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The Effect of Technological Innovation on the Quantity and Quality of Employment in Ghana

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Innovation is widely considered to be a primary source of economic growth and policies to encourage firm level innovation are topical on the agenda in most countries. Similarly, firm-level relationship between innovation and employment is an important topic of research because the effects of innovation on employment at the firm level have important ramifications on how different agents resist or encourage innovation. Although the impact of innovation on employment is of particular interest, the relationship between innovation and employment is not clear cut. Individual innovations may destroy jobs but innovation can also stimulate demand. The paper consequently investigates the effect of innovation (process and product innovations) introduced at the firm level on employment, specifically, the quantity and quality of employment. To this effect, the study adopts both linear and non-linear models to examine the relationship between technological innovation and employment in both manufacturing and service firms in Ghana by using firm-level survey on a number of small, medium and large firms. Our results indicate that product innovation is positively associated with employment in Ghana. In terms of innovation and employment quality we find that skill biased technological change that predicts capital skill complementarity does not wholly translate in the Ghanaian context.

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Abstract

Innovation is widely considered to be a primary source of economic growth and policies to encourage firm level innovation are topical on the agenda in most countries. Similarly, firm-level relationship between innovation and employment is an important topic of research because the effects of innovation on employment at the firm level have important ramifications on how different agents resist or encourage innovation. Although the impact of innovation on employment is of particular interest, the relationship between innovation and employment is not clear cut. Individual innovations may destroy jobs but innovation can also stimulate demand. The paper consequently investigates the effect of innovation (process and product innovations) introduced at the firm level on employment, specifically, the quantity and quality of employment. To this effect, the study adopts both linear and non-linear models to examine the relationship between technological innovation and employment in both manufacturing and service firms in Ghana by using firm-level survey on a number of small, medium and large firms. Our results indicate that product innovation is positively associated with employment in Ghana. In terms of innovation and employment quality we find that skill biased technological change that predicts capital skill complementarity does not wholly translate in the Ghanaian context.

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Technological Innovation and Employment in Ghana

1.0 Introduction

Technological innovation is widely considered as a primary source of economic growth and policies to encourage firm level innovation are topical on the agenda in most countries. The firm-level relationship between innovation and employment is an important topic of research because the effects of innovation on employment at the firm level influence the extent to which different agents resist or encourage innovation.

Innovations typically introduced at the firm level have immediate effects on employment. There is however pessimism in public discourse due to the fear that innovation would destroy jobs because of the indirect nature of the effect of innovation on employment. Several compensation mechanisms however exist that have been shown to counterbalance the initial effect of innovation and render the final effect undetermined (see Vivarelli, 1995, ch. 2 and 3; Petit, 1995; Pianta, 2005; and Piva and Vivarelli, 2005). Thus innovation can create or destroy employment depending on market structure, institutional setting and the type of innovation a firm introduces. The relationship between innovation and employment is however not clear cut, yet evidence suggests that on average innovating firms have a high probability of survival and grow more than firms that do not innovate.

Analysis of the effects of innovation on employment is generally carried out by distinguishing between process and product innovations. Schumpeter (1934) defines product innovation as 'the introduction of a new good or a new quality of a good' and process innovation as 'the introduction of a new method of production or a new way of handling a commodity commercially'. This distinction is important because of the different impact each type of innovation has on employment. Pianta (2003) notes, the development (or the adoption) of process innovations, introduced mainly through new investment, leads to greater efficiency of production, with savings in labour and/or capital, and with a potential for price reductions. This usually results in higher productivity and loss of employment but given that process innovations increase product quality or reduce prices, a rise in demand (when elasticity is high) may result in more jobs. Product innovations on the other hand usually increase the variety and quality of goods with new market opportunities that leads to greater production and employment.

A number of previous studies mainly on developed countries have provided evidence on the relationship between innovation and employment at the firm level. Such studies differ widely by methodology and data used with the majority using a survey of firms which asks specific questions on the type of innovation undertaken. In general, product innovation is observed to be associated with employment growth even though there is no clear balance between displacement (job losses) and compensation (job gains) effects (see, Entorf and Pohlmeier, 1991; König, Licht and Buscher, 1995; Van Reenen, 1997; Greenan and Guellec, 2000; Smolny, 1998 and 2002; Garcia, Jaumandreu and Rodriguez, 2002; Peters, 2004). R&D is mostly found to positively affect employment growth (see, Blechinger et al. 1998, and Regev, 1998). Effects of process innovation on the other hand are not clear cut, the impact depends on the specification used (see, Ross and Zimmerman, 1993; Doms, Dunne and Roberts, 1995 or Blanchflower and Burguess, 1999). Evidence of the overall employment impact of innovation at the firm level tends to be positive; firms which innovate in products, but also in processes, grow faster and are more likely to expand their employment than non-innovative ones, regardless of industry, size or other characteristics (Pianta, 2003)[1].

In terms of innovation and quality of employment, technology-skill complementarities which have been the focus of most empirical work predict that technological upgrading will lead to a higher demand for skilled relative to unskilled labour. Hamermesh (1993) notes, 'we are fairly sure that technological change is ……complementary with skill' (p. 135). Against this background, the main questions addressed in this study are as follows: Is there a positive or negative association between innovation and employment in Ghana at the firm level? If there is, does the type of innovation matter in terms of its impact on the quantity of employment defined in terms of the number of existing jobs and the quality of employment (defined in terms of proportion of skilled labour out of the workforce and job attributes).

This study is important because in recent times, attention has been on the impact of innovation on quality of jobs with several studies on the skill biased nature of technological innovation, which mostly focus on developed countries. Such studies ignore the net employment gains from innovation but focus on the types of jobs created out of innovation (i.e. skilled/white collar

[1] Reenen (1997) finds overall positive effects of indicators of innovation on the quantity of employment after controlling for firm level characteristics in studies of UK firms.

verses unskilled/blue collar jobs). Thus the relevance of examining the effect of innovation on the quantity and quality of employment in a developing country context cannot be overemphasized. Subsequently, the answer from a series of statistical analysis indicates a positive association between innovation and employment, particularly through product innovation. Results on the impact of innovation on quality of employment however indicate that skill biased technological change that predicts capital skill complementarity does not wholly translate in the Ghanaian context in that, although product innovation increase the employment probability of highly skilled workers, process innovation rather increases the employment probability of low skilled workers. The main contribution of this study is the use of firm level data of actual innovation activity to investigate the effect of innovation on the quantity and quality of employment. We are not aware of the existence of any such study on Ghana.

2.0 **Policies on Technological Upgrading in Ghana**

Ghana, like many other African countries lags behind most non-African countries in terms of technology. This gap keeps widening because while Ghana maintains its traditional exports, most other non-African countries have moved away from concentrating mainly on traditional products and are diversifying. One of the reasons for the concentration on traditional exports has been attributed to poor technological know-how and the inability to constantly upgrade production process and organizational structure. This has made the country less competitive in the global world. Most countries that have become competitive globally have invested in technological upgrade and modernization. A clear example is the East Asian experience and indeed, lessons from the East Asian experience attest to the fact that good technological policies can help businesses to develop and increase their competitiveness.

Until recently, Ghana did not have a clear policy on innovation although the country has been nursing the dream of rapid social and economic development that depends on the knowledge and tools derived from science and technology. The dream began with the country's independence, where efforts were made to develop a science and technology capacity, but very little was seen in terms of the linkage between this capacity and socio-economic development. After the overthrow of the first nationalist government, the dream of rapid socio-economic development based on science and technology was halted. Although, subsequent governments attempted to revive the idea, there was little to no success because of changes in the sector ministry responsible to oversee the science and technology policy agenda of the country.

In the second half of 2010, the country developed its first national science, technology and innovation policy to boost its ambition of becoming a middle-income country. Amongst several other objectives, this policy was designed to aid the achievement of national objectives such as poverty reduction, competitiveness of enterprises, sustainable environmental management and industrial growth. Specifically concerning innovations, the policy seeks to create conditions for the improvement of scientific and technological infrastructure for research and development and innovation. The ministry that is now responsible for the national science, technology and innovation policy is the Ministry of Environment, Science and Technology (S&T).

The policy document contains several sector-specific objectives. Particularly concerning the country's industrial development, there are several initiatives to boost the development of local firms. This is against the background that such local firms are largely informal and characterised by obsolete and indigenous technologies. It is believed that with improvements in science, technology and innovation, the industrial sector could increase production and processing to increase wealth and create jobs. The policy also sought to revisit the non-resource based industries like the assembly of radio, television and motor vehicles, which dominated the country's earlier periods of industrialization. Specifically, the programmes and activities to be pursued in the industrial sector as part of the country's national science, technology and innovation policy include the:

- Strengthening of systems and mechanisms for the acquisition, assessment, adaptation, adoption and application of essential technologies for industrial activities;
- Encouragement of R&D activities that develop equipment and machinery for industries;
- Encouragement of quality assurance in manufacturing;
- Promotion of S&T activities that would accelerate technology transfer and innovations;
- Creation of incentives to promote investment and support R&D by the private sector;
- Facilitation of capacity in engineering design and manufacturing technology to enhance national development;
- Enhancement of industrial technology development infrastructure;

- Promotion and facilitation of recyclable material technologies and application to minimize industrial waste in the environment;
- Promotion of scientific knowledge acquisition and development of technologies in the new and emerging sciences of biotechnology, materials science, micro-electronic and laser technology;
- Creation of national capacity to exploit opportunities for innovation addressing climate change;
- Establishment of industrial parks, innovation centres and business incubators to foster linkages between the knowledge centres (i.e. research institutes and universities) and productive enterprises;
- Institutionalization of regular interaction between research institutions/universities and the private sector;
- Promote industrial attachments for S&T students.

Although there were no explicit declarations on process and product innovations, the only specific reference to these concepts was with the government's quest to encourage the private sector to support the funding for R&D activities. Categorically, it was suggested that these investments will cater for the needs of the micro, small and medium enterprises (MSMEs), which can be nurtured to become the cutting edge for the commercialization of novel products or processes.

As of now, no substantive evaluation exists to analyse the extent to which these policy objectives have been achieved or influenced production and processing opportunities of local firms in the country. Notable successes have been the initiatives of the firms themselves, particularly the few with foreign partners aided by some government policies. For instance, the government has been influential in providing infrastructure in the telecommunication and agriculture industries (National Annual Progress Report, 2012). The rate of expansion in the ICT sector grew substantially from 17% in 2011 to about 23.4% in 2012, while the rate of telephone penetration increased by about 16% between 2011 and 2012. The capacity for broadband more than tripled between 2011 and 2012. Three packaging houses in various parts of the country and a Perishable Cargo Centre at the country's main international airport were also commissioned. These significant improvements in infrastructural development presuppose that firms and industries which are part of the Ghanaian communities will see these benefits trickling down to them. Interestingly, the proportion of Ghanaians with access to internet declined by about 7% between 2011 and 2012. Direct efforts in improving the quality of fruits and vegetables to be exported were also made through infrastructural development.

Besides the specific help offered by the government to pursue a development agenda based on science and technology, some other parastatals have been equally helpful in providing direct assistance to some specific firms. For instance, the Ghana Regional Appropriate Technology Industrial Service (GRATIS) Foundation came up with a model and tested some equipment for cocoa and industries that process food. To promote easy access to these and allow for proper management, new roads to these sites were constructed and Management Boards were established to help manage these three packs.

Ghana's educational system generally does not produce enough graduates for industrial development. In addition, there is usually a mismatch between what the industry needs and the kind of graduates that are produced by the countries' institutions in the area of skills development. This means that the country will need to upgrade the skills of its manpower and ensure that there is a match between the skills of manpower and what the country needs for its developmental process. To ensure this happens, GRATIS Foundation in 2012 sought accreditation from the National Accreditation Board to set up a University College of Applied Technology to offer a Higher National Diploma (HND), a Bachelor of Science and a Masters Program in Engineering, Welding, Material Science, Pneumatics etc. The government also intends to provide incentives for science and technology teachers, increase funds for science and technology, provide up-to-date tools and equipment for teaching science and provide attractive incentives for students who want to study science. About 321 people, out of which women were the dominant group, were given special training in how to use new equipment provided by GRATIS. Further, 487 Technical Apprentices were trained in Machining in 2012. In particular, these apprentices were given training in short courses in Metal Machining, Welding and Fabrication and Foundry Works. GRATIS Foundation did not only provide training for skills development but also tried to gather funds from the Council for Technical and Vocational

Education and Training (COTVET), to furnish the Ghana Industrial Skills Development Centre to upgrade the youth in technical apprenticeship.

Another policy identified in the GSGDA (2010) to help MSMEs is the provision of support to large businesses to subcontract processes and goods from MSMEs. This is because they recognize large firms, both domestic and foreign alike, are a good source of technology opportunities for these MSMEs. Second, recognizing the important role that MSMEs play in the economy, the need to bring into line existing medium scale manufacturers behind the needs of MSMEs is of prime importance. Under the GSGDA (2010), government has promised to promote the necessary technology to make the sector grow.

In addition, the GSGDA (2010) aims at pursuing technology transfer. Indeed, one main benefit that FDI brings is the promotion of technological transfer. The GSGDA requires effective monitoring of FDI to ensure technology is transferred. This is expected to be done by agencies like the Ghana Investment Promotion Authority (GIPA). Under the GSGDA (2010), efforts will be made to ensure that FDIs do comply with technology transfer agreements to impact positively on the progress and employment of trained Ghanaians.

According to Bartel and Oberg (2006), the main factors influencing technological upgrade are the regulations surrounding competition and trade policies, skills, physical infrastructure, financing and technology and supply clusters. Competition can be enhanced through investment in Research and Development. Overall, in 2012, whilst the share of Research and Development (R&D) expenditure as a percentage of GDP lingered at 0.5%, the number of firms and businesses supported to take on R&D in 2012 increased by 31.3% from 2010 (National Annual Progress Report, 2012). Further, more publications on research findings were seen in 2012 compared to 2010 with the number of research findings adopted by industry increasing by 16.7% during the same period (National Annual Progress Report, 2012). Also, GSGDA (2010) seeks the new Ghana Investment Promotion GIPC law to resolve the anomaly in the Ghana Investment Act, 1994, which favours only foreign firms and precludes local SMEs from getting incentives, all in the bid to foster competition among firms within the economy.

3.0 Literature review

Technological innovations typically introduced at the firm level have an immediate effect on employment. Pessimism however exist in public discourse due to the fear that innovation would destroy jobs mainly because of the indirect nature of the effect of innovation on employment. Nonetheless, several compensation mechanisms exist that can counterbalance the initial effect of innovation and render the final effect undetermined (see Vivarelli, 1995, ch. 2 and 3; Petit, 1995; Pianta, 2005; and Piva and Vivarelli, 2005). In sum, innovation can create or destroy employment depending on market structure, institutional setting and the type of innovation a firm introduces.

The analysis of the effects of innovation on employment is generally carried out by distinguishing between process and product innovation. Schumpeter (1934) defines product innovation as ‘the introduction of a new good or a new quality of a good’ and process innovation as ‘the introduction of a new method of production or a new way of handling a commodity commercially’. Theoretically, while both innovations can be interpreted as the random result of a firm’s investment in research and development, product innovations are mostly undertaken to reinforce demand thereby noted for their labour-friendly impacts whereas process innovations are directed at the production process thereby associated with labour-saving impacts (see Vivareli, 2012, Dachs and Peters, 2014).

This distinction is important due to the different impact each type of innovation has on employment. According to Pianta (2003), the development (or the adoption) of process innovations, introduced mainly through new investment, leads to greater efficiency of production, with savings in labour and/or capital, and with a potential for price reductions. This usually leads to higher productivity and loss of employment, however, to the extent that process innovations increase product quality or reduce prices, a rise in demand (when elasticity is high) may result in more jobs. Product innovations on the other hand usually increase the variety and quality of goods with new market opportunities that leads to greater production and employment.

Although process and product innovation are closely interlinked and mostly coexist in many innovative firms, they are different and result from separate innovative processes that are undertaken with different objectives. Pianta (2001) focused on the differences and identified a distinction between two strategies of technological competitiveness and cost or price competitiveness. Technological competitiveness is associated with a dominance of product innovation and requires substantial internal innovative efforts including research, development, design and new investment with the objective of increasing market share and opening up new markets. A strategy of cost competitiveness on the other hand as rooted in process innovation, focuses on achieving efficiency through diverse technological efforts (engineering, design, etc) with the objective of reducing labour cost and increasing production flexibility. The two strategies are noted to have contrasting effects on employment.

In practice however, the distinction between these two types of innovation are not clear-cut, since process innovation often accompanies product innovation and more importantly, there are likely reverse labour employment effects. Table 1, adopted from Dachs and Peters (2014), summarizes some of the potential labour employment effects of both innovation types.

Table 1: Firm Level Employment Effects

	Displacement Effects (Employment-reducing Effects)	Compensation Effects (Employment-creating Effects)
Product Innovation	Productivity effect: New products require less (or more) labour input Indirect demand effect: Decrease in demand of existing substitutes	Direct demand effect: New products increase overall demand Indirect demand effect: Increase in demand of existing complementary products
Process Innovation	Productivity effect: Less labour input for a given output	Price effect: Cost reduction passed on to price expands

As indicated in table1, both process and product innovations are associated with labour savings (displacement effects) and labour-stimulating effects (compensation effects). For instance, productivity increases that arise out of process innovations that involves the purchase of a capital-intensive equipment will require less labour. This innovation immediately calls for the displacement of labour and reduces unit cost. If the reduction in unit cost is passed on as a reduction in price, the demand for the product could increase thereby increasing production and employments all over again. Therefore, the total employment effect of the process innovation depends on several factors such as the direct labour displacement effect of the new equipment, the competitive conditions the firm is facing, customer's response to the product or its substitutes, the delay with which rivals react to changes and the rate of new firm entry and exit. Alternatively, when a new product is successfully introduced into a market, it creates new demand for the innovating firm in the form of an overall market expansion, thereby increasing employment. However, if the new product replaces an old one, labour demand for the old product will decrease and the overall employment effect can be ambiguous.

The theoretically antecedents to these counteracting explanations originated from Marx's compensation theory (See Marx, 1961). The theory in summary attempted to dispel concerns about the direct harmful effects of technological change by pointing to some market mechanisms that are able to counterbalance the direct impact of process innovation and the job creating effects of product innovations. The explanations mostly evolve around six different market mechanisms that are triggered by technical change. These mechanisms work through the following: additional employment in the capital goods sector, decreases in prices, new investments, decreases in wages, increases in income (generated through increased productivity) and new products. Vivarelli (2014) provides intuitive explanations for each of the mechanisms.

Research indicates that technological diffusion occurs through different channels, for example, explicitly via licensing agreements or implicitly by trade through interaction of individuals from different countries with different technology. Technologies that are not commercially available are usually diffused via FDI. Technology from foreign firms can be transferred to domestic firms through a number of channels that include labour mobility (Glass and Saggi, 2002), demonstration effect (Wang and Blomstrom, 1992) and the influence on domestic firms through competition which can lead to reduced market share and employment. In situations where domestic firms supply inputs to foreign firms (backward linkages) or where foreign firms' supply inputs to domestic firms, spill-overs can be experienced. FDI therefore serves as one of the main channels through which technology and skills that are embodied in goods and services can be transferred to local firms which can in turn foster their growth.

FDI contributes to technological upgrading through direct movement of trained personnel, demonstration and competition effects out of which local firms are able to assimilate and improve their production technology and management. Advanced technology out of imported machinery and equipment in foreign-invested enterprises also contributes to improve the technology level of host firms (Fu and Gong, 2011). Other channels include improvement in innovative efficiency through superior innovative management practices by multinationals (Fu, 2008) and significant knowledge transfer within the supply chain through horizontal, backward, forward and vertical linkages. Technological upgrading could also emerge through exporting and importing activities of domestic firms. This occurs when importers improve their technology by incorporating into their production processes state-of-the-art imported capital goods or inputs, which may not be available domestically (Grossman and Helpman, 1991). Similarly, exporters can learn about new technologies or products through interaction with more knowledgeable foreign buyers or may be forced to improve their technology more frequently out of the exposure to fierce competition abroad (Almeida and Fernandes, 2008).

Although it may seem obvious that local firms benefit from foreign direct investment, some studies emphasise certain conditions need to be present for local firms to experience significant spill-overs[2]. The first is absorptive capacity of local firms and the second is the existence of adequate links between the activities of the foreign and local firms. Cohen and Levinthal (1989) define absorptive capacity as the ability of firms to identify, assimilate and make use of knowledge from the environment. Absorptive Capacity is usually measured by the gap between foreign and domestic technology, intensity of R&D by local firms or how much human capital local firms have. With regards to the first definition, studies find evidence of spill-overs when the gap is not very wide[3]; small firms or firms with a greater proportion of their workers being unskilled would not have the capacity to absorb the benefits FDI brings in. Wang and Blomstrom (1992) similarly emphasise the importance of local firms to have a desire to learn and also have absorptive capacity if the transfer is to be diffused faster. In addition, the extent to which technology can be diffused will depend on the sectors in which these foreign firms operate. This evidence suggests that the impact of spill-overs on growth of firms will occur if firms have a minimum threshold of skilled workers and technology.

Another strand of literature finds no evidence of technological spill-overs on domestic firms' growth. For example, in firm and industry level study for manufacturing firms in Indonesia and Morroco, Blomstrom and Sjoholm (1999) and Haddad and Harrison (1993) both respectively find no evidence of technological spill-overs coming from FDI on growth. In a related study on

[2] See for instance Cohen and Levinthal, 1989; Girma, 2005
[3] See Kokko et.al. (1996)

manufacturing and non-manufacturing firms in Czech Republic, Djankov and Hoekman (1998) also find no evidence of technological spill-overs. Others suggest FDI can compete with domestic firms, capture their market share and adversely affect them with consequential effects on employment. This means that although FDI can benefit local firms in the form of technological spillovers, employee training etc., these benefits could be offset or sometimes outweighed by the negative market share competition. Aitken and Harrison (1999) confirm this in their influential study of Venezuelan manufacturing firms. They explain their results using a market-stealing hypothesis where while FDI may promote technological diffusion, they can gain market share at the expense of the local firms and force the domestic firms to produce smaller outputs at an increased cost. As a result, the overall benefit of FDI is reduced.

Also in the short term, FDIs can hinder local firms' technological improvement. For instance, Aitken and Harrison (1997, 1999) argue that in an imperfect market, firms have to incur substantial fixed costs. Nevertheless, being more efficient, foreign firms' marginal cost is likely to be lower compared to that of domestic firms. This enables them to dominate local firms in terms of market share. Furthermore, FDI can prevent local firms from accessing their technology if they seek formal protection of their intellectual property, domestic firms may as a result not benefit from their presence. Developments in most African economies present a less optimistic scenario on the effectiveness of activities of foreign investors and openness to influence firm technological upgrading. The premise for this view is because the necessary conditions required for the spill-over or externality effects of such international technology diffusion to be realised are either limited or their linkages are few. For example, there is limited labour mobility in Africa with foreign firms providing firm-specific training which limits the benefits of labour mobility for local firms. The manufacturing sector, which tends to provide the strongest linkages, is small and the local firms do not have the capabilities to extract or learn from their greater interaction with the global economy. This is worsened by the inability of increased inflow of international investments out of the numerous deregulation and privatization to increase such spill-overs since these new investments are still into extraction industries with little value additions rather than production that has more linkages (Morrissey, 2012).

In general, several empirical studies have attempted to establish the impact of innovation on employment mainly in developed countries. Given the type of innovation has ramifications on employment, such studies have tried to find the link between product and process innovations and employment. Existing studies have approached the concept of innovation from different perspectives, we focus on studies that analysed innovation at the firm level and defined innovation in terms of product and process innovations. Empirical research in this area include Entorf and Pohlmeier (1990), Smolny (1998), Greenan and Guellec (1997), Ross and Zimmerman (1993), Zimmerman (1991), Harrison et al (2008), Hall, Lotti and Mairesse (2008) and Lachenmaier and Rottmann (2011). In general, these studies confirm the positive employment impact of product innovation as stipulated in theory, but reached no conclusion on the employment effect of process innovation. Table 2, summarizes the main findings of these studies by indicating the main variables used to measure process and product innovation.

Table 2: The Effect of Innovation of Employment

Study	Data	Proxy for Technology	Results
Entorf and Pohlmeier (1990)	Cross-section of 2,276 West German Firms in 1984	Dummy for Process and Product Innovation	Positive employment impact of product innovation; no effect of process innovation
Smolny (1998)	Panel of 2,405 West German Manufacturing firms (1980 – 1992)	Dummy for Process and Product Innovation	Positive employment impact of product innovation; no effect of process innovations
Greenan and Guellec (1997)	Balanced panel of up to 5919 firms 1985-91 in France	Indicator of intensity of process and product innovations	Product innovations create more jobs at sector level; process innovations create more jobs at firm level (zero at sector level)
Ross and Zimmerman (1993)	5,011 German firms (manufacturing) from Munich IFO Institute in 1980	Dummy for Process Innovation	Negative effect of process innovations on employment
Zimmerman (1991)	3,374 German firms in 16 industries from IFO	Dummy for Process Innovation	Negative effect of process innovations
Harrison et al (2008)	Panel of 20,000 firms in France, Germany, Spain and UK	Dummy for Process and Product Innovation	Process innovation tends to displace employment, while product innovation is basically labor friendly
Hall, Lotti and Mairesse (2008)	A panel of Italian Manufacturing firms (1995-2003)	Dummy for Process and Product Innovation	Positive employment contribution of product innovation and no evidence

			of employment displacement due to process innovation
Lachenmaier and Rottmann (2011)	Panel of German Manufacturing Firms (1982 – 2002)	Dummy for Process and Product Innovation	A higher positive impact of process rather than product innovation

The conclusion that emanates from empirical studies outlined in table 2 is that product and process innovations follow different processes for which reason their determinants and impact on employment are different. Aside the quantitative impact of technology on the levels of employment, a stream of literature has shown that the relationship between technology and employment also has a qualitative aspect (Srour, Taymaz and Vivarelli, 2013).

The concept of skill biased technological change is mostly referred to by the literature on innovation and employment quality. The concept, developed by Griliches (1969) and Welch (1970), underpinned by the hypothesis of capital skill complementarity, suggests that employers' increased demand for skilled workers is driven by new technologies that are penetrating into modernized industries, and which only workers with a higher level of skill can operate. Various studies have attempted to verify this assertion because of the more recently surge in information technology and the spread in computer use especially at the firm level.

Overall, the results have remained largely empirical depending on the indicator for technology. For instance, Berman, Bound and Griliches (1994) provided evidence for the existence of strong correlations between within industry skill upgrading and increased investment in both computer technology and R&D in the U.S. manufacturing sector between 1979 and 1989. Katz and Krueger (1998) similarly showed the spread of computer technology in the US since 1970 could in fact explain as much as 30 to 50 percent of the increase in the growth rate of relative demand for skilled labour.

Machin and Van Reenen (1998) in a related study provided evidence of the skill biased technological change through a cross-country study on seven OECD countries and asserted a positive relation between R&D expenditure and relative demand for skilled workers. Lastly, Duguet and Greenan (1997) is one of the very few studies that makes a clear conclusion on the impact of technological innovations on firm skill structure. The study used five types of innovation (product improvement, new product, product imitation, process breakthrough and process improvement) on a panel of 4,954 French manufacturing firms (1986-1991) to show a skill bias in favour of conception labour and execution labour (blue-collar workers) as against capital.

In other work, Berndt, Morrison, and Rosenblum (1992) examine the impact of investments in high technology capital on the demand for skilled labour using the Bureau of Economic Analysis (BEA) data on industries. The study regressed the nonproduction share in total employment on a capital-intensity measure and a measure of the share of high tech capital in total capital. Their finding subsequently, point to both capital-skill complementarity and complementarity of high tech capital and skills. Overall, empirical evidence point to the complementarity between educated or skilled labour and technological change (Welch 1970; Bartel and Lichtenberg 1987; Mincer 1989; Lillard and Tan 1986; Gill 1990).

The literature above leads to the formulation of the following hypotheses:

- **H1:** Product innovation is positively associated with quantity of employment.
- **H2:** Process innovation is negatively associated with quantity of employment.
- **H3:** Product innovation is positively associated with employment of highly skilled workers.
- **H4:** Process innovation is positively associated with employment of highly skilled workers.

4.0 Estimation strategy

The relationship between innovation (product and process) and employment is investigated by looking at the impact these have on quantity of employment which we define in terms of the number of existing jobs. The analysis begins with the specification of a labour demand function. The labour demand function of a firm is theoretically represented as dependent on technology T, product quality Q in addition to observable variables X and non-observable variables λ. (König et al. 1995, Lachenmaier/Rottmann 2007 and Zimmerman 2009 among others).

$$L_i = f(T_{i,}Q_{i,}X_{i,}\lambda_i) \quad (1)$$

Changes in product quality are viewed as product innovation and process innovation occurs when changes are made in the manufacturing process. Overall, reduction in labour demand is expected as a result of process innovation, yet cost reduction out of process innovation can translate into price reduction which is expected to increase demand for a firm's products. Increased production out of high demand results in increased employment, the net effect on employment as to whether the indirect effect based on turnover outweighs the direct negative effect of reduced demand for labour depends on the extent of price reduction and the price elasticity of demand. With regards to product innovation, expected effects on employment are based on the changes in demand emanating from new or improved products.

Empirical investigation of the impact of innovation on employment at the firm level is carried out by taking the logarithm of equation (1) to yield the following;

$$lnL_i = \varepsilon_{LT} lnT_i + \varepsilon_{LQ} lnQ_i + \varepsilon_{LX} lnX_i \quad (2)$$

Where ε represents the respective elasticities of labour demand. By introducing other control variables "X" for firm characteristics, the following regression equation is obtained;

$$lnL_i = \beta_0 + \beta_1 PD_i + \beta_2 PZ_i + \beta_3 Age_i + \beta_4 FDI_i + \beta_5 Skill\ level_i + \beta_6 Assets_i + \beta_7 Union_i + \beta_8 Manu_i + u_i \quad (3)$$

Where L_i denotes the logarithm of employment level of firm *i* regressed on a set of covariates that include product innovation (PD), process innovation (PZ), age of the firm, foreign direct investment, skill composition of workers, log of assets, union density and sector. Least squares estimation techniques are used to analyse the impact of innovation on employment. Further investigation of the impact of innovation on the quality of employment is undertaken by estimating equation (3) above for both skilled and unskilled labour. The expectation here is that innovation will lead to increased demand for skilled relative to unskilled labour.

Skill levels usually measured with educational levels or blue/white collar occupations according to recent studies have experienced a general increase pointing to the skill biased nature of current technological change. Conceptually and empirically, production/nonproduction worker distinction closely mirrors the distinction between blue- and white-collar occupations and the blue-collar/white-collar classification, in turn, closely reflects an educational classification (Berman et al, 1994). As a result, the study further examines the effect of innovation on employment quality by adopting the logistic model in binary and multinomial forms. Here, quality of employment is defined first, by skill composition of the workforce and second by attributes of the job (decent work). Classification of workers based on skill enables us to group workers into high and low skilled jobs based on the position on the job. High quality jobs (requiring highly skilled workers) include managers, supervisor, foremen, technicians, accountants, engineers and other mid-level managers whereas low quality jobs consist of cleaners, messengers, apprentice and labourers. Two distinct categories are subsequently created out of workforce composition consisting of firms that employ 50 percent or more highly skilled workers out of their total workforce against those whose highly skilled workers out of total workforce is below 50 percent.

The second classification of employment quality is based on job attributes out of decent work description of jobs. According to the International Labour Organisation, (2016) ‘Decent work sums up the aspirations of people in their working lives. It involves opportunities for work that is productive and delivers a fair income, security in the workplace and social protection for families, better prospects for personal development and social integration, freedom for people to express their concerns, organize and participate in the decisions that affect their lives and equality of opportunity and treatment for all women and men’.

The population of Ghana has increased rapidly over the past decades with a current annual increase of 230,000, the workforce continues to expand. This notwithstanding, formal wage employment has not been in the position to accommodate the increasing workforce due to the stagnation. Consequently, the economy is faced with the challenges of unemployment and underemployment and in the absence of a social security system, majority of the workforce are found in the informal sector since only a few people can afford not to work. Jobs in the informal sector tend to be of low quality in micro and small enterprises where mostly, both employers and workers operates in unsafe conditions. In general, remuneration is low (often below the minimum wage) with extended working hours and only a few receive paid leave. Most workers are not covered by health insurance or any pension scheme. Against this background coupled with increasing casualization of labour due to the high cost of labour in Ghana, it can be deduced that it is the highly skilled (professional) who face relative inelastic demand for their labour services that are in the position obtain jobs with attributes similar to those outlined under decent work classification of jobs.

As a result, to investigate the effect of innovation of on the quality of employment, we develop a variant form of Likert scale based on job attributes, out of which jobs are classified into high, medium and low quality jobs. Job attributes used include the existence of a written contract of employment; entitlement to paid leave, paid medical bills for employees and their dependents and a retirement package in the form of a contribution to pension. A job is classified high-quality which is synonymous to highly skilled workforce if employment conditions include at least three of the aforementioned attributes; medium-quality if it has at least one and low-quality if the job has none of the attributes. The choice between employing these different skill categorisations is therefore modelled in a multi skill setting.

This model assumes each firm selects among three mutually exclusive alternatives in their demand for labour. Demand for high-quality workers (indexed D_h), medium-quality (indexed D_m) and low-quality (indexed D_l). A firm compares the maximum productivity attainable given each alternative and selects the alternative which yields the maximum output.

Let V_{ji} be the maximum output attainable by firm *i* if it employs labour with different skills $j=D_h$, D_m, D_l. *S*uppose this indirect output function can be decomposed into a non-stochastic component (S) and a stochastic component (ϵ):

$$V_{ji} = S_{ji} + \epsilon_{ji} \quad (4)$$

where S_{ji} is a function of observed variables and ϵ_{ji} is a function of unobserved variables. The probability that firm *i* will select the j^{th} skill level is given by

$$P_{ji} = Pr[V_{ji} > V_{ki}]\ for\ k \neq j, k = D_h, D_m, D_l \quad (5)$$

or, substituting in from (4),

$$P_{ji} = Pr[S_{ji} - S_{ki} > \epsilon_{ki} - \epsilon_{ji}]\ for\ k \neq j, k = p_u, p_r, s, u \quad (6)$$

If the stochastic components have independent and identical Weibull distributions, the difference between the errors (ϵ_{ki} - ϵ_{ji}) has a logistic distribution and the choice model is multinomial logit (McFadden, 1974).[4] To estimate this model, a functional form of the non-stochastic component of the indirect output function S_{ji} must be specified. When approximated in a linear form (S_{ji} = βjXi), this yields an empirical specification of the form

$$P_{ji} = \frac{exp(\beta_j X_i)}{exp(\beta'_{Dh} X_i) + exp(\beta'_{Dm} X_i) + \exp(\beta'_{Dl} X_i)} \quad (7)$$

where Xi is a vector of independent variables that explain the demand for the different skill levels and β_j is the parameter vector.

McFadden (1974) suggests several measures of goodness-of-fit for the multinomial logit model, the likelihood ratio statistic is the most commonly used. Accordingly, the null hypothesis for testing that the three skill level model collapses to a dichotomous model is that $\beta_{Dh} = \beta_{Dm} = \beta_{Dl}$. This is tested using a likelihood ratio test. Given that coefficients obtained in the logistic estimation serve to provide a sense of the direction of the effects of the covariates (innovation) on the demand for various skills, and cannot be used to indicate the magnitude of impact, we examine the magnitude of impact by using marginal effects.

Based on the above literature and specifications, the following a priori signs are expected from the regressors.

Table 3: A priori Signs of Regressors

Product Innovation	Positive
Process Innovation	Indeterminate
Firm Age	Positive
FDI	Positive
Share of highly skilled workforce	Indeterminate
Wage per worker	Negative
Log of Assets	Positive
Union density	Indeterminate
Sector	Indeterminate

[4] Weibull distribution has a unimodal bell shape roughly similar to the normal distribution, justifies the use of multinomial logit.

Based on the skilled biased nature of innovation, workers with specialised skills (highly skilled) constitute a larger proportion of the workforce of innovative firms compared to their non-innovative counterparts who employ low skilled labour, on the other hand, because of the high productivity of highly skilled workers, the effect of the share of highly skilled workforce on employment remains indeterminate. Assets which are used as a proxy for firm size due to our inability to use the standard employment measure because the dependent variable is employment is expected to be positively related to employment since large firms employ more than small firms. FDI and firm age are expected to positively affect employment due to the positive spill-over effect and growth of firms associated with age respectively. In terms of compensation to labour, the higher the wage per worker, the greater the disincentive to employ more particularly given labour is paid the valued of its marginal product. Unions exits to protect the rights of members in terms of conducive work environment and adequate remuneration, these activities serve to protect existing workers but can have a dampening effect on employment, in the Ghanaian context, union activity is not as pervasive as elsewhere particularly in micro and small firm, consequently, its effect on employment is indeterminate. The relationship between sector of employment and the level of employment cannot be established apriori in Ghana given there exist very few large manufacturing firms who as theory postulate employ more people relative to service firms.

5.0 Data and Results

5.1 Data

The data set used for the study is from an enterprise survey on the employment effects of different development policy instruments in Ghana based on a stratified random sample of firms registered with the Association of Ghana Industries (AGI) and the National Board for Small Scale Industries (NBSSI). The survey was conducted between July and September 2015 for 600 firms out of which 428 responded. The survey collected information from firms in Ashanti, Brong-Ahafo, Western, Central, Eastern, Greater Accra and Volta regions. Data was collected for the years 2013 and 2014. The survey gathered firm level information including the firm’s background, characteristics of the owner, information about production, inputs, revenue, profits, assets, exports, employment, technologies, innovations, foreign direct investments and finances.

Firms additionally responded to questions on public policies, business supports and perceptions on the broader business environment. Firms surveyed were sampled from the manufacturing and service sectors. About 88 percent of firms surveyed were either registered with the Registrar-General's department or with the District Assembly or with both institutions. 7 percent had foreign ownership and about 11 percent of them had foreign partners.

Technological innovation in the form of either product or process innovation by the firm is generated out of response to the following question; 'did the firm introduce a new or significantly improved product or service in 2014 and 2013' respectively and 'has the firm introduced any new or significantly improved methods of producing or offering services respectively. These responses are direct indicators of whether a firm has undertaken product or process innovation or both. Due to the potential problem of endogeneity between innovation and employment coupled with the intuitive lag effect of innovation on employment, lag values of product and process innovations are used (i.e. product innovation in 2013 and process innovation in 2013).

Total employment is the summation of full-time permanent, full-time casual and part time workers (a headcount of number of employees at all levels). Out of this, employees are categorised into high skilled consisting of managers, production managers, engineers, scientist, accountants and technicians. Moderately skilled consist of workers at mid management level including secretaries, sales personnel, foremen, machine operators, electricians and assistants while low skilled are workers at the bottom of operations at the firm made up of cleaners, labourers and apprentices. In terms of compensation to employees, firm were asked the average wage (excluding in-kind payments) paid monthly to the various categories of workers (managers, professionals, technicians, office workers, sales personnel, service workers and production workers). The total value of wages paid is obtained by multiplying the average by the number of employees in each category. Subsequently, average wage per worker is obtained by dividing total compensation by number of employees. Assets are valued based on reported market values of all assets owned by the firm.

Table 4: Descriptive Statistics

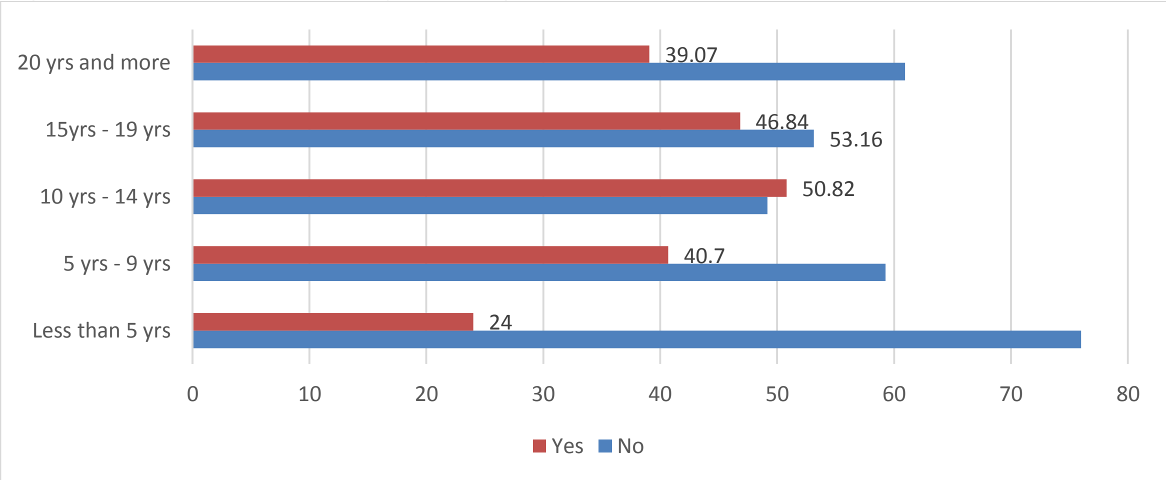
Variables	All		Innovators		Non-innovators	
	Mean	SD	Mean	SD	Mean	SD
Employment	54.3	15.9	61.8	17.3	22.6	17.4
Log of wage per worker	6.12	1.73	6.19	1.55	5.77	2.09
Log of value of assets	10.07	3.44	10.39	3.41	8.48	3.15
Firm age	17.65	13.28	19.15	13.53	11.26	9.91
Union density	0.13	0.34	0.15	0.36	0.07	0.26
Proportion of highly skilled workers constituting 50% or more out of total employment	17.5%		12.8		4.7%	
FDI	13.6%		11.9%		1.7%	
ISO Certification	10.3%		9.3%		1%	
Book Keeping	76.2%		65.2%		11%	
Training	58.9%		53.3%		5.6%	
Manufacturing	352		286		66	
Service	76		61		15	
Total number of firms	428		347		81	

* An innovating firm is one that innovated at least once between 2013 and 2014.

In table 4, descriptive statistics of variables are presented based on innovators, non-innovators and the overall sample. Average age of a firm in the sample is 17.7 years, although it is important to note that innovators are on average relatively older than non-innovators. In total 81 percent of our sample have engaged in at least one form of innovation (product or process innovation), out of this, 82 percent are manufacturing firms while the remaining are in services. Innovating firms tend to have higher employment than their non-innovating counterparts and pay higher wages relative to non-innovators. Similarly, when it comes to valuation of assets which is used as a proxy for firm size because our dependent variable is employment (mostly used to measure firm size), innovators are observed to possess high valued assets than non-innovators. Overall, about 18% of firm in our sample have highly skilled workers constituting 50 percent or more of their total workforce out of which 13 percent are innovators. This is an indication of a possible technology skill complementarity within firms in Ghana yet to be investigated further. In addition, ISO certification, book keeping and training dummies are used to measure the effect existence of such international standards certification, good practice of record keeping and the availability of training within the firm have on the likelihood of employing more highly skilled workers.

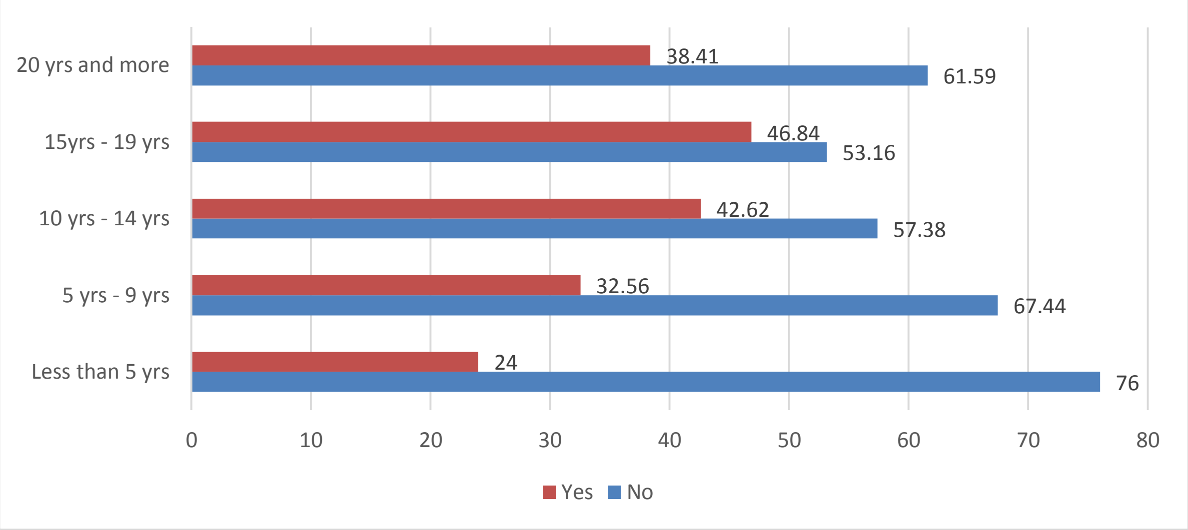
The relationship between firm age and innovation has been explained in empirical studies within the pursuit of legitimacy context by new firms. Particularly in Africa, evidence support Aldrich and Fiols'(1994, p.664) conclusion that 'early phases of an industry's life also implies that many promising new activities (product or process) never realize their potential because founders fail to develop trusting relations with stakeholders, are unable to cope with opposing industries, and never win the institutional support'. Deraniyagata and Semboja (1999) in a study on trade liberalization, firm performance and technological upgrading in Tanzania found a positive relationship between firm age and its technological capabilities.

Figure 1: Product Innovation by Firm Age



Wignaraja's (2002), similarly found a positive association between firm age and its involvement in innovation activity in Tanzania due mainly to experience out of learning by doing over the years. Subsequently, Huergo and Jaumandreu (2004) concluded that it can be anticipated that innovation varies with age of the firm since older firms are more likely to innovate than younger firms. In Ghana, a closer look at the data used by type of innovation and firm age, shown in figure 1 and 2, indicates that innovation whether product and process is more popular among older firms (10 years and above) than among younger firms. Thus innovation is mostly undertaken by older firms although the incidence of product compared to process innovation is higher among firms regardless of age.

Figure 2: Process Innovation by Firm Age



5.2 Results

Table 5 presents the results from OLS regressions of employment on a composite measure of innovation out of both product and process innovations and other firm specific and industry characteristics. Due to the lag effect of innovation on employment, we use the lag value of innovation and also control for the lag of employment since currently level of employment largely depends on previous employment. Our results indicate that innovation (product and process innovations) positively and significantly influences employment, these results are robust when we introduce union density and an industry dummy (manufacturing) as shown in column 2. As expected, older firms have a higher level of employment similar to firms with high asset value (used as a measure of firm size). In addition, foreign direct investment positively influences employment at the firm level in Ghana. This is consistent with theory since FDI is associated with superior technology and resources which increases productivity and efficiency. It is however important to note that, the correlation between FDI and innovation is nearly insignificant with a correlation coefficient of 0.05 in our data.

Premised on the fact that employment and level of technology might be higher in some sectors than in other, industry specific effects are controlled for through the inclusion of a manufacturing sector dummy, the results indicate on average manufacturing firms have a lower level of employment relative to service firms in our sample. Overall, in terms of the effect of skill composition on employment, we find that the proportion of highly skilled workers is negatively related to the level of employment.

Table 5: Determinants of Employment (Composite Innovation)

Log of employment	(1)	(2)
Innovation	0.493***	0.488***
	(0.120)	(0.118)
Firm Age	0.011***	0.012***
	(0.004)	(0.004)
Foreign Direct Investment	1.023***	1.020***
	(0.189)	(0.183)
Proportion of skilled labour	-1.587***	-1.705***
	(0.225)	(0.215)
Log of value of assets	0.024**	0.018**
	(0.009)	(0.009)
Employment 2013	0.006***	0.006***
	(0.002)	(0.002)
Log of wage per worker	-0.0001	-0.0001
	(0.000)	(0.000)
Union density		0.197
		(0.153)
Manufacturing		-0.479***
		(0.107)
Constant	2.007***	2.431***
	(0.144)	(0.162)
Observations	346	346
R-squared	0.548	0.570

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1 *Innovation here consist of both product and process innovations.

The effect of innovation on employment is posited to be different based on the type of innovation. Theoretically product innovation leads to increased employment due to the availability of variety that increases market share and consequently employment. Process innovation on the other hand, decreases employment because of the labour saving nature of improved processes in the short run but is expected to eventually increase employment out of efficiency gains which translate into reduced cost of production. Consequently, we regress employment on the lag values of both product and process innovations in addition to other covariates as in table 2.

The results in table 6 indicate that the product innovation dummy is positive and significant, suggesting the possibility of important demand enlargement effects that eventually results in increased employment. Process innovation on the other hand is negative although not significant. In accordance with previous studies, this suggests that firms may be opting for more labour saving alternatives in their decision to process innovate. Results on all other variables are consistent in terms of the direction and the effect on employment, which proves the robustness of our results. In general, results of our study corroborate recent studies on employment effects of innovation (Zimmerman 2008, Harrison et al. 2008) although these studies focus on developed countries.

Table 6: Determinants of Employment

Log of Employment	(1)	(2)
Product Innovation 2013	0.292**	0.291**
	(0.127)	(0.122)
Process Innovation 2013	-0.020	-0.016
	(0.122)	(0.116)
Firm age	0.013***	0.014***
	(0.004)	(0.004)
Foreign Direct Investments	0.970***	0.972***
	(0.190)	(0.185)
Proportion of skilled labour	-1.686***	-1.809***
	(0.227)	(0.219)
Log of value of Assets	0.024**	0.018*
	(0.009)	(0.009)
Employment 2013	0.006***	0.006***
	(0.002)	(0.002)
Union density		0.171
		(0.155)
Manufacturing		-0.492***
		(0.110)
Log of wage per worker	-0.0001	-0.0001
	(0.000)	(0.000)
Constant	2.314***	2.744***
	(0.120)	(0.149)
Number of observations	346	346
R-squared	0.538	0.561

Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

The results from the binary logistic model of employment quality presented in table 7 further indicate the importance of product innovation within firms in Ghana. With a binary dependent variable of employing 50 percent or more highly skilled workers relative to less, the average marginal effects shown in table 7 reiterates the importance of product innovation as it increases the probability of employing more highly skilled workers (high quality labour). All other covariates do not show a significant impact on employment of more highly skilled workers except FDI and Book keeping which decrease and respectively increase the employment probability of more highly skilled workers among Ghanaian firms.

Table 7: Logistic Regression Results on Determinants of Quality of Employment

Variable	Marginal effect
Product Innovation	0.071*
	(0.041)
Process Innovation	-0.010
	(0.047)
Firm age	0.000
	(0.001)
FDI	-0.139*
	(0.080)
Log of assets	-0.005
	(0.003)
I.S.O. Certification	-0.113
	(0.083)
Training	-0.0001
	(0.039)
Bookkeeping	0.168***
	(0.056)
Manufacturing	-0.044
	(0.043)
Union density	0.039
	(0.049)
Observations	416
Pseudo R^2	0.067

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

Results from the multinomial logit model of employment quality based on decent work attributes are presented in table 8. Interestingly, these results show significant effects of process innovation on the quality of employment as process innovation is found to increase the probability of employing low skill workers whereas the probability of employing high skilled workers is decreased. The implication for this result could be that firms in Ghana do not necessarily go in for upscale technology which is expected to be labour saving particularly in reference to low skilled workers. This implicitly indicates that Ghanaian firms may be far from the technology frontier in any given industry. Product innovation on the other hand as expected, increases the probability of employing high skilled workers.

Table 8: Multinomial logistic Regression Results of the Effect of Technological Upgrading on Employment Quality

	Low	Moderate	High
Product innovation	-0.162***	-0.038	0.200**
	(0.058)	(0.073)	(0.082)
Process innovation	0.170**	0.014	-0.183**
	(0.075)	(0.074)	(0.074)
Firm Age	-0.008***	-0.007***	0.015***
	(0.002)	(0.003)	(0.003)
FDI	-0.315***	-0.097	0.413***
	(0.039)	(0.092)	(0.095)
ISO Certification	-0.169**	-0.236***	0.404***
	(0.073)	(0.089)	(0.112)
Training	-0.330***	-0.114*	0.444***
	(0.054)	(0.059)	(0.052)
Log of Value of Assets	-0.015***	0.003	0.012**
	(0.005)	(0.005)	(0.006)
Manufacturing	0.174***	0.108	-0.283***
	(0.047)	(0.069)	(0.079)
Union	-0.035	-0.181**	0.215*
	(0.092)	(0.089)	(0.111)
Number of observations	416		
Pseudo R^2	0.27		

Standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1

6. Conclusion

This study examined the impact of innovation (product and process) on employment of innovating small, medium and large firms in Ghana. The results obtained are informative about the firm-level relationship between innovation and employment in manufacturing and service firms in Ghana. The relationship between innovation and employment is a topical research and policy issue for a number of reasons. First, it contributes to the extent to which different agents at the firm level resist or encourage innovation, second, innovation creates incentives on the part of agents (managers and workers) in the determination of the type of innovation introduced with its consequent output, price and employment effects. Subsequently, this motivates the need to understand this relationship at the firm level to inform policy on innovation.

Although our results are informative about the relationship between innovation and employment, within manufacturing and service firms in Ghana, we only take a first look at this important topic. The rationale is that our data does not allow the use of a dynamic model for which reason our results are not informative about the displacement and compensation effects of innovation on employment. This notwithstanding, we use the simple ordinary least squares and the logistic regression models to investigate the effects of product and process innovations on the quantity and quality of employment respectively.

Our results indicate that the effect of product innovation on the quantity of employment is positive and robust across all specifications. However, no significant relationship was found between process innovation and level of employment. In addition, firms that employ more highly skilled workers are observed to have lower employment levels. FDI, assets and firm age are all observed to have a positive and significant association with the level of employment at the firm level.

The effects of product and process innovations on the quality of employment are however revealing. We find that product innovation increases the probability of employing more highly skilled workers. This is robust to whether we define skills in terms of white/blue collar jobs or in terms of job attributes based on decent work categorisation. Process innovation on the other hand is found to increase the employment probability of low skilled workers and has a dampening effect on the likelihood of employing highly skilled workers. Thus the skill biased technological change that predicts capital skill complementarity does not wholly translate in the Ghanaian contest.

The findings from this study are very insightful, particularly to economic policy makers on innovation need recognise innovation as the key to job creation in firms in Ghana. As demonstrated by our results, it is important to focus on the positive employment effects of innovation in order to formulate appropriate policies to bolster innovative strength of firms as a panacea to reducing persistent unemployment in Ghana.

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