Innovation and employment in Sub-Saharan Africa: Evidence from Uganda micro-data

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Abstract

This paper analyses the relationship between innovation and employment at firm level with the objective of understanding the contribution of the different innovation strategies in fostering employment growth in Uganda. Using National Innovation Survey (of 705 Ugandan firms) for the period 2011–2014 and following closely Harrison et al (2014) structured approach that relates employment growth to process innovations and to the growth of sales separately due to innovative and unchanged products, we find positive effects of product innovation on employmentat firm level, while process innovation has no discernable impact on employment. Although there is evidence to suggest displacement of labour in some cases where firms only introduce new process, this effect is compensated by growth in employment from new products, which for most firms are introduced simultaneously with new process. Results suggest that source of innovation as well as size of innovating firms or end users of innovation matter for job growth. Innovation that develops from within the firm itself (user) and involving larger firms has greater impact on employment than that developed from outside or coming from within smaller firms. Innovation is important for firm survival (innovative firms are one and half times more likely to survive in the innovation driven economy environment than those that do not innovate). Accordingly, supporting policies need to be correctly tailored since the impact of innovation on employment depends on the innovation strategy (type) and characteristics and sector of the innovative firms (small, large, industry, etc). Policies to spur investment, particularly in innovative sectors and firms with high growth potential would have long lasting effects on job creation.

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1 Introduction

A common challenge that African countries face is how to create sustainable jobs and employment opportunities amidst rapid population growth. In 2005, the African Ministerial Council on Science and Technology (AMCOST) adopted Africa's Science and Technology Consolidated Plan of Action (CPA) which defines the African Union (AU) agenda for harnessing science, technology and innovation (STI) to boost economic growth and improve the lives of African people. Despite these efforts and increased financial support to promote innovation activity, progress in expanding innovation ecosystem and in reducing unemployment has been limited. This raises a question whether Africa policy makers and other stakeholders are aware of the business model that can drive scale, or is it simply a lack of understanding of the link between innovation and employment?

While there is a widespread recognition that innovation[2] can spur economic growth and create jobs, the question remains how to link innovation to job creation, poverty reduction, sustainable livelihoods and the improved well-being of the African people (NPCA, 2014). Africa has an impressive market size of over 1 billion people, with over 841 million in Sub–Saharan Africa. With two-thirds of this population under the age of 23, innovation has the potential to harness demographic dividend for socio-economic transformation in Africa. By 2040, Africa is expected to be home to one-fifth of the world's young people and Africa's labour force is estimated to reach 1.1 billion, overtaking China's or India's (MGI, 2010).

This demographic dividend, together with the growing labour force, urbanization and the rise of the middle class consumers offer huge opportunity to Africa today and for her long–term growth, as much as it supported the growth of East Asian economies 40 years ago. Many would point to the fact that if Africa can provide its young people with the education and skills they need, this large workforce could accelerate Africa's integration into the global economy. This anticipated demographic dividend has galvanized political commitment and resources across Africa. With the view that policies to spur investments, particularly in innovative sectors with high growth potential could have long lasting effects on job creation, many governments have put in place supporting policies (e.g. patent protection), and institutions and innovation funds[3] established, to promote innovation. Over US$ 0.25 billion are invested every year by African governments, private sector and international sources combined in promoting innovation across the continent. Africa private investment technological innovation spending now accounts for

[2] 'Innovation', as defined by OECD's *Oslo Manual*, is 'the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations' (OECD, 2005). We define employment as the number of economically-active persons who are in wage-paid job or self-created work that earn them income.

[3] Examples include Rwanda Innovation Fund (RIF) endowed with over US$ 30 million, Malawi Innovation Challenge Fund, endowed with US$ 8 million from the UNDP and UK DFID, Botswana Innovation Fund, etc.

close to 10 percent of the emerging market's total.[4] The results are a wave of technology innovation hubs scattered across Africa.

This emerging market of technological innovation is further supported by improvements in national systems of innovation especially universities and facilities that provide learning environment for experimentation and nurturing young talents and skills. Universities are competing to set up software and hardware incubation centres that serve to link them to industry. Countless innovation products are being developed where Africa's youths are playing an important role especially in the quickly expanding information and communication technology (ICT) sector, often with government support, in the growing ambition to seize 'demographic dividend'.

However, more still needs to be done. According to UNESCO (2007) and NPCA (2014), R&D intensity in most of African countries is still far below the 1% which is the current target for AU member countries. Globally, Africa accounted for less than 1 percent of the total world expenditure on R&D in 2000, compared with Asia's 30.5 percent, North America's 37.2 percent, Europe's 27.2 percent, and Latin America and the Caribbean's 2.9 percent (UNESCO, 2004, cited in Mugabe, 2011). The low R&D intensity partly explains the low human capital, including low number of researchers and technological and innovation capabilities in Africa and the employment situation.

ILO (2018) cites Africa as the place with the highest rate of vulnerable employment globally, remaining at around 66 percent against the global average of 46.3 percent. These are people who have limited access to social protection schemes and are often confronted by low and highly volatile earnings. According to ILO, 290 million African workers were in vulnerable forms of employment in 2017 and was expected to rise to about 299 million in 2018, with the largest increase happening in sub-Saharan Africa. Lack of decent work opportunities is exacerbated by the prevalence of informal economy, which accounts for over 76 per cent of GDP in Tanzania, 89.2 per cent in Madagascar and 93.5 per cent in Uganda. The informal sector contributes 60-80 per cent of employment in the region, and 90 percent of new jobs, with 9 out of 10 workers in both rural and urban areas holding only informal jobs (ILO, 2018). The growing youth employment challenge in Africa suggests that the progress of creating sustainable jobs and employment opportunities, from a decade of innovation activities has been slow.

A crucial question then arises about the effectiveness of the approaches and strategies adopted by African governments and other stakeholders to promote innovation and create jobs. The relative importance of the various innovation strategies in creating jobs is yet to be determined, and existing literature is still unclear about the firm-level employment effects of the current innovation approaches. While the benefit of innovation for economic growth is widely recognised, less known is its relationship with employment at firm- and sector-levels, more especially in a specific context of African countries. Understanding this relationship is important for the design of micro-policies to spur investment in innovation-driven sector and harness employment growth.

[4]Our own estimates based on various government sources. This includes direct funding to innovation activities and funding to line ministries directly responsible for innovation and several other institutions and agencies in the innovation ecosystem.

The rapidly evolving literature on innovation and employment focuses on northern developed countries. Even in countries where such studies have been conducted, the evidence is mixed (process innovation has a small negative or no effect on employment for European firms, with some positive effects for Africa, South Asia, Middle East and North-Africa, Eastern Europe and Central Asia) so that it is difficult to generalize from one country's experience to another.

This study uses firm-level experiences in Uganda, to provide insights on the employment impact of innovation, and in improving our understanding of the role of different innovation strategies in fostering employment growth. The study offers a few lessons for other African countries seeking to harness innovation to achieve their employment goals. Uganda provides a very interesting case for studying this relationship for two reasons. First, Uganda has over 60 percent of her population below the age of 25 and is ranked among countries with the highest rate of youth unemployment in Sub-Saharan Africa.[5] At the same time, Uganda is among the 82 world nations which have advanced technological and innovation capabilities.

Second, harnessing the potential of Uganda's youth continues to be at the forefront of government policy. Over the last decade, Uganda has implemented several initiatives that focus on supporting young people through digital spaces and transforming brilliant ideas into commercially-viable businesses. Leading the way, the Incubation Support Initiative (ISI) under the Uganda Communications Commission (UCC) has since its inception in 2011, provided financial support to varieties of ICT innovation activities—ranging from a simple ICT solutions such as digital saving platforms using mobile phones (to foster financial inclusion), to a software application that enables farmers keep track of their finances, and vehicle tracking system, to a complex ICT embedded systems and robotics. Other schemes include the ICT Innovation Fund, initiated by the President and targets innovation start-ups; the National ICT Initiatives Support Programme (NIISP) under the Ministry of ICT & National Guidance, and those under the Ministry of Science and Technology. Through these initiatives, government has committed over $5 million, over the last six years, in an effort to create innovation ecosystems that is hoped to lift millions of youths in the country from unemployment to active participation in the global economy.

These initiatives have created diverse opportunities for public-private partnership, a vibrant framework of cooperation and collaboration between business community, development professionals, industry and academia who appreciate that innovation is key in tackling the complexities of today's business and development challenges. What is lacking, however, are studies that can provide insights into the employment effects of such innovation initiatives or that can provide estimates of the magnitude of such relationship. We are not aware of any study that provides documented accounts of the different innovation strategies in fostering employment growth and the comparisons between within-firm and reallocation effects of innovation or whether firm size matters for employment–innovation relationship. This study endeavours to fill this gap by

[5] Employment (according ILO and international recommendation on labour statistics) is defined as economically-active persons (usually, aged 15-64) who were in paid or self-employment for a specified period at the time when data is compiled (ILO, 2000).

providing evidence on the effects of innovation on employment growth—and how such relationships can be harnessed for job creation—in the specific context of Uganda.

Objectives of the study

This study investigated the linkage between innovation and employment in Uganda. The specific objectives of the study were to analyse:

(i) comparative growth in employment at firm-level for start-ups and established enterprises that undertake process and product innovation;
(ii) growth in employment at firm level, for enterprises using innovation developed by the enterprises (users themselves) and for those using innovation developed by other enterprises and institutions (i.e. within-firm versus reallocation effect of innovation);
(iii) the effect of innovation on firm sales and employment.

2 Literature review

2.1 Theoretical literature

The debate on economic impacts of innovation goes back to Schumpeter (1934), who viewed the relationship between innovation, growth and competition, as a process of 'creative destruction'. Schumpeter put forward a theory of innovation as the main factor promoting long-term growth. By contrast, the neoclassical growth theory that followed in the 1950s, pioneered by Solow (1956, 1957) emphasises the importance of technological progress in the determination of the levels of production, employment and income. In his 'Technical Change and the Aggregate Production Function' Solow (1957) analysed the effect of individual factors on the long-term growth of the U.S. economy, and found that technological progress rather than labour and capital was the main driver of economic growth in 1909-1949.

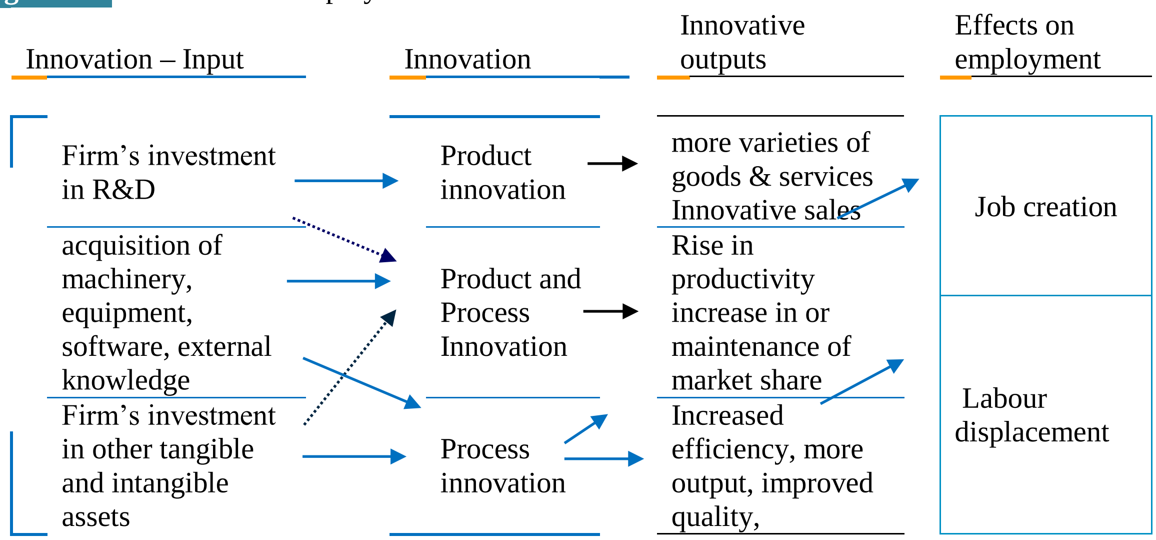
The impetus to innovation literature is attributed to the advent of endogenous growth theory (Romer, 1986) and the incorporation of innovation as an endogenous source of growth (Aghion and Howitt, 1992). Romer (1986) related increasing returns to long-run economic growth and subsequently developed a theory of growth based on endogenous technical change (Romer, 1990).[6] Grossman and Helpman (1994) highlight the importance of investment in Research and Development (R&D) and the resulting spillovers in explaining the relationship between innovation and growth. Jones (1995) provides a modified version of Romer's model which is consistent with time series evidence on R&D spending and growth rates. All these contributors to endogenous growth literature are consistent about the role of technology and innovation in economic

[6]This paper will not attempt to review the burgeoning theoretical literature on endogenous growth. A comprehensive review of the work until mid-1990s can be found in Bardhan (1995).

growth, but offer no valuable insights into the firm-level relationship between innovation and employment.

New generation of growth theory, which draws partly from the theory of industrial organisation casts innovation as the main engine of modern-day growth through its impact on firm productivity. The theoretical mechanisms (based on this literature) linking growth at firm-level to innovation output operate through investment in R&D, machinery, equipment, software, and other tangible and intangible assets (e.g. patents) and innovation inputs in order to develop new product and process (Figure 1).

Figure 1. Innovation – employment link



Source: Author's own illustration

In theory, *ceteris paribus*, new products or significantly improved products create a new demand, which allows innovating firms to employ more people. As for process innovation, the direction of changes in employment depends on several factors.

By increasing labour productivity, process innovation enables the production of more goods and services with less labour, and may lead to job losses. It will lead to a higher demand for the firm's products thus employment if the firm shares this efficiency gain with the consumers via lower prices. The extent of these displacement and compensation effects depend on demand elasticity and whether the improvement in production processes is labour or capital-augmenting (Harrison 2008). There is no a priori theoretical basis to predict which of the two will prevail. The overall effect of innovation on employment can only be ascertained empirically.

2.2 Empirical literature

The growing strand of literature on the link between innovation and employment take a more sectoral approach, partly because of the recent availability of reliable longitudinal data sets. Examples of studies that explore the linkage between innovation and employment in agriculture, include Bhatia and Gangwar (1981) and Agarwall (1981) who looked at the effects of process innovation on farm-level employment in India; De Klerk (1984) on maize farms in South Africa and (Inukai 1970) on rice farmers in Thailand. The studies took process innovations to include mechanization, new irrigation methods, and use of fertilizers in crop farming or new feeds in dairy farming.

Bhatia and Gangwar (1981) used survey data to study the effect of mechanisation on farm-level employment of 965 small farms in Karhal district of India and found that mechanization on its own tends to have a negative effect on farm employment. The effect worsens with increase in farm size and when mechanization is used for ploughing and harvesting operations instead of sowing. Process innovation in general and mechanization in particular, tends to have a positive effect on employment only when it is accompanied with product differentiation and strong forward and backward linkages between agriculture and manufacturing industries, while other types of process innovation such as new feeds, fertilizers and irrigation systems tend to have positive impact on employment. Product innovation (which comprises use of high-yield-variety seeds as the primary innovation type) tends to have positive impact on employment.

In manufacturing, Agbesor (1984) examined the effects of process and product innovation on firm-level employment in manufacturing firms in Nigeria; and Aryee (1984) and Usha (1985) on footwear industry in Ghana and India, respectively. They all found a positive employment impact of product innovation, while process innovation (technological change) tends to be characterized by skill-bias and capital-intensity. Van Reenen (1997) matched the London Stock Exchnage database of manufacturing firms with the innovation database of the Science Policy Research Unit at the University of Sussex to create a panel of 598 British firms over 1976–1982. His findings reveal a positive relationship between innovation and employment. Chennells and Van Reenen (1999) survey the evidence on the effects of technical change on skills, wages and employment, focusing on over 70 empirical studies that have used direct measures of technology (rather than associating technology with a residual time trend). They find evidence of a positive correlation between wages and innovation. While their results show that product innovations can elevate employment growth, they find no evidence of a robust effect of the process innovations or R&D expenditure on employment.

Falk (1999) used probit model to analyse the link between technological product and processes innovations and expectations about future employment for different types of labour in manufacturing firms in Germany. He found that innovation of products that are new for the market is on average most important to determine the growth of a firms' expected labor hiring. Introduction of new market products was more important than any other measure of product innovation in determining the expected employment probabilities for homogeneous labour. Further, technological innovation was found to have the strongest impact on university graduates, and simultaneous introduction of new products and new processes had a stronger impact on the employment expectations of university graduates than product innovations alone.

Piva and Vivarelli (2003) used a Generalized Method of Moments (GMM-SYS) in an employment equation augmented for technology for 575 Italian manufacturing firms over the period 1992-1997. They also found a significant positive relationship between innovation and employment. Janz and Peters (2003) in their cross-country investigation of the link between innovation and productivity in Germany and Sweden found that the success of innovation increased with the effort of innovation and the proportion of workers highly skilled.

Hall et al. (2008) applied the model proposed by Harrison et al. (2008) to Italian manufacturing firms and found that product innovation contributed about half the employment growth in these firms during the period 1995-2003, but no evidence of employment displacement effect stemming from process innovation. Polder et al. (2009) for the Netherlands, found that ICT affects productivity indirectly through innovation in services, but not in manufacturing, and that product and process innovations affect productivity only if accompanied by organizational innovation in both services and manufacturing.

More recently, Buerger (2012) examined the co-evolution of R&D expenditures, patents and employment using data on four manufacturing sectors across Germany for 1999–2005. The study found a positive and significantly high correlation between patents and employment in two high-tech sectors (medical and optical equipment, and electrics and electronics), and no correlation in two low-tech sectors (chemicals and transport equipment).

Harrison et al. (2014) used firm-level data from the third wave of the Community Innovation Survey for four European countries: France, Germany, Spain and the UK, and a discrete model that relates employment growth to process innovations and to the growth of sales separately due to innovative and unchanged products. They found that product innovations were job-creating and that process innovation displaced less employment in services than in manufacturing, but overall, the compensation effect outweighed the displacement effect hence the net effect was positive.

Vivarelli (2014) estimated direct labour-saving effect of process innovation and job creating impact of product innovation for the economies of Italy and US over 1960 – 1988. Their findings reveal that other than falling prices, the other compensation mechanisms were ineffective in limiting employment losses. Cirera and Sabetti (2016) applied the same theoretical model of Harrison et al. (2014) to a sample of over 15,000 firms in Africa, South Asia, Middle East and North-Africa, and Eastern Europe and Central Asia, and found a positive direct effect of innovation on employment. They further found that, the impact of innovation diminished with firms' transition to the technological frontier. The effect was highest in lower income countries and the African region, where firms are further away from the technological frontier.

On the whole, recent micro-econometric studies, especially those based on reliable panel data, offer a substantial evidence of the possible job-creating impact of innovation. Most studies have found positive effects of product innovation on employment, but the evidence on process innovation is mixed. For European firms, process innovation usually has a small negative or no effect on employment, although for Africa, South Asia, Middle East and North-Africa and Eastern Europe and Central Asia, it is more likely to be positive. The balance between the perceived displacement and compensation effects of process and product innovation vary from one study to another. However, the overall effect of innovation on employment is generally positive in these studies.

These studies also show that new job-creation prospects of innovation depend on the type of innovation, as well as the sector and characteristics of the innovative firms. Effects of innovation on employment are likely to be more positive in services than in manufacturing. The negative effect of process innovation reported in the studies are linked in some cases, to the widespread use of information and communication technologies (ICTs), which are assumed to displace the least qualified employees. The impacts of innovation on employment in the services sector are bound to vary across different sub-sectors and according to the level of qualification of the labour force in individual African countries.

The existing studies have mostly focused exclusively on manufacturing, yet much of the new employment in recent years seems to be in services. Apart from limited representation of the various sectors of the economy none of the studies focuses on the effect of firm-size. Dissecting aggregate productivity growth into various micro-components provides a better understanding of the sources of growth, and for sectoral and micro-level policies to harness employment. Further to these, existing studies also tend to focus exclusively on indirect effect, particularly at the level of end-users. Yet, most of the innovations employed by end-users in services and manufacturing industries are sourced from other firms. Jobs created at source are often not covered in empirical and theoretical literature.

3 Methodology

3.1 Model specification

To examine the impact of innovation on firm-level employment, we follow Harrison et al (2008) and (2014), which related employment growth to process innovations and growth of sales separately due to innovative and unchanged products.

The firm's annual output Y_{it} of old product ($i = 1$) and new product ($i = 2$) depends on quantity and quality of inputs, level of technology and other factors that affect productivity, that is,

$$Y_{it} = \theta_{it} F(K_{it}, L_{it}, M_{it})\, e^{\eta + \omega_{it}}, \quad i=1,2;\ t=1,2 \quad (1)$$

where K, L and M are capital, labour and intermediate inputs. The parameter η represents an observed firm-idiosyncratic 'fixed' effect. η captures all unobservable factors that make a firm more or less productive than the average firm using the same methods of production (θ). w stands for product and time-specific productivity shocks with $E(\omega_{it}) = 0$ (w accounts for the unobservable shifts in the production function arising from factors other than innovation activities).

The change in efficiency of producing old products θ_{12}/θ_{11}(= $\ln\theta_{12} - \ln\theta_{11}$) is expected to be larger for firms which introduce process innovations in producing them. The impact of product innovation on employment growth depends on the relative efficiency of producing old and new products (θ_{22}/θ_{11}). If new products are produced more efficiently than old products, this ratio is less than 1, and therefore, employment does not grow one-for-one with the growth in output due to new products.

The rate of growth in output of old product over the survey period 2011–2014 is given by $\ln Y_{12} - \ln Y_{11}$ and the rate of output growth of new product is given by Y_{22}/Y_{11}. The rate of employment growth (l) due to process innovation and growth of output due to innovative and unchanged products over the survey period 2011–2014, between 2011 (t=1) and 2014 (t=2) is represented by:

$$l = \alpha_0 + \alpha_1 d + y_1 + \beta y_2 + \mu \qquad (2)$$

where α_0 is the average efficiency growth in production of the old products, while d is a dummy variable which takes the value 1, if the firm has implemented a specific process innovation not associated with a product innovation (i.e. process innovation only). Variable d allows us to identify directly the productivity (or displacement) effect of process innovation on employment. Variable y_1 is the rate of growth in output of old products, while y_2 is the rate of output growth of new product and allows us to identify the gross effect of product innovation on employment. β : efficiency parameter, captures the relative efficiency of the production of old and new products[i], while μ = - ($\omega_{12} - \omega_{11}$) + ξ represents overall disturbances in which ξ accounts for miscellaneous (uncorrelated) errors.[7] Old and new products may be sold at different prices. Since we do not have information on firm-level prices, we use nominal sales growth instead of real output growth in our estimation equation, where $g_1 = y_1 + \pi_1$ and $g_2 = \pi_2 y_2$, with $\pi_1 = \left(\frac{P_{12} - P_{11}}{P_{11}}\right)$ being the rate of increase of the prices of old products and π_2 the price difference between the new product and the old product in period 1. By substituting the growth in nominal sales, g_1: the nominal growth rate of sales due to old products, and g_2: nominal growth in sales that is due to new products, for the growth in real production

[7] As long as the firm makes its investment decisions for the innovations in advance and the shocks are considered unpredictable, innovations will not be correlated with ω and μ and an OLS estimator would suffice to estimate equation (2) consistently. The resulting innovations will be correlated with these shocks if we assume that firms make these investments within the period affected by the shocks ω .

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in equation (2), and taking into account endogeneity problem arising from possible correlation of y_2 with productivity shocks and by its necessary replacement by g_2, the estimation equation becomes:[8]

$$l - g_1 = \alpha_0 + \alpha_1 d + \beta\, g_2 + v \qquad (3)$$

where $l - g_1$: employment growth minus the growth of sales due to the unchanged products) is our dependent variable and $v = -\pi_1 - \beta\pi_2 y_2 + u$ is the new unobserved disturbance. To control for changes in the prices of old products (identify an effect of process innovation on employment net of direct compensating price variations), we deduct an industry price growth index π (taken as a rough proxy for price growth index of old product π_1) from the nominal sales growth of unchanged products, leading to the adjusted dependent variable $l - (g_1 - \pi)$, that is,

$$l - (g_1 - \pi) = \alpha_0 + \alpha_1 d + \beta g_2 + v \qquad (4)$$

This leaves the term $-(\pi_1 - \pi)$ in the error term, and $\pi_2 y_2$ is assumed to be uncorrelated with the price differences and the productivity shocks. This adjustment partly corrects the attenuation bias in the estimated α_1. To capture the *within-firm* and *reallocation* effects of innovation, and influence of firm-size and start-up versus established firms, in driving scale, dummy variables are used.[9] The final estimation equation is:

$$\ell = \alpha_0 + \alpha_1 d + \beta g_2 + \phi\, h + \varphi S + \gamma N + u \qquad (5)$$

where dependent variable $\ell = l - (g_1 - \pi)$; and h is a dummy for source of innovation, which takes the value 1 if the innovation is developed by the enterprise itself. *S* is size class dummy: S=1 if firm in sample is large (250 employees and above in 2011), S=2 if medium (50 to 249 employees in 2011), and S=3 if firm in the sample is small (less than 50 employees in 2011).*N* takes the value 1 if the firm was established in 2011-2014 (newly established).Table 1 defines the variables of our model.

[8] The variable y_1 has a coefficient equal to one and can thus be substracted from l on the left-hand side of the estimation equation – leading to $l - (g_1 - \pi_1)$.

[9] All regressions include industry, size and source dummies. Source dummy takes the value 1 if the innovation is developed by the enterprise, enterprise group or by enterprise adapting what was developed by others. The size dummy takes the value 1 if innovating firm in sample is large (250 employees and above in 2011), S=2 if medium (50 to 249 employees in 2011), S=3 if innovating firm in the sample is small (less than 50 employees in 2011). Dependent variable is net labor growth (minus growth in sales of old product).

Table 1. Variable definition	
Variable	Definition
Dependent variable	Employment growth minus the growth of the sales due to old products fit by an index of products prices: empl_2014−empl2011/empl_2011 rate of change of total employment of the company throughout the period.
Independent variables:	
Process innovation	A dummy variable which takes value 1 if the firm reports to have introduced new or significantly improved production process during 2011 - 2014.
Product innovation	Dummy variable which takes the value 1 if the enterprise reports having introduced new or significantly improved products during 2011-2014 (new to the market or only new to the firm).
Firm Size, S	Set of size dummy variables according to the firm's number of employees in 2011. Categories are 20-49, 50-249, 250+ employees.
Sales growth due to old products, g_1	$g_1 = g - s(1 + g)$
Sales growth due to new products, g_2	$g_2 = s(1 + g)$
Share of sales with new products	Share of turnover in 2014 due to new or significantly improved products introduced during 2011-2014.
Industry	Set of industry dummies according to the firm's main business activity during the period 2011-2014.
Newly established (start-up)	Dummy variable being 1 if the firm was established during 2011 - 2014 .
Source of innovation	Dummy variable being 1 if the innovation was developed by the enterprise itself

Dependent variable is net labor growth minus growth in sales of old product: $l-(g_1-\pi)$

3.2 Data type and source

To estimate the effect of innovation on employment at firm-level, we used data from National Innovation Survey (NIS) 2011–2014 conducted by the Uganda National Council for Science and Technology (UNCST) in collaboration with Uganda Bureau of Statistics.[ii] This is the most comprehensive survey on innovation in Uganda. The survey employed a stratified sampling strategy, where firms were stratified by sector size, and location.[iii] The survey differentiates between product and process innovation, and two non-technological innovations: marketing and organization.

Basic variables set out in the questionnaire include employment and sales in the years 2011- 2014, and information about whether the firm has introduced process and product innovations during this period. The variable measuring the share of the firm sales in 2011–2014 and employment arising from new or improved products introduced since 2011 or during the period 2011–2014 — viewed as a sales-weighted estimate of the firm product innovations—allowed us to decompose total sales in sales of "new" and "old" products and employment growth into two components: employment driven by changes in sales under old products/ process and employment driven by growth in sales under the new products/process.[iv]

4 Estimation results

4.1 Descriptive statistics

This section presents descriptive statistics with a summary in Table 2 that captures the key variables used in econometric analysis. Table 2 shows wide dispersion in employment at firm level. Across firms, variability in employment growth is larger among innovators compared to non-innovating firms.

Table 2. Descriptive statistics

	N(observations)=533			N(firms)=705	
	Obs	**Mean**	**Std. Dev**	**Min**	**Max**
Dependent Variable:					
Employment	533	26.751	156.427	1	3197.875
Employment Growth	533	1.078	0.635	-0.909	7.633
if Innovator	389	1.330	0.654	-0.909	7.633
if Non-Innovator	144	0.976	0.572	-0.865	7.631
Independent Variables:					
Non-innovator	533			0	1
Innovator	533	0.539		0	1
Product Innovator	533	0.456	0.495	0	1
Process Innovator	533	0.413	0.493	0	1
Both Product & Process Innovator	553	0.240	0.327	0	1
(Innovation expenses / Sales)	--	--	--	--	--

Source: Author's calculation based on UNCST – National Innovation Survey 2011 – 2014
Notes: Classification as an innovator means that the firm has introduced an innovation to the market in the preceding year. This variable is further broken down into product and process innovator according to the type of innovation the firm has introduced.

There is substantially more variability between product and process innovations, as further illustrated in Table A1, and tends to over-represent industry and large-scale firms.

The services sector in Uganda is dominated by small and informal retail trade activities with low innovation intensity. Other innovation surveys that relate firm size to innovation have also found that the dominant (large) firms tend to innovate more for fear of losing their market share or dominant position to competitors.

Table A2 (in the Appendix) distinguishes product innovations by their degree of novelty: product new to firm and new to main market. The extent of novelty varies widely across innovating firms, and tends to over-represent foreign firms, which happen to dominate products that are new to market. This should not be seen as a surprise. Foreign owned businesses (some of which are multinationals) also face stronger incentives to significantly improve their products (or introduce new products) and upgrade their production processes.

Table A2 further shows government support for innovation activities. The number of firms that received government financial support for innovation were 9.7 percent in the industry, and 16.1 percent in the services sector. However, due to lack of additional information it is difficult to estimate the support going to start-ups innovators.
Domestic firms emerged as bigger spenders on technological innovation, which include investment in R&D, acquisition of machinery, equipment and software, and other external knowledge (*e.g.* patents, licences, trademarks).

With regards to source or origin of innovation, Table A3 distinguishes between innovations developed by the firm itself and by those developed by other firms. Again, the sample shows a large variability among firms. Firms that developed their own innovation account for 59.8 percent of users (firms) in the sample; against 15.3 percent that rely on innovation developed by other enterprises or institutions (—i.e. innovation originating from outside the users' organisation environment). In-house (product) innovation finds higher use among services firms than among industry firms.

Most of the innovating firms are large and medium-sized firms which have cash on hand to finance new production processes or development of new product. Quite often they have foreign affiliates. They can also afford to hire or acquire foreign license. Large and established firms have the time to experiment with and develop a new idea (since they have been in existence for long in most cases). They are also likely to be the main players in export sector, and because export markets are highly competitive, they provide the incentives for productivity improvements. The importance of in-house innovation across sectors (Table A4) is driven by the need to preserve business confidentiality.

The importance of internally generated process innovation is driven by the desire by firms to keep information about their production process away from their competitors. This tendency is greater among industry-firms than services-firms. Generally, firms in services sector tend to care more about the product itself than the process of making it.

Table A5 shows the share of total turnover (sales) due to old and new products (firms' sales are important in this study because of its connection with innovation, wages and employment growth.). New products are distinguished by degree of novelty: between products new to firm and to main market. In a way, the share of innovative sales amounts to weighing each innovation by it degree of success in total turnover. As Table A5 shows, the contribution of product innovation to firm turnover is still small—at 21.7 percent for firms in the sample; compared with 78.3 percent of the turnover generated from old product. The high level of sales generated from old products suggests that new or significantly improved products are introduced without causing displacement of the old products, which continue to sell alongside new products (contributing to firm employment).

4.2 OLS estimation results

4.2.1 Innovation and employment growth

Table 3 presents the estimation results. The coefficient for process innovation is negative and statistically significant across enterprise groups, with exception of industry sector and for large enterprises. This shows that introduction of a new process leads to a decrease in employment for services and in small and medium size enterprises. The results show no evidence for a displacement effect of process innovation for firms in the industry sector and large enterprises. This is due to a larger pass-through of productivity growth in lower prices imperfectly picked up by -industry price indices. These results may require further investigation, by extending the analysis to different time periods.

The constant α_0 shows a positive average productivity growth for industry and services, and size samples, and this growth might have happened because of process innovation.

Table 3. OLS estimation for employment, by sector and size of enterprises

	All firms	Industry	Services	Very small	Small	Medium	Large
Constant	0.04**	0.05**	0.09	-0.15**	-0.04**	-0.03	-0.03***
	(0.02)	(0.17)	(0.03)	(0.08)	(0.11)	(0.01)	(0.005)
Process innovation	-0.13***	0.06***	-0.05**	-0.05***	-0.02*	- 0.01**	0.01***
only (d)	(0.04)	(0.02)	(0.06)	(0.03)	(0.07)	(0.008)	(0.002)
Sales growth due to	0.47***	0.57***	0.51**	0.56***	0.52***	0.45***	0.41***
new products (g_2)	(0.15)	(0.06)	(0.05)	(0.13)	(0.08)	(0.06)	(0.09)
No of firms	705	196	509				

Note: OLS estimates.Dependent variable is net labor growth minus growth in sales of old product: $l-(g_1-\pi)$

Standard errors in parentheses. Coefficients and standard errors robust to heteroskedasticity. And 1, 5, and 10 percent levels of significance are denoted by ***, ** and *, respectively. All regressions include industry and size dummies, restricted to add up to zero in order to preserve the interpretation of the constant.

The coefficient representing the elasticity of sales attributed to product innovation on employment growth is below unity in all OLS specifications, but statistically significant and positive in all cases, and 0.4 on average for the whole sample (Table 3). The fact that the coefficient is significantly less than one for all OLS specifications (both industry and services, and size samples) would suggest that new products are produced more efficiently than old products. The results seem robust since we controlled for the endogeneity of the sales growth (due to unobserved price changes or correlation with the non-technological productivity shocks that might produce a downward bias in this coefficient, overstating the productivity gains, from the production of new products. While the links with sales and wages have the expected positive signs (and statistically significant), the job creating impact of innovation proves robust after accounting for time, industry, firm size and geographical fixed effects. This suggests that innovation that develops from within the firm and involving larger firms has more impact on job-creation than that is developed from outside or within smaller firms.

4.2.2 A within-firm and a between-firm effect

Table 4 presents the results of estimating the basic specification of our extended model through introducing dummy variables that account for the *within-firm* and *reallocation* effects of innovation, and the influence of firm-size. As observed in the OLS estimates in Table 4, the elasticity of sales attributed to product innovation on employment growth is statistically significant and positive in all specifications, and is three times higher (0.630) for samples with innovation developed by the enterprises than samples with innovation developed by other enterprises or institutions (0.274).

Table 4. OLS estimation, accounting for source of innovation and firm size

	Innovation developed by the enterprise[1]	Innovation developed by other enterprise or institution
Process innovation only (*d*)	-0.0037**	-0.0083***
	(0.001)	(0.056)
Sales growth due to new products (g_2)		
Total sample	0.630***	0.274**
	(0.048)	(0.052)
Size < 50 employees in 2011 (small)	0.140***	0.031***
	(0.13)	(0.071)
Size 50 to 249 employees (medium)	0.571***	0.334**
	(0.03)	(0.055)
Size 250 employees and above (large)	0.678***	0.202 **
	(0.06)	(0.05)
Constant	-0.016**	-0.034
	(0.02)	(0.07)

Note: Dependent variable is net labor growth minus growth in sales of old product: $l-(g_1-\pi)$

1, 5, and 10 percent levels of significance are denoted by ***, ** and *, respectively. All regressions include industry, size and source dummies, constrained to sum to zero in order to preserve the interpretation of the constant. The key explanatory variables are the process innovation only dummy d and sales growth due to new products g_2 variables.

This coefficient of sales attributed to product innovation is also larger for large firms than small firms—i.e. the within-firm effect varies across the OLS specifications, and is larger for large firms than for small enterprises. This implies positive and higher employment elasticity of sales (attributed to new product) in cases where innovations are developed by the enterprises and especially if it is a large firm. Taken together, these results suggest that reallocation effect explains only around one-third of employment growth; most employment growth is attributed to within-firm innovation and improvement in productivity among established user (or large) firms.

4.2.3 Employment growth by start-ups and established enterprises

Table 5 compares the employment effects of product innovation between newly established firm (i.e. enterprises established during 2011–2014) and those established before 2011 (‘well established’). The elasticity of sales attributed to product innovation on employment growth is statistically significant and positive in all OLS specifications. However, the elasticity is on average higher for the pooled sample and for ‘well’ established firms (0.493) than for start-ups (0.227).

Disparities also emerge across size samples for both newly established and old enterprises: large firms dominate employment effects arising from product innovation. Interestingly, the constant α_0 of the OLS regression is lower for established firms than for newly established ones, which suggests lower productivity growth attributed to process innovation for established enterprise samples, thus potentially lower labour displacement for well established enterprises. This is likely due to net compensation effect from increased demand for firm’s established brand, expansion into new markets (e.g. regional markets) and fall in product prices.

Table 5. OLS estimation, involving start-ups (newly established) innovating firms

	Newly established enterprise[1]	Enterprise in operation before 2011
Process innovation only (*d*)	-0.158** (0.066)	-0.0097*** (0.008)
Sales growth due to new products (g_2):		
Total sample	0.227** (0.459)	0.493** (0.054)
Small size enterprise	0.022* (0.133)	0.019*** (0.041)
Medium size enterprise	0.091* (0.655)	0.334** (0.055)
Large size enterprise	0.308**(0.047)	0.432 ***(0.052)
Constant	-0.016*** (0.029)	-0.043*** (0.119)

Note: [1]Newly established enterprises (start-ups) sample include enterprises established during 2011– 2014.
Dependent variable is net labor growth minus growth in sales of old product: $l-(g_1-\pi)$
Standard errors in parentheses. Coefficients and standard errors robust to heteroskedasticity.
***, ** and * stand for 1, 5, and 10 percent levels of significance, respectively.

4.3 Diagnostic tests

The natural way of ending the discussion on the OLS results is to provides some 'robustness' checks. Table 6 reports test results, with the introduction, in turn, of different groups of dummies which account for sectors, and firm size. The reliability of the model is confirmed by the coefficient of lagged employment, assuming a value between those observed in the estimate in OLS and the within-group (which is the case in Table 5).[10]The two tests of the validity of the estimator AR(1) and AR(2) indicate both the absence of serial correlation. AR(1) is significantly negative, while AR(2) is not significant. The Sargan test confirm the validity of the instruments (the Sargan test does not reject the null hypothesis of joint validity of the instruments).

Table 6. Robustness checks dependent variable: employment

	Coefficient	within-group	OLS
Employment (-1)	0.557***	0.371***	0.78***
	(0.015)	(0.016)	(0.004)
Constant	0.170		0.11**
	(0.139)		
Sector dummies (2 sectors)	Yes	Yes	Yes
Size class dummies (3 classes)	Yes	Yes	
AR (1)	-5.674***		
AR (2)	0.335		
Sargan test /1	56.092		
Observations	705	705	705

Notes: Firm size: Small (20–49 employees), medium (50–249), large (250+)
Robust standard errors , in parentheses and 1, 5, and 10 percent levels of significance are denoted by ***, ** and *, respectively.
AR(1) and AR(2) are tests - with distribution N(0,1) - on the serial correlation of residuals.

1/ The Sargan-test has a χ^2 distribution under the null hypothesis of validity of the instruments.

5 Conclusions and implications for policy

This paper provides evidence on the effects of innovation on employment growth, with the goal of contributing to our understanding the contribution of different innovation strategies in fostering employment growth in Uganda. We disentangle the effects of innovation on employment growth due to process innovations and to the growth of sales separately arising from innovative and unchanged products using a dataset of 705 Ugandan firms observed over a four year period (2011-2014).

Three major conclusions emerge from the findings. Product innovation leads to employment growth at firm level, while process innovation has no discernable impact on employment. Although there is evidence to suggest displacement of labour in some cases where firms only introduce new process, this effect is compensated by price effects that

[10] See Arellano and Bond (1991)

translate into increased demand for firm product and by growth in employment from new products, which for most firms are introduced simultaneously with new process innovation. Secondly, source of innovation as well as firm characteristics particularly, size of innovating firms or end users of innovation and sector matter for job growth. Innovation that develops from within the firm itself (user) and involving larger firms has greater impact on employment than that developed from outside or coming from within smaller firms. This is evident from the share of employment growth in which reallocation effect explains only around one-third of employment growth; most employment growth comes from within-firm innovation and improvement in productivity among established user firms. It is also supported by evidence linking employment with sales with wages.

In addition, the coefficient linking sales and employment proves robust after accounting for time, industry firm's size and fixed effect, suggesting that firm size and age (how established the firm is) matter. Thirdly, sector of innovative firm matter for employment growth and evidence based on discrete-time duration model suggests that innovation is important for firm survival.

These conclusions have important implications for policymakers and stakeholders in innovation ecosystem. Supporting policies need to be correctly tailored since the impacts depend on the innovation strategy (type) and characteristics and sector of the innovative firms (small, large, industry, etc). Policies to spur investment, particularly in innovative sectors and firms with high growth potential would have long lasting effects on job creation.

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Notes

[i] Following Harrison et al (2008), $Y_{1t} = \theta_{1t} F\left(K_{1t}, L_{1t}, M_{1t}\right)^{e\eta + \omega_{1t}}$ is firm output of product 1 (i.e. 1 represents old product; otherwise 2 if new product) in year t. θ is Hicks-neutral technology parameter while K, L and M represent capital, labour and intermediate consumption. η is an unobserved firm–idiosyncratic "fixed" effect which makes the firm more or less productive relative to average firm applying the same technology *(θ)*, and ω stands for product and time–specific productivity shocks with $E(\omega_{1t}) = 0$.

In practice, in our data, years t = 1 and t = 2 are 2011 and 2014, and firms may have already started introducing new products in 2011. This does not affect the rationale of our model, but must be kept in mind in the precise interpretation of our estimates.

Note that the variable y_1 has a coefficient equal to 1 and can thus be subtracted from ℓ on the left hand side of the equation for estimation.

We are interested in estimating the change in efficiency of producing old products $\left(\theta_{12} / \theta_{11}\right)$ and the relative efficiency $\left(\theta_{22} / \theta_{11}\right)$ of producing old and new products.

[ii] For full documentation, see UNCST (2016). National Innovation Survey 2011 – 2014: 2016 Report, Kampala: Uganda National Council for Science and Technology.

[iii] Sector breakdown is usually industry and other services. Industry includes mining and quarrying, manufacturing, construction, electricity, gas, steam and air conditioning supply, and services comprise wholesale and retail trade, transport and storage, hotels, information and communication, financial and insurance services, real estate, professional and technical services. Geographic regions within a country are selected based on which cities/regions collectively contain the majority of economic activity. For more details see UNCST (2016).

[iv]In addition, the survey provides information on firms' R&D and other innovation expenditures, as well as objectives of innovation, and cooperation and patenting activities, but also the origin of innovation (whether it originated from within the firm itself, or developed by another company), which forms a key contribution of our paper.

Unfortunately, there are not available information sources for firm wages and firm characteristics in other productive sectors, such as services and there are no means to verify the identified product and process innovation and the wrongly attributed cases, or the cases that do not constitute an innovation at all.

Appendix

Table A1. Share of enterprises that had product and process innovation, Uganda, 2011–2014 (%)

Indicator	Firm size (% of firms)			Sectors (% of firms)		
	Small	medium	Large	All sectors	Industry	Services
Product only innovators	10.3	12.0	6.4	11.2	7.2	12.8
Product & process innovators	51.5	55.1	87.2	48.2	59.2	44.1
New goods1/	37.3	42.1	53.0	38.8	54.0	33.0
New services 1/	50.3	57.0	83.7	52.3	50.6	52.9
Process only innovators 2/	11.4	20.1	--	12.7	13.7	12.4
Innovating enterprises (Total)	74.2	88.6	100.0	77.0	85.7	73.7

Source: Author's calculation based on UNCST – National Innovation Survey 2011 – 2014

Notes: Firm size: small (20–49 employees), medium (50–249), large (250+)

1/ Firms with new or significantly improved goods or services.

2/ Total process innovation, including new or significantly improved methods of manufacturing or producing goods and services, logistics, delivery or distribution method, and/or supporting activities for production processes. Firms could engage in more than one type of process innovation.

Table A2. Novelty of innovation by sector and legal ownership, Uganda

Indicator	Percentage of firms		Percentage of firms	
	Industry	Services	Domestic firms	Foreign firm
Product innovators	7.2	12.8	11.3	10.8
Product new to firm 1/	66.0	69.6	68.1	71.1
Product new to market 2/	47.6	46.5	43.3	70.5
Process innovators	13.7	12.4	13.3	7.7
Spend on technology (technological innovation)	62.2	61.9	62.4	58.8
Received financial support from government 1/	9.7	16.1	14.2	--

Source: Author's calculation based on UNCST – National Innovation Survey 2011 – 2014

Notes: Firm size: very small (1 – 19 employees), small (20–49), medium (50–249), large (250+) Technological innovation expenditure includes in-house and external R&D expenditure, acquisition of machinery, equipment and software, and other external knowledge.

1/ A new to firm product is introduction of a significantly improved good or service to the firm that was already available from competitors in the industry.

2/ Firms whose new product/service is also new to the main market. A new to market innovation is an innovation activity, which saw the introduction of a new good or service by the firm onto its operating market before other competitors.

Table A3. Source of product innovation by sector and firm-size

Innovation developed by:	Percentage of firms			Percentage of firms			
	Total	Industry	Services	Very Small	Small	Medium	Large
Own enterprise	59.8	55.4	61.6	58.7	59.8	61.4	68.4
Own enterprise group	26.3	20.3	28.9	23.3	29.4	27.0	45.7
Other firm and adapted in enterprise environment	27.7	24.1	29.2	26.9	27.0	28.9	37.9
Enterprise in collaboration with other enterprise or institution(s)	18.1	15.6	19.2	17.0	21.7	17.7	14.1
Other enterprise(s)/institutions	15.3	16.0	15.0	14.9	14.3	15.9	25.3

Source: Author's calculation based on UNCST – National Innovation Survey 2011 – 2014

Table A4. Source of process innovation by sector of Ugandan firms

Innovation developed by:	Percentage of firms		
	Total*	Industry	Services
The enterprise itself	45.1	55.8	40.4
Own enterprise group	11.1	10.8	11.3
Other firm, and adapted by the enterprise	13.1	12.6	13.3
The enterprise in collaboration with other enterprise or institution(s)	3.7	2.1	4.5
Other enterprise(s)/institutions	4.7	3.8	5.2

Note: * 1.3 percent of firm did not respond to the question

Source: Author's calculation based on UNCST – National Innovation Survey 2011 – 2014

Table A5. Proportion of total turnover attributed to product innovation (%), 2014

Product innovation	Change in turnover due to new /old product (%)			Change in turnover due to new/old product (%)			
	Total	Industry	Services	Very Small	Small	Medium	Large
New product also new to the market	7.8	1.3	9.1	5.2	10.9	7.5	16.5
New product new to the firm	13.9	5.4	15.6	5.9	18.0	28.5	9.9
Product unchanged or marginally modified (old product)	78.3	93.4	75.1	88.9	70.9	64.2	73.6
Total		100.0	100.0	50.0	7.3	29.1	13.3

Source: Author's calculation based on UNCST – National Innovation Survey 2011 – 2014

Table **Error! Main Document Only.**. Product and process innovators, growth of employment and sales, 2011 - 2014[1]

	Sector sample		Size sample		
	Industry	Services	Small	Medium	Large
Number of firms	196	509			
Non-innovators (%)	14.3	26.3	25.8	11.4	100.0
Process only (%)	13.7	12.4	10.2	20.1	-
Product innovators (%)	7.2	12.8	7.8	12.0	6.4
o/w product & process innovators	59.2	44.1	51.5	55.1	87.2
Sales growth (%) 2/					
All firms	*18 .5*	*18 .4*		*22.7*	*32.3*
Non-innovators	14.4	16.3		21.2	30.9
Process only	11.2	16.1		24.1	30.9
Product innovators	25.6	23.1		28.2	37.8
o/w old products	−15.9	−3.2		−14.1	−8.9
New products	41.5	26.3		42.2	46.7

Source: Author's calculation based on UNCST – National Innovation Survey 2011 – 2014

1Rates of growth for the whole period 2011–2014.

2/ Employment and sales growth are measured over three-year period, 2011 – 2014. Employment growth is measured as change in full-time employees. Sales growth is measured as change in local nominal currency. Sales growth for each type of firm is the average of variable g and averages for old and new products are the averages of variables g1 and g2, respectively.