative to capital due to capital irreversibility and to South African companies shifting production back to South Africa as a response to the lifting of economic sanctions whilst keeping Swazi plants in operation to cover their variable costs. Second, lower productivity firms are growing faster relative to higher productivity plants. Third, there is entry of lower ALP firms.

An in-depth analysis using the conventional approach found that the ALP growth is driven largely by net-entry, then by cross-firm market share-shift and negatively by within firm technical change. This result is robust to controlling for confounding effects of plant turnover in the Baily *et al*. (1992) method. Using the Levinsohn and Petrin (2012) approach also produces the same order of importance for APG components. That is, the net-entry contribution explains most of the changes in APG followed by input reallocation, while technical efficiency remains negative per year.

However, the most interesting case is the combined input reallocation reflecting cross-plant movements. The average reallocation of the input bundle from low to high productivity incumbent plants is 0.15% per year. However, isolating the average annual rate of labour reallocation from the contribution of all inputs put together produces 3.25%. Furthermore, paid employment shows positive growth in every year and accounts for an average of about 98% of all labour reallocated per year. These results are robust to ‘single-deflation’ by the manufacturing value-added deflator and ‘double-deflation’ by consumer price index. Furthermore, the annual average of net-entry contribution to APG is 58.01% and is mainly accounted for by the dramatic increase of APG in 1998 and 1999 due to firm entry.

Finally, the analysis reveals that individual contributions by the extensive and intensive margins of resource reallocation to APG decisively *dominate* technical efficiency in the manufacturing sector in Swaziland. Firms were not investing more on improving production efficiency through innovation and adoption of new technologies than they moved labour to higher activity producers. This conclusion remained robust regardless of the deflation procedure used in the estimation of the real value-added production function. The novelty of our results lies in the use of microfoundations to define aggregate productivity growth.

Our future research will focus on separating the contribution of each factor and intermediate input to APG. Given that the APG framework nests many situations around the development and introduction of new goods, this enquiry should also estimate fixed costs and the “gap” terms in Eq.15 to further understand the productivity dynamics during a period of market reforms. Petrin *et al*. (2011) estimate the impact of primary and intermediate inputs on productivity growth and estimate the orders of magnitude and potential volatility of input-gaps. Petrin and Sivadasan (2013) use input-gaps to estimate output losses due to allocative inefficiency.

**APPENDIX**

**Appendix A.1: Manufacturing and Survey ALP (19942003)**

*Notes*: S-productivity denotes ALP measured by the natural logarithm of real value-added/labour ratio calculated from survey data and the equivalent M-productivity calculated from real value-added sourced from the World Bank Indicators and paid labour sourced from IMF Country Reports for Swaziland (1999, 2000, 2003, and 2008).

**Appendix A.2: ALP Distribution for Selected Years (1994, 1997, 2000, 2003)**

****

*Notes*: Single deflation of the ratio of real value-added to aggregate annual employment.

**Appendix A.3: Evolution of the First Quartile of ALP by Industry (1994-2003)**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **EVOLUTION OF FIRST QUARTILE ALP BY INDUSTRY** | | | | | | | | | |
| isic2 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
| Food (15) | 1.00 | 0.70 | 0.83 | 0.88 | 0.91 | 0.81 | 0.73 | 0.74 | 0.68 | 0.52 |
| Textile (17) | 1.00 | 0.61 | 0.58 | 0.73 | 1.37 | 0.72 | 0.47 | 0.65 | 0.17 | 0.34 |
| Apparel (18) | 1.00 | -16.15 | 16.46 | 10.99 | 13.17 | 9.77 | 11.50 | -23.31 | 7.47 | 3.95 |
| Wood (20) | 1.00 | 0.66 | 0.68 | 0.64 | 0.61 | 0.55 | 0.81 | 0.80 | 0.58 | 0.25 |
| Pulp & Paper (21) | 1.00 | 1.27 | 1.55 | 1.51 | 1.60 | 1.63 | 1.49 | 0.73 | 1.55 | -0.11 |
| Printing & Publishing (22) | 1.00 | 0.93 | 0.92 | 0.83 | 0.79 | 0.86 | 0.93 | 0.69 | 0.74 | 0.62 |
| Chemicals (24) | 1.00 | 1.11 | 0.82 | 1.08 | 0.80 | 0.99 | 1.03 | 0.80 | 0.89 | 0.95 |
| Rubber (25) | 1.00 | 1.02 | 0.93 | 0.77 | 0.87 | 0.81 | 0.90 | 0.95 | 0.70 | 0.51 |
| Non-Metallic Minerals (26) | 1.00 | 0.96 | 0.61 | 0.40 | 0.43 | 0.47 | 0.62 | 0.22 | 0.41 | 0.59 |
| Basic Metals (27) | 1.00 | -0.05 | 3.13 | 3.25 | 3.13 | 3.16 | 1.49 | 1.18 | 0.17 | 2.00 |
| Fabricated Metal (28) | 1.00 | 0.84 | 1.23 | 0.92 | 1.10 | 1.30 | 0.94 | 0.80 | 0.74 | 1.02 |
| Furniture (29) | 1.00 | 0.94 | 0.90 | 1.10 | 1.07 | 0.96 | 0.86 | 1.02 | 1.07 | 0.27 |
| Other Manufacturing (36) | 1.00 | 1.75 | 0.95 | 1.03 | 0.85 | 1.24 | 1.20 | 0.59 | 0.82 | 1.02 |
| **Sector Mean** | **1.00** | **-0.42** | **2.28** | **1.86** | **2.05** | **1.79** | **1.77** | **-1.09** | **1.23** | **0.92** |
| **Sector Median** | **1.00** | **0.93** | **0.92** | **0.92** | **0.91** | **0.96** | **0.93** | **0.74** | **0.74** | **0.59** |
| **Std Dev (** | **0.00** | **4.75** | **4.31** | **2.83** | **3.41** | **2.50** | **2.94** | **6.68** | **1.91** | **1.05** |

*Source*: Author’s calculations.

**Appendix A.4: Evolution of the Third Quartile of ALP by Industry (1994-2003)**

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | **EVOLUTION OF THIRD QUARTILE ALP BY INDUSTRY** | | | | | | | | |
| isic2 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 |
| Food (15) | 1.00 | 0.88 | 0.94 | 0.94 | 1.05 | 1.06 | 1.07 | 1.00 | 0.95 | 0.92 |
| Textile (17) | 1.00 | 0.63 | 0.81 | 0.97 | 0.94 | 1.13 | 0.66 | 0.83 | 0.50 | 0.77 |
| Apparel (18) | 1.00 | 1.11 | 1.12 | 0.70 | 1.38 | 0.92 | 0.73 | 0.62 | 0.64 | 1.54 |
| Wood (20) | 1.00 | 0.84 | 0.66 | 0.79 | 0.99 | 1.17 | 1.06 | 0.73 | 0.77 | 0.69 |
| Pulp & Paper (21) | 1.00 | 1.00 | 1.01 | 1.25 | 1.20 | 1.22 | 1.42 | 1.34 | 1.14 | 1.09 |
| Printing & Publishing (22) | 1.00 | 0.82 | 0.87 | 0.87 | 1.00 | 1.03 | 1.08 | 1.08 | 0.97 | 1.01 |
| Chemicals (24) | 1.00 | 0.95 | 0.95 | 1.29 | 0.96 | 1.04 | 1.13 | 1.20 | 1.33 | 0.95 |
| Rubber (25) | 1.00 | 0.85 | 0.93 | 0.70 | 0.87 | 0.88 | 0.76 | 0.65 | 0.62 | 0.58 |
| Non-Metallic Minerals (26) | 1.00 | 0.83 | 0.80 | 0.65 | 0.84 | 0.91 | 0.82 | 0.87 | 0.98 | 0.90 |
| Basic Metals (27) | 1.00 | 0.99 | 0.70 | 0.73 | 0.70 | 0.71 | 0.55 | 0.53 | 1.00 | 0.96 |
| Fabricated Metal (28) | 1.00 | 0.84 | 0.92 | 0.75 | 0.76 | 0.89 | 0.83 | 0.84 | 0.90 | 0.83 |
| Furniture (29) | 1.00 | 0.91 | 0.87 | 0.78 | 0.78 | 0.78 | 0.74 | 0.82 | 0.87 | 1.34 |
| Other Manufacturing (36) | 1.00 | 0.86 | 0.84 | 0.54 | 0.71 | 1.12 | 0.88 | 0.85 | 0.73 | 0.74 |
| **Sector Mean** | **1.00** | **0.89** | **0.88** | **0.84** | **0.94** | **0.99** | **0.90** | **0.87** | **0.88** | **0.95** |
| **Sector Median** | **1.00** | **0.86** | **0.87** | **0.78** | **0.94** | **1.03** | **0.83** | **0.84** | **0.90** | **0.92** |
| **Std Dev (** | **0.00** | **0.11** | **0.12** | **0.22** | **0.19** | **0.15** | **0.24** | **0.23** | **0.23** | **0.26** |

*Source*: Author’s calculations.

**Appendix A.5: Estimation of the Wooldridge-Petrin-Levinsohn Production Function**

This Appendix relies on Petrin, Poi and Levinsohn (2004), Galuščák and Lizal (2011) and Wooldridge (2009). The value-added function is specified as in Levinsohn and Petrin (2003):

, (1.1)

where all variables are expressed in the natural logarithm. is a constant term, the coefficients are output elasticities with respect to labour and capital, in that order. The unobserved productivity is and is a sequence of shocks that is assumed to be conditionally mean independent (CMI) of current and past inputs.

The demand for intermediate inputs is assumed to be a function of capital and the unobserved productivity

(1.2)

Levinsohn and Petrin (2003) demonstrate the monotonicity property of the demand function for intermediates under mild assumptions which allow for the inversion of Eq.1.2 as

(1.3)

and productivity adjusts according to a Markov process as

(1.4)

where is productivity innovation.

Then, (1.1) can be expressed as either

(1.5)

or

(1.6)

where

(1.7)

. (1.8)

To complete the first stage, the function in Eq.1.6 is approximated with a third-degree polynomial in, and is estimated using O.L.S.

The final stage sets out to identify. First, the values of Eq.1.6 are estimated as

(1.9)

Then, using a potential estimate for say it is possible to estimate the productivity series as

. (1.20)

In terms of Levinson and Petrin (2003), a consistent nonparametric approximation to is given by the predicted values from the nonlinear regression

(1.21)

Thus, given and, the estimate of solves the minimization of the squared regression residuals

. (1.22)

This procedure closes with a bootstrap based on random sampling from observations to construct standard errors of the capital and labour coefficient estimates as in Horowitz (2001).

In stark contrast to the two-step approach, Wooldridge (2009) proposes to simultaneously estimate the capital and labour coefficients by assuming CMI of the i.i.d error term with respect to current and past values of.

**CMI Assumption I:**

. This means the error term is conditional mean independent of, or uncorrelated with, the present and past production inputs. ■

Wooldridge (2009) restricts the dynamics of the unobserved productivity shocks and writes

(1.23)

where and the productivity innovation can be written as

. (1.24)

The innovation in (1.24) may reflect heterogeneity and persistence in firm-level managerial ability, labour quality, etc.; see Gebreeyesus (2008).

**CMI Assumption II:**

. Given the quasi-fixed nature of capital in firms due to irreversibility (see, for example, Caballero and Engel, 1999 and Bertola and Caballero, 1994), the productivity innovation is uncorrelated with the state variable and all past inputs and their functions, but correlated with and.■

Substitution of Eq.1.23 and Eq.1.24 into Eq.1.1 yields

(1.25)

where . Notably, the arguments in the j(g()) function are now lagged capital and intermediate inputs which can be approximated with low-order polynomials as in Levinsohn and Petrin (2003).

**CMI Assumption III:**

. The error is conditional mean independent of current capital and past values of all production inputs. In the presence of the productivity innovation in this Condition is identical to Conditional Mean Independence Assumption2 above. ■

Therefore, (1.1) becomes

(1.26)

or

. ■■■ (1.27)

**Appendix A.6: Proportion of Non-Zero Input Observations**

|  |  |  |  |
| --- | --- | --- | --- |
| Industry (ISIC) | Investment | Material | Energy |
| Food and Food Products(15) | 45.39 | 100.00 | 94.09 |
| Textile (17) | 30.51 | 100.00 | 99.44 |
| Apparel (18) | 20.31 | 100.00 | 100.00 |
| Wood and Wood Products (20) | 35.51 | 100.00 | 90.65 |
| Paper and Paper Products (21) | 61.82 | 100.00 | 89.09 |
| Printing, Publishing (22) | 23.12 | 100.00 | 96.48 |
| Chemicals and Chemical Products (24) | 26.36 | 100.00 | 90.70 |
| Rubber and Plastic Products (25) | 49.09 | 100.00 | 98.18 |
| Other non-metallic Minerals (26) | 29.45 | 100.00 | 93.25 |
| Basic Metals (27) | 9.68 | 100.00 | 100.00 |
| Fabricated Metal Products (28) | 33.16 | 100.00 | 91.98 |
| Machinery and Equipment (29) | 46.00 | 100.00 | 100.00 |
| Furniture and Other Manufacturing (36) | 32.32 | 100.00 | 97.98 |
| Average | 34.06 | 100.00 | 95.53 |

*Source*: Author’s calculations from Data Compiled by the CSO

**Appendix A.7: Aggregate multifactor productivity growth rate, Swaziland manufacturing 1994–2003: LP APG decomposition, manufacturing value-added index Single-deflator.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Value-Added Growth | APG (0) | APG Decomposition: (0)= (1) + (2) + (3) | | | | | |
| Technical Efficiency (1) | Reallocation | | | | Net Entry (3) |
| Total Reallocation (2) | Labour Reallocation | Working Proprietors Reallocation | Paid Employees Reallocation |
| 1995 | 7.76 | 2.51 | 0.91 | -9.65 | 1.39 | -1.48 | 2.87 | 11.25 |
| 1996 | 23.10 | 16.03 | 3.17 | -7.89 | 0.92 | -0.16 | 1.08 | 20.74 |
| 1997 | -44.35 | -34.12 | -3.08 | 18.52 | 9.31 | -0.06 | 9.37 | -49.56 |
| 1998 | 265.55 | 240.84 | 1.67 | -1.74 | 0.69 | 0.02 | 0.67 | 240.91 |
| 1999 | 275.57 | 261.04 | 1.23 | 9.22 | 2.94 | -0.02 | 2.95 | 250.59 |
| 2000 | -16.28 | -16.07 | -14.97 | -5.48 | 0.42 | -0.14 | 0.56 | 4.38 |
| 2001 | 37.42 | 34.85 | 8.71 | 20.43 | 0.42 | 0.43 | -0.01 | 5.72 |
| 2002 | -20.74 | -21.81 | -3.04 | -29.53 | -1.15 | -1.21 | 0.06 | 10.76 |
| 2003 | -36.71 | -33.05 | -22.31 | 2.69 | 8.35 | -1.62 | 9.97 | -13.43 |
| **Mean** | **54.59** | **50.02** | **-2.77** | **-0.38** | **2.33** | **-0.42** | **2.75** | **53.48** |
| **Median** | **7.76** | **2.51** | **0.91** | **-1.74** | **0.92** | **-0.14** | **1.08** | **10.76** |
| **Std Dev** | **125.32** | **116.24** | **9.66** | **15.46** | **3.70** | **0.75** | **3.90** | **110.93** |

*Notes*: As in Nishida *et al.* (2013), numbers are percentage growth rates. The plant-level multifactor productivity is calculated by using production function parameters that vary across 2-digit ISIC. We obtain the estimates by using Wooldridge (2009). APG represents the aggregate productivity growth with entry and exit, which is defined as aggregate change in final demand *minus* aggregate expenditure in inputs, holding input constant. We use value-added share (Domar) for weights. APG is decomposed into four components: (1) technical efficiency, (2) reallocation, and (3) net entry term, using Eq. 17 in text.

**Appendix A.8: Aggregate multifactor productivity growth rate, Swaziland manufacturing 1994–2003: LP APG decomposition, consumer price index double-deflator.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Value-Added Growth | APG (0) | APG Decomposition: (0)= (1) + (2) + (3) | | | | | |
| Technical Efficiency (1) | Reallocation | | | | Net Entry (3) |
| Total Reallocation (2) | Labour Reallocation | Working Proprietors Reallocation | Paid Employees Reallocation |
| 1995 | 27.96 | 19.22 | 7.23 | -0.95 | 2.53 | -0.89 | 3.41 | 12.94 |
| 1996 | 21.85 | 11.94 | 1.63 | -7.17 | 1.40 | -0.30 | 1.71 | 17.48 |
| 1997 | -41.95 | -27.47 | -1.81 | 20.30 | 10.07 | -0.05 | 10.11 | -45.96 |
| 1998 | 268.72 | 235.19 | 1.93 | -1.48 | -0.04 | 0.01 | -0.05 | 234.74 |
| 1999 | 270.96 | 251.41 | 0.97 | 8.69 | 3.01 | -0.01 | 3.01 | 241.75 |
| 2000 | -17.72 | -17.44 | -16.14 | -6.01 | 0.61 | -0.18 | 0.79 | 4.72 |
| 2001 | 42.77 | 39.22 | 9.56 | 23.23 | 0.53 | 0.44 | 0.09 | 6.44 |
| 2002 | -23.53 | -24.96 | -4.76 | -31.25 | -1.23 | -1.28 | 0.05 | 11.06 |
| 2003 | -36.51 | -31.45 | -22.93 | 3.59 | 9.67 | -0.43 | 10.10 | -12.10 |
| **Mean** | **56.95** | **50.63** | **-2.43** | **0.99** | **2.65** | **-0.27** | **2.92** | **52.34** |
| **Median** | **21.85** | **11.94** | **0.97** | **-0.95** | **1.40** | **-0.18** | **1.71** | **11.06** |
| **Std Dev** | **124.24** | **111.90** | **10.59** | **16.20** | **4.12** | **0.52** | **4.09** | **107.13** |

*Notes*: As in Nishida *et al.* (2013), numbers are percentage growth rates. The plant-level multifactor productivity is calculated by using production function parameters that vary across 2-digit ISIC. We obtain the estimates by using Wooldridge (2009). APG represents the aggregate productivity growth with entry and exit, which is defined as aggregate change in final demand *minus* aggregate expenditure in inputs, holding input constant. We use value-added share (Domar) for weights. APG is decomposed into four components: (1) technical efficiency, (2) reallocation, and (3) net entry term, using Eq. 17 in text.

**REFERENCES**

Ackerberg D, K. Caves and G. Frazer (2008), “Structural identification of production functions”, Working Paper.

Aghion P. and P. Hawit (2009), *The Economics of Growth*, The MIT Press, London, England.

Aghion P., M. Braun, and J. Fedderke, (2007), “Competition and productivity growth in South Africa”, *Economics of Transition,* 16(4): 741-768.

Alfaro, L., Charlton A., and Kanczuk F. (2008), "Firm-Size Distribution and Cross Country Income Differences." National Bureau of Economic Research Working Paper 14060.

Annual Report (2012)

Asplund and Nocke (2006), “Firm Turnover in Imperfectly Competitive Markets”, *Review of Economic Studies* **73**, 295–327.

Bai C., C. Hsieh, and Y. Qian (2006), "The Return to Capital in China", *Brookings Papers on Economic Activity*, 2: 61-88.

Baily M, C. Hulten and D. Campbell (1992), “Productivity Dynamics in Manufacturing Plants”, *Brookings Papers Economic Activity, Microeconomics* 1:187–267

Baily, Bartelsman and John Haltiwanger (1996),” Downsizing and Productivity Growth: Myth or Reality?”, *Small Business Economics*, Vol. 8(4): 259-278.

Banerjee and Moll, 2010, Why Does Misallocation Persist? *American Economic Journal: Macroeconomics*, Vol. 2, No. pp. 189-206

Banerjee, A. V. and E. Duflo (2005), "Growth Theory through the Lens of Development Economics." In Handbook of Economic Growth, Vol. 1 A, ed. P. Aghion and S. N. Durlauf, 473-552. Amsterdam: Elsevier.

Bartelsman E, J. Haltiwanger, S. Scarpetta (2004), “Microeconomic evidence of creative destruction in industrial and developing countries”, *World Bank policy research working paper 3464*.

Bartelsman E., J. Haltiwanger, and S. Scarpetta (2013), "Cross Country Differences in Productivity: The Role of Allocative Efficiency", *American Economic Review,* 103(1): 305–334.

Bruno, M. (1978), “Duality, Intermediate Inputs and Value-Added” in Fuss M. and D. McFaden, Eds: Production Economics: A Dual Approach to Theory and Applications, Vol.2, Amsterdam.

Caballero R.J. and M.L. Hammour (1994), “The Cleansing Effect of Recessions”, *The American Economic Review*, Vol. 84, No. 5, pp. 1350-1368.

Central Bank of Swaziland (19952003), “Annual Reports

De Loecker and Konings (2006); “Job reallocation and productivity growth in a post-socialist economy: Evidence from Slovenian manufacturing”, *European Journal of Political Economy*, Vol. 22: 388–408.

Doraszelski and Jaumandreu (2013), R&D and productivity: Estimating endogenous productivity, mimeograph.

Edwards L, F. Flatters, M. and Y. Ramkolowan (2013), “Swaziland Economic Diversification Study Final Report”, DNA Economics.

Edwards L. (2006), “Has South Africa Liberalised its Trade?”, Trade and Poverty Project, Southern African Labour and Development Research Unit, University of Cape Town.

Ericson R. and A. Pakes (1995), “Markov-Perfect Industry Dynamics: A Framework for Empirical Work”, *The Review of Economic Studies*, Vol. 62, No. 1 (Jan., 1995), pp. 53-82.

Escribano A. and R. Stucchi (2014), “Does recession drive convergence in firms’ productivity? Evidence from Spanish manufacturing firms”, *Journal of Productivity Analysis*, 41:339–349

Fedderke J., C. Kularatne and M. Mariotti (2005), “Markup Pricing in South African Industry”, Department of Economics, University of California.

Foster L, Haltiwanger J, Krizan C (2001) Aggregate productivity growth: Lessons from microeconomic evidence, NBER chapters, 303–372.

Foster L, J. Haltiwanger, C. Syverson (2008), “Reallocation, firm turnover, and efficiency: selection on productivity or profitability?”, *The American Economic Review*, 98(1):394–425

Galuščák And Lizal (2011); “The Impact of Capital Measurement Error Correction on Firm-Level Production Function Estimation”, CNB Working Paper Series.

Gebreeyesus (2008); “Firm turnover and productivity differentials in Ethiopian manufacturing”, *Journal Productivity Analysis,* Vol. 29, No. 2, Special issue on Transitioning Economics : 113-129.

Griliches Z. and H. Regev (1995), “Firm productivity in Israeli industry”, 1979-1988, *Journal of Economics*, 65(1):175–203.

Haltiwanger (1997); “Measuring and Analysing Aggregate Fluctuations: The Importance of Building from Microeconomic Evidence”, *Review*: 55-77.

Hammouda H.B., S. N. Karingi, A. E. Njuguna, and M. S. Jallab(2010); “Growth, productivity and diversification in Africa”, *Journal Productivity Analysis*, 33:125–146.

Ho *et al*. (2014), Productivity, Reallocation, and Economic Crisis: Evidence from Ecuadorian Firm-Level Data, Mimeograph.

Hsieh C. and P. Klenow (2009), "Misallocation and Manufacturing TFP in China and India." *Quarterly Journal of Economics*, (124)4: 1403-48.

IMF Country Report (2000).

Isaksson (2010), “Structural Change and Productivity Growth: A Review with Implications for Developing Countries”, Research and Statistics Branch, Programme Coordination and Field Operations Division, UNIDO.

Jonsson G. and A. Sumbranian (2001), “Dynamic Gains from Trade: Evidence from South Africa”, *IMF Papers*.

Jovanovic (1982), “Selection and Evolution of Industry”, *Econometrica*, Vol.15 (3): 649-670.

Kambourov G., (2009), Labour Market Regulations and the Sectoral Reallocation of Workers: The Case of Trade Reforms, *Review of Economic Studies,* Vol. 76, 1321-1358.

Kwon H., F. Narita andM. Narita (2009), “New Evidence on Japan’s Aggregate Productivity Growth in the 1990s”, Mimeo.

Levinsohn and Petrin (1999), “When Industries Become More Productive, Do Firms?: Investigating Productivity Dynamics”, University of Michigan.

Levinsohn J. and Petrin A. (2003), “Estimating Production Functions Using Inputs to Control for Unobservables”, *Review of Economic Studies,* 7: 317-341.

Lileeva A. (2008), “Trade Liberalization and Productivity Dynamics: Evidence from Canada”, *The Canadian Journal of Economics*, pp. 360-390.

Liu and Tybout (1996), “Productivity Growth in Chile and Columbia: The Role of Entry, Exit and Learning”, in M.J. Robets and J.R. Tybout, Eds.: Industrial Revolution in Developing Countries, The World Bank, Oxford University Press.

Masuku M.B. and Dlamini T.S. (2009), “Determinants of Foreign Direct Investment in Swaziland”, *Journal of Development and Agricultural economics*, Vol. 1(5): 177-184.

Melitz M. (2003), “The Impact of Trade on Intra-Industry Reallocations and Aggregate Industry Productivity”, *Econometrica*, Vol. 71, No. 6., pp. 1695-1725.

Nielson Ø. A. and F. Schiantarelli (2003), “Zeros and Lumps in Investment: Empirical Evidence on Irreversibilities and Nonconvexities”, *The Review of Economics and Statistics*, Vol. 85, No. 4, pp. 1021-1037.

Nishida M., A. Petrin and S. Polanec (2013), “Exploring reallocation’s apparent weak contribution to growth”, *Journal Productivity Analysis*.

OECD (2001), “Measurement of Aggregate and Industry-Level Productivity Growth”, *OECD Manual*.

Olley, S., and A. Pakes, (1996), “The dynamics of productivity in the telecommunications equipment industry”, *Econometrica,* 64: 1263– 1298.

Pack (1990), "Learning and Productivity Change in Developing Countries," in G. Helleriner, ed.,

Pages C., G. Pierre and S. Scarpetta, (2008), “Job Creation in Latin America and the Caribbean Recent Trends and Policy Challenges”, Palgrave Macmillan and the World Bank.

Pakes A. and R. Ericson (1998), “Empirical Implications of Alternative Models of Firm Dynamics”, *Journal of Economic Theory*, 79: 1-45.

Petrin A. and J. Sivadasan (2013), “Estimating Lost Output from Allocative Inefficiency, with an Application to Chile and Firing Costs”, *The Review Of Economics And Statistics,* 95(1): 286–301.

Petrin A. and J. Levinsohn (2012), “Measuring aggregate productivity growth using plant-level data**”,** RAND Journal of Economics Vol. 43(4): 705–725.

Petrin A., B.P. Poi and J. Levinsohn (2004), “Production function estimation in Stata using inputs to control for unobservables”, *The Stata Journal*, 4(2): 113–123.

Petrin A., T.K. White and J.P. Reiter (2011), “The impact of plant-level resource reallocations and technical progress on U.S. macroeconomic growth”, *Review of Economic Dynamics*, 14: 3–26

Restuccia D. and Rogerson R. (2012), “Misallocation and Productivity”, mimeo

Restuccia D. and Rogerson R. (2008), "Policy Distortions and Aggregate Productivity with Heterogeneous Establishments." *Review of Economic Dynamics*, 11(4): 707-20.

Stock and Watson (2003), *Introduction to Econometrics*, Reading, MA: Addison–Wesley.

Syverson, C. (2004), “Product Substitutability and Productivity Dispersion.” *Review of Economics and Statistics*, 86(2): 534–50.

Tibiyo TakaNgwane (2010), Annual Report.

Van Biesebroeck (2005), “Firm Size Matters: Growth and Productivity Growth in African Manufacturing”, *Economic Development and Cultural Change*, pp.545-583

Van Biesebroeck (2007), “Robustness of Productivity Estimates”, *The Journal of Industrial Economics*, Vol. 55 (3): 529-569.

Wooldridge J.M. (2001), “Applications of Generalized Method of Moments Estimation”, *The Journal of Economic Perspectives*, Vol. 15(4): 87-100.

Wooldridge J.M. (2009), “On estimating firm-level production functions using proxy variables to control for unobservables”, *Economics Letters*, 104: 112–114.

1. The phrase ‘primary inputs’ is used interchangeably with ‘factor inputs’. [↑](#footnote-ref-1)
2. Van Biesenbroek (2005) undertakes a similar analysis but has access only to RPED surveys which have a short time dimension. [↑](#footnote-ref-2)
3. Resource reallocation refers to reallocation of resources across incumbent firms and reallocation of resources in response to firm turnover, where firms/plants/establishments are used interchangeably. [↑](#footnote-ref-3)
4. Levinsohn and Petrin (1999) refer to the learning-by-doing and learning-by-watching effects as the real productivity case. [↑](#footnote-ref-4)
5. Tibiyo TakaNgwane is a State Owned Enterprise whose purpose is to actively pursue commercially viable projects in all sectors of the economy, Annual Report (2012). [↑](#footnote-ref-5)
6. See the Central Bank of Swaziland Reports (1995-2003) on industrial unrests and IMF Staff Report (2000, pp.13) on the need to review the Industrial Relations Act. [↑](#footnote-ref-6)
7. The intermittence and lumpiness of capital projects as well as indivisibility contribute to the non-smoothness in the adjustment path of capital stock; see Nilsen and Schiantarell (2003). Indivisibility ensures that investment occurs only in discrete increments. [↑](#footnote-ref-7)
8. See; for example, Lileeva (2008, Fig.1) for the case of Canada within NAFTA where the evolution of growth generated from the ‘Between’ and ‘Within’ terms continuously shift towards the right. Escribano and Stucchi (2014, Fig.1) find productivity improvement for Spanish manufacturing firms during a recession. [↑](#footnote-ref-8)
9. The best measure of labour input according to OECD (2001) is hours worked. Although the legal length of a work-day is 8 hours and public holidays are known for the Swazi manufacturing sector, there is no information on worker absenteeism, variation in overtime, evolution of part-time work, sick leave and employee slack time due to ill-health. Furthermore, in the absence the total number of hours worked that can be divided by the average annual number of hours actually worked in full-time jobs, the use of full-time equivalent employment is not feasible for the labour input definition contained in Doraszelski and Jaumandreu (2013, Appendix A) and OECD (2001). [↑](#footnote-ref-9)
10. Embodied technology refers to advances in the design and quality of new vintages of capital goods and intermediate inputs, and disembodied technology refers new blueprints, scientific results and new organizational techniques, see OECD (2001). [↑](#footnote-ref-10)
11. The difference between Baily *et al*. (1992) and Haltiwanger (1997) is that the latter introduces the covariance term. [↑](#footnote-ref-11)
12. Van Biesebroeck (2005) uses data from the RPED surveys of the World Bank spanning a maximum of five years for each country. [↑](#footnote-ref-12)
13. What also stands out as a stylized fact from this analysis is that the sources of growth for ALP differ by country, period in a country and methodology applied to the sector in question. For example, in their analysis of the manufacturing sector in 19952000 as opposed to the 19972001 above, De Loecker and Konings (2006) use the Foster *et al.* (2001) decomposition of ALP and find ‘within’ firm productivity growth of 123.4% and reallocation growth of -11.7% compared to 68% and 18% above, respectively. Simply by discarding the first two years and the last year of study, significantly different results are produced; see note 5 in Nishida *et al*. (2013) for the case of Chile, Columbia and Slovenia. [↑](#footnote-ref-13)
14. We made an attempt to remove any potential outliers as in Nishida *et al.* (2013) by applying the Stata “**Winsor**” command to the plant-level labour productivity at *p*(0.01), which specifies the proportion of observations to be modified in each tail. This created too many missing values and therefore we abandoned the procedure. Another approach involved identifying outliers and removing them sequentially, beginning with the largest. When the very first outlier where was removed, decompositions for both 1998 and 1999 disappeared. Again, this procedure was abandoned. However, it was considered not fatal to use the data ‘as is’ given the large similarities between our results and the results found in the literature, and the fact that the Swazi manufacturing sector is highly concentrated and these are real and important firms. [↑](#footnote-ref-14)
15. Appendix A.2 shows 100% of non-zero intermediate observations compared to an average of only 34% for investment. Therefore, choosing investment as a proxy in this case would truncate 66% of the observations in the panel dataset. [↑](#footnote-ref-15)
16. A detailed exposition of the Levinsohn-Petrin-Wooldridge estimation of the production parameters is found in Appendix A.1. [↑](#footnote-ref-16)
17. A full derivation of the empirical LP Model and its transformation into WLP Model is presented in Appendix A.5. [↑](#footnote-ref-17)
18. We used the **ivreg2** Stata command with **gmm2s** and **cluster** for each firm in order to generate efficient IV-GMM parametric estimates of the WLP functional specification. This empirical model was exactly identified; hence, rejected the hypotheses of over- and under-identification as well as weak identification. [↑](#footnote-ref-18)
19. Direct orthogonality tests for CMI assumptions confirm the validity of our instruments: that is, the contemporaneous capital variable and the elements of the thirddegree polynomial entered the model significantly. [↑](#footnote-ref-19)
20. The constant returns to scale in the other estimation methods is potentially induced by simultaneity and selection problems explained in detail in Wooldridge (2001). [↑](#footnote-ref-20)
21. Galuščák and Lizal (2011) corrects for measurement error in the capital series by running an O.L.S. on, where is the i.i.d. measurement error, are instruments and the predicted values of capital are. The estimation proceeds with linear approximation of the unknown function for consistency and coefficient standard errors are derived nonparametrically through bootstrapping that reflects uncertainty in capital adjustment. Since our focus is in labour productivity, improvement in the capital input measurement to investigate industries’ scale economies is left for future work. [↑](#footnote-ref-21)