Firm Innovation and Employment in South Africa: Examining the Role of Export Participation and Innovation Novelty

Karmen Naidoo, Marta Bengoa, Erika Kraemer-Mbula and Fiona Tregenna

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DSI/NRF SOUTH AFRICAN RESEARCH CHAIR IN INDUSTRIAL DEVELOPMENT

Karmen Naidoo

Marta Bengoa

Erika Kraemer-Mbula

Fiona Tregenna

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Abstract

This paper studies the effect of process and product innovation on firm-level employment growth in South Africa. We contribute through two novel extensions, analysing how export participation and the degree of novelty of innovation affect the innovation-employment relationship. We find process innovation to be more employment generating than product innovation. Furthermore, both process and product innovations have larger positive effects on employment growth for exporting firms relative to non-exporting firms. Finally, firms that introduce more radical innovations (new to the market) experience a higher positive employment effect than firms that introduce less radical innovations (new to the firm).

Keywords: process innovation; product innovation; employment; exporting firms; South Africa

JEL codes: D2, J23, L2, O14, O33

About the authors

Karmen Naidoo, Senior Research Associate, DST/NRF South African Research Chair in Industrial Development, University of Johannesburg, South Africa. Email: knaidoo@umass.edu

Marta Bengoa, DST/NRF South African Research Chair in Industrial Development, University of Johannesburg, South Africa. Email: mbengoa@ccny.cuny.edu

Erika Kraemer-Mbula, DST/NRF/Newton Fund Trilateral Research Chair in Transformative Innovation, the 4th Industrial Revolution and Sustainable Development, University of Johannesburg, South Africa. Email: erikakm@uj.ac.za

Fiona Tregenna, DST/NRF South African Research Chair in Industrial Development, University of Johannesburg, South Africa. Email: ftregenna@uj.ac.za

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Contents

List of Tables

List of Figures

1. Introduction

Innovation and technical change are core drivers of long-run economic growth in both developed and developing countries. The ways in which different types of innovation affect employment growth are complex, and their effect is uneven across countries – even when conditional on their level of development. Although South Africa is among the most developed countries in Africa, it has one of the world's highest unemployment rates. Unemployment in South Africa is an endemic problem and has remained above 20% for most of the post-apartheid period (Festus et al. 2016). The official unemployment rate, which excludes the 'discouraged' unemployed, reached a 15-year high in 2019, at over 29% (Statistics South Africa 2019).

South African public policy has acknowledged the importance of innovation as a driver of productivity and employment growth. At the national level, research and development (R&D) expenditure averaged about 0.81% of GDP between 2005 and 2018 (Human Sciences Research Council [HSRC] 2019), with expenditure by private companies accounting for over half of gross domestic expenditure on R&D (Department of Science and Technology 2017).[1]

South Africa thus faces the dual and interrelated imperatives of employment creation and improving R&D and innovation. While innovation can foster employment through various channels, there are also concerns that innovation can lead to labour-displacing productivity improvements, which potentially could worsen unemployment. It is important to understand the extent to which there is any trade-off between innovation and employment creation, and also if firms' export behaviour and the novelty of innovation may mediate this relationship.

We build a database using two waves of the South African National Innovation Survey (NIS) that cover the period 2005 to 2012 and include disaggregated data at the firm level. Very little research has emerged from this database, which is not yet publicly available. This novel database allows us to investigate how different types of innovation – innovation in processes and in products – affect employment growth among South African firms. We use an original approach to assess how participation in international trade and the degree of novelty of innovation mediate between innovation and employment while controlling for relevant firm and industry characteristics.

Furthermore, there is considerable heterogeneity among South African firms – in terms of size, productivity, labour intensity and innovativeness, and plausibly also in the innovation-employment relationship. This underscores the importance of providing evidence for the heterogeneous effects of different types of innovation on employment at the firm level, as well as for heterogeneous effects on different types of firms (exporters vs. non-exporters). The study results are informative for policies intended to incentivise and support innovation through the larger employment-creation effects.

[1] In more recent years, the South African government has increased spending on higher education and science councils, which contributes toward gross expenditure on R&D.

Our paper makes three key contributions to the literature. First, this is the first paper to isolate and analyse the different effects of process and product innovation on employment in South Africa. South Africa is a particularly relevant case for the analysis of this relationship, given its extremely high rate of unemployment. However, this study is also relevant beyond South Africa, as it contributes to the sparse literature on this topic for African countries, and for developing countries more widely. Furthermore, we add to the very limited evidence of disaggregated effects for the manufacturing and services sectors, since the literature has traditionally focused almost exclusively on manufacturing.

Second, we contribute to the literature by comparing exporting and non-exporting firms in terms of the effects of process and product innovation on employment. Firms' export status is especially relevant, since compensating-demand effects may be stronger for firms with access to external markets and has not been explored fully in the context of developing countries. A third contribution of our paper is the dimension of the novelty of innovation, which has been analysed very little in the existing literature on this topic. We explore how the degree of novelty of innovation (new to the firm vs. new to the market) affects employment growth. This is particularly relevant for latecomer firms (such as those in South Africa), which are generally adopters of existing technologies, making the incidence of radical innovation less frequent (Kraemer-Mbula and Wamae 2010).

The rest of the paper is structured as follows. Section 2 discusses the relevant literature. The econometric approach is outlined in section 3. Section 4 discusses the data and presents the descriptive statistics and analysis. Section 5 presents the main results and discussion, and section 6 concludes.

2. Literature review

We first present a conceptual framework for analysing the firm-level linkages between innovation and employment growth, as the effects are complex and heterogeneous. Second, we review the empirical evidence of the effects of innovation on employment growth.

2.1 Process and product innovation: Linkages with employment growth

The theoretical linkages between different types of innovation and employment are discussed in detail in Vivarelli (2014) and Calvino and Virgillito (2018).

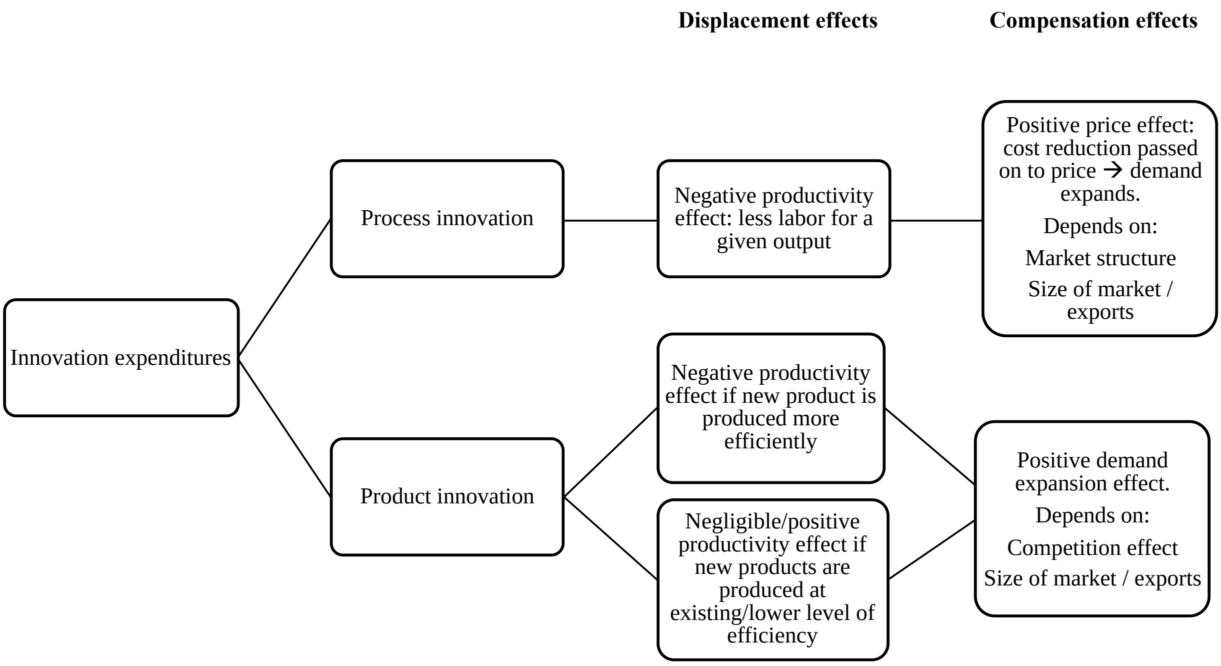
At the micro-level, innovation[2] can have competing displacement and compensating effects on employment creation, at least in the short to medium run. We summarize these effects in

[2] Schumpeter (1934) was the first to define and establish the distinction between process and product innovations. The Organisation for Economic Co-operation and Development defines business innovation as "a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm" ([OECD] 2018: p. 33). In other words, innovation requires some form of novelty, whether it is new to the world or new to the firm.

Figure 1. Product innovation can increase the demand for labor, since more output growth requires more labor to produce it. The magnitude of a positive employment effect depends on the potential productivity-displacement effect, as well as the degree of demand compensation. If new products are produced at the existing level of efficiency, there will be negligible labor-displacement effects within the firm. However, if new products are produced more efficiently than existing products at the firm level, this could reduce the employment elasticity of new product sales. This output-employment elasticity will determine the degree to which output expansion from demand effects, in turn, expands employment. Firms that can compete in international markets might potentially experience larger demand effects.

Process innovations have the potential to reduce the demand for labor through the increased efficiency effect, especially when they are first implemented. At a given level of output, therefore, less labor is required to produce a given product. In a competitive market, process innovation could reduce the costs of production, which would pass through to reduced prices. Then, if there is a sufficiently large demand-compensation effect, output and employment could expand. In a less competitive market setting, cost reductions may not pass through to price, limiting the compensation effect. In essence, there are no clear theoretical predictions about the influence of different types of innovation on employment growth. Empirical evidence on this relationship therefore is illuminating.

Figure 1: Effects of process and product innovation on employment



Source: Authors' elaboration, adapted from Harrison et al. (2014).

2.2 Firm-level empirical evidence of the relationship between innovation and employment

There is an extensive literature exploring the innovation-employment relationship. The microeconomic literature suggests that there is a positive relationship between innovation and employment, particularly with innovation measured by R&D (Bogliacino, Piva and Vivarelli 2012; Vivarelli 2014). Besides the intrinsic limitations of capturing innovation through R&D as a proxy (Gault 2018), these studies are not able to isolate the displacement and compensation effects of innovation and use measures that less accurately capture innovation outputs such as new products or processes.

We focus here on micro-level empirical evidence that isolates the effects of process and product innovation. Studies of this nature have been conducted primarily on mature economies. Vivarelli (2014) and Calvino and Virgillito (2018) provide comprehensive overviews of the empirical literature on the links between innovation and employment. For developed economies, the empirical literature shows heterogeneous effects of process and product innovation on employment. The heterogeneity in results can be attributed to the use of different methodologies, labour market characteristics in particular economies, or the use of firm and industry controls.

The seminal Van Reenen (1997) paper studies British manufacturing firms between 1976 and 1982 and finds innovation to be associated with higher firm-level employment.[3] Product innovations are found more likely to increase labour demand than process innovations. Lachenmaier and Rottmann (2011) and Ortiz and Salas Fumás (2020) find positive effects of both process and product innovation on employment in German and Spanish firms respectively.

Harrison et al. (2014) developed a testable firm-level model that is able to distinguish between the effects of process and product innovation on employment. Their method offers an important improvement over previous dynamic panel models in that it allows the separation of the productivity effects of innovation from the compensating demand effects. Our paper follows in this vein, with some extensions, as explained in section 2.3 below. In their study of firms in France, Germany, Spain and the UK from 1998 to 2000, Harrison et al. (2014) find that product innovation has a positive influence on employment across all countries, while process innovation typically has a negative effect on manufacturing employment growth. The process innovation effect is non-significant for firms in services, indicating that the demand-compensation mechanism is particularly strong in the services sector.

Table OA.1 in the Online Appendix provides a review of the studies that follow the Harrison et al. (2014) methodology. Hall, Lotti and Mairesse (2008) studied Italian manufacturing firms over the period 1995 to 2003 and find that product innovation has a significantly positive effect on employment growth, although the estimates are smaller compared to empirical

[3] The number of process and/or product innovations is considered as headcounts of innovation.

studies in other European countries. In addition, they find no significant employment-displacement effects arising from process innovation. Lim and Lee (2019) studied South Korean manufacturing firms, but they also account for market structure. They show that product innovation has a positive effect on employment growth. Process innovation has no effect on average, but a negative effect in monopolistic markets.

There are various characteristics specific to developing countries that could affect the ways in which innovation affects employment. Our study controls for foreign ownership, an important determinant of firm employment growth in developing countries (Bhaumik, Estrin and Meyer 2007; Dachs and Peters 2014). Dachs and Peters' (2014) analysis of 16 countries demonstrates that the smaller employment growth that foreign-owned firms experience is the consequence of higher productivity increases compared to domestically owned firms. Vivarelli (2014) argues that technology transfer to developing countries through FDI spillovers has a positive effect on productivity, which could hamper employment growth. Still, the overall effect is conditional on the compensating mechanisms discussed above.

Firms in lower-income countries are thought to have limited capacity to conduct in-house R&D, and therefore commonly make use of imported licenses. This is not entirely the case for middle-income countries, which have, on average, an R&D-to-GDP ratio that is more than three times higher than that of low-income countries (World Bank 2019).[4] In addition, as this group of countries increases participation in international trade, the returns to investment in innovation become higher. Across many developing countries, however, unemployment levels are high and levels of skills and productivity are lower than in advanced economies. Therefore, the innovation-employment relationship is likely to differ between developed and developing countries, making it important to explore this relationship further in the latter.

There are several relevant studies for developing countries, predominantly for Latin America. De Elejalde, Giuliodori and Stucchi (2015) focus on manufacturing firms in Argentina from 1998 to 2001. They find that product innovation has a positive effect on employment growth, but process innovation has no significant effect. Looking at firms in the service sector in Uruguay, Aboal et al. (2015) find that product innovation generates employment, whereas process innovation has no significant effect. Crespi, Tacsir and Pereira (2019) built a dataset of manufacturing firms in Argentina, Chile, Costa Rica and Uruguay. Their results show product innovation to be positive and significant in all cases. However, process innovation does not have a significant effect on employment growth, except in the case of Costa Rica, where it is positive. Overall, in most cases, new products are produced at about the same level of efficiency as existing products.

The recent innovation data modules linked to the World Bank Enterprise Surveys have enabled more innovation studies on developing countries; however, none of these studies includes South Africa. Using this data, Cirera and Sabetti (2019) constructed a dataset of firms

[4] This is illustrated by the levels of R&D investment as a percentage of GDP in upper-middle-income countries such as Brazil (2017) at 1.26%, or China (2018) at 2.9%, compared to low-income countries such as Rwanda (2016) at 0.67%, Ethiopia (2017) at 0.27%, or Burundi (2018) at 0.21% (latest data available from the World Bank 2019).

in 53 developing countries from 2013 to 2015. Their results reveal that product innovation has a significantly positive effect on employment growth, while process innovation does not. Okumu, Bbaale and Guloba (2019) estimated the association between innovation and employment growth among manufacturing firms in 31 Sub-Saharan African countries, using the same data. Their pooled ordinary least squares (OLS) results indicate that employment growth is positively associated with both process and product innovation. Similarly, Avenyo, Konte and Mohnen (2019) use the data for five Sub-Saharan African countries, employ a dose-response model and find that product innovation has a positive effect on employment growth.

On balance, the evidence points to a positive effect of product innovation on employment growth at the firm level. The employment effects of process innovation are more complex and depend on the various compensating mechanisms affecting the firm. As Calvino and Virgillito (2018) highlight, a positive effect of innovation on employment growth at the firm level does not suggest that this is the case at the sectoral or macroeconomic levels of aggregation. The authors point out that, while product innovation tends to have a positive effect on employment growth at the sectoral level, process innovation has a smaller effect since competition dynamics, such as business stealing, are observed at the sectoral level.

2.3 Mediating effects: Export behaviour and the novelty of innovation

Our analysis differs from the previous studies discussed above. We make an original contribution to the literature by extending our study along two dimensions: examining the mediating role of export participation in the innovation-employment relationship, and focusing on the differential employment effects of the degree of novelty of innovation.

A number of studies show a positive link between innovation and export performance at the firm level (see, for instance, Aw, Roberts and Xu 2008; Caldera 2010), including in developing and emerging market contexts (Avenyo, Tregenna and Kraemer-Mbula 2021; Bravo-Ortega, Benavente and González 2014; Hwang, Hwang and Dong 2015; Wu, Wu and Zhang 2020). This literature suggests that more innovative firms may self-select into export participation. Innovation can also enhance export performance through improving efficiency and lowering marginal costs (especially process innovation), as well as enabling firms to produce better quality and more differentiated goods (especially product innovation).

However, the study of innovation-export-employment dynamics is more scarce. Boermans and Roelfsema (2016) use an instrumental variable structural model to estimate the effect of innovation and export performance on employment growth in small Dutch firms. They find that both innovation and export performance exert a positive effect on employment growth. In a study of Chinese manufacturing firms from 1998 to 2007, Dosi and Yu (2019) find that productivity improvements as a result of process innovations are negatively associated with employment growth, yet this is more than compensated for by the positive export channel.

The differential effects of the novelty of innovation on employment growth have also been studied only sparsely. Cirera and Sabetti (2019) extend their analysis to examine the differential effect of the degree of novelty of innovation on employment growth and show that there are no different employment effects when comparing a product upgrade with introducing a new product. However, service firms that introduce more radical innovations see an additional positive employment effect, but this is not the case for manufacturing firms.

Overall, the international empirical evidence is mixed. The positive effect of product innovation on employment growth at the firm level seems to be positively augmented for exporting firms, and potentially also within firms that introduce more substantial innovations, although the scarcity of evidence means there is no consensus in the literature on these dimensions. In the case of South Africa, this is an empirical question that demands further investigation and that has pertinent policy implications. Standardised survey data, such as that used in this paper, is suitable for generating more comparable estimates across countries.

3. Econometric model and estimation strategy

Our paper follows the approach of Harrison et al. (2014) and extends it by analysing the effects of firms' export status and the novelty of innovation. We use separate indicators for process and product innovation to assess the different effects on employment growth, which is our key dependent variable. An important aspect of this model is that we use the growth of sales of new products as the measure of product innovation.

The model assumes two periods: the first period is when the firm produces only an 'old' product; the second is when the firm introduces some form of product innovation ('new product') that is sold alongside the old product. We can write the production technology for the old and new products as separate production functions. The first-period production function of the old good can be represented as $Y_{11i} = \theta_{11}F(K_{11i}, L_{11i}, M_{11i})e^{\eta_i}$, where there are three inputs to production, namely capital (K), labour (L) and intermediate goods (M). θ represents the Hicks neutral technological productivity index, and η is idiosyncratic firm characteristics (firm fixed effect). In the second period, both the old and new product are produced according to the following production functions:

$$Y_{12i} = \theta_{12}F(K_{12i}, L_{12i}, M_{12i})e^{\eta_i - \mu_i} \qquad (1)$$

$$Y_{22i} = \theta_{22}F(K_{22i}, L_{22i}, M_{22i})e^{\eta_i - v_i}, \qquad (2)$$

where μ_i and v_i represent unanticipated productivity shocks to the production of the old and new products by firm *i* respectively.

From this, we can derive a labour-demand function, as explained in Harrison et al. (2014). The growth of employment at the firm level can then be decomposed over the two periods into four components: the growth in production of the old product (assuming production meets demand); the growth in production of the new product; the change in efficiency of producing the old product (related to process innovation); and the unanticipated productivity shock of the old product (error term). As a result, we arrive at Equation 3:

$$l_i - y_{1i} = \alpha_0 + \alpha_1 d_i + \beta y_{2i} + u_i, \quad (3)$$

where l is employment growth over the period, $y_1$is the nominal growth in sales of old products, y_2 is the nominal growth in sales of new products, and d is a dummy variable indicating whether the firm introduced process innovations. The β parameter is the relative efficiency of production of the old and new products; if β is less than one, new products are more efficiently produced than old products. The constant term, α_0, represents (minus) the average efficiency growth in the production of old products.

The model is able to identify the gross effect of product innovation on employment growth through the term relating to the sales growth of new products. The dependent variable is the excess of employment growth over the sales growth of old products; therefore, linking this directly to the growth of new products indicates the additional employment growth that could be generated by the sales of new products. In addition, the gross displacement effect of process innovation is identified through the dummy variable on process innovation.

There are some concerns about potential endogeneity. If innovation is correlated with omitted variables, such as productivity, then innovation will be correlated with the error term, making the OLS estimates inconsistent. A firm's productivity could depend on time-invariant factors such as management and organisational capacity, or on productivity shocks that vary over time. Since the equation is estimated as a growth equation, we partial out the time-invariant portion of firm productivity. To account for the productivity shocks, we use an industry dummy, which can absorb any industry-wide shocks in each period. With these measures, there are sufficient reasons to assume that process innovation is exogenous. As discussed in Harrison et al. (2014), the plans and expenditures for these types of innovations are typically made in advance of when they are applied in practice, and therefore are unlikely to be correlated with unforeseen productivity shocks.

Another important source of potential endogeneity is measurement error in y_1 and y_2, since we do not observe the relative prices of old products and new products. In the data, we observe nominal sales growth, which means that the price changes are captured by the error term and can result in y_2 being correlated with the error term, making the β estimate biased. To overcome this issue, we use price indices at the industry level to correct the sales growth of the old product.[5]

We estimate the equation as follows:

$$l_i - g_{1i} = \alpha_0 + \alpha_1 d_i + \beta g_{2i} + u_i, \quad (4)$$

where g_1 is the real sales growth of old products and g_2 is the observed sales growth of new products. Given the absence of firm-level prices, g_2 is an imperfect proxy for new product sales growth. To alleviate any concerns about potential bias, we use an instrument for this variable. Following Harrison et al. (2014), the preferred instrument relates to an indicator of how important a firm's introduced product innovation is to the expansion of the range of

[5] We use industry-level price indices provided by Statistics South Africa (StatsSA) (South Africa's statutory statistics agency) to deflate sales.

products produced by the firm (we refer to the instrument as expanded range). Therefore, we code the variable from zero to three, where zero indicates that it is not relevant, one indicates low relevance, two indicates medium relevance and three is high relevance. The underlying reasoning is that product innovation that is relevant for increasing the range of products will be tied to increasing expected sales, but does not necessarily rely on price changes. In addition to this, we conduct robustness checks using an additional instrument, namely an indicator of whether the firm reported R&D expenditures continuously throughout the survey period. The motivation for this instrument is that R&D expenditure plans are typically decided ahead of time, and therefore the continued rollout of the expenditure over time will not necessarily be related to productivity shocks.

Lastly, we estimate Equation 4 with and without firm-level control variables. We use three firm controls: a dummy variable indicating if the firm's headquarters is in a foreign country; a dummy indicating if the firm exports; and the share of high-skilled employees.

4. Data and descriptive analysis

4.1 Data

This paper uses the two latest waves of the South African National Innovation Survey (NIS). The survey design follows the Community Innovation Survey 4 based on the Oslo Manual, which constitutes the international guideline for the collection and interpretation of innovation data in the business sector. Measuring innovation through surveys is a relatively recent and ongoing process in South Africa. Currently, three waves of National Innovation Surveys are available, covering the periods 2002 to 2004, 2005 to 2007 and 2010 to 2012.[6]

The survey instrument collects general information about the firm, such as the main business activity, number of employees and total turnover. This is followed by several sections capturing the incidence of innovation (i.e. whether the firm introduced a new or significantly improved product or process to the market), as well as a range of features of such innovations, such as their origin, novelty, and the destination of their products or processes.

The South African NIS is based on a random stratified sample of enterprises in the South African Business Register. The original sample was drawn from a sample frame of 30 standard industrial classification (SIC) codes and four size classes (120 strata). This is one of the first papers to exploit this rich new dataset on firm-level innovation activities in the South African context. We use the 2005 to 2007 and 2010 to 2012 surveys.[7] The dataset contains 757 firms in 2005 to 2007 and 746 firms in 2010 to 2012, across industry and services sectors. For consistency with the existing literature, we focus on manufacturing and services, therefore

[6] These three waves were commissioned by the Department of Science and Innovation (DSI) from the Centre for Science, Technology and Innovation Indicators (CeSTII), a statistical and policy research unit located within the Human Sciences Research Council. See Kraemer-Mbula and Sehlapelo (2016).

[7] The first wave was conducted for the period 2002 to 2004, but it does not have all the variables of interest and therefore was not used here. No surveys were conducted in the years between these waves.

exclude mining (69 firms) and utilities (30 firms) from our analysis. The sectors in our dataset are 1) manufacturing; 2) wholesale and retail trade; 3) transport, storage and communication; and 4) financial intermediation, computer activities, research and development, architectural engineering and technical testing. The latter three sectors are grouped together as services, but sub-industry controls are used where relevant (see section 5 for further details).

While this dataset offers a unique opportunity to explore the effect of innovation on employment growth, we are confronted with some data limitations. We are unable to create a panel dataset of firms across the two waves due to the inconsistent use of firm identification codes in the surveys over time. Instead, we create a pooled cross-sectional dataset using the two waves and control for the time period. In addition, firm-level price indicators would provide more accurate results, but we use industry-level deflators given the lack of this information. Finally, we are unable to estimate the changes in the composition of employment by skill level, because the data for this question is reported as an average (one observation) over the period covered by each wave. There is no other information on employee characteristics that would allow us to assess the effect of innovation on the composition or quality of employment.

We observe employment and turnover in 2005 and 2007 for the first survey, and in 2010 and 2012 for the second survey, allowing us to construct growth measures for each respective two-year period.[8] In addition, we observe whether firms introduced process and/or product innovations in each of the respective periods. This allows us to have information on before and after the introduction of innovations. In the latter year of each survey, we observe the percentage of sales due to new products, which is used to determine the sales growth of old and new products. The indicator for process innovation is related to whether the firm used new or significantly improved methods for the production or supply of goods and services.

4.2 Descriptive analysis

Table 1 presents descriptive statistics by sector. In the appendix, Table A.1 provides variable descriptions, and Table A.2 a correlation matrix.

About 43% of firms have 50 or fewer employees (micro- and small firms), 12% are classified as medium (51 to 100 employees), and the remaining 44% are large firms (more than 100 employees).[9] The average firm growth within each wave is 17%, with services firms growing faster than manufacturing. There is a higher propensity for firms to innovate in the manufacturing sector, with 66% of firms classified as innovators, compared to 54% of services firms. The majority of innovators innovate along both process and product dimensions.

[8] The first year of data provided within each survey is based on firm recall.

[9] While broadly representative of the South African population of firms, there may be some oversampling of large firms in the South African NIS. Kerr, Wittenberg and Arrow (2014) use data from the South African Quarterly Employment Survey and show that, in 2010, 50% of firms had fewer than 50 employees, 18% were classified as medium, and about 32% were classified as large. Kerr et al. (2014) show that 35% of firms were in the manufacturing sector and 49% of firms were in the services sectors that are represented in our survey dataset, therefore the sectoral composition correlates with that of the population of firms.

In both sectors, innovating firms exhibit higher employment and sales growth rates on average. Overall, it is clear that services firms have grown faster than manufacturing firms in the period of our analysis. In general, firms that are only process innovators exhibit the fastest employment growth. For the services sectors, firms that only innovate in processes experience the fastest employment and sales growth. Notably, innovating firms are considerably more skill-intensive than non-innovating firms, particularly in the services sector.

Table 1: Firm characteristics

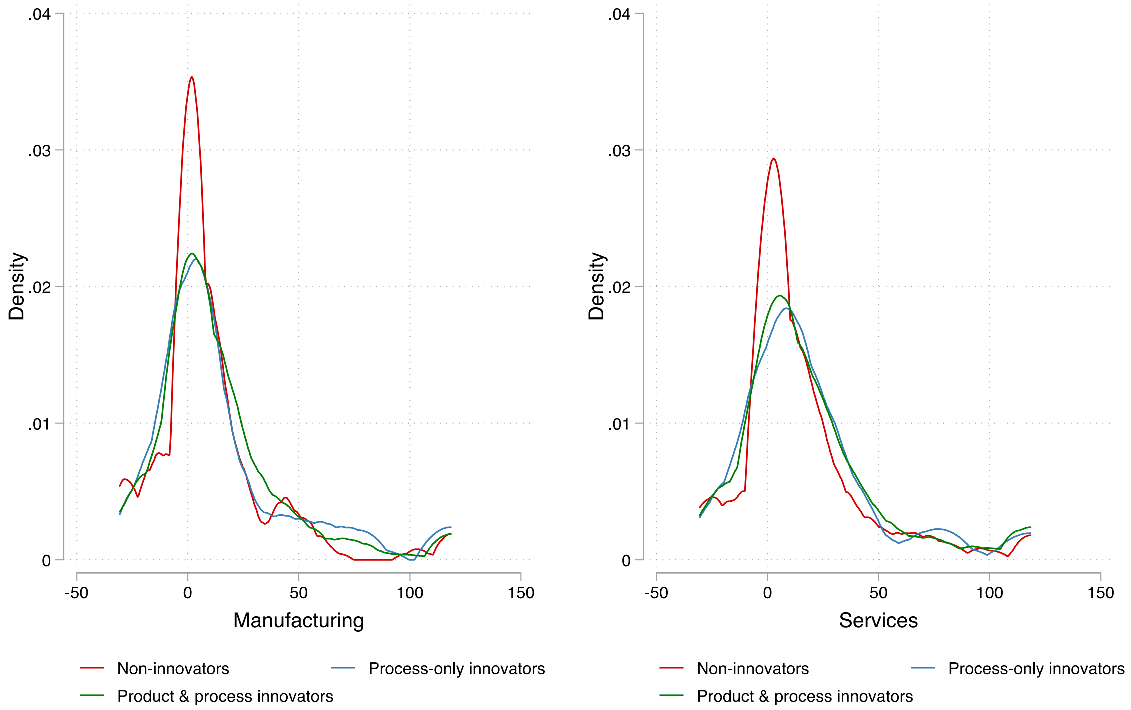
	Industry	Services	All
Number of firms	629	775	1 404
Innovation status (% of firms)			
Non-innovators	33.86	45.55	40.31
Process innovators only	9.38	10.84	10.19
Product innovators only	11.29	9.16	10.11
Process or product innovators	66.14	54.45	59.69
Exporters (% of firms)	56.92	43.23	49.36
Size distribution (% of firms)			
Micro (1–10)	11.13	20.9	16.52
Small (11–50)	25.12	28	26.71
Medium (51–100)	11.61	12.77	12.25
Large (> 100)	52.15	38.32	44.52
Employment growth (%)			
All firms	14.18	19.32	16.98
Non-innovators	11.25	15.77	14.07
Process innovators only (%)	17.53	21.83	20.01
Product innovators only (%)	13.80	25.22	19.43
Process or product innovators	15.62	22.27	18.90
Sales growth (%)			
All firms	27.29	42.98	35.86
Non-innovators	23.02	42.18	35.10
Process innovators only (%)	16.59	34.32	26.96
Product innovators only (%)	8.39	48.69	28.54
Process or product innovators	29.27	43.63	36.34

Notes: This is the pooled data, including the surveys from 2005 to 2007 and from 2010 to 2012. Services include wholesale and retail trade, transport and communications, and financial intermediation, R&D and technical engineering activities. Firm size is measured by the average number of employees in the initial year of each wave.

Figure 2 illustrates the distribution of employment growth by innovation status for each broad sector. For manufacturing firms, the mean employment growth differential between innovating and non-innovating firms does not appear large. However, the tail of the distribution indicates that high-growth firms are more likely to be innovators. For firms in services, the growth distributions of innovating firms lie to the right of non-innovating firms.

High-growth firms in services are also more likely to be innovators, particularly process innovators.

Figure 2: Distribution of employment growth (%) by innovation status: Manufacturing and services firms



Notes: This is the pooled data, including the surveys from 2005 to 2007 and from 2010 to 2012.
Source: Authors' elaboration.

5. Estimation results

5.1 Baseline specifications

The results for the main specification are presented in Table 2, showing both OLS estimates and IV estimates using the *expanded range* – an indicator of how important a firm's introduced product innovation is to the expansion of the range of the firm's products – as an instrument for the growth in sales of new products. Summary statistics are presented in Table A.3 (Appendix).

Looking first at the OLS results presented in Table 2, the constant represents (minus) the productivity growth of producing old products, which is about 2.3% on average for each two-year period. This estimate indicates the gradually declining employment for a given production of the old product due to rising productivity. Worth noting is that the estimate of process innovation is positive and significant, suggesting there is no overall labour displacement as a result of process innovations over the period. The coefficient of the new product sales growth variable indicates the relative efficiency of producing old and new products, with a value of less than one indicating that new products are produced more efficiently than the old products. The coefficient shown here is substantially less than one, suggesting that the production of new products generates less employment than that of old products. That is, the production of new products is less labour-intensive, with higher productivity levels, than is the production of old products. While relatively small, the employment-generating effect associated with product innovation is nonetheless positive.

Table 2: The effects of innovation on employment

Dependent variable: *l-g₁*	(1) OLS	(2) IV	(3) OLS	(4) IV
Process innovator only (d)	3.718***	3.687***	4.025***	4.017***
	(0.271)	(0.285)	(0.280)	(0.296)
New product sales growth (g_2)	0.353***	0.329***	0.402***	0.396***
	(0.020)	(0.059)	(0.022)	(0.071)
Constant ($-\alpha_0$)	-2.297***	-2.174***	-2.214***	-2.184***
	(0.196)	(0.353)	(0.278)	(0.415)
Wave dummies	yes	yes	yes	yes
Industry dummies	yes	yes	yes	yes
Controls	no	no	yes	yes
Observations	1 328	1 328	1 207	1 207
R^2	0.430	0.429	0.426	0.426

Notes: Robust standard errors are reported. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The tests for endogeneity of *new product sales growth* do not provide strong indications that the variable is endogenous (Table A.4, Appendix). However, given the potential bias in our OLS results due to the endogeneity concerns discussed above, particularly related to measurement error, we also conduct IV estimations. The OLS and IV results are highly consistent, and we present both methods for each set of results. The first stage of the IV estimation is presented in Table A.5 (Appendix) and shows that the instrument, *expanded range*, is positively and significantly correlated with the endogenous variable, *new product sales growth*, hence confirming its relevance. The test of excluded instruments also confirms that the instrument is valid.

The IV results in Table 2 then confirm that there is declining employment in the production of old products due to productivity improvements over time. The introduction of process innovation, however, has a positive effect on employment growth. This result contrasts with the estimates of Harrison et al. (2014) in European countries, but is consistent with the cases of Argentina and Uruguay (Aboal et al. 2015; De Elejalde et al. 2015).

There are two potential mechanisms through which this could be occurring. The first is that these process innovations are not generating productivity gains, and therefore labour is not displaced. The second, and more plausible, channel is that the productivity gains induce a demand effect through a price reduction, which compensates for the displacement effect. We cannot fully disentangle these effects. Finally, we see that new products are produced more efficiently than old products, with a coefficient in the range of 0.33 to 0.4. This estimate is substantially lower than the estimates for other countries presented in Table OA.1 (Online Appendix), which fall in the range of 0.63 to 1.75. This finding suggests a significantly lower employment elasticity of new product growth in South Africa, consistent with existing evidence on the South African labour market, discussed below.

When we add controls to the estimation (foreign ownership, export dummy, and share of high-skilled workers), our results remain significant, although the effect of process innovation and new product sales growth on employment is now larger. This is consistent with the finding that foreign-owned firms produce new products with greater efficiency than existing products, which slows down employment growth (Dachs and Peters 2014).

We further explore heterogeneity by industry. These results, presented in Table 3, suggest that the decline in employment from the production of old products due to productivity enhancements is greater in services than in manufacturing. Process innovations have a larger employment-generating effect in manufacturing compared to in services. This could be due to the tradable nature of manufacturing in that productivity enhancements that reduce product prices make these firms more competitive in international markets, where the potential for compensating demand growth is higher. Finally, new products in both sectors are produced more efficiently than old products.

Table 3: The effects of innovation on employment by sector

Dependent variable: l-g_1	(1) Manufac. OLS	(2) Manufac. IV	(3) Services OLS	(4) Services IV	(5) Manufac. OLS	(6) Manufac. IV	(7) Services OLS	(8) Services IV
Process innovator only (d)	4.131*** (0.422)	4.170*** (0.431)	3.515*** (0.345)	3.334*** (0.376)	4.787*** (0.440)	4.910*** (0.454)	3.636*** (0.351)	3.520*** (0.376)
New product sales growth (g_2)	0.308*** (0.029)	0.331*** (0.081)	0.376*** (0.028)	0.326*** (0.084)	0.386*** (0.033)	0.453*** (0.109)	0.425*** (0.030)	0.394*** (0.098)
Constant ($-\alpha_0$)	-1.898*** (0.210)	-2.028*** (0.487)	-1.894*** (0.160)	-3.024*** (0.572)	-1.969*** (0.385)	-2.312*** (0.653)	-1.482*** (0.259)	-1.094** (0.513)
Wave dummies	yes	yes	yes	yes	yes	yes	yes	yes
Industry dummies	no	no	yes	yes	no	no	yes	yes
Controls	no	no	no	no	yes	yes	yes	yes
Observations	597	597	731	731	534	534	673	673
R^2	0.401	0.400	0.439	0.450	0.406	0.403	0.443	0.450

Notes: Robust standard errors are reported. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

An important feature that could also enhance firm productivity is the existence of technological or knowledge spillovers between firms that operate in similar areas of technology (Bloom, Schankerman and Van Reenen 2013). We use a firm-level proxy that captures whether competitor firms or firms in the same sector are an important source (ranked as high or medium) of information for new innovation projects or the completion of existing innovation projects. When we include this control variable for knowledge spillovers, we find that the magnitude of the process innovation and product innovation effects is larger for both sectors (see Table OA.2 in the Online Appendix). The coefficient of knowledge spillovers itself is positive and significant across all specifications, emphasising that inter-firm spillovers contribute positively to employment growth.

We observe some general differences between firms in advanced and developing countries, along with distinctive aspects relating to the results for South Africa. First, the coefficient of process innovation found in this study is positive, in common with the findings of some other studies for developing and emerging economies (see summary in Table OA.1). This points to the compensating demand-enlargement effect outweighing any labour displacement from process innovation, which contrasts with the results for most studies of high-income countries.

The size of the coefficients of process innovation for the case of South Africa is within the range found for other developing economies with positive coefficients. These net employment outcomes of process innovation reflect both potential displacement effects (which depend primarily on labour market characteristics) and potential compensation effects (which depend primarily on product market characteristics) (see section 2.1). The particular characteristics of the South African labour market seem to result in an adjustment to shocks at the employment (quantity) margin rather than at the wage (price) margin, in comparison with the situation in other countries (Erten, Leight and Tregenna 2019). In terms of product markets, recent firm-level evidence for South Africa's manufacturing sector points to high levels of concentration and high mark-ups by international standards (Fedderke, Obikili and Viegi 2019), which might affect the compensating demand-enlargement channel and hence the magnitude of the positive coefficient of process innovation.

Second, the relative productivity of the manufacturing of new products is substantially higher in South Africa than in other economies. While there is employment generation that is associated with new production, the effect is smaller than that found in comparative countries, due to the relatively higher productivity in the manufacture of new products that is partially labour-displacing. This suggests a low employment elasticity of sales growth for new products in South Africa, driven by productivity gains. The rising productivity may be associated in part with the pronounced trends towards capital intensification in South Africa, along with technological change that is skills-biased. South Africa's manufacturing sector has historically had a large share of heavy (capital-intensive) industry (Kaplinsky 1995). Also, there is considerable evidence that this capital intensity has increased over time. Black, Craig and Dunne (2016) show a continuously rising capital-labour ratio in South Africa's manufacturing sector from 1970 to 2013. There also is evidence that South African firms improve productivity through unskilled labour-saving technological progress, where the adoption of high-tech production methods has raised the skill intensity of production (Edwards 2004).

5.2 Employment effects by export orientation

In relation to the first of our two sets of extended results, Table 4 disaggregates the results by export orientation and sector. We find that, for both sectors, process and product innovation lead to larger employment effects for firms that export relative to firms that do not. These effects are more pronounced for manufacturing firms compared to firms in service-related industries. In particular, the effect of process innovation on employment growth is more than twice as high for exporting manufacturing firms than for domestically oriented manufacturing firms. We suggest that this provides evidence of strong compensating demand mechanisms, where firms that can compete in international markets are able to reap greater growth returns from productivity improvements.

Table 4: The effects of innovation on employment by export orientation

	(1) Manufac. OLS Non-exporter	(2) Manufac. IV Non-exporter	(3) Services OLS Non-exporter	(4) Services IV Non-exporter	(5) Manufac. OLS Exporter	(6) Manufac. IV Exporter	(7) Services OLS Exporter	(8) Services IV Exporter
Process innovator only (d)	2.651***	2.620***	2.698***	2.699***	5.569***	5.779***	4.450***	4.408***
	(0.590)	(0.754)	(0.453)	(0.492)	(0.536)	(0.509)	(0.530)	(0.563)
New product sales growth (g_2)	0.418***	0.402*	0.407***	0.407***	0.363***	0.485***	0.451***	0.368***
	(0.052)	(0.227)	(0.036)	(0.129)	(0.043)	(0.133)	(0.051)	(0.141)
Constant	-2.180***	-2.107**	-1.310***	-1.260*	-3.102***	-4.086***	-2.045***	-3.107***
	(0.382)	(1.041)	(0.308)	(0.741)	(0.542)	(1.160)	(0.513)	(0.959)
Wave dummies	yes	yes	yes	yes	yes	yes	yes	yes
Industry dummies	no	no	yes	yes	no	no	yes	yes
Controls	yes	yes	yes	yes	yes	yes	yes	yes
Observations	201	201	366	366	333	333	307	307
R^2	0.433	0.433	0.481	0.481	0.401	0.392	0.432	0.428

Notes: Robust standard errors are reported. The corresponding results without controls are presented in Table OA.3 (Online Appendix), and the results remain consistent. * p < 0.10, ** p < 0.05, *** p < 0.01.

5.3 Employment effects by novelty of innovation

Finally, in a second extension we investigate the heterogeneous employment effects of innovations of different degrees of novelty. Table 5 presents the results of an interacted specification, in which we identify the different marginal effects of introducing a product that is new to the firm but not new to the local or international market. The negative coefficient of the interaction terms suggests that firms that introduce product innovations that are only new to the firm experience a smaller employment growth premium relative to firms that introduce products that are new to the market. This indicates that the degree of novelty of the innovation is important in mediating employment effects. Firms pursuing more radical innovations (not only new to the firm but also to the market) experience faster rates of employment growth.

Table 5: The effects of innovation on employment by novelty of innovation

	(1)	(2)	(3)	(4)
		New to the firm vs. new to the market		
	Manufac. OLS	Manufac. IV	Services OLS	Services IV
Process innovator only (d)	2.719***	3.126***	1.715***	1.797***
	(0.365)	(0.416)	(0.291)	(0.335)
New product sales growth (g_2)	0.637***	0.575***	0.722***	0.664***
	(0.037)	(0.101)	(0.037)	(0.111)
New product sales growth x new to the firm	-0.512***	-0.407***	-0.612***	-0.571***
	(0.043)	(0.061)	(0.043)	(0.074)
Constant	-1.192***	-1.300***	-0.825***	-1.042**
	(0.299)	(0.457)	(0.225)	(0.467)
Wave dummies	yes	yes	yes	yes
Industry dummies	no	no	yes	yes
Controls	yes	yes	yes	yes
Observations	534	534	673	673
R^2	0.589	0.581	0.638	0.636

Notes: Robust standard errors are reported. The corresponding results without controls are presented in Table OA.4 (Online Appendix) and the results remain consistent. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

5.4 Robustness analysis

We checked the validity of our instrument by adding an additional instrument, indicating whether or not the firm reported R&D expenditures for each year of both surveys (see Tables A.6 and A.7). The first stage confirms the relevance of the instruments, and overidentification tests confirm the validity. The pattern of results remains broadly the same for the full sample and by sector, but the magnitudes of the coefficients change slightly. The employment-generating effect of process innovations, across both sectors, seems to be slightly larger than earlier estimates, although within a similar range. Finally, the relative productivity of producing new products compared to old products is estimated to be slightly higher, suggesting a substantial labour displacement in the production of new goods and services. These results are consistent with our main specification and provide a range of plausible estimates for our model.

Similar results emerge when conducting the same robustness analysis on the instrument by export participation. The employment-generating effect of process innovation is slightly larger than earlier estimates for both sectors, and there is some indication of a lower labour-absorptive capacity of new sales growth. The productivity growth of producing old products and services (the constant) is now smaller for exporters in both manufacturing and services. This suggests a marginally lower estimate of labour displacement from the productivity growth related to the continued production of old products and services. These estimates remain in line with those relating to the main set of results.

6. Conclusion

This paper evaluates the effect of process and product innovations on employment using data from manufacturing and services firms in South Africa, which offers an important case given the country's extremely high unemployment rate and the paucity of evidence for African countries. In novel extensions to Harrison et al. (2014), we investigate the mediating effects of firms' export status and of the degree of novelty of innovation.

Overall, we find that innovation has a positive effect on employment growth, driven primarily by process innovation. When disaggregated by sector, we find that process innovation has a larger employment-creating effect for manufacturing firms relative to service firms. The sectoral heterogeneity may be related to the tradable nature of manufacturing, where process innovations that enhance productivity could lead to a larger compensating effect through higher demand from international markets.

Notably, the relationship between product innovation and employment growth is positive and significant; however, the estimates are substantially smaller than for other developing and developed countries. This suggests that the production of new products and services in South Africa tends to be less labour-absorbing than those in comparative countries.

In assessing the different employment effects by the export orientation of firms, we find that both process and product innovations have larger positive employment effects in exporting manufacturing firms compared to those in services and those that do not export. This is one of the few papers examining innovation-export-employment linkages, offering nuanced insights into the role of exports as a mediating factor in the innovation-employment relationship. Firms introducing more radical innovations experience a higher employment growth premium relative to firms introducing less novel products (e.g. products that are new to the firm but not new to the market). Therefore, the degree of innovation novelty is also an important mediating factor in the innovation-employment relationship, and our paper contributes new estimates to this nascent literature. The positive role that radical innovation plays in mediating the effect of innovation on employment suggests that it may also assist in these firms' efforts to catch up to the global technological frontier.

Our results show that, overall, there is no trade-off between innovation and employment creation by South African firms, and that there is heterogeneity in this relationship by type of innovation and also by type of firm (exporters vs. non-exporters). Worth noting is that, since our analysis is at the firm level, we do not capture the overall effects of innovation on employment at the macro-level. For instance, innovation can be expected to enhance aggregate productivity and competitiveness, including through positive spillovers and externalities between firms.

Our findings suggest that policy support for innovation is consistent with efforts to increase employment creation, and also that innovation policies need to be tailored by type of innovation and type of firm. Policies that incentivise and support substantial innovations will be beneficial to employment growth. In addition, there are important linkages between supporting innovation and supporting export performance at the firm level. Exports could compensate for the potential negative productivity effects of innovation on employment growth at the firm level. This underscores the importance of coordination between innovation policy and trade and industrial policy.

There are important avenues for future research. One of these would be to disentangle the potential mechanisms through which process innovation affects employment growth. This would require a better understanding of the pass-through of productivity improvements to prices, paying particular attention to the export orientation of the firm and the competitive nature of the industry.

References

Aboal, Diego, Paula Garda, Bibiana Lanzilotta, and Marcelo Perera. 2015. "Does Innovation Destroy Employment in the Services Sector? Evidence from a Developing Country." *Emerging Markets Finance and Trade* 51 (3): 558–577.

Avenyo, Elvis Korku, Fiona Tregenna, and Erika Kraemer-Mbula. 2021. "Do Productive Capabilities Affect Export Performance? Evidence from African Firms." *European Journal of Development Research* 33 (2): 304–329.

Avenyo, Elvis Korku, Maty Konte, and Pierre Mohnen. 2019. "The Employment Impact of Product Innovations in Sub-Saharan Africa: Firm-Level Evidence." *Research Policy* 48 (9): 103806.

Aw, Bee Yan, Mark J. Roberts, and Daniel Yi Xu. 2008. "R&D Investments, Exporting, and the Evolution of Firm Productivity." *The American Economic Review* 98 (2): 451–456.

Bhaumik, Sumon K., Saul Estrin, and Klaus E. Meyer. 2007. "Determinants of Employment Growth in MNEs: Evidence from Egypt, India, South Africa and Vietnam." *Comparative Economic Studies* 49: 61–80.

Black, Anthony, Stephanie Craig, and Paul Dunne. 2016. "Capital Intensity, Industrial Policy and Employment in the South African Manufacturing Sector." *REDI3x3 Working Paper 23*. http://www.redi3x3.org/sites/default/files/Black%20et%20al%202016%20REDI3x3%20Working%20Paper%2023%20Capital%20intensity%20and%20employment%20FINAL_0.pdf.

Bloom, Nicolas, Mark Schankerman, and John van Reenen. 2013. "Identifying Technology Spillovers and Product Market Rivalry." *Econometrica* 81 (4): 1347–1393.

Boermans, Martijn A., and Hein Roelfsema. 2016. "Small Firm Internationalization, Innovation, and Growth." *International Economics and Economic Policy* 13 (2): 283–296.

Bogliacino, Francesco, Mariacristina Piva, and Marco Vivarelli. 2012. "R&D and Employment: An Application of the LSDVC Estimator Using European Microdata." *Economics Letters* 116 (1): 56–59.

Bravo-Ortega, Claudio, Jose Miguel Benavente, and Álvaro González. 2014. "Innovation, Exports, and Productivity: Learning and Self-Selection in Chile." *Emerging Markets Finance and Trade* 50 (sup1): 68–95.

Caldera, Aida. 2010. "Innovation and Exporting: Evidence from Spanish Manufacturing Firms." *Review of World Economics* 146 (4): 657–689.

Calvino, Flavio, and Maria Enrica Virgillito. 2018. "The Innovation-Employment Nexus: A Critical Survey of Theory and Empirics." *Journal of Economic Surveys* 32 (1): 83–117.

Cirera, Xavier, and Leonard Sabetti. 2019. "The Effects of Innovation on Employment in Developing Countries: Evidence from Enterprise Surveys." *Industrial and Corporate Change* 28 (1): 161–176.

Crespi, Gustavo, Ezequiel Tacsir, and Mariano Pereira. 2019. "Effects of Innovation on Employment in Latin America." *Industrial and Corporate Change* 28 (1): 139–159.

Dachs, Bernhard, and Bettina Peters. 2014. "Innovation, Employment Growth, and Foreign Ownership of Firms." *Research Policy* 43 (1): 214–232.

De Elejalde, Ramiro, David Giuliodori, and Rodolfo Stucchi. 2015. "Employment and Innovation: Firm-Level Evidence from Argentina." *Emerging Markets Finance and Trade* 51 (1): 27–47.

Department of Science and Technology. 2017. *South African National Survey of Research and Experimental Development: Statistical Report 2015/16*. Pretoria: Government of South Africa.

Dosi, Giovanni, and Xiaodan Yu. 2019. "Technological Catching-up, Sales Dynamics, and Employment Growth: Evidence from China's Manufacturing." *Industrial and Corporate Change* 28 (1): 79–107.

Edwards, Lawrence. 2004. "A Firm Level Analysis of Trade, Technology and Employment in South Africa." *Journal of International Development* 16 (1): 45–61.

Erten, Bilge, Jessica Leight, and Fiona Tregenna. 2019. "Trade Liberalization and Local Labor Market Adjustment in South Africa." *Journal of International Economics* 118: 448–467.

Fedderke, Johannes, Nonso Obikili, and Nicola Viegi. 2018. "Markups and Concentration in South African Manufacturing Sectors: An Analysis with Administrative Data." *South African Journal of Economics* 86: 120–140.

Festus, Lyle, Atoko Kasongo, Mariana Moses, and Derek Yu. 2016. "The South African Labour Market, 1995–2015." *Development Southern Africa* 33 (5): 579–599.

Gault, Fred. 2018. "Defining and Measuring Innovation in all Sectors of the Economy." *Research Policy* 47 (3): 617–622.

Hall, H. Bronwyn, Francesca Lotti, and Jacques Mairesse. 2008. "Employment, Innovation, and Productivity: Evidence from Italian Microdata." *Industrial and Corporate Change* 17 (4): 813–839.

Harrison, Rupert, Jordi Jaumandreu, Jacques Mairesse, and Bettina Peters. 2014. "Does Innovation Stimulate Employment? A Firm-Level Analysis Using Comparable Micro-Data from Four European Countries." *International Journal of Industrial Organization* 35: 29–43.

Human Sciences Research Council (HSRC). 2019. "South African National Survey of Research and Experimental Development: Statistical Report 2017/18." http://www.hsrc.ac.za/en/research-data/view/4863.

Hwang, Yun-Seop, Mun-Ho Hwang, and Xiaoxu Dong. 2015. "The Relationships Among Firm Size, Innovation Type, and Export Performance With Regard to Time Spans." *Emerging Markets Finance and Trade* 51 (5): 947–962.

Kaplinsky, Raphael. 1995. "Capital Intensity in South African Manufacturing and Unemployment, 1972–1990." *World Development* 23 (2): 179–192.

Kerr, Andrew, Martin Wittenberg, and Jairo Arrow. 2014. "Job Creation and Destruction in South Africa." *South African Journal of Economics* 82 (1): 1–18.

Kraemer-Mbula, Erika and Watu Wamae. 2010. *Innovation and the Development Agenda*. Ottawa: OECD/IDRC.

Kraemer-Mbula, Erika, and Desiree Sehlapelo. 2016. "Measuring the South African National System of Innovation," in M. Scerri (ed.), *The Emergence of Systems of Innovation in*

South(ern) Africa: Long Histories and Contemporary Debates. Johannesburg: MISTRA and Real African Publishers.

Lachenmaier, Stefan, and Horst Rottmann. 2011. “Effects of Innovation on Employment: A Dynamic Panel Analysis.” *International Journal of Industrial Organization* 29 (2): 210–220.

Lim, Jisun, and Keun Lee. 2019. “Employment Effect of Innovation under Different Market Structures: Findings from Korean Manufacturing Firms.” *Technological Forecasting and Social Change* 146: 606–615.

Okumu, Ibrahim Mike, Edward Bbaale, and Madina Mwagale Guloba. 2019. “Innovation and Employment Growth: Evidence from Manufacturing Firms in Africa.” *Journal of Innovation and Entrepreneurship* 8: 7.

Organisation for Economic Co-operation and Development [OECD]. 2018. *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data on Innovation*. Paris: OECD Publishing.

Ortiz, Javier, and Vicente Salas Fumás. 2020. “Technological Innovation and the Demand for Labor by Firms in Expansion and Recession.” *Economics of Innovation and New Technology* 29 (4): 417–440.

Schumpeter, Joseph. 1934. *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest and the Business Cycle*, translated from the German by Redvers Opie. New Brunswick (U.S.A.) and London (U.K.): Transaction Publishers.

Statistics South Africa. 2019. *Statistical Release PO211, Quarterly Labour Force Survey, Quarter 3: 2019.* Pretoria: StatsSA, Government of South Africa. http://www.statssa.gov.za/publications/P0211/P02113rdQuarter2019.pdf.

Van Reenen, John. 1997. “Employment and Technological Innovation: Evidence from U.K. Manufacturing Firms.” *Journal of Labor Economics* 15 (2): 255–284.

Vivarelli, Marco. 2014. “Innovation, Employment and Skills in Advanced and Developing Countries: A Survey of Economic Literature.” *Journal of Economic Issues* 48 (1): 123–154.

World Bank. 2019. “World Development Indicators.” https://databank.worldbank.org/source/world-development-indicators (date last accessed 31 October 2019).

Wu, Feifei, Huaqing Wu, and Xianfeng Zhang. 2020. “How Does Innovation Activity Affect Firm Export Behavior? Evidence from China.” *Emerging Markets Finance and Trade* 56 (8): 1730–1751.

Appendix

Table A.1: Definitions of variables

Variable	Definition
Employment growth	Log difference in number of employees within each survey period
Initial firm size	The size of the firm, measured by the number of employees, in the initial year of each survey
Turnover growth	Log difference in turnover within each survey period
Innovator	Dummy variable = 1 if the firm introduced new products or processes in the survey period
Process innovator only	Dummy variable = 1 if the firm is engaged in process innovation only, not in product innovation
Foreign head office	Dummy variable = 1 if the firm's head office is in a foreign country, not South Africa
Exporter	Dummy variable = 1 if the firm exports some or all of its sales
Skills intensity	The percentage of employees who have a university or technical school degree or diploma
Industry dummy	An indicator variable for the four main sectors in our dataset: manufacturing; wholesale and retail trade; transport, storage and communications; and financial sector, R&D and engineering
Wave dummy	Dummy variable indicating the wave from 2010 to 2012
New product sales growth	Nominal growth in sales related to a firm's new product. This is calculated by using the proportion of sales attributed to new products in the last year of each survey wave. It is assumed that this product was not produced in the first year
Old product sales growth	Real sales growth at the firm level of products produced throughout the survey period
Expanded range	Main instrument used in the 2SLS model indicating the degree of importance of innovation in expanding the range of products within the firm

Source: Authors' elaboration

Table A.2: Correlation matrix

	Employment growth (ln)	Initial firm size (ln)	Turnover growth (ln)	Innovator dummy	Foreign head office	Exporter	High-skill share
Employment growth (ln)	1.000						
Initial firm size (ln)	-0.154	1.000					
Turnover growth (ln)	0.235	-0.014	1.000				
Innovator	0.022	0.295	0.022	1.000			
Foreign head office	0.027	0.112	0.035	0.131	1.000		
Exporter	-0.006	0.242	-0.022	0.231	0.187	1.000	
High-skill share	0.013	-0.153	-0.020	0.097	0.124	0.076	1.000

Source: Authors' elaboration

Table A.3: Summary statistics

	2005-2007 (wave 1)				
	Obs.	Mean	Std. dev.	Min	Max
Employment growth (log)	513	0.147	0.319	-1.098	1.897
Old product sales growth (log)	513	0.020	0.995	-7.540	7.070
Process innovation only	513	0.107	0.310	0	1
New product sales growth (log)	513	5.297	5.594	0	16.476
Expanded range	513	1.308	1.267	0	3
R&D expenditure (continuous) (log)	513	0.203	0.402	0	1
Foreign head office	513	0.197	0.398	0	1
Exporter	513	0.495	0.500	0	1
High-skill share	513	19.292	22.443	0	100
	2010-2012 (wave 2)				
	Obs.	Mean	Std. dev.	Min	Max
Employment growth (log)	694	0.124	0.553	-5.697	5.481
Old product sales growth (log)	694	-6.415	6.685	-22.104	14.766
Process innovation only	694	0.104	0.305	0	1
New product sales growth (log)	694	10.477	4.423	0	20.476
Expanded range	694	1.010	1.196	0	3
R&D expenditure (continuous) (log)	419	0.456	0.499	0	1
Foreign head office	694	0.190	0.393	0	1
Exporter	694	0.556	0.497	0	1
High-skill share	694	16.850	23.728	0	100

Source: Authors' elaboration

Table A.4: Test of endogeneity

Test of endogeneity: *New product sales growth (g_2)*	(1) All firms	(2) All firms	(3) Manufac.	(4) Manufac.	(5) Services	(6) Services
Wu-Hausman test						
F-stat	0.1595	.008	0.0735	0.3589	0.4368	0.1082
P-value	0.6896	0.9289	0.7864	0.5494	0.5089	0.7423
Wave dummies	yes	yes	yes	yes	yes	yes
Industry dummies	yes	yes	no	no	yes	yes
Controls	no	yes	no	yes	no	yes

Source: Authors' elaboration

Table A.5: First-stage estimation of main results

Dependent variable: *New product sales growth (g_2)*	(1) All firms First stage OLS	(2) All firms First stage OLS	(3) Manufac. First stage OLS	(4) Manufac. First stage OLS	(5) Services First stage OLS	(6) Services First stage OLS
Process innovator only	-1.921***	-1.925***	-1.887***	-2.023***	-1.924***	-1.841***
	(0.375)	(0.399)	(0.578)	(0.640)	(0.496)	(0.515)
Expanded range	1.641***	1.461***	1.643***	1.376***	1.622***	1.463***
	(0.105)	(0.109)	(0.141)	(0.150)	(0.153)	(0.155)
Constant	3.222***	2.831***	3.509***	3.106***	2.645***	1.479***
	(0.248)	(0.318)	(0.315)	(0.456)	(0.435)	(0.490)
Partial R^2 of excluded instruments	0.164	0.136	0.176	0.132	0.153	0.128
Test of excluded instruments:						
F stat	245.52	180.36	135.88	84.29	112.53	88.92
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000
Wave dummies	yes	yes	yes	yes	yes	yes
Industry dummies	yes	yes	no	no	yes	yes
Controls	no	yes	no	yes	no	yes
Observations	1 328	1 207	597	534	731	673
Model F stat	151.30	92.30	115.18	53.26	102.37	57.85
Prob > F	0.000	0.000	0.000	0.000	0.000	0.000

Notes: Robust standard errors are reported. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table A.6: Robustness analysis: The effects of innovation on employment

Dependent variable: $l-g_1$	(1) All	(2) Manufacturing	(3) Services
Process innovator only (d)	5.136***	5.714***	4.819***
	(0.401)	(0.573)	(0.535)
New product sales growth (g_2)	0.239***	0.314***	0.239***
	(0.048)	(0.079)	(0.064)
Constant	-1.749***	-2.250***	-2.239***
	(0.323)	(0.513)	(0.525)
Wave dummies	yes	yes	yes
Industry dummies	yes	no	yes
Controls	yes	yes	yes
Observations	932	428	504
R^2	0.375	0.368	0.393

Notes: Robust standard errors are reported. The table reports the 2SLS IV estimation, using the expanded range and continuous R&D expenditure variables as instruments for the nominal sales growth of new products. * p < 0.10, ** p < 0.05, *** p < 0.01

Table A.7: Robustness analysis: The effects of innovation on employment by export orientation and innovation novelty

	(1)	(2)	(3)	(4)	(5)	(6)
	Non-exporter		Exporter		Innovation only new to the firm	
	Manufacturing	Services	Manufacturing	Services	Manufacturing	Services
Process innovator only (d)	3.841***	3.905***	6.566***	5.895***	4.217***	3.094***
	(0.968)	(0.663)	(0.623)	(0.806)	(0.556)	(0.496)
New product sales growth (g_2)	0.261**	0.295***	0.384***	0.226***	0.465***	0.518***
	(0.107)	(0.084)	(0.099)	(0.087)	(0.083)	(0.093)
New product sales growth x new to the firm	-	-	-	-	-0.305***	-0.409***
	-	-	-	-	(0.061)	(0.072)
Constant	-1.764***	-1.800***	-3.745***	-2.568***	-1.634***	-0.162
	(0.558)	(0.659)	(0.875)	(0.789)	(0.398)	(0.449)
Wave dummy	yes	yes	yes	yes	yes	yes
Industry dummy	no	yes	no	yes	no	yes
Controls	yes	yes	yes	yes	yes	yes
Observations	143	267	285	237	428	504
R^2	0.347	0.342	0.384	0.426	0.475	0.520

Notes: Robust standard errors are reported. The table reports the 2SLS IV estimation, using the expanded range and continuous R&D expenditure variables as instruments for the nominal sales growth of new products. * p < 0.10, ** p < 0.05, *** p < 0.01

The South African Research Chair in
Industrial Development (SARChI)
31 Henley Road, Auckland Park,
Johannesburg, South Africa

General enquiries:
Koketso Manyane-Dlangamandla
Email: koketsom@uj.ac.za
Tel: +27 011 559 7454