Catching Up To The Technological Frontier?

Understanding Firm-Level Innovation and Productivity in Kenya

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EXECUTIVE SUMMARY

Rationale for this report

Kenya's economy has undergone a significant process of structural transformation over the last decade. Since 2002, the economy has shown an accelerating trend with GDP growth increasing steadily from below 1 percent in 2002 to 7 percent in 2007. After a slowdown in GDP growth to 1.5% and 2.7% in 2008 and 2009 respectively, economic growth started to rebound in 2010. Amidst this positive growth context, in October 2013, the Kenyan Government launched the Second Medium-Term Plan (MTP-2) of the Vision 2030. The aim of Kenya's Vision 2030 is to create "a globally competitive and prosperous country with a high quality of life by 2030" and to shift the country's status to upper-middle income level.

While the improvement in economic performance in the past decade is remarkable, there are indications that achieving such ambitious targets might be difficult, especially given the slow rate of employment generation. More importantly, while investment has continued to accelerate over the last decade, driven mainly by public investment, aggregate productivity growth has remained stagnant since the 1970s and turned negative during the 2008-09 economic crisis and during the macroeconomic instability period in 2011. Therefore, attaining the high rates of growth and the degree of transformation envisioned in Kenya's Vision 2030 requires a renewed emphasis on boosting productivity. Only by increasing productivity can Kenyan firms become globally competitive and generate the quantity of high quality jobs required to boost incomes and achieve shared prosperity.

A central element to boosting productivity is increasing knowledge capital investments and innovation activities at the firm-level. However, we know very little about the nature and impact of these activities and investments on knowledge capital in developing countries in general, and in Kenya in particular. The aim of this report is to provide a rich description of the nature of firm-level innovation and investments in knowledge capital in Kenya, using data from more than 500 firms in various sectors, derived from the most recent Enterprise Survey (2013) and the linked 2014 innovation module, and to better understand the link between innovation activities and productivity and employment.

How to measure firm–level innovation

Innovation requires the transformation of knowledge capital or innovation inputs, both tangible and intangible—such as training, equipment, Research and Development (R&D) or intellectual property acquisitions—into innovation outcomes; for instance the introduction of new products, improved quality, new production processes, or organizational changes. Firms invest in knowledge inputs in order to increase their capabilities and produce innovative outcomes. As well as requiring tangible assets such as technology, equipment, and the physical production facilities, innovation needs intangible assets such as human capital, scientific and creative capital, and organizational capital. In turn, these inputs require specific innovation activities. For example, firms invest in training in order to increase the available human capital. The combination of these inputs yield innovation outcomes in the form of new or improved products and services, production and delivery processes, business organization, and patented intellectual property. However, achieving the outcomes is heavily dependent on the ability of the firm in question, on the specific sector and country context, and on the enabling environment and policy framework in place.

These innovation outcomes can impact firm performance in different ways. Successful innovations are likely to increase firm-level productivity by improving the capacity to transform factors of production into more and better products, and by more efficiently creating products of higher value. Second, the increase in productivity is expected to increase the marginal productivity of labor, and as a result, increase the quality of jobs, i.e.: more productive jobs. Third, more productive firms are expected to push less productive firms out of the market, thereby increasing the overall efficiency of the economy. This will improve allocative efficiency. All this, however, depends on the quality of the innovation and the ability of firms to translate innovation outcomes into improved performance.

A challenge of measuring innovation outcomes is the subjective nature of many of the questions used in the surveys. The Oslo manual, which is the main reference for these type of surveys, defines innovation as "… the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations." The Enterprise Survey (ES) use this definition to identify innovations by directly asking firm managers and owners whether they have implemented "new" or "significant" changes or improvements in the last three years. This is problematic since "significant" is a highly subjective term, and is also self-reported. It is therefore important to supplement analysis of innovation outcomes with some measures of revealed expenditure on innovation inputs. The following box summarizes the main knowledge inputs and innovation outcomes measured in the innovation survey:

Innovation in the Enterprise Survey follows a similar methodology than the Oslo manual. First, the survey measures several innovation or knowledge inputs and activities that firms carry out in order to accumulate knowledge and capabilities that facilitates innovation. These are grouped into four categories:

- Research and development - the source of R&D (internal vs external) as well as expenditure;
- Capacity building- investments in training for innovation;
- Equipment and technology expenditure for innovation; and
- Purchase/licensing of inventions or other knowledge forms - expenditure on the purchase of intellectual property.

Similar to the innovation surveys based on the Oslo Manual, the ES innovation survey measures the following types of innovation outcomes:

- Product innovations;
- Process innovations;
- Organizational innovations; and
- Marketing innovations.

The Kenyan innovation policy framework

The innovation policy framework in Kenya in the period prior to 2013 was characterized by large institutional fragmentation and the absence of a strong coordinating institution to mobilize government efforts in the area of Science, Technology, and Innovation (STI). Vision 2030 lays out the role of STI in economic growth, with particular focus on priority growth sectors. The Science, Technology and Innovation Act of 2013 is an attempt to improve on the STI institutional framework, in a bid to complement the policy goals of Vision 2030. However, this new framework has not yet been implemented.

This weak institutional framework for STI is translated in the lack of innovation policy support instruments. Only certain programs for supporting technology transfer or intellectual property rights exist, although these tend to be small and mainly focused on providing relevant information to firms. In addition, some programs that target assistance for market access also support innovation via quality certification or by providing information on new markets and technologies. Other types of innovation instruments, such as R&D tax incentives, have yet to be developed. Therefore, the STI institutional framework in Kenya can be described as an embryonic policy framework.

The firm–level innovation landscape in Kenya

The analysis of the report shows some important stylized facts regarding firm level innovation in Kenya. Regarding innovation outcomes and outputs, the study suggests that:

- Firm level innovation rates are relatively high as compared to international standards; however these are incremental, meaning that the degree of innovativeness is low. Specifically, 53 percent of firms are product and/or process innovators, 40 percent of the firms introduced product innovations; and 38 percent introduced process innovations.
- Innovation rates are even higher when it comes to marketing innovation; 69 percent of firms performed marketing improvements. However, only 11 percent of product innovators and 18 percent of process innovators introduce innovations that are new to the national market and a mere 2 percent of firms are international innovators.
- Organizational innovation is the weakest type of innovation in Kenya; only 27.8 percent of firms surveyed carried out organizational innovations.
- In terms of sectors, innovation is more prevalent in manufacturing and hotels and restaurants, than in services. The chemical sector is the most innovative. Organizational innovation is more prevalent in Machinery and Equipment and less common in services.
- In terms of the size of firms, medium and large firms are more innovative than small firms.
- Product and process innovation rates are higher in younger (below 10 years old) and in older firms (more than 30 years old).
- Firms that do not participate in international markets are also less innovative.
- There is very little correlation between product and/or process innovators and organizational innovators. Firms do not tend to introduce complementary organizational innovations when implementing product or process innovations, and this may limit the impact of these innovations.
- According to managers, the main reason why innovations are implemented is to improve the quality attributes of existing products and processes.
- There is very little knowledge appropriation by firms in terms of registering patents and other instruments. 18.5 percent of firms apply for some type of knowledge property, of which 5.5 percent apply for a patent, but in many cases these forms of knowledge appropriation are not successfully registered.

Regarding innovation inputs and activities:

- Investments in innovation inputs are very concentrated in a few firms (one firm has more than 80 percent of all R&D) and their intensity is similar to those in countries with the same income levels. The share of firms investing in innovation activities is similar to the average in other emerging markets and developing countries.
- Kenyan firms appear to rely less on external sources for knowledge capital investments and innovation than similar countries. Further, two thirds of product and process innovations are developed internally, suggesting little cooperation between firms and with universities.
- There is a mismatch between Kenya's ranking in terms of innovation outcomes and inputs. While the level of investments in innovation or knowledge inputs are in line with those in other similar income per capita countries, and below most advanced countries, the levels of innovation outcomes are much larger than those in advanced economies and many similar countries. This is indicative that the degree of "innovativeness" of the innovation outcomes introduced is low, and reinforces the idea of very incremental innovation happening in Kenyan firms.

Firm–level innovation and performance

Regarding the impact of innovation activities on firm-level performance and productivity, the estimation results for our sample of Kenyan firms cannot find a statistically significant impact on productivity. Also, we cannot find evidence of positive complementarities between different types of innovation in increasing productivity. These results reinforce the idea that a lot of the measured innovation activity is so incremental that it has little impact on productivity.

Regarding employment generation, the information reported in the survey suggests that innovation is likely to have a positive impact on employment creation. While there is a clear increase in the demand for skilled labor resulting from product and process innovations, the impact on unskilled labor is more uncertain, although likely to be positive. Innovation appears to bias the relative demand for skilled labor. Also, contrary to some of the findings in the literature, there is little distinction between product and process innovation in terms of employment generation.

Overall conclusion and policy implications

Firm-level innovation activity in Kenya is higher than that in similar income per capita countries, particularly in product and process innovation, but less so in terms of organizational innovation. It also appears to be low in innovativeness intensity, i.e.: it is incremental. While it is unsurprising that innovations in countries far from the technology frontier are incremental and far from radical,the question then is to what extent incremental innovations contribute to productivity growth. The findings of the paper suggest that innovations do not appear to have an impact on productivity. Furthermore, the findings suggest that the causal chain that connects knowledge capital investments and activities (such as R&D or training) to products, process, or organizational innovations, which are then translated into increased firm productivity, breaks down in the case of Kenyan firms.

It is difficult to identify the factors that hinder a positive linkage between innovation activities and productivity, but the empirical analysis in the paper suggests that there are some important obstacles to innovation. First, when benchmarked internationally, more innovation outcomes are produced with less knowledge capital investments, which suggests low "innovativeness" of these innovation outcomes, and therefore they are likely to be insufficient to impact productivity. Second, and related to the first point, the empirical analysis suggests that a lack of access to finance significantly constrains investments in R&D. Third, Kenyan firms appear to have an overreliance on internal sources for financing and executing knowledge capital investments and introducing innovations. This may indicate a deficit in the research, knowledge, and information infrastructure, as well as the absence of cooperation with other firms and research institutions. Fourth, the poor educational level of the available labor force hampers the capacity of firms to transform knowledge capital into innovation outcomes. This reinforces the complementary role skilled labor plays in innovation and highlights the need to enhance the supply of skilled labor.

In terms of policy implications, these results suggest three levels at which innovation policy should be focused.

At the firm level it is important to:

- Support the capacity of firms to convert innovation outcomes into productivity gains. Information failures and asymmetries, where firms lack the resources and the understanding to gather the required information, resources and know-how to innovate, increase the uncertainty to innovate due to the higher likelihood that the innovation outcome will fail or be commercially unviable. This is exacerbated by coordination failures where the individual costs of improvements are very high, especially for Small and Medium Enterprises (SMEs) since the supply of advisory services is insufficient and tends to target large firms. This requires support programs that target productivity and innovation by improving the information, capabilities and management skills of firms. Technology extension services can address these market failures and help to realize improved organizational, managerial, and technological changes. These services provide information on managerial and production practices, and how to adopt them, in order to increase productivity and competitiveness.

- Enhance R&D financing and cooperation among firms and academic institutions
  - In the presence of financial failures to fund innovation, R&D support is likely to be required to boost knowledge investments. The international experience suggests that gradual partial subsidies to high quality projects are more effective than indirect support by tax exemptions. Supporting these high quality projects, in conjunction with firms and university projects (see below) can have a positive impact on the amount and quality of R&D.
  - Support should be provided to enhance cooperation between firms, encourage private sector-university linkages, and remove coordination failures by providing subsidies to high quality innovation projects that involve several firms and/or firms and academic institutions.

At the sector level it is imperative to:

- Improve the quality of the physical and human capital infrastructure for innovation, including research labs, as a means of improving the availability and quality of innovation services for firms.
- Enhance the supply of skilled labor, especially in areas such as Science, Technology, Engineering, and Math (STEM) skills, which are highly complementary to the introduction of innovations.

At the institutional level, and given the current institutional vacuum regarding innovation policy, it is critical to finalize and implement the projected institutional framework in the Science, Technology and Innovation Act of 2013. This would help to better coordinate and design instruments, effectively diagnose and evaluate policies, and incentivize dialogue with the private sector.

SECTION ONE

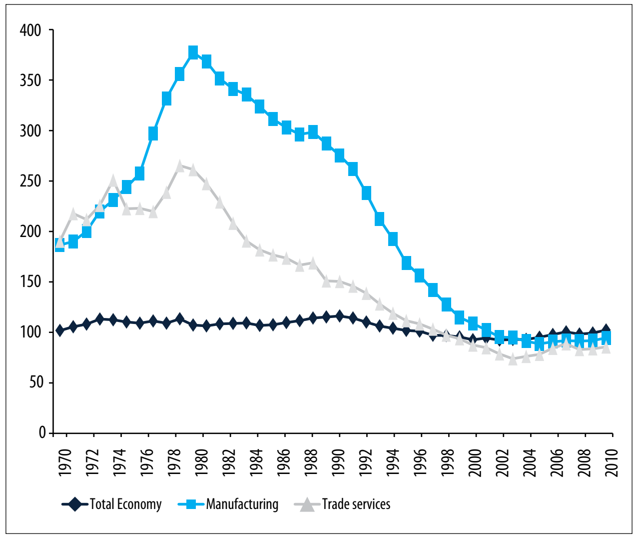
INTRODUCTION

Kenya's economy has undergone a significant process of structural transformation over the last decade. The economy showed an accelerating trend after 2002 with GDP growth increasing steadily from below 1 percent in 2002 to 7 percent in 2007. The economy has been hit by several shocks since 2007, starting with the post-election violence in January 2008, which led to a slowdown in GDP growth to 1.5% and 2.7% in 2008 and 2009 respectively. Nevertheless, economic growth started to rebound in 2010 and recent predictions suggest higher growth rates during the period 2014-2018, exceeding the growth rates before 2008.

Amidst this positive growth context, in October 2013, the Kenyan Government launched the Second Medium-Term Plan (MTP-2) of the Vision 2030. The aim of Kenya's Vision 2030 is to create "a globally competitive and prosperous country with a high quality of life by 2030" and to shift the country's status to upper-middle income level. While the improvement in economic performance in the past decade is remarkable, there are indications that achieving such ambitious targets might be difficult, especially given the slow rate of employment generation.

Comparing Kenya with similar countries in terms of GDP per capita in other regions suggest some relative underperformance in the Kenyan economy. Kenya's economic growth is driven primarily by the services sector and an over reliance on the domestic market. This indicates a significant lack of competitiveness that prevents firms from competing in international markets. It acts to constrain the potential of the economy in terms of future growth and employment creation. This, combined with accelerating population growth, explains the high levels of youth unemployment in Kenya. New entrants to the labor market, who are on average 20 years old, face an unemployment rate close to 35 percent. More importantly, while investment has continued to accelerate over the last decade, driven mainly by public investment, aggregate productivity growth has remained stagnant since the 1970s and turned negative during the 2008-09 economic crisis and during the macroeconomic instability period in 2011 (Figure 1).

FIGURE 1. PRODUCTIVITY LEVELS IN KENYA: VALUE ADDED (KHS) PER WORKER (1969-2010)



Source: Authors' own elaboration from data from de Vries et al. (2013)

Attaining the high rates of growth and the degree of transformation envisioned in Kenya's Vision 2030 requires a renewed emphasis on boosting productivity. Only by increasing productivity can Kenyan firms become globally competitive and generate the quantity of high quality jobs required to boost incomes and achieve shared prosperity.

In order to boost productivity, there is need for broad-based innovation and investment in knowledge capital. Innovation is the engine of the 'creative destruction' process that spurs economic dynamism and transformation and is at the center of the development process (Schumpeter 1942). Innovation contributes to the twin goals of shared prosperity and poverty reduction by generating productivity gains that increase employment, raise wages, and improve access for the poor to products and services. Investing in innovation increases the capabilities of firms, enabling them to integrate in global value chains and compete in international markets, while facilitating the adoption of new technologies that improve labor productivity.[1]

While innovation has the potential to generate large productivity gains and significantly improve allocative efficiency[2]—the ability of the economy to allocate resources in more productive ways—we know very little about the nature and impact of firm-level innovation activities and investments on knowledge capital in developing countries in general, and in Kenya in particular. Firm-level innovation activities such as R&D, or outcomes such as patenting, tend to be negligible in these countries, and there is little understanding regarding the impact of innovation efforts on performance or the main barriers to the adoption of innovative activities.

The aim of this report is to provide a rich description of the nature of firm-level innovation and investments in knowledge capital in Kenya, and the link between innovation activities and productivity and employment. Specifically, we set out to answer the following questions:

- How prevalent is firm-level innovation in Kenya, and what sorts of firms innovate?
- What are the main types of knowledge capital investments that firms implement?
- What are the main determinants and barriers to firm-level innovation?
- What are the links between innovation activities and productivity or employment?

In order to answer these questions we use the most recent enterprise survey (2013) and the linked 2014 innovation module. This is the most comprehensive innovation survey implemented in Kenya to date, as it links a full innovation questionnaire answered by 549 firms in the manufacturing and services sectors, with information on the characteristics of firms.[3] In addition, it allows analysis of firm-level innovation in manufacturing as well as services.

The report is structured as follows. Following this introduction, section 2 describes Kenya's policy framework for innovation. Section 3 defines the different measures of innovation, and describes the datasets used in the analysis. Section 4 provides an explanation of the firm level innovation landscape in Kenya. Section 5 analyzes the main determinants of innovation in the manufacturing and services sectors as well as the relationship between innovation and firm performance. The last section provides conclusions and policy recommendations regarding firm-level innovation in Kenya.

1 At the aggregate level, theories of economic growth put innovation at the center of the growth process since the seminal work of Solow (1957), where economic growth is driven by technical change. This interest in innovation was reinforced by the emergence of "new growth theory" emphasizing the role of knowledge accumulation for the growth process and 'Schumpeterian" creative destruction arising from a competitive R&D sector as the main engine of growth (Aghion and Howitt, 1992; Romer, 1986). At the micro or firm level, where innovation occurs, Klette and Kortum (2004) show how innovation activities create rich firm-level dynamics. In their model innovation increases product quality and make firms more competitive, which increases their revenue and size and forces existing firms producing old and obsolete versions of the product to exit the market.

2 Lentz and Mortensen (2008), using Danish firm-level data, find that up to 75% of productivity growth comes from reallocation of inputs to innovating firms, of which 25% is entry and exist of firms and 50% reallocation to growing innovative firms.

3 This dataset provides a larger source of information and sample than the previous 2007 enterprise survey, which had a sample of 396 firms but no comprehensive innovation questionnaire, and the 2012 innovation survey, implemented by the Ministry of Education, Science and Technology (MoEST),which had a sample of 160 firms.

SECTION TWO

THE INNOVATION POLICY FRAMEWORK

The innovation policy framework in Kenya in the period prior to 2013 was characterized by large institutional fragmentation and the absence of a strong coordinating institution to mobilize government efforts in the area of Science, Technology, and Innovation (STI). Vision 2030 lays out the role of STI in economic growth, with particular focus on priority growth sectors. The 2013 Act and the First Medium Term Plan (2008-2012) provide rationalization guidelines for both policy and institutional arrangements regarding innovation and technology, so as to align them with productivity and enterprise growth.

The Science, Technology and Innovation Act of 2013 is an attempt to improve on the STI institutional framework, in a bid to complement the policy goals of Vision 2030. The new STI institutional framework, under the STI Act of 2013, is comprised of three main elements:

i. The National Commission for Science, Technology and Innovation (NACOSTI)

The National Commission for Science, Technology and Innovation (NACOSTI) is an autonomous government institution, with the role of leading inter-agency efforts to develop policy on science, technology, and innovation–across all levels of government. It also assures the relevance and quality of science, technology, and innovation programs, while keeping track of progress in research systems.

ii. The Kenya National Innovation Agency (KENIA)

This Agency, also established under the Science, Technology and Innovation Act of 2013, is the implementation arm for the country's STI agenda and policy, and funded by the Research Fund. Its role is to institutionalize linkages between universities, research institutions, the private sector, the Government and other actors. It also aims for the creation of science and innovation parks, institutes or schools, or designated existing institutions as centers of excellence in priority sectors. Finally, one of its most important roles is to develop and continuously benchmark national innovation standards based on international best practices.

iii. The National Research Fund

The Fund aims at mobilizing resources to develop research capacity and scientific information. It will also compile and maintain a national database of expenditure on research and innovation–both internally and by other agencies.

This new framework, however, has not yet been implemented and the bulk of innovation policy remains the responsibility of the MoEST.

This weak institutional framework for STI is translated in the lack of any significant innovation policy support instruments. Only certain programs for supporting technology transfer or intellectual property rights exist, although these tend to be small and mainly focused on providing relevant market information to firms. In addition, some programs that target assistance for market access also support innovation via quality certification or by providing information on new markets and technologies. Other types of innovation instruments, such as R&D tax incentives, have yet to be developed. Therefore, the STI institutional framework in Kenya can be described as an embryonic policy framework.

SECTION THREE

DATA DESCRIPTION AND MEASUREMENT OF INNOVATION

3.1 THE DATA

In order to examine the innovative behavior of firms in Kenya, we use the World Bank 2013 Enterprise Survey (ES) and its linked innovation module. This is the most comprehensive survey on innovation information carried out in Kenya to date. It complements the first national innovation survey conducted by the MoEST in 2012 involving 160 firms, as well as a pilot innovation survey conducted in 2013 involving 310 establishments, mainly in the services sector. The 2013 ES, which corresponded to the period of analysis 2010-2012, covered information regarding innovation activities and outcomes for 549 firms,[4] including micro firms and also those in the services sectors. Table 1 shows the distribution of firms by sector and size. The survey uses a stratified sampling strategy, where firms are stratified by industry, size, and location.[5] Despite its small sample size, the 2013 ES improves on the previous one of 2007, which was less sector representative. Furthermore, it is the largest and most representative survey available, as it includes innovation information. An additional advantage is that the survey collects substantial balance sheet data and other information regarding the investment climate, which enables the linkage of innovation efforts to performance and potential obstacles.

3.2 MEASURING INNOVATION

Innovation requires the transformation of knowledge capital or innovation inputs, both tangible and intangible—such as training, equipment, R&D or intellectual property acquisitions—into innovation outcomes such as the introduction of new and improved products, new production processes, or organizational changes (see Boxes 1 and 2). Firms invest in knowledge capital inputs in order to increase their capabilities and produce innovative outcomes. As well as requiring tangible assets such as technology, equipment, and the physical production facilities, innovation needs intangible assets such as human capital, scientific and creative capital, and organizational capital. In turn, these inputs require specific innovation activities. Firms invest in training in order to increase the available human capital. In addition, firms invest in R&D, software, and digitalization or copyrights, patents and licenses in order to increase their scientific or innovative capital. In the case of the creative industries, innovation involves investment into developing these creative assets. Finally, innovation also requires organizational capital through investments in marketing and branding, adoption of new business models, design and prototyping, or corporate alliances and networks.

TABLE 1 DISTRIBUTION OF FIRMS BY SECTOR AND SIZE ENTERPRISE SURVEY 2013 (NUMBER OF FIRMS)

	Size				
Sector	**Large**	**Medium**	**Small**	**Micro**	**Total**
Computer and related activities		2	5		7
Construction			4		4
Hotels and restaurants	9	19	18		46
Manufacturing	66	99	100	15	280
Transport, storage and communications	8	9	7	1	25
Wholesale and retail	12	49	99	24	184
Total number of firms	95	178	233	40	546

Source: Author's own elaboration from the Enterprise Survey (2013)

4 The module of the ES targeted a total of 713 firms, but only 549 of these firms are surveyed in the full innovation module.

5 Industry stratification uses four manufacturing industries (food, textiles and garments, chemicals and plastics, other manufacturing) and two service sectors (retail and other services).Regional stratification includes five regions: Central, Nyanza, Mombasa, Nairobi, and Nakuru. Finally, size stratification uses the following size definition: micro (1 to 4 employees); small (5 to 19 employees); medium (20 to 99 employees); and large (more than 99 employees).

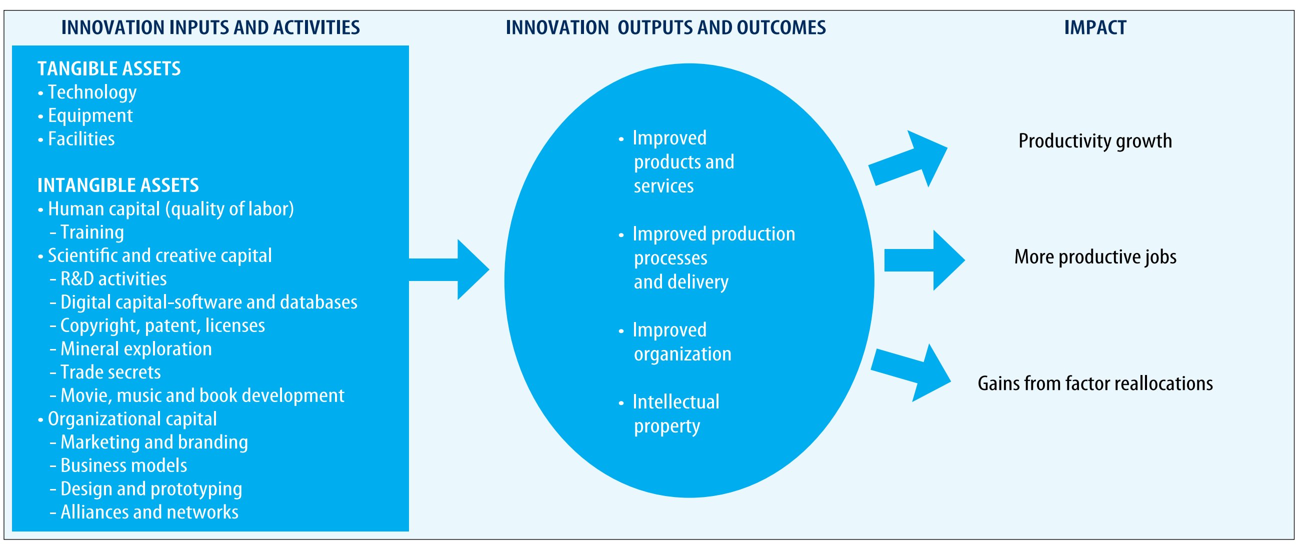
As illustrated in Figure 2, the combination of these inputs yield innovation outcomes in the form of new or improved products and services, production and delivery processes, business organization, and patented intellectual property. However, achieving the outcomes is heavily dependent on the ability of the firm in question, on the specific sector and country context, and on the enabling environment and policy framework in place.

These innovation outcomes can impact firm performance in different ways. Successful innovations are likely to increase firm-level productivity by improving the capacity to transform factors of production into more and better products, and by more efficiently creating products of higher value. Second, the increase in productivity is expected to increase the marginal productivity of labor, and as a result, increase the quality of jobs, i.e.: more productive jobs.[6] Third, more productive firms are expected to push less productive firms out of the market, thereby increasing the overall efficiency of the economy. This will improve allocative efficiency. All this, however, depends on the quality of the innovation and the ability of firms to translate innovation outcomes into improved performance.

To measure innovation, one can focus on both measuring inputs and innovation activities, and/or measuring innovation outcomes. The early innovation measurement literature focused on a specific set of innovation inputs that were easier to quantify, for instance R&D, or the intensity of the technology used. These early efforts were followed by the implementation of the Oslo Manual type of surveys, which mainly focus on measuring innovation outcomes such as product/process improvements or patents at the firm level. A third generation of synthetic innovation indicators, such as the OECD STI scoreboard, were developed later on. These indicators combine innovation inputs and outputs/outcomes in order to facilitate cross-country benchmarking and comparisons.

Innovation input indicators are often calculated at the aggregate level using different sources such as national accounts or by aggregating firm-level or sector information. On the other hand, innovation outcomes are mainly gauged by using firm-level innovation surveys.

FIGURE 2. THE INNOVATION FUNCTION



Source: Author's own elaboration

6 The impact of innovation on the level of employment at the firm level depends on the type of innovation implemented. For example, some products innovations are likely to increase the demand for labor by expanding production lines, while on the other hand, some process innovations can reduce the demand for labor when improving the efficiency in which existing products are produced. What effect is larger is an empirical question, but most empirical studies suggest that the employment creation effect is larger. See section 5 for an empirical analysis for Kenya.

BOX 1

INNOVATION ACTIVITIES

Innovation or knowledge inputs are activities that are associated with the development of innovation at the firm level. They are grouped into four main categories:

i. Research and development – firms are surveyed about the source of R&D (internal vs external) as well as expenditure on this component;
ii. Capacity building - firms report on the expenditure carried out in training for producing innovations;
iii. Purchase/licensing of inventions or other knowledge forms - firms report on the purchase of inventions or intellectual property that help introducing innovations; and
iv. Intellectual property - firms report on whether they applied for patents, utility models, trademarks, copyright design or registered an industrial design.

A challenge of measuring innovation outcomes is the subjective nature of many of the questions used in the surveys. The Oslo Manual, which is the main reference for these types of surveys, defines innovation as "…the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations." Most surveys use this definition to identify innovations by directly asking firm managers and owners whether they have implemented "new" or "significant" changes or improvements in the last three years.[7] This is problematic since "significant" is a highly subjective term, and is also self-reported. It is therefore important to supplement analysis of innovation outcomes with some measures of revealed expenditure on innovation inputs.

Several authors have advocated a focus on knowledge capital assets as a better measure of innovation, and in recent years there has been a renewed effort to better measure and capture investments in intangible assets using data from different sources (see framework developed by Corrado et al. (2005) and box in Appendix 1). While this approach offers a clearer and broader measure of firms' capabilities, it faces the challenge of being unable to obtain the information required from existing innovation surveys. Moreover, it is important to highlight that this measure of innovation assets is not equivalent to innovation outcomes; inputs can be more or less efficiently used, and therefore, there is some uncertainty about the type and extent of innovation outcomes that can be produced by firms using these knowledge assets.

In general, any sound analysis of innovation activity should combine a focus on both knowledge capital inputs and innovation outcomes. Although the ES innovation survey does not provide enough information on some of these intangible assets, it provides information on various sources of knowledge capital and innovation outcomes (see Box 1 and Box 2 for a detailed overview of the information available in the ES innovation questionnaires).

7 The impact of innovation on the level of employment at the firm level depends on the type of innovation implemented. For example, some products innovations are likely to increase the demand for labor by expanding production lines, while on the other hand, some process innovations can reduce the demand for labor when improving the efficiency in which existing products are produced. What effect is larger is an empirical question, but most empirical studies suggest that the employment creation effect is larger. See section 5 for an empirical analysis for Kenya.

BOX 2

INNOVATION OUTCOMES IN THE ENTERPRISE SURVEY

Similar to the innovation surveys based on the Oslo Manual, the ES innovation survey measures the following types of outcomes:

i. Product innovations
ii. Process innovations
iii. Organizational innovations
iv. Marketing innovations

For each of these outcomes, the survey includes information about the:

- Extent (number) of innovations introduced
- Impact on the specific operational aspects of the firm
- Level of automation involved in their adoption
- Level of novelty of the innovation(s)–local market, national market and international market
- Channels used to acquire business intelligence
- Acquisition of talent as part of the innovative process
- Level of collaboration in the development of the innovation(s) and the impact of the number of staff(skilled and unskilled) that the firm had.

Product innovations are essentially new, redesigned, or substantially improved goods or services. In the context of the survey, there are 3 metrics used:

a. New products to the firm
b. Significantly improved products
c. New products to the market.

Process innovation is the implementation of new or significantly improved production or delivery methods. Specifically:

a. Innovation methods for manufacturing products or offering services
b. Innovative logistics, delivery, or distribution methods for inputs, products, or services
c. Innovative supporting activity for processes, such as maintenance systems or operations for purchasing, accounting, or computing.

The following are not considered to be process innovations: Minor changes or improvements; an increase in production or service capabilities through the addition of manufacturing or logistical systems which are very similar to those already in use; ceasing to use a process; simple capital replacement or extension; changes resulting purely from changes in factor prices; customization; regular seasonal and other cyclical changes; and trading of new or significantly improved products.

Organizational innovation means the implementation of a new organizational method in business practices, workplace organization, or external relations. This type of innovation is grouped into: structural innovations which are meant to impact responsibilities, accountability, command lines, and information flows, as well as the number of hierarchical levels; the divisional structure of functions (research and development, production, human resources, financing, etc.) or the separation between line and support functions; and procedural innovations, which consist of changes to routines, processes, and operations of a company. Thus, these innovations change or implement new procedures and processes within the company, such as simultaneous engineering or zero buffer rules.

Marketing innovations are changes made to incorporate the advances in marketing science, technology or engineering to increase the effectiveness and efficiency of marketing, in order to gain competitive advantage.

SECTION FOUR

THE FIRM–LEVEL INNOVATION LANDSCAPE IN KENYA

The evidence emerging from case studies suggests that innovation, commonly seen as the work of highly educated labor in R&D intensive companies with strong ties to the scientific field, is inevitably a "first world" activity (Farberger et al 2010). Innovation in developing countries, as demonstrated in Box 3 below, is better characterized as an attempt to try out new or improved products, processes, or ways to do things (Bell and Pavitt, 1993; Kline and Rosenberg, 1986). This is a process of technology adoption, imitation and adaptation that takes place far from the technological frontier, where firms adopt incremental (as opposed to radical) changes (Fagerberg et al. 2010). It is also a process that requires the combination of different innovation outcomes, and modes of innovation, in addition to product and processes, such as marketing or organizational innovations (Bell and Pavitt, 1993).

4.1 HOW INNOVATIVE ARE KENYAN FIRMS

The objective of the rest of this section is to provide a detailed description of the extent and intensity of firm-level innovation activity in Kenya. We start by summarizing the aggregate picture arising from the innovation survey for the period 2009-2012.

4.1.1 Innovation outcomes

Firm-level innovation rates in Kenya are relatively high

Innovation outcomes in Kenya are relatively high (Figure 3) according to the ES. 53 percent of firms in the survey introduced either a product or a process innovation during the period 2010-1012; 39.8 percent of the firms introduced product innovations; and 38 percent introduced process innovations. Innovation rates are even higher when it comes to marketing innovation; 69.2 percent of firms performed marketing improvements. On the other hand, only 27.8 percent carried out organizational innovations.[8] In sum, introducing significant changes to products and processes, and especially marketing, is relatively common in Kenya.

These results from the 2013 ES survey are much more modest than those from the 2012 national innovation survey carried out by the MoEST, which indicated an overall innovation intensity of 89.9 percent; 70.9 percent of firms introduced product innovations, 92.4 percent introduced process innovations; and 85.4 percent introduced organization and marketing innovations. The results are also below, although more

BOX 3

AN EXAMPLE OF FIRM LEVEL INNOVATION IN KENYA - FAIRBROOKS WATER PURIFICATION

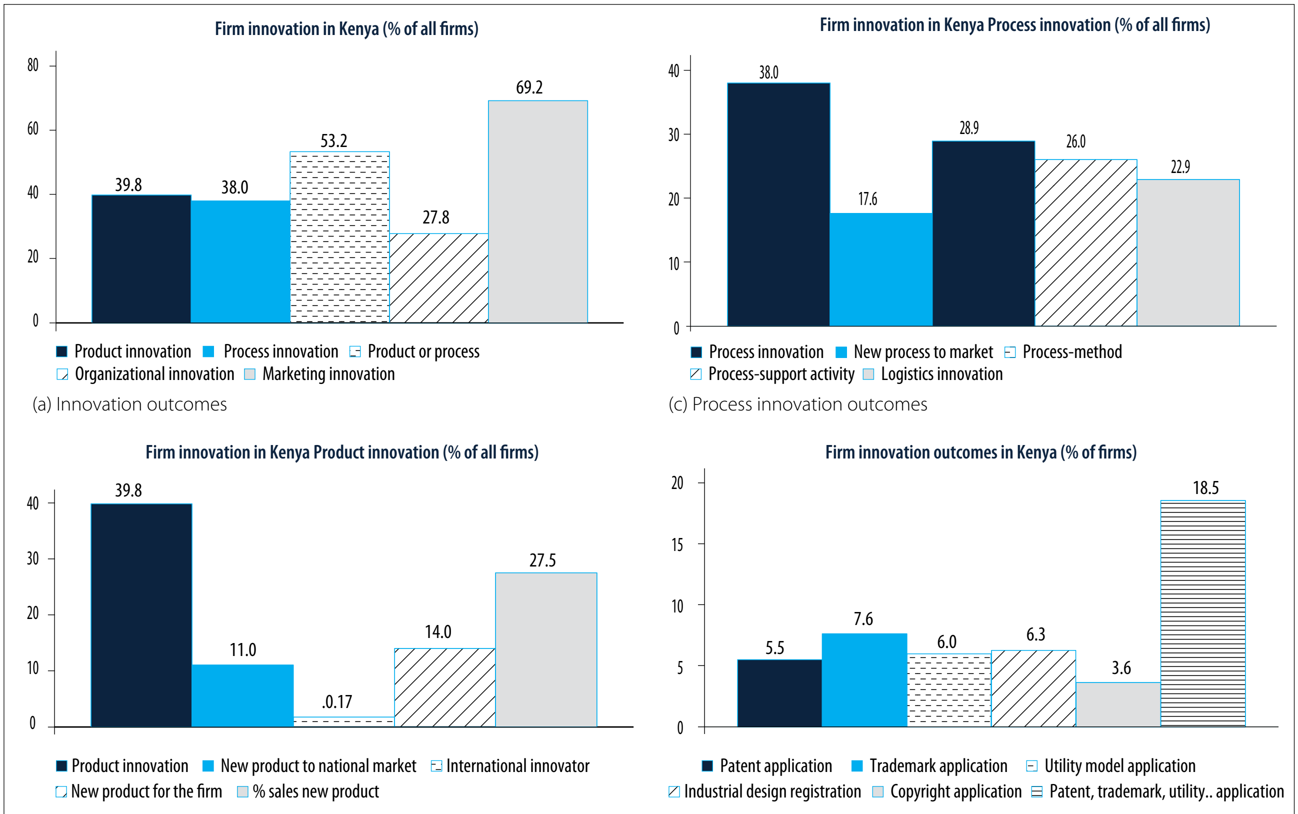
Fairbrooks Water Purification, a venture supported by the Kenya Climate Innovation Center (KCIC), has developed an innovative PVC-based tube system that filters water in an effective and cost-efficient way. First, ground water is pumped into a high tower; in a second phase, gravity pushes the water through a tube system that filters out bacteria, sediments, and other particles. This innovative system can produce up to 10,000 liters of clean and safe water per hour.

This innovative company started three years ago and is already an inspiration for many new local entrepreneurs. The system is patented and has been sold to large hotels, restaurants, and many organizations across the country. The system costs around US$12,000 and mainly targets institutions and the service sector. However, the company is working to bring this innovation to a larger part of the population.

Source: InfoDev (2015)

8 Only medium and large companies were asked about organizational innovations.

FIGURE 3. INNOVATION OUTCOMES (% ALL FIRMS)



(a) Innovation outcomes

(c) Process innovation outcomes

(b) Product innovation outcomes

(d) Applications for patents, trademarks

Source: Enterprise Survey (2014)

in line with, the ones from the 2013 pilot innovation survey that covered mainly services, which found that 62.9 percent of firms were product or process innovators, of which 42.5 percent of firms introduced products and 37.5 percent introduced processes; 73 percent focused on organization; and 65.1 percent on marketing innovations. The discrepancies are likely to be the result of the smaller sample sizes and sector compositions of the other two surveys.

However, innovation in Kenya is largely incremental and there are hardly any international innovators

Panels (b) and (c) in Figure 3 show that when the only factor being considered is whether the innovative product or process is new to the country, then innovation rates fall substantially. Only 11 percent of firms introduced products perceived to be new to the country and 17.6 percent of firms introduced new processes to the country. Given the narrowness of Kenya's domestic market in comparison to international markets, this suggests that most innovations mainly consist of small improvements to existing products and processes, or the incorporation of products that are already produced by other firms in the domestic market. Furthermore, only 1.7 percent of firms (3.4 percent of product innovators) introduce radical innovations—innovations that are new to international markets. Given the level of economic development in the country, this is unsurprising, but raises questions about the degree of innovativeness and the large aggregate innovation rates observed in this survey.

Innovations generate significant revenue

In terms of firms that introduce product innovations, 27.5 percent of sales are driven by these innovations. This figure is significant if the multi-product nature of firms is considered, and the fact that the revenues of firms tend to be diversified across various products.

Process innovations target production processes but also logistics and support services

Regarding the type of process innovation (Figure 3, panel c) that is most common, most changes occur in production methods, followed by support activities to the production process, and logistical improvements; 14 percent of firms introduced all three types of process innovation at the same time.

There is very little knowledge appropriation by firms

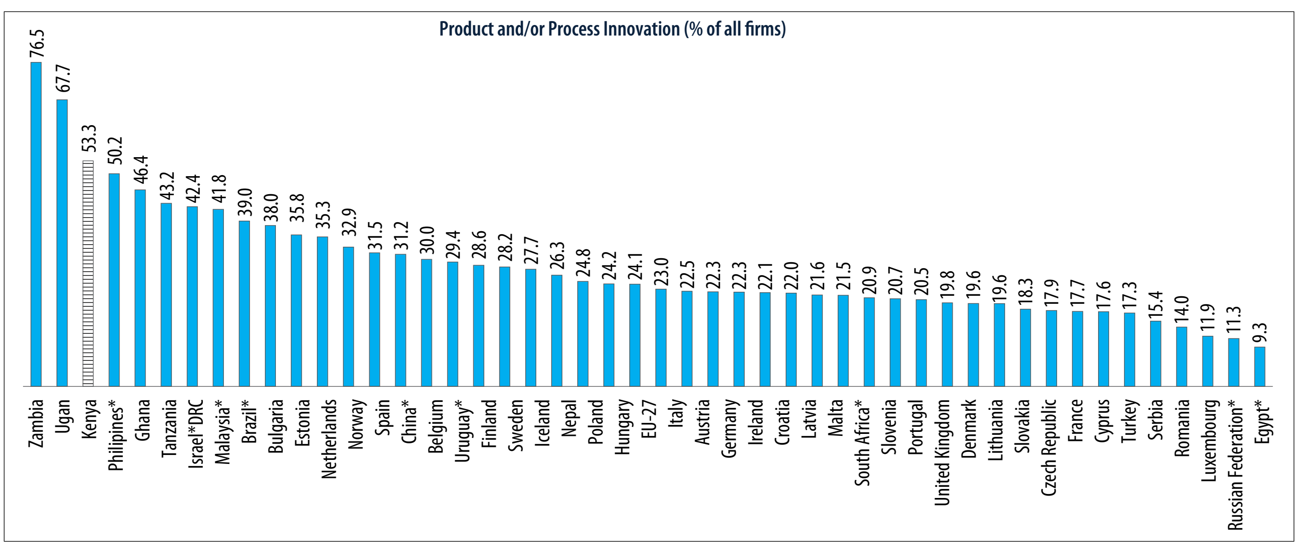
One of the main indicators of innovation outcomes is the extent to which knowledge capital investments can be commercialized and appropriated through patents, copyrights, trademarks, etc. In line with other developing countries, levels of innovation knowledge appropriation in Kenya are low. As a percentage of al firms, 18.5 percent apply for some type of knowledge property, of which 5.5 percent apply for a patent, 7.6 percent apply for a trademark, 6 percent for a utility model, and 3.6 percent for copyright. Bearing in mind that these are applications, and that a significant number of applications are not granted,[9] knowledge appropriation as a result of innovation is minor. This perhaps indicates that the new knowledge generated is likely to be negligible, reinforcing the idea of the incremental nature of existing innovations. In addition, only 6.2 percent of firms successfully register their industrial designs.

Innovation rates in Kenya are high compared to international standards

Innovation rates in Kenya are high when compared to international standards. They are higher than rates in most emerging markets or across the EU, and come below only a few African countries such as Zambia or Uganda (see Figure 4).

Contrary to expectations, innovation rates that are measured as outcome innovations at the firm level are higher in developing countries, which are further away from the technological frontier and have lower productivity levels, than in developed countries. The reason for this finding is not clear, but there are some possible explanations. The first is related to the subjective nature of the questions in the survey measuring innovative outcomes and the quality of the survey implementation, which in developing countries could bias innovation rates upwards.[10] The second explanation to consider when interpreting these results is that the surveys refer to formal companies and since developing countries often have sizeable informal economies, these indicators are less representative of the wider economy. In order to properly measure innovation activity therefore, we need to include informal firms. A third explanation is that developing countries are further away from the technological frontier and therefore, it is less expensive to make the incremental improvements which translate in the data to higher innovation activity. A final explanation is that given the extent of market failures and challenges in the business environments in developing countries, firms need constant changes

FIGURE 4 BENCHMARKING KENYA'S INNOVATION OUTCOMES



*Source: UNESCO statistics, CIS-2010 and Enterprise surveys. *only manufacturing firms*

9 According to the Kenya Intellectual property institute (KIPI), only around 60 patents are granted per year and close to 600 have been granted in total since 2001. These are mainly granted to foreign companies since local companies find it difficult and costly to comply with the internationally harmonized application procedures.

10 In addition of the subjectivity of the question, another challenge of the innovation measure is that the information provided is completely self-reported and difficult to verify. Nonetheless, we have reviewed the written explanations of the self-reported innovations to verify that the descriptions provided are indeed innovations.

in production and management in order to survive in the market–otherwise known as survival innovation. In this case, the impact of innovations on productivity in developing countries should be less visible, given the prevalence of incremental and survival innovations.

Whatever the main explanation behind these high rates, it is important to stress that firms in Kenya in the formal sector implement a large number of innovations, even in comparison to international standards. However, also in line with the experience in most countries, innovation rates fall considerably when one considers whether the changes implemented are new to the country; and almost disappear when considering innovations that are new to international markets, as Figure 5 shows for a subset of developing countries.

Organizational innovation is the weakest type of innovation in Kenya

Table 2 benchmarks Kenya's innovation outcomes with that of other emerging markets and developing countries. To facilitate the comparison with other surveys, we focus only on firms in the manufacturing sector. While product, process and marketing innovation rates are higher than the average innovation rates, organizational innovation is similar to the average innovation rates observed in emerging markets.

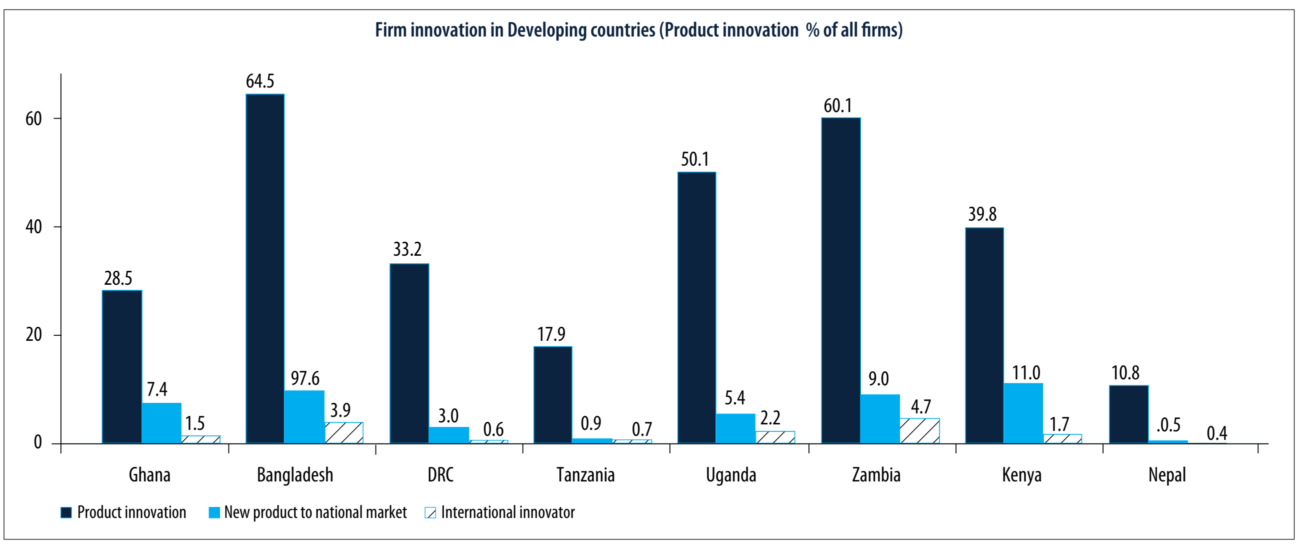
4.1.2 Innovation inputs and knowledge capital investments

The subjective nature of the questions regarding innovation outcomes as well as their self-reported nature emphasizes the need to supplement analysis with measures of innovation inputs and knowledge capital investments. Unless there are significant disparities in the measurement of innovation outcomes across countries, or in terms of efficiency regarding which knowledge inputs are transformed into innovation outcomes, comparing innovation activities across countries can help to understand the nature of innovation outcomes.

Purchase of equipment is the main innovation input for firms in Kenya

Figure 6 panel (a) shows the percentage of firms carrying out innovation activities (inputs). For 44.2 percent of firms, the main assets for innovation are investments in equipment, machinery, and software. Also 32.2 percent of firms invested in training, while only 4% purchased licenses or patents. Regarding R&D, 23.4 percent of firms invested in R&D;[11] 22.4 percent invested mainly in intramural (in-house) R&D while 4.6 percent invested in extramural, and only 3.8 percent invested in both intra and extra-mural R&D.

FIGURE 5 BENCHMARKING KENYA'S PRODUCT INNOVATIONS BY THEIR DEGREE OF INNOVATIVENESS



Source: Enterprise survey (2014)

11 This contrasts with existing data from the census of industrial production, suggesting that only 7.9 percent of firms invest in R&D, and the services survey suggesting 2.9 percent of firms investing in R&D in services sector.

TABLE 2 BENCHMARKING INNOVATION OUTCOMES (% OF FIRMS IN MANUFACTURING SECTOR)

	Product innovators	Process innovators	Product or process innovators	Organizational innovation	Marketing innovation
Brazil[a]	23.0	32.0	38.0	54.0	48.0
China[a]	25.1	25.3	30.0		
Colombia[a]	4.6	20.0		13.6	10.8
Egypt[a]	6.0	8.3	9.3	6.2	3.6
Israel[a]	34.2	30.9	42.4	50.6	57.9
Malaysia[a]	29.5	33.3	39.0	28.1	28.0
Philippines[a]	38.0	44.0	50.2	58.0	50.4
Russian Federation[a]	8.0	5.9	11.3	4.0	3.4
South Africa[a]	16.8	13.1	20.9	52.6	23.3
Uruguay[a]	17.2	24.5	28.6	8.4	4.8
Kenya[b]	**46.7**	**37.6**	**57.7**	**31.3**	**66.3**
Tanzania[b]	18.4	40.8	50.7	27.2	61.5
Uganda[b]	56.7	60.1	78.8	46.1	88.4
Zambia[b]	60.7	77.2	81.3	28.2	97.1
Nepal[b]	17.0	34.0	41.3	19.6	92.7
Average excl. Kenya	**25.4**	**32.1**	**40.1**	**30.5**	**43.8**

Source: Author's own elaboration from [a] UNESCO Statistics and [b] Enterprise Surveys. Data corresponds to different years, the last year of each country with information available.

Investments in innovation inputs are highly concentrated and not large

Figure 6 shows the average value of these activities as a percentage of total sales at innovative firms, those firms that introduce some form of innovation. Investments in R&D and training come in on average at below 1 percent of sales, while the purchase of licenses is almost negligible. Investment in equipment, machinery, and software is 3.8 percent of sales.

In addition, the total value of investments in R&D, training, and purchase of licenses and patents is concentrated in a few large firms. A single firm in the sample is responsible for more than 80% of R&D investment.[12]

The share of firms investing in innovation activities is similar to the average in other emerging markets and developing countries

Table 3 benchmarks the share of firms investing in innovation activities in Kenya against other countries; developing countries, emerging markets and the EU average. The table suggests that Kenya ranks close to the average of this group of countries in terms of implementing innovation or knowledge inputs.

12 This figure likely overestimates the true R&D firm effort due to the fact that some firms that claim to have invested in R&D cannot recall the actual value invested.

TABLE 3 BENCHMARKING INNOVATION INPUTS (% OF FIRMS IN THE MANUFACTURING SECTOR)

	Intramural R&D	Extramural R&D	Acquisition of machinery, equipment and software	Acquisition of other external knowledge	Training
Brazil[a]	4.7	1.9	34.1	4.8	26.5
China[a]	63.3	22.1	66.0	28.1	71.5
Colombia[a]	26.8	8.9	85.8	7.2	19.8
Egypta	41.3	5.5	74.3	11.0	56.9
Ghana[a]	42.1	14.0	80.7	15.8	86.0
Indonesia[a]	48.3	5.2	39.3	21.6	37.0
Israel[a]	48.9	32.2	85.1	12.9	52.6
Malaysia[a]	42.5	15.8	64.9	29.8	50.2
Russian Federation[a]	18.9	20.0	64.0	12.7	18.3
South Africa[a]	54.1	22.4	71.2	24.8	69.6
Uruguay[a]	11.1	1.2	20.3	4.4	15.1
Kenya [b]	**37.3**	**8.8**	**66.6**	**6.7**	**47.9**
Tanzania[b]	39.1	7.6	59.2	15.9	34.2
Uganda[b]	10.0	3.1	41.9	3.1	19.2
Zambia[b]	21.7	12.4	44.4	6.4	25.2
Nepal[b]	**7.6**	**0.5**	**38.8**	**3.0**	**26.9**
EU27 min[a]	**8.2**	**5.8**	**25.2**	**2.0**	**8.9**
EU27 max[a]	**81.3**	**54.8**	**98.8**	**53.1**	**96.4**
Average excl. Kenya	**33.5**	**13.7**	**58.5**	**15.1**	**42.0**

Source: Author's own elaboration from UNESCO Statistics[a] and Enterprise Surveys[b]

Kenyan firms appear to rely less on external sources for knowledge capital investments

Excluding the acquisition of equipment and machinery, Kenyan firms appear to rely less on extramural R&D and other sources of external knowledge. As we will see below, this is also the case for external sources of information for innovation outcomes, which may indicate an insufficient supply of research and knowledge services in the country, as well as a reluctance to collaborate with other firms or universities in terms of innovation.

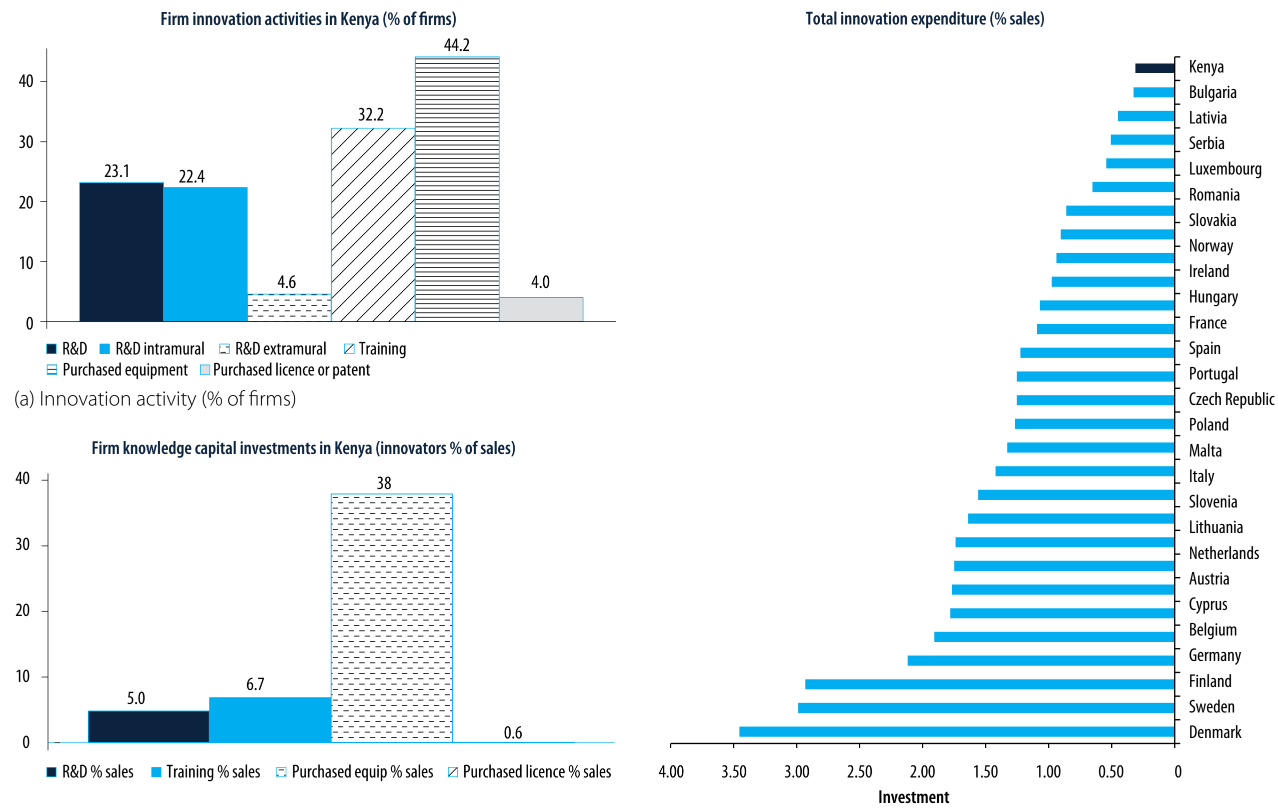
The level of investment as a share of sales is on par with the minimum level in the EU

Figure 6 panel (c) shows the average value of these activities as a percentage of total sales compared with EU countries. Kenya ranks at the bottom of these countries but at similar levels to Bulgaria. Therefore, for firms that invest in knowledge inputs, these investments appear to be in line with the level of investment predicted by GDP per capita levels.

There is a mismatch between Kenya's ranking in innovation outcomes and inputs

While Kenya ranks very high in innovation outcomes, it comes in the middle of the group in terms of innovation inputs and activities. This could be explained by virtue of Kenyan firms being more productive in terms of innovation production, but more likely it suggests a lower degree of innovativeness in the improvements introduced in product and services, than in other emerging markets.

FIGURE 6 INNOVATION ACTIVITIES



(a) Innovation activity (% of firms)

(b) Innovation activities (% of sales)

(c) Benchmarking innovation

Source: Enterprise Survey (2014) and CIS (2010)

4.2 WHO ARE THE INNOVATORS?

This section provides a breakdown of the aggregated innovation findings in terms of firm characteristics (sector and size).

Innovation is more commonplace in manufacturing and hotels and restaurants, rather than in services

Figure 7 panel (a) shows innovation outcomes by broad sector breakdown (for sectors with more than 20 firms in the sample). The graph shows that product and process innovation rates are similar for manufacturing and hotels and restaurants, while lower for wholesale and retail. As expected, given the nature of their business, marketing innovations are more common in the services sector. On the other hand organizational innovation is more prevalent in manufacturing.

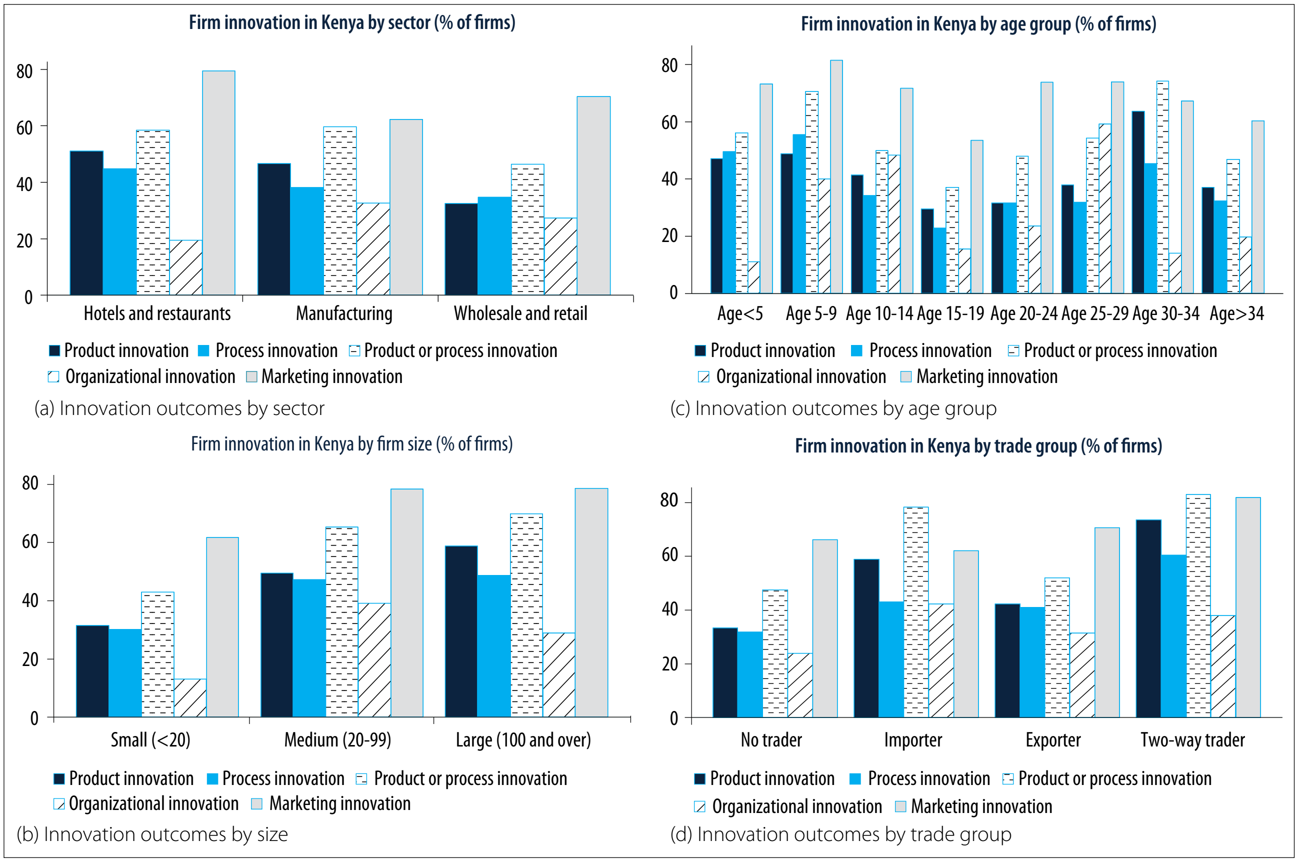
The chemical sector is the most innovative

The table in Appendix 2 shows the breakdown of innovation outcomes by sub-sector using the ISIC 2 digits sector classification, for sectors with more than 20 firms in the sample. The chemicals sector appears to have the greatest frequency of both innovation outcomes as well as outcomes such as patents and trademarks applications. In addition, this sector has the highest occurrence of firms carrying out innovation inputs and the most sizeable investments in these knowledge capital activities.

Organizational innovation is more commonly found in machinery and equipment and less prevalent in services

Organizational innovation is a key element for productivity growth by virtue of improvements in the quality of management (Boom and Van Reenen, 2012). The table in Appendix 2 shows that organizational innovation is more common place in machinery and equipment, as well as in the servicing of motor vehicles, and less prevalent in the services sectors. Among the manufacturing sectors, food is the one with the lowest rate of organizational innovation.

FIGURE 7 INNOVATION OUTCOMES BY GROUP



Source: Enterprise survey (2014)

Patents and trademark applications are infrequent, particularly in textiles

Regarding innovation outputs such as patents, trademarks, and copyrights, these forms of knowledge appropriation are very rare in the textiles sector, where knowledge appropriation largely occurs via the registration of industrial designs. Of the services sectors, transport is the one with the most innovation outputs, mainly applications to trademarks, copyright, and industrial design registration.

R&D and training are more prevalent in manufacturing than in services

More firms in manufacturing engage in R&D and training than do firms in services. However, investments in equipment are more common in services. This contrasts with Loof (2005) who finds greater R&D intensity in services than in manufacturing in Sweden.

When looking at the intensity of investments, the most sizeable R&D and training investments are in the chemicals, food, and transport services sectors, and to a lesser extent, in wholesale trade. R&D and training investments are almost negligible in the textiles sector. Purchase of equipment is the most significant form of knowledge capital across all sectors.

Medium and large firms are more innovative than small firms

In line with Schumperian views of innovation, medium and large firms appear to be more innovative than small firms, but innovation rates are similar between medium and large firms (Figure 7, panel b). Product and process innovation is slightly more prevalent among large firms than among medium firms, while organizational innovation is more prevalent at medium sized firms.

Product and process innovation rates are higher in younger and older firms

Product and process innovation rates are higher in firms that have been in existence for less than 10 years, and in firms that have been operational for between 30 and 34 years (Figure 7, panel c). However, organizational innovations are less prevalent in very young and very old firms. This suggests that different types of innovation hold greater relevance or feasibility at different stages of the firm's life cycle.

Firms that do not participate in international markets are also less innovative

The productivity literature shows that productivity is greater among two-way traders—those firms that both export and import—than single exporter, importers and firms that do not trade. Similarly, Figure 7 panel (d) shows that product and process innovation rates are higher among two-way traders than they are among importers or exporters, while rates of organizational innovations hold steady between importers and two-way traders. Firms that do not participate in international markets are less innovative.

There is very little correlation between product and/or process innovators and organizational innovators

Figure 7 and the table in Appendix 2 suggest little correlation between product and/or process innovation and organizational innovation. Firms that adopt product and/or process innovations are unlikely to also introduce organizational innovations. Polder et al. (2010) find positive effects of product and process innovation on productivity when combined with organizational innovation in the example of the Netherlands. Thus, the lack of organizational innovation among Kenyan firms may undermine the potential for productivity growth that would arise from the complementarity between product/process innovation and organization innovation.

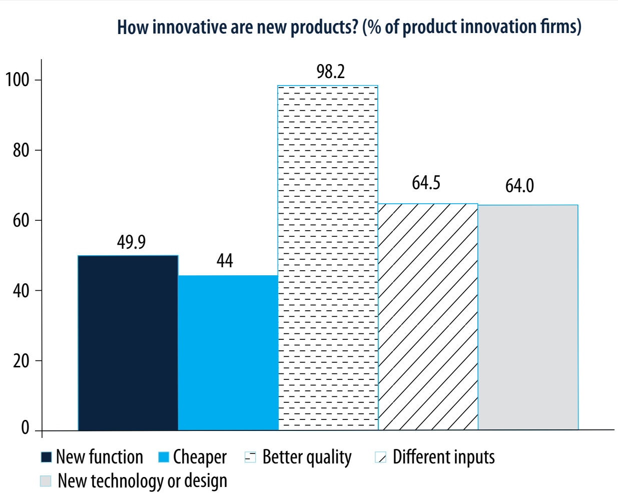
4.3 MAIN CHARACTERISTICS OF THE INNOVATION PROCESS

The innovation survey provides qualitative information regarding the description of the innovation processes. Here we summarize some of this information.

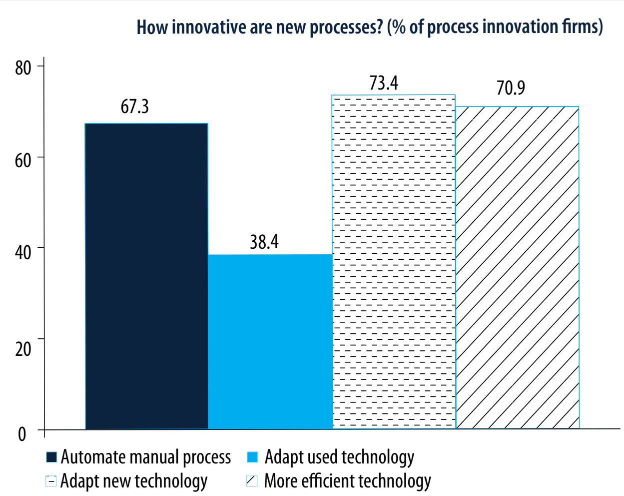
Innovations aim at increasing the quality attributes of existing products and processes

While only 14 percent of firms introduced new products, innovations are aimed at increasing the quality of the product. As Figure 8 panel (a) shows, the perception is that in almost all cases, product innovations improve the quality of the product. 64.5 percent of the cases introduced a new technology or design and used different inputs, and 50 percent of the cases introduced a new function. The cost attribute is the focus in only 44 percent of cases. This suggests a link between product innovations and quality upgrading.

FIGURE 8 HOW INNOVATIVE ARE NEW PRODUCTS AND PROCESSES



(a) Product innovators



(b) Process innovators

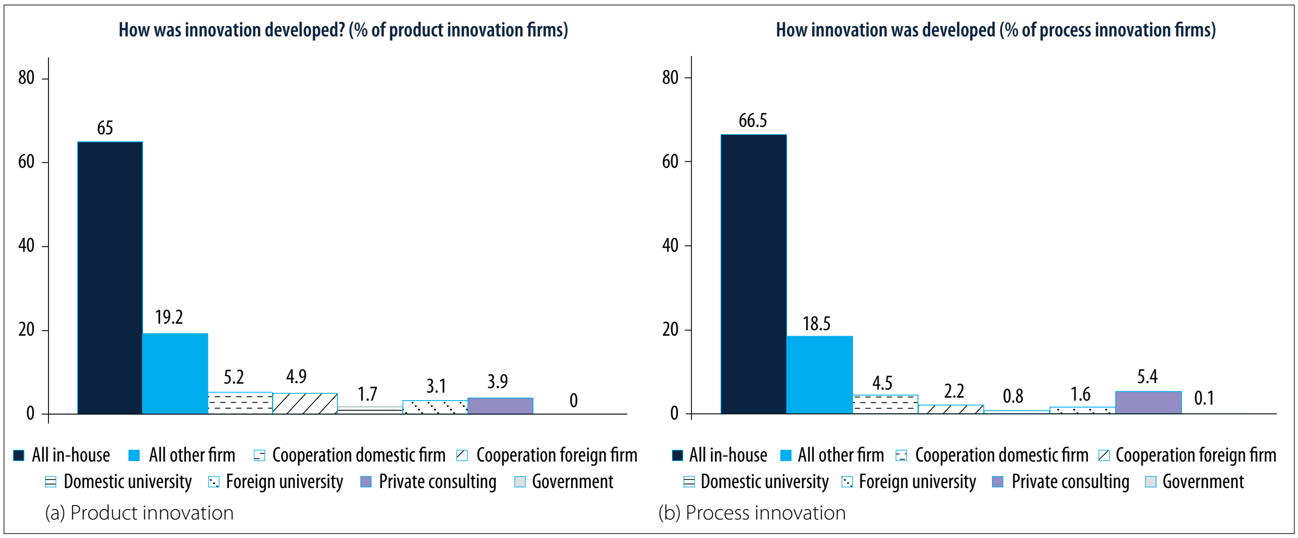
Source: Enterprise survey (2014)

In terms of process innovations, firms introduce improvements to improve the quality of the production processes via adapting new technology in 73.4 percent of cases, while in 70.9 percent of cases, the aim is to use more efficient technology. 67.3 percent of firms look to automate manual processes while the desire to adapt used technologies is cited by only 38.3 percent of cases as the main reason to innovate.

Two thirds of product and process innovations are developed in-house, suggesting little cooperation and few external links

Figure 9 shows that two-thirds of product and processes innovations are fully developed in-house, which aligns with the finding that most of the main innovation activities, such as R&D, are developed internally. 19 percent of innovations are developed entirely by a different firm and only 15 percent of innovations are developed in conjunction with other companies, consultants or universities. This suggests very little reliance on external sources of knowledge and cooperation. It also suggests less cooperation and reliance on external sources than has been observed in other developing and emerging markets, as shown in Table 3 above.

FIGURE 9 HOW WAS INNOVATION DEVELOPED?



Source: Enterprise survey (2014)

SECTION FIVE

INNOVATION AND FIRM–LEVEL PERFORMANCE

Innovation is the outcome of firms' investments in knowledge capital and management decisions. The ultimate objective of these investments is to produce innovations that positively impact firm performance by increasing productivity, employment, sales, profits, market shares, or markups. However, there is uncertainty regarding the extent to which firms are able to convert knowledge capital investments into innovation outcomes and furthermore, whether these innovation outcomes are likely to impact firm performance. Innovation is risky since it is almost impossible to determine ex ante whether the introduction of a new product, process, or organizational change will lead to an increase in sales or productivity.

In general, most of the evidence of the impact of innovation on productivity and firm level performance has been focused on developed countries. Regarding the connection to employment, the case study literature has emphasized the possibility that innovation acts as a mechanism to reduce employment, and also, as a force for skill bias, as it increases the relative demand for skilled labor. While this is very important, this argument suffers from a real deficit of evidence, especially regarding developing countries and firm-level information. In a recent survey of the literature, Vivarelli (2012) suggests that the more recent micro-econometric literature tends to support a positive link between technology, proxied as R&D and/or product innovation, and employment, especially when focusing on high-tech sectors. Vivarelli (2012) also finds significant evidence in favor of the skill-biased hypothesis across different OECD countries, different economic sectors, and different types of innovation.

In one of the few existing micro-econometric studies, Harrison et al. (2006) study the impact of innovation on employment using a comparable dataset of firms from France, Germany, Spain, and the UK. The authors find that product innovation has a positive impact on employment, but that process innovation has a displacing effect on employment. However, the positive impact of product innovation generating employment is larger than the displacement effect of process innovation, and the net effect of innovation on employment tends to be positive. Using a similar methodology, Hall et al. (2007) find a low but positive effect of product innovation on employment in Italy, and no displacement effect from process innovation. Thus, the scarce evidence in existence suggests an overall positive impact of innovation on employment, but more research is needed to understand if these results also hold for firms in developing countries that are further away from the technological frontier.

In relation to the impact of innovation on productivity, Hall (2011) provides a comprehensive survey of the empirical work. The survey mainly focuses on 16 existing empirical studies using the workhorse empirical model, the Crepon-Douget-Mairesse (CDM) model (Crepon et al., 1998), implemented using firm-level data in OECD countries and a few emerging markets. Hall's (2011) main finding is that in general, most studies find a positive correlation between product innovation and productivity, but the impact of process innovation is ambiguous. According to Hall (2011), the problem with process innovation is that it cannot be measured in the surveys beyond the dichotomous variable of whether or not the firm implements process innovations.[13] In general, these studies suggest that innovation has a positive impact on productivity.

The evidence for developing countries, however, is scarce. One relevant study is Goedhuys et al. (2008), which examines the main drivers of productivity in Tanzania. The authors do not find any link between R&D, product and process innovations, licensing of technology, or training of employees, and productivity. The results suggests that Tanzanian firms are struggling to convert knowledge inputs into productivity improvements due to the poor enabling environment for business, which is the main constraint on productivity according to their empirical results.

13 The intensity of product innovations can be approximated by the share of total revenue associated to the product innovation.

In addition, there are indications that in developing countries, investments in knowledge capital are smaller than in developed countries. For example, Goni and Maloney (2014) demonstrate that investments in R&D as a share of GDP are smaller in developing countries than in developed countries. One potential explanation for this is the absence of complementary factors to enable R&D, such as education, the quality of scientific infrastructure, and the private sector, which is weaker in countries far away from the technological frontier.

A related strand of the literature has empirically analyzed some of these complementary factors. Polder et al. (2010) find significant complementarities between different knowledge inputs and innovation outcomes in the Netherlands. The authors find that:(i) ICT investment and usage are important drivers of innovation; (ii)there is a positive effect on productivity of product and process innovation when combined with organizational innovation; and(ii) there is evidence that organizational innovation is complementary to process innovation. Miravete and Pernias (2006) find evidence of complementarity between product and process innovation in Spain's tile industry, and Cassiman and Veugelers (2006) find important complementarities between internal R&D and external knowledge acquisitions.

A final element is the lack of an enabling business environment in many developing countries and existing market failures in the supply of technical infrastructure, human capital or technology, as well as recent evidence of low management quality in firms in developing countries (Bloom et al, 2012). This raises questions about the efficiency of transformation of knowledge inputs by firms into innovation outcomes, and further, into improvements in firm performance (see Figure 2 above).

In the following section we empirically analyze this question for Kenyan firms, and try to identify the degree to which innovation activity has translated into improved performance in terms of productivity and employment growth. The next sub-section describes the empirical methodology, while the following sub-sections describe the empirical analysis regarding impact.

5.1 METHODOLOGY AND DATA DESCRIPTION

In order to estimate the impact of innovation activity on performance, we follow a logical framework based on the one described in Figure 2, which is the basis of the CDM model (Crepon et al., 1989). The framework holds that firms invest in knowledge inputs that can be transformed into innovation outcomes according to the efficiency of their innovation function. At a later stage, these innovation outcomes impact productivity which is contingent on the capacity of firms to transform innovation outcomes into improvements in product quality and efficiency. As a result, the CDM model requires the estimation of three main components: the knowledge function; the innovation equation; and the productivity equation.

When estimating these components, there are two critical choices that need to be considered. The first is to define the scope of the knowledge inputs and innovation outcomes to be included in the analysis. This is often related to the availability of data in the innovation surveys. In most CDM applications, data is restricted to the use of R&D for knowledge activities; for innovation outcomes, either product and process innovation dummies, or the number of patents and the revenue associated to new products, are used. This paper extends the traditional CDM model to include R&D as well as two other main knowledge activities: (i) the acquisition of equipment for innovation, and (ii) the training of workers for innovation activities. Regarding innovation outcomes, in addition to product and process innovations, the paper focuses on organizational innovations, since as we saw earlier, some of the literature suggests important complementarities with process innovations.[14]

The second choice when examining these three innovation components relates to how the model is solved. Decisions regarding knowledge inputs and innovation outcomes can be made simultaneously and there can be feedback effects, especially between innovation outcomes and productivity. There are two main approaches in the literature on how to solve the model. Crepon et al. (1998) suggest solving the model simultaneously using Asymptotic Least Squares.[15] Meanwhile, Griffith et al. (2006) assume that there are no feedback effects and solve the model sequentially,

14 The innovation survey does not provide information on the number of patents, unless there has been a patent application, which is extremely limited and often applications are not granted. We have some information about the share of revenue associated to product innovation; however, some of the numbers are very large especially when the products are not newly introduced. For that reason we concentrated on using the usual dichotomous variables.

15 This implies solving the knowledge function, innovation equation, and productivity equation simultaneously by maximum likelihood.

instrumenting knowledge activities in the innovation equation, and innovation outcomes in the productivity equation, to avoid endogeneity.

The approach in this paper is closer to the one advocated by Griffith et al. (2006), and solves the model sequentially, although for robustness we also estimate the model using a similar method to the original CDM approach. There are however, two main assumptions that the paper follows when solving the model: (i) firms first determine the intensity of input choices; and (ii) choices about the different types of innovation outcomes (product, process, or organization) are made simultaneously.

The detailed methodology is described in Appendix 3. The following sections present the results of estimating the three innovation components sequentially. First, we focus on understanding the determinants of investing in knowledge inputs and their intensity, proxied by R&D per worker and by the total spent on R&D, training, and equipment for innovation by worker. Second, we focus on understanding the determinants of product, process, and organization innovation, and the role of knowledge inputs in the probability of introducing either type of innovation. Finally, we measure the impact of innovation on productivity, and then on employment.

Table 4 contains the definition of the variables used in the analysis. To understand the determinants of knowledge input intensity, we focus on three sets of variables. First, we examine the characteristics of firms, for instance, size, age, and the existence of

TABLE 4 VARIABLE DESCRIPTION

	Variables	Description
	Knowledge intensity	
a	R&D intensity	Intramural and extramural R&D expenditure per worker.
b	Research intensity	Sum of R&D, equipment and training expenditure per worker.
	Innovation outcomes	
c	Product innovation	Dummy with value 1 if any new or significantly improved product or service introduced by this establishment.
d	Process innovation	Dummy with value 1 if any new or significantly improved process introduced by this establishment.
e	Organization innovation	Dummy with value 1 if establishment make any changes in its organizational structure by creating, dissolving or merging any units of departments.
	Productivity	
f	Sales per worker	Logarithm of sales per worker.
g	VA per worker	Logarithm of value added per worker.
	Enabling environment	
h	Lack of finance	How Much Of An Obstacle is Access To Finance. Index 0: not an obstacle to 4: very severe obstacle.
i	Trade costs-obstacles	This is the principal component of two indices how much of an obstacle is transport and customs and trade regimes. Index 0: not an obstacle to 4: very severe obstacle.
j	Telecommunications obstacles	How Much Of An Obstacle is Telecommunications. Index 0: not an obstacle to 4: very severe obstacle.
k	Government obstacles	This is the principal component of five government obstacle indices. How much of an obstacle is tax rates, tax administration, business licensing and permits, political instability and corruption. Index 0: not an obstacle to 4: very severe obstacle.
l	Education obstacle	How Much Of An Obstacle is inadequately educated labor force. Index 0: not an obstacle to 4: very severe obstacle.
	Demand pull	
m	Two-way traders	Firms that are exporters and importers.
n	Demand (-)	Firms that report that demand either at home or abroad has decreased.
o	Share(t-3)	Markets share three years ago.
	Firm characteristics	
p	Log(K/L)	Capital intensity defined as the log of the ratio of capital to labor in the firm.
q	Log (lab)	Log of employment.
r	Foreign	Whether the firm is at least 25% foreign owned.
s	Age	Age of the firm.
t	Medium	Whether the firm has between 50-99 workers.
u	Large	More than 99 workers.

foreign capital ownership. Second, as in Crepon et al. (1998), we use the importance of demand factors in incentivizing investments in innovation inputs. This is measured in three dimensions: (i) the firm's market share at the beginning of the period; (ii) whether firms are facing a reduction in their demand, and; (iii) the degree of integration in international markets, measured by a dummy with value one if the firm exports and imports (two-way traders). Third, we introduce the impact of various investment climate measures to understand how these affect knowledge investments. Specifically, we look at: lack of finance; trade costs-obstacles; telecommunications obstacles; and various government regulation obstacles. We also follow the literature to determine: which variables are used to explain the different innovation outcomes; to decide on the degree of capital intensity of the firm as the capital per worker ratio; the quality of human capital using the degree to which firms perceive the absence of an adequately educated labor force as an obstacle; the size of the firm; and the intensity of the knowledge investments.

In what follows, we summarize the main findings of the estimations. The detailed econometric description can be found in Appendix 4.

5.2 THE DETERMINANTS OF INVESTING IN KNOWLEDGE INPUTS

Table A4.1 in Appendix 4 shows the estimates of the knowledge function.

International competition, pressure for diversification, and access to finance appear to be the main determinants of R&D intensity

Two-way traders and firms that face shrinking demand domestically or internationally have larger R&D intensity. Firms that feel greater financial constraints will invest less in knowledge inputs. This suggests that international competition and pressure for diversification are important predictors of R&D intensity, while access to finance is likely to be an important inhibitor of these investments. Interestingly, firms with foreign ownership tend to invest less in R&D, while, in line with some of the literature, size does not appear to be a consideration. Finally, neither market power nor the obstacles explored—telecommunications, trade, or government obstacles—seem to have an impact on knowledge capital investment intensity. This emphasizes the role of external demand factors in explaining R&D intensity.

Demand factors also explain the intensity of investments in knowledge activities

Applying a broader measure of knowledge capital investments, including equipment and training, yields very similar results to the ones on R&D, albeit with two differences. Lack of finance does not have a significant role in explaining knowledge intensity investments when the definition is expanded and so it appears less binding after machinery, equipment and training are included. Second, foreign owned firms appear to invest more in knowledge inputs when considering machinery, equipment and training, which is likely the result of the fact that they carry out R&D abroad or in related firms.

Foreign firms appear to invest less in R&D but more on overall research activities

Foreign owned firms appear to invest more in knowledge inputs when considering machinery, equipment, and training, which is likely the result of the fact that they carry out R&D abroad or in related firms.

In the case of R&D, the only variables that appear to explain the decision to invest are: a decreasing domestic or international demand; larger market share at the beginning of the period in 2008 (t-3); the perception of greater incidence of government obstacles; and obstacles regarding access to finance. Firms that claim to be more finance constrained are less likely to engage in R&D, while firms that have larger sector market shares and greater incentive to diversify due to contracting demand, are more likely to implement R&D.

Finally, the results of the expanded decision to invest in knowledge activities in general show large heterogeneity when trying to explain the investment decision. Larger firms and two-way traders are more likely to engage in these knowledge investments.

5.3 THE INNOVATION FUNCTION

As suggested above, although firms invest in knowledge, there is uncertainty as to whether these investments will result in specific innovations. Therefore, the second stage of understanding the relationship between innovation and performance is to determine the role that knowledge capital investments play in producing innovation outcomes (Table A4.2 in Appendix 4).

Managers introduce innovations to diversify and upgrade products rather than replace them

It is important to start by analyzing the subjective reasons to innovate, as stated in the survey by the firms' managers. Figure 10 shows the main reasons for product (panel (a)) and process (panel (b)) innovation. For product innovations, the main reasons given are to diversify existing products via increasing market share or improving their quality, rather than replace existing products. For process innovations, the main reasons are very much related to increasing the quality attributes of the product and production processes.

Innovators are more likely to invest in knowledge inputs

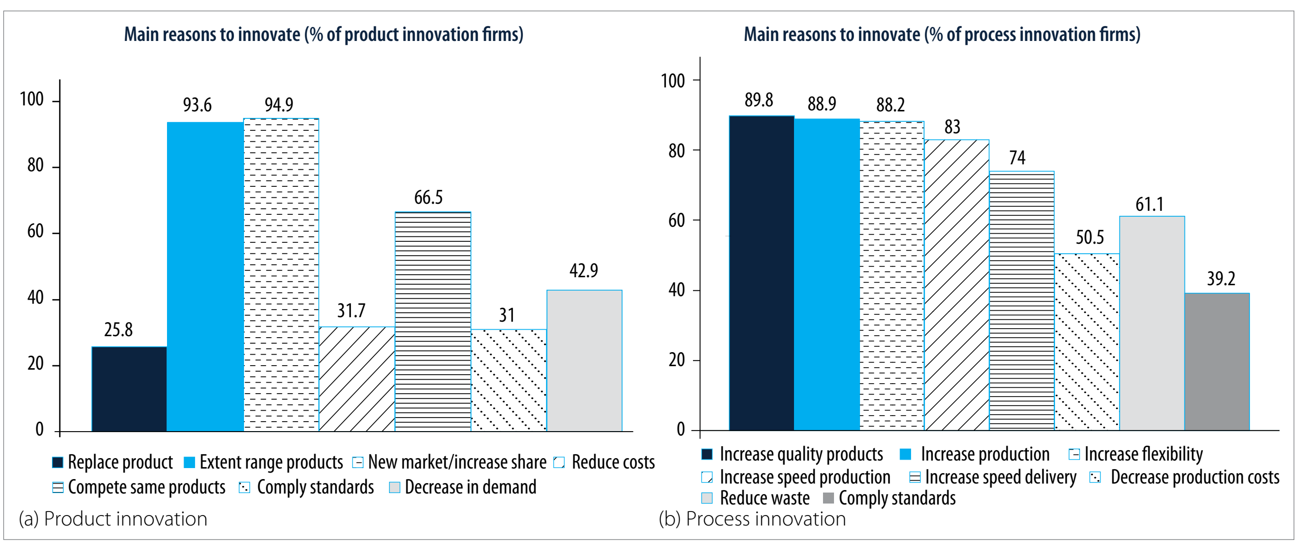
Given these reasons for innovation, a key question is to what extent firms invest in R&D, equipment, and training in order to increase these quality attributes. Table A4.2 shows that in Kenya, the percentage of product, process, and/or organization innovators is larger in firms that have some investment in R&D or in research in general, than firms that do not have any investments. However, a significant number of firms still carry out innovations without any knowledge capital investments stated. For example, 24.4 percent of firms not performing knowledge capital investments are product or process innovators. For these firms, the results raise questions about the degree to which some of these innovations surpass very simple imitation when there are no investments in knowledge capabilities to develop them.

TABLE 6 PERCENTAGE OF FIRMS ENGAGING IN KNOWLEDGE CAPITAL INVESTMENTS BY INNOVATOR GROUP

	Product innovators	Process innovators	Organization innovators	Product/process innovators	Number of firms
No R&D	31.58%	29.50%	28.81%	45.25%	400
R&D	75.71%	64.08%	34.02%	87.14%	142
No knowledge inputs[a]	18.06%	11.57%	18.75%	24.07%	216
At least one knowledge input[a]	56.52%	56.19%	39.44%	75.96%	210
All knowledge inputs[a]	76.47%	62.86%	42.86%	85.29%	70

Source: Author's own elaboration from the Enterprise Surveys[a] R&D, training and equipment

FIGURE 10 REASONS TO INTRODUCE PRODUCT INNOVATIONS



Source: ibid

But a few firms with significant knowledge investment intensity do not innovate

Figure 11 shows the cumulative distribution function of the intensity of knowledge capital investments. Both graphs show that the distribution of knowledge capital investments for innovators does not dominate non-innovators, which implies that some non-innovators have greater knowledge capital investments than similar innovators, and therefore, suggests that knowledge capital investments do not always imply innovation outcomes.

In order to better measure the impact of knowledge capital investments on innovation, we estimate the probability of introducing an innovation (see table A4.2 in Appendix 4). Below, we summarize the main findings of the estimations.

Knowledge investments do not appear to impact the probability of innovating significantly

Knowledge capital investments do not appear to impact the probability of introducing innovations; we find a negative sign only in association with R&D and organizational innovation.

Product and process innovation decisions are highly correlated

Estimates show a negative and statistically significant correlation between the two equations, which suggest simultaneity between product and process innovation decisions and the need to control for this correlation by estimating both equations simultaneously.

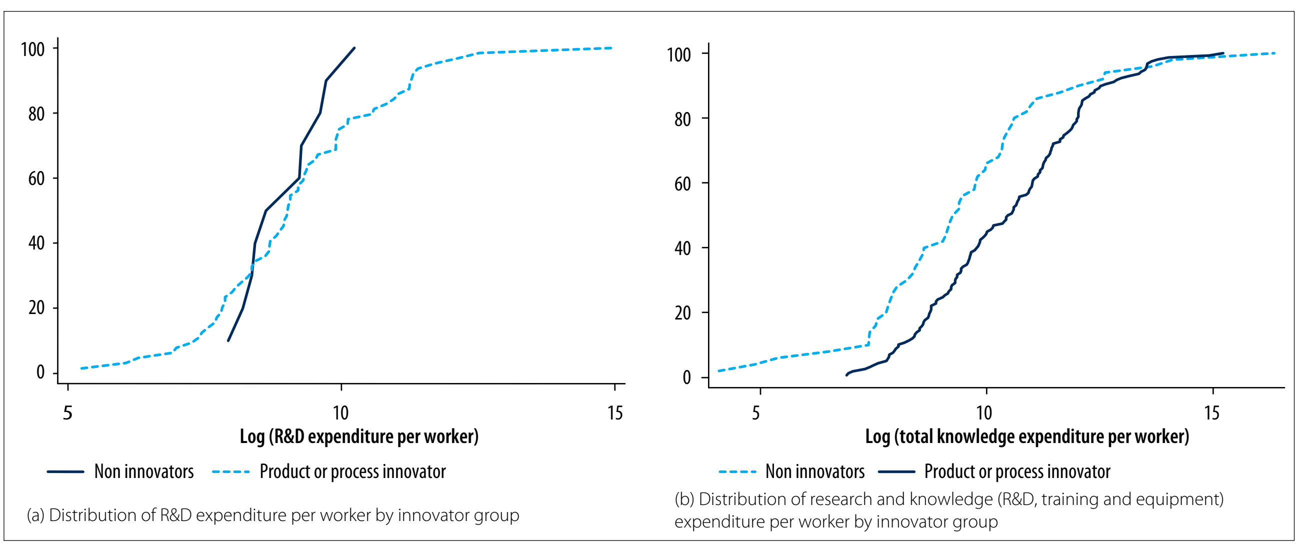
Larger and more capital intensive firms are more likely to innovate, and lack of an adequately educated work force is a major deterrent

The estimates indicate there is a greater likelihood of firms that are more capital-intensive introducing product or process innovations. Larger firms are more likely to introduce product innovations, while firms with a larger perceived obstacle in the form of educational levels of the labor force, are less likely to introduce process innovations. The most surprising result is the fact that as with the non-instrumented results, investment in knowledge activities, both R&D and broad knowledge inputs, is not statistically significant in increasing the probability of product and process innovation.

Organizational innovation decisions do not appear to be taken jointly with product or process innovations

When organizational innovation is introduced, the decision to introduce product and process innovations are still correlated, but the correlations with the residuals of the organizational innovation equation are not statistically significant. This suggests that organizational innovation decisions are taken independently of product and process innovations. The results again suggest the importance of large firms and capital intensity, although only for product innovation, and that the educational levels of the labor force can act as an obstacle for both product and process innovation. Medium sized firms appear to be more likely to implement organizational innovations. Again, we do not find evidence that investments in knowledge capital are statistically significant in

FIGURE 11 CUMULATIVE DISTRIBUTION FUNCTIONS OF KNOWLEDGE CAPITAL INVESTMENTS BY INNOVATOR GROUP



Source: Author's own elaboration from Enterprise survey (2014) affecting the probability of innovation. The exception is a marginally significant coefficient of R&D on organization innovation.

Kenyan firms' investments in knowledge and acquisition of capabilities do not necessarily translate into firm-level innovations

Overall, the results of the innovation equation suggest that Kenyan firms' investments in knowledge and acquisition of capabilities in the form of R&D, equipment, and training, do not necessarily translate into firm-level innovations. This result is unsurprising for R&D, since it is likely that the type of small incremental innovations do not require significant acquisition of capabilities through R&D. However, it is more surprising for total knowledge capital investments, since even imitations tend to require some form of acquisition of machinery and training of workers.

5.4 INNOVATION AND PRODUCTIVITY

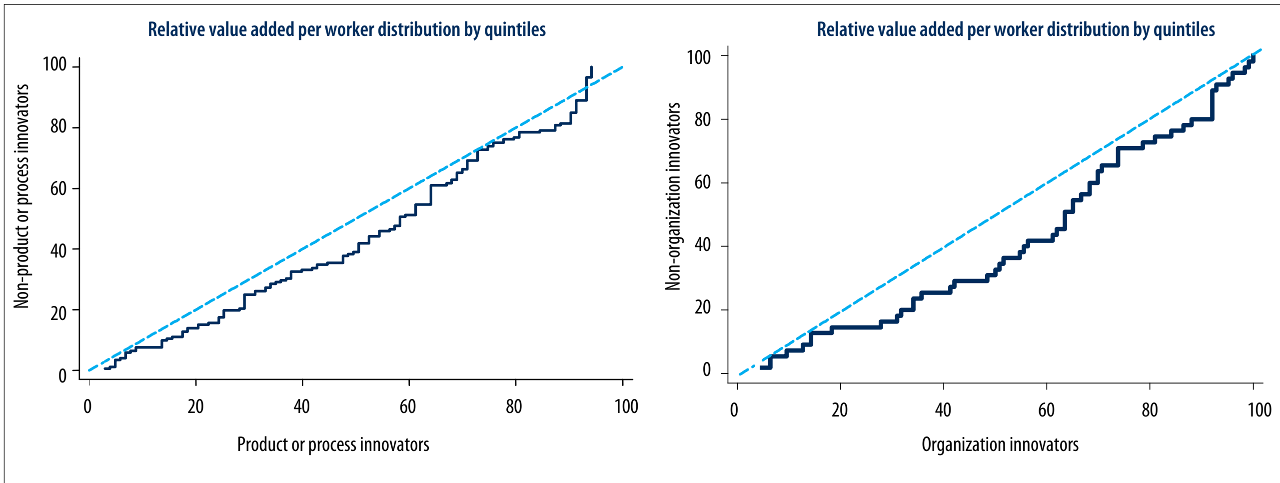
The final stage in determining the impact of innovation on performance is to estimate the productivity equation. For productivity measures, we use two proxies of labor productivity: the logarithm of sales per worker, and the logarithm of value added per worker. Although value added per worker is a better measure of labor productivity, the existence of missing observations for material inputs in some firms significantly reduces the sample when using this variable.

One important element to consider is the potential endogeneity of innovation outcomes to productivity, since firms that are more productive are potentially more likely to carry out innovations. The lack of panel structure in the dataset does not allow the inclusion of firm-level fixed effects that could attenuate part of this endogeneity problem.

Innovators tend to be more productive than non-innovators, although not for all productivity levels

Figure 12 shows the relative distribution of value added per worker for both innovators and non-innovators. The diagonal of the graph marks the points at which the distribution would be equal for both groups at each percentile; therefore, any points below the diagonal suggest larger labor productivity levels for innovators. In the case of product and process innovators, panel (a), innovators tend to be more productive except in the lower and especially, in the larger quintiles. The picture for organizational innovators, panel (b), is also similar. Therefore, although the productivity distribution of innovators does not completely stochastically dominate non-innovators, productivity levels are higher for innovators at most quintiles. This could be the result of innovations increasing productivity, as well as more productive firms becoming innovators.[16]

FIGURE 12 RELATIVE CUMULATIVE DISTRIBUTION FUNCTIONS–INNOVATORS AND NON-INNOVATORS



(a) Product and process innovators

(b) Organization innovators

Source: Author's own elaboration from Enterprise survey (2014)

16 As a result, the empirical analysis should control for this potential reverse causality between innovation and productivity, by either instrumenting innovation or estimating the innovation and productivity equation simultaneously.

Innovation outcomes do not have a statistically significant impact on productivity

The main result that emerges from the estimates is that innovation is not statistically significant in increasing productivity for our sample of Kenyan firms, with or without instrumenting. Only capital intensity appears to be statistically significant in the sales per worker specifications using R&D to predict innovation.

We cannot find evidence of positive complementarities between types of innovation

Also, we introduce interactive innovation dummies to capture complementarities between different types of innovation. However, the coefficients are not statistically significant.

As proposed in the previous section, as a robustness test we estimate stage 2 and stage 3 simultaneously as a system of equations by maximum likelihood and allowing for correlations in the innovation decisions. Table A4.6 in the Appendix shows the results for sales per worker. The results confirm the lack of statistically significant impact of innovation on productivity.

One needs to interpret these results with caution, given the low number of observations and the lack of panel structure of the dataset. Overall the main result of the estimates is that firm level productivity appears to be largely unexplained and there is no statistically significant impact of innovation on productivity. This is at odds with most of the evidence in OECD countries summarized in Hall (2011), but it is consistent with some evidence in other developing countries such as Tanzania (Goedhuys et al., 2008). It suggests that the capacity to transform innovation outcomes into increases in productivity in these countries is much lower due to more incremental and survival type of innovation.

5.5 INNOVATION AND EMPLOYMENT

A final important element to analyze when looking at the impact of innovation on performance is employment. As suggested above, most of the evidence regarding the impact of innovation on employment in OECD countries suggests that: (i) although process innovation can have a negative effect on firm level employment, the positive impact of product innovation more than offsets this potential negative effect, which makes the overall effect positive; and, (ii) innovation is skill-biased and tends to increase the demand for skilled labor relatively more than the demand for unskilled labor.

We know very little about the employment dynamics associated with innovation in developing countries. Therefore, it is important to analyze the impact of innovation on employment in these countries. This is particularly important in Kenya, given the need for the country to absorb the large number of people entering the labor market every year.

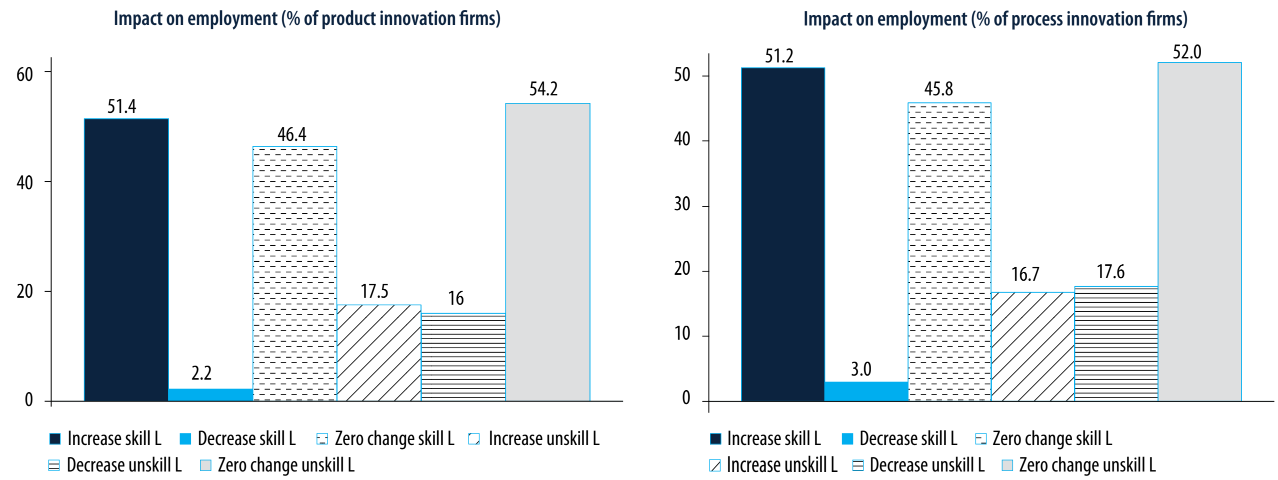
Before starting the analysis it is important to stress that the overall impact of innovation on employment cannot be measured only by using firm-level data. Firm-level surveys allow the capture of direct impacts of innovation on the employment levels in the firm. However, there are other general equilibrium effects of innovation on employment, such as potentially changing markets shares, competition, and prices that affect the demand for labor and that can be very difficult to identify and quantify.

The ES survey allows the exploration of the hypothesis of skill-biased labor growth based on the responses from firm managers to questions about the impact of innovation. Specifically, for product and process innovations, the questionnaire asks about the impact each innovation type has had on skilled and unskilled workers. One caveat for the analysis is that the respondents only report whether employment has increased or decreased, rather than the numbers of workers, so we cannot precisely gauge the total level of employment generated or destroyed as a result of the innovation.

Changes in labor associated to product and process innovation are remarkably similar

The results are summarized in Figure 13. The first three bars represent the share among innovators in relation to changes in skilled workers associated with the particular innovation, and the last three bars are related to unskilled labor. The percentages are remarkably similar when comparing labor changes associated with product and process innovations.

FIGURE 13 THE IMPACT OF INNOVATION ON SKILLED/UNSKILLED EMPLOYMENT



(a) Product innovation

(b) Process innovation

Source: Enterprise survey (2014)

Innovation increases skilled labor

Starting with product innovations, half of product innovators (51.4 percent) increased the number of skilled workers, while only 2.2 percent reduced the number of skilled workers, and 46.4 percent did not change skilled labor.

The impact of innovation on unskilled labor is small in size and uncertain in sign

Regarding unskilled labor, 17.5 percent of product innovators increased the number of unskilled workers, while 16 percent decreased the number, and 54.5 percent did not change unskilled employment. The percentages for process innovation are very similar; with perhaps slightly more firms showing a decrease inthe number of unskilled workers (17.7 percent) as a result of process innovation.

Although it is not possible to know the precise number of workers, if we assume relatively similar size in the variation in increases or decreases of employment, the results suggest three important findings: (i) the numbers of skilled labor seems to increase as a result of innovation; (ii) the numbers of unskilled labor appear to remain the same for product innovation and perhaps decrease for process innovation; and (iii) there is clear skill-bias arising from innovation in the demand for employment.

To further understand the potential differentiated impact on employment of both product and process innovation, we focus the analysis on those firms that introduced both types of innovation during the period and examine what happened to net employment. Although this group represents 25.14 percent of firms in the innovation survey, it allows us to compare the impacts of product and process innovations simultaneously.

Table 12 tabulates the number of firms introducing both product and process innovations, and the impact on skilled workers (upper part of the tables) and unskilled workers (middle part of the table). The cells in yellow denote firms where there has been an increase in employees, either because the effects of product and process innovations are positive at least in one case or because they remained the same in the other case. The orange cells indicate where there has been no impact on employment, according to the manager. Finally the cells in red indicate firms where employment levels have decreased. Firms where there are increases in one type of innovation and decreases in another are classified as uncertain. The last column summarizes the net impact on employment.

TABLE 12 DISTRIBUTION OF CHANGES IN SKILLED AND UNSKILLED EMPLOYMENT FOR PRODUCT AND PROCESS INNOVATORS (NUMBER OF FIRMS)

Skilled workers				
As a result of product/process innovation	**Increased**	**Remained the same**	**Decreased**	**Net impact (% of firms)**
Increased	69	7	1	61.59%
Remained the same	9	46	1	33.33%
Decreased	0	3	2	4.35%
Uncertain effect				0.72%
Unskilled workers				
As a result of product /process innovation	**Increased**	**Remained the same**	**Decreased**	**Net impact (% of firms)**
Increased	25	3	7	25.00%
Remained the same	2	58	3	48.33%
Decreased	0	4	18	20.83%
Uncertain effect				5.83%
All skilled and unskilled workers				**Net impact (% of firms)**
Increased				37.68%
Remained the same				21.74%
Decreased				6.52%
Uncertain effect				34.06%

Source: Author's own elaboration from Enterprise survey (2014)

The positive impact of innovation on skilled labor is significant for highly innovative firms, and those that do product and process innovation, but is small for unskilled labor

The impact on skilled workers is largely positive, and only in 4.35 percent of firms has there been an unambiguously negative impact on skilled workers. Although we do not know the size of this employment reduction it is unlikely that the decrease in 4.35 percent of firms is larger than the increase in 61.6 percent of firms. Therefore it is plausible to conclude that innovation increases skilled employment for product and process innovators.

Looking at unskilled labor changes, the pattern changes somehow. Employment stays the same for most firms and the percentage of firms where unskilled labor increased and decreased is similar at 25 percent vs. 20.6 percent. Assuming similar trends in the increases and decreases would imply a slight increase in unskilled employment associated with innovation, but this is not comparable to the positive change in skilled labor.

Finally at the bottom of the table we add the impacts on skilled and unskilled workers. The 'uncertain effect' category is much larger now (34.1 percent), and this is likely due to the fact that firms show a simultaneous increase and decrease in labor, when examining skilled and unskilled labor changes, for both product and process innovations. Most firms (37.7 percent) experience an increase in net employment, while in 21.7 percent of cases, employment levels remained the same, and in 6.5 percent of cases, firms experienced an unambiguous negative reduction in employment. Unless the firms in the uncertain effect category experienced a large employment reduction, it is likely that the net impact of product and process innovations on employment is positive.

In Table A4.7 in the Appendix, we try to estimate econometrically the impact of innovation on total full time employment. The estimates, however, are not statistically significant. This is due to several reasons. First, it is possible that unaccounted factors, such as large demand shocks, impact the results, as the period of analysis in part falls under a recession. Second, the dependent variable is the growth in permanent workers, and it is possible that adjustments in employment may occur with other types of labor such as temporary or family workers. Finally, it is also possible that innovation affects employment levels in the year of their inception, rather than over the whole period.

Overall, likely positive impact of innovation on direct employment, although skilled-bias

Overall, and although the data does not permit conclusions regarding the impact of innovations on total employment, the information reported suggests that innovation is likely to have a positive impact on employment creation. While there is a clear increase in the demand for skilled labor resulting from product and process innovations, the impact on unskilled labor is more uncertain, although likely to be positive. Innovation appears to bias the relative demand for skilled labor. Also, contrary to some of the findings in the literature, there is little distinction between product and process innovation.

SECTION SIX

CONCLUSIONS AND POLICY IMPLICATIONS

Accelerating the process of economic development in Kenya and achieving the ambitious targets laid out in the Plan 2030 will require a substantial increase in firm-level productivity. Central to the attainment of this goal is increasing knowledge capital investments and innovation activity. This paper has provided a snapshot of the degree of firm-level innovation in Kenya as well as its links to economic performance for the period 2009-2012 with a view to better measure how Kenyan firms in the manufacturing and services sectors can contribute to achieve this objective.

Although the absence of panel structure in the dataset and the small sample do not facilitate the estimation of very robust statistical effects, the paper provides some important findings. The main conclusion of the paper is that firm-level innovation activity in Kenya appears to be high and even larger than in similar countries, but the extent of innovativeness is low or very incremental. While it is expected that innovations in countries far from the technology frontier are not radical innovations, the question is to what extent these incremental innovations contribute to productivity growth as compared to innovations in OECD countries. The answer that we find in the empirical analysis is that the innovations do not have a statistically significant impact on productivity. Therefore, the positive causal chain whereby knowledge inputs are translated into innovation outcomes, and then into productivity, breaks down in the case of Kenyan firms. This suggests that in contrast with OECD countries, some of the innovations implemented are so minor, or are based on imitation, to the extent that they do not have a significant impact on productivity (survival innovation).Although, similar results have been found in other developing countries, more research is needed to better understand the nature of this incremental innovation.

It is difficult to identify the main obstacle that hinders a positive linkage to productivity, but the empirical analysis in the paper has some important suggestions. First, innovation outcomes in Kenya are more common than in other countries with similar GDP per capita, but investments in knowledge inputs are similar to that of other countries. This suggests a mismatch in relative terms between inputs and outcomes, and the need for greater investment in knowledge inputs in order to make innovation outcomes more innovative and transformational. Second, and related to the first point, the empirical analysis suggests that a lack of access to finance significantly holds back investment in R&D. Third, there is an over reliance by Kenyan firms, at least when comparing them to other countries, on internal sources for knowledge capital investments and innovation sources, which may indicate the absence of a solid research and knowledge infrastructure, as well as a lack of cooperation with other firms and institutions. Forth, the inadequate educational levels of the labor force affects the capacity of firms to transform knowledge inputs into innovation outcomes, which reinforces the complementary role of skilled labor for innovation, and the need to support appropriate technical skillsets in the labor force.

Regarding the impact of innovation on employment, the analysis of the qualitative information regarding labor changes associated with innovations suggests the likelihood that innovation activities have increased employment levels. However, the results differ significantly between skilled and unskilled workers. While there is a clear increase in the demand for skilled labor resulting from product and process innovations, the impact on unskilled labor is likely to be positive, but less so and more uncertain. This suggests that the increases in the demand for labor associated to innovation are skilled bias.

In terms of policy implications, these results suggest three levels to which innovation policy should be focused.

At the firm level it is important to:

- Enhance the capacity to convert innovation outcomes into productivity gains. Information failures and asymmetries where firms lack resources and understanding to gather the required information, resources and know how to innovate, increase the uncertainty to innovate due to potential failure and also affect the quality of innovations. This is exacerbated by coordination failures where the individual costs of improvements are very high, especially for SMEs since the supply of services is insufficient and tends to target large firms. This requires support programs that target productivity and innovation by improving firms' information, capabilities and management skills. Technology extension services can address these market failures and help to realize improved organizational, managerial, and technological changes. These services provide information on managerial and production practices and how to adopt them, in order to increase productivity and competitiveness.
- Enhance R&D financing and cooperation among firms and academic institutions
    - o In the presence of financial failures to fund innovation, R&D support is likely to be required to boost knowledge investments. The international experience suggests that gradual partial subsidies to high quality projects are more effective than indirect support by tax exemptions. Supporting these high quality projects, in conjunction with firms and university projects (see below) can have a positive impact on the amount and quality of R&D.
    - o Support should be provided to enhance cooperation between firms, encourage private sector-university linkages and remove coordination failures by providing subsidies to high quality innovation projects that involve several firms and/or firms and academic institutions.

At the sector level it is imperative to:

- Improve the quality of the physical and human capital infrastructure for innovation, including research labs, as a means of improving the availability and quality of innovation services for firms.
- Enhance the supply of skilled labor, especially in areas such as STEMS, which are highly complementary to the introduction of innovations.

At the institutional level, and given the current institutional vacuum regarding innovation policy, it is critical to finalize and implement the projected institutional framework in the Science, Technology and Innovation Act of 2013. This would help to better coordinate and design instruments, effectively diagnose and evaluate policies, and incentivize dialogue with the private sector.

This report is one of the first empirical analyses to our knowledge that has examined innovation activity at the firm level, and its impact on firm performance in Kenya. We hope that the recent release of the innovation module of the enterprise survey and the upcoming release of the second wave of the second national innovation survey by the Ministry of Education Science and Technology will expand research in this area and enable the tracking of firms' innovation behavior over time to better understand the contribution of innovation to productivity growth and shared prosperity.

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APPENDIX 1. MEASURING INTANGIBLE ASSETS

The CHS framework for measuring intangible assets

CHS (2005, 2009) classify firm spending on intangibles into three main categories: computerized information; innovative (scientific and creative) property; and economic competencies. They include the following sub-categories:

1. Computerized information
    - Computer software: own use, purchased, and customized software
    - Computerized databases

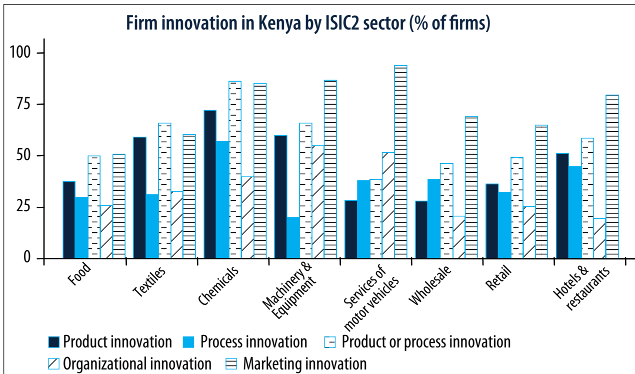
2. Scientific and creative property
    - Research and Development (R&D) in science and technology (spending for the development of new products and production processes, usually leading to a patent or license)
    - Mineral exploration (spending for the acquisition of new reserves)
    - Copyright and license costs (spending for the development of entertainment and artistic originals, usually leading to a copyright or license); and development costs in the motion picture, radio and television, sound recording, and book publishing industries
    - Other product development, design, and research expenses (not necessarily leading to a patent or copyright), such as new product development costs in the financial services industry, new architectural and engineering designs, and R&D in the social sciences and humanities

3. Economic competencies
    - Brand equity (advertising expenditures and market research for the development of brands and trademarks)
    - Firm-specific human capital (spending on developing workforce skills; for example, on-the-job training and tuition payments for job-related education)
    - Organizational capital (costs of improvement in organizational structures).

Source: Corrado et al. (2005). See Dutz et al. (2012) for an application for the case of Brazil[17]

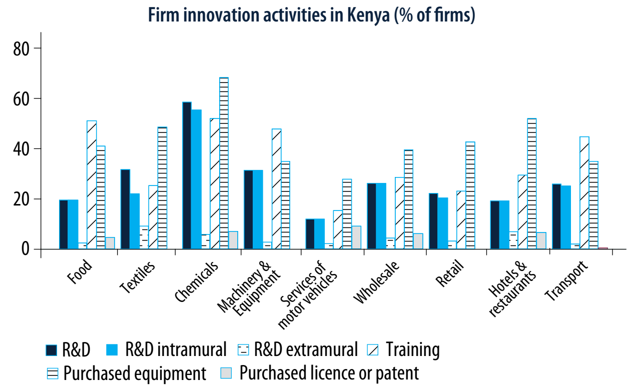
17 Corrado, Carol, Charles Hulten and Daniel Sichel (2005). Measuring Capital and Technology: An Expanded Framework, In Corrado, D., Haltiwanger, J. and Sichel D. (eds.), Measuring Capital in the New Economy, Studies in Income and Wealth. Vol 65, 11-45. Chicago: The University of Chicago Press.
Mark A. Dutz, Sérgio Kannebley Jr., Maira Scarpelli and Siddharth Sharma (2012) "Measuring Intangible Assets in an Emerging Market Economy. An Application to Brazil" World Bank Policy Research Working Paper 6142

APPENDIX 2. INNOVATION RESULTS BY ISIC 2 DIGITS

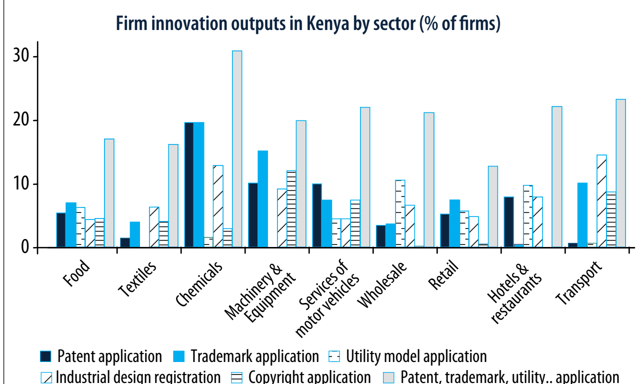


Note: Only sectors with at elast 20 firms in the sample

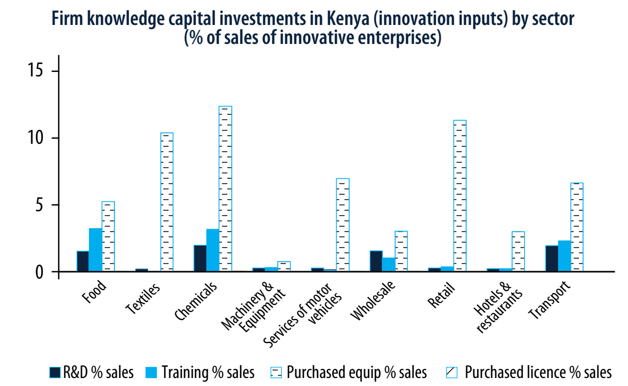
(a) Innovation outcomes by sector



(c) Innovation activities by sector



(b) Innovation outputs by sector



(d) Knowledge capital investments by sector

Source: ibid

APPENDIX 3. METHODOLOGY

The knowledge function

The first step of the model is to specify the choice of knowledge capital investment intensity. To this end, we extent the CDM model in two main directions. First, when measuring knowledge intensity, we also include other knowledge capital investments in addition to R&D, such as equipment and training for innovation (see table 4). Second and differently from Griffith et al. (2006), who only have data on R&D activities for innovators, the enterprise survey asks the question of knowledge activities to all firms. As a result, in our dataset zero research intensity is an important outcome of knowledge capital investments that we need to incorporate this to the model. Therefore, rather than using a generalized Tobit model, often implemented in CDM model, we use a generalized Poisson estimator in order to better cater for the number of zeroes in the data.

Specifically we estimate the following model

$$\ln\{E(k_i)\} = x_i\,\beta, k \sim Poisson \qquad \text{(I)}$$

Where k_i is knowledge intensity for firm i; x_i is a vector of determinants of knowledge intensity and β is a vector of estimated coefficients. We follow the literature on the determinants of knowledge activities in the Schumpeterian tradition and use as determinants variables to represent market share, diversification and demand conditions, and firm level characteristics such a size and technological opportunities. In order to avoid simultaneity between knowledge activities and market share we use firm's market share before the introduction of any innovation activities three years ago. For diversification and demand conditions we use whether domestic or external demand is decreasing for the firm and whether the firm is a two-way trader, exporter and importer. Technological opportunities are captured by ISIS 2 digits sector dummies. In addition, we control for firm size, age and whether the firm is foreign owned. Finally, and more importantly, we extend the model and introduce variables that represent the perceptions about the business environment for the firm. Specifically, we use indices reflecting firms' perceptions on how much of an obstacle lack of finance, trade costs, telecommunications and government policies and regulations are (see table 4 for the definition of the variables used).

The innovation function

The second step is to determine the innovation equation. One important element in the decision to innovate is that firms decide simultaneously what innovation outcomes to produce based on existing knowledge capital investments. As a result, one should expect some correlation between the decisions to carry out product and process innovations, and perhaps organizational innovations. In order to incorporate these correlations in the empirical estimation, we use a multivariate Probit framework, which allows us to estimate the decision to innovate in the different areas simultaneously and, therefore, correcting for potential correlation in these decisions.

Specifically, we estimate m Probit equations for the probability of innovate, where m equals 3 when considering the three types of innovation.

$$i^*_{im} = \beta'_m X_{im} + \varepsilon_{im}, m = 1,..3 \qquad (2)$$

Iim=1 if i*im>0 and 0 otherwise (3)

Where the log-likelihood function can be expressed as:

$$L = \sum_{i=1}^{n} w_i \log \Phi_3(\mu_i;\Omega)$$

$$\mu_i = (K_{i1}\beta_1^{'}X_{i1}, K_{i2}\beta_2^{'}X_{i2}, K_{i3}\beta_3^{'}X_{i3}) \tag{4}$$

And allowing for correlation in the errors across equations, matrix Ω elements are:

$$\begin{aligned} &\Omega_{kk} = 1, k = 1,..3 \\ &\Omega_{21} = \Omega_{12} = K_{i1}K_{i2}\rho_{21} \\ &\Omega_{31} = \Omega_{13} = K_{i3}K_{i3}\rho_{31} \\ &\Omega_{32} = \Omega_{23} = K_{i3}K_{i2}\rho_{32} \end{aligned} \tag{5}$$

The likelihood function depends on the multivariate standard normal distribution.[18]

As a determinant for the innovation equations we follow the literature and control for size and capital intensity, proxied by the ratio of capital to labor. One important input of the innovation function is the number of technical staff in the establishment that can facilitate the transformation of knowledge inputs into innovation outcomes. Given that the data on skilled labor is uncompleted we proxy skilled labor by an index of how much of an obstacle is inadequately labor force.

Finally, given the potential endogeneity of knowledge capital investments in the innovation outcomes, we use the predicted values from the Poisson process in the first stage in order to instrument knowledge activities, for both R&D intensity and total research intensity.

The productivity Equation

The final stage to estimate the impact of innovation on firm performance is to derive the productivity equation. We approximate productivity using a Cobb-Douglas function where sales (Y) are a function of capital (K), labor (L) and innovation outcomes (H).

$$Y = f(H, K, L)$$

$$Y_i = H_i K_i^{\alpha} L_i^{\beta}$$

$$\frac{Y_i}{L_i} = \frac{H_i K_i^{\alpha} L_i^{\beta}}{L_i} \frac{L_i^{\alpha}}{L_i^{\alpha}} \tag{6}$$

Transforming equation 6 in logarithm form and adding sector controls (Xi) we have:

$$\log(Y_i / L_i) = \delta_0 + \delta_1 \log(H_i) + \alpha \log(K / L_i) + (\beta + \alpha - 1)\log(L_i) + \delta_2 X_i + \varepsilon_i \tag{7}$$

Equation (7) can be estimated by OLS. However given the potential simultaneity between innovation outcomes and performance, we use the predicted values of the innovation outcomes as instruments and correct the standard errors by removing the mean squared error from the VCE of the second stage (Greene, 2012). Specifically we estimate by OLS the following equation:

$$\log(Y_i / L_i) = \delta_0 + \delta_1 \hat{\mathrm{Prod}}_i + \delta_2 \hat{\mathrm{Proc}}_i + \delta_3 \hat{organ}_i + \delta_4 \log(K / L_i) + \delta_5 \log(L_i) + \delta_2 X_i + \varepsilon_i \tag{8}$$

Robustness

The set of equations (1), (4) and (8) above are solved sequentially and instrumented at each stage following Griffith et al. (2006). This, however, assumes no major feedback effects from productivity to innovation and from innovation to knowledge capital investment. As a robustness test, we re-estimate the second and third stages, innovation functions and productivity, simultaneously by maximum likelihood and compare the results with the sequential method.

18 In order to solve the likelihood function we use the mvprobit command (Cappelari and Jenkins, 2003),.

APPENDIX 4. MAIN ECONOMETRIC RESULTS

A4.1 The determinants of investing in knowledge inputs

Table A4.1 shows the results of the first stage, the determinants of the intensity in knowledge capital investments. As shown in the methodology in Appendix 3, we use a Poisson estimator in order to account for the number of firms with zero investments. Columns (1) and (2) show the results for R&D intensity and research (sum of R&D, training and equipment) intensity.

Regarding R&D intensity (column 1), two-way traders and firms that face shrinking demand domestically or internationally have larger R&D intensity. Also, firms with greater perceptions of being financially constrained invest less on knowledge inputs. This suggests that international competition and pressure for diversification are important predictors of R&D intensity, while access to finance is likely to be an important inhibitor of these investments. Interestingly, firms with foreign ownership tend to invest less on R&D, while in line with some of the literature size does not appear to matter for these investments. Finally, neither market power position nor none of the obstacles explored; telecommunications, trade or government obstacles appear to have an impact on knowledge capital investments intensity. This emphasizes the role of external demand factors in explaining R&D intensity.

Looking in column (2) to a broader measure of knowledge capital investments, including equipment and training, yields very similar results to the ones on R&D, but with only two differences. First, lack of finance does not have a significant role explaining knowledge intensity investments when broadening the definition, so it appears less binding when including machinery, equipment and training. Second, foreign owned firms appear to invest more in knowledge inputs when considering machinery, equipment and training, which is likely the result of the fact that they carry out R&D abroad or in related firms.

Columns (3) and (4) estimate the same specifications for robustness as (1) and (2), but this time looking at the decision (not the intensity) to invest. Thus, we use a Probit model to estimate the probability that firms incur any R&D (3) or R&D, machinery, equipment and training (4) investments.

In the case of R&D, the only variables that appear to explain the decision to invest are having a decreasing domestic or international demand, larger market share at the beginning of the period in 2008(t-3), the perception of greater incidence of government obstacles and the perception of how important is access to finance as an obstacle. Firms that claim to be more finance constrained are less likely to engage in R&D, while firms that have larger sector market shares and that have more incentive to diversify due to contracting demand are more likely to implement R&D. The coefficient on government obstacles is, however, puzzling. Firms which perceive government regulations to be more of an obstacle are also more likely to engage in R&D, which could be explained by the potential endogeneity of these perceptions to firm performance.

Finally, the results for the expanded decision to invest in knowledge activities in general (column (4)) show large heterogeneity when trying to explain the investment decision, since our model only captures that larger firms and two-way traders are more likely to engage in these investments.

TABLE A4.1 KNOWLEDGE INTENSITY FUNCTION

	(1)	(2)	(3)	(4)
	R&D per worker[a]	Research[c] per worker[a]	R&D[b]	Research[b]
Two-way traders	2.2068***	1.6164***	-0.3313	0.6213*
	(0.5308)	(0.6021)	(0.2957)	(0.3506)
Demand (-)	1.1358**	0.6906**	0.4990**	0.3860
	(0.4602)	(0.2687)	(0.2168)	(0.2512)
Share(t-3)	0.0816	0.1294	0.1121**	-0.0300
	(0.1789)	(0.0822)	(0.0509)	(0.0509)
Lack finance	-1.0077***	-0.2799	-0.2169***	-0.0800
	(0.2323)	(0.2384)	(0.0839)	(0.1020)
Telecom_obstacle	0.1638	-0.1330	-0.0596	0.0611
	(0.1788)	(0.1375)	(0.0738)	(0.0770)
Government_obstacle	0.0519	-0.1024	0.2279***	0.1143
	(0.2125)	(0.1670)	(0.0833)	(0.0909)
Trade cost-obstacle	0.0741	0.2695	0.0706	-0.0382
	(0.1894)	(0.1703)	(0.0861)	(0.0928)
Foreign	-2.6251**	1.4251**	0.0153	0.2597
	(1.0939)	(0.6933)	(0.3457)	(0.4803)
Age	0.0223*	0.0056	0.0041	-0.0004
	(0.0124)	(0.0073)	(0.0058)	(0.0062)
Medium	-0.6479	0.3018	-0.1275	0.4967**
	(0.6092)	(0.4088)	(0.2450)	(0.2505)
Large	0.9423*	0.8550	-0.0415	1.0750***
	(0.5720)	(0.5436)	(0.3259)	(0.3833)
Constant	9.5586***	12.0140***	0.4488	-0.4120
	(1.0723)	(0.8891)	(0.5277)	(0.5885)
Observations	388	347	427	339
ISIC-2 digits dummies	YES	YES	YES	YES

*Robust standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1*
[a] *Poisson non-linear model estimator on the level of expenditure*
[b] *Probit model on the decision to invest on R&D or research and equipment*
[c] *Research and equipment defined as expenditure for knowledge activities including R&D, both intramural and extramural, training and equipment for innovation activities*

A4.2 The innovation function

In order to measure the impact of knowledge capital investments on innovation, we estimate the probability of introducing an innovation, equation (4) above. Table A4.2 shows different estimates of equation (4). The first six columns estimate individual Probit equations for product, process and organization innovations and using observed R&D and research and equipment intensity. Columns (7) to (10) show the bivariate Probit estimates allowing for correlation between product and process innovation decisions, and instrumenting knowledge intensity with the predicted values of the previous stage. Finally, columns (11) to (16) implement the multivariate framework to also include organization innovation.

In general the individual equations without instruments show very little predicted value of the model. Knowledge capital investments do not appear to impact the probability of introducing innovations; we only find a negative sign associated to R&D and organizational innovation. However, these estimates are likely to be biased given the potential endogeneity between knowledge capital investments and innovation outcomes.

In order to correct for this endogeneity we instrument knowledge intensity with the predicted values estimated in the previous stage. In addition, we allow for simultaneity in the decision to innovate for the different types of innovation allowing for correlation of the error terms. Estimates of equations (7) to (10) that consider only product and process innovation show a negative and statistically significant correlation between the two equations, which suggest simultaneity between product and process innovation decisions and the need to control for this correlation.

The estimates also indicate that firms that are more capital intensive are more likely to introduce product or process innovations. Larger firms are more likely to introduce product innovations, while firms with a larger perceived obstacle in education of the labor force are less likely to introduce process innovations. The most surprising result is fact that similarly to the non-instrumented results, investment in knowledge activities, both R&D and broad knowledge inputs, is not statistically significant in increasing the probability of product and process innovation.

Columns (11) to (16) replicate the estimations but add organizational innovation to the simultaneous equations. Adding organizational innovation implies a loss of observations since the organizational module was only implemented to firms considered medium and large in the sampling frame.[19] The decision to introduce product and process innovations are still correlated, but the correlations with the residuals of the organizational innovation equation are not statistically significant, which suggests that organizational innovation decisions are done independently from product and process innovations. The results again suggest the importance of large firms and capital intensity, although only for product innovation, and education of the labor force as an obstacle for both product and process innovation. Medium sized firms appear to be more likely to implement organizational innovations. Again, we do not find evidence that investments in knowledge capital are statistically significant in affecting the probability of innovation; with the exception of a marginally significant coefficient of R&D on organization innovation.

Overall, the results of the innovation equation suggest that in the case of Kenyan firms' investments in knowledge and acquisition of capabilities in the form of R&D, equipment and training do not necessarily translate into firm level innovations. This result is not surprising for R&D, since it is likely that the type of small incremental innovations do not require significant acquisition of capabilities via R&D; but is more surprising for total knowledge capital investments, since even imitations tend to require some degree of acquisition of machinery and training of workers.

19 In the sample, however, there are small firms that were asked about organizational changes due to the fact that some firms had de facto lower employment levels than previously thought in the sampling frame.

TABLE A4.2 INNOVATION FUNCTION

	Individual regressions						Bivariate probit				Multivariate probit					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
	product-R&D	process-R&D	organ-R&D	product-Research	process-Research	organ-Research	product-R&D	process-R&D	product-Research	process-Research	product-R&D	process-R&D	organ-R&D	product-Research	process-Research	organ-Research
Log(K/L)	0.1437*	0.1236	0.1786	0.1383	0.1121	0.1738	0.1351**	0.1980***	0.1321**	0.1975***	0.1358	0.1807**	0.0816	0.1324	0.1814**	0.0672
	(0.0723)	(0.0718)	(0.1024)	(0.0808)	(0.0792)	(0.1160)	(0.0657)	(0.0699)	(0.0661)	(0.0699)	(0.0880)	(0.0842)	(0.0992)	(0.0882)	(0.0837)	(0.0976)
Educ_ obstacle	-0.0880	-0.1749	-0.1228	-0.0685	-0.2012*	-0.2062	-0.1334	-0.1997**	-0.1369	-0.2022**	-0.2386**	-0.2609*	-0.1649	-0.2525**	-0.2699*	-0.1654
	(0.0940)	(0.0908)	(0.1385)	(0.1057)	(0.0962)	(0.1391)	(0.0944)	(0.0919)	(0.0947)	(0.0919)	(0.1214)	(0.1413)	(0.1436)	(0.1214)	(0.1413)	(0.1437)
Medium	0.3712	0.2479	0.7755*	0.2472	0.1163	1.1492**	0.3928	0.3602	0.3699	0.3462	0.6315	0.2404	0.6784*	0.6171	0.2332	0.6831*
	(0.2752)	(0.2750)	(0.3737)	(0.3012)	(0.2986)	(0.4084)	(0.2675)	(0.2810)	(0.2686)	(0.2824)	(0.3877)	(0.3656)	(0.4034)	(0.3887)	(0.3662)	(0.4043)
Large	0.3803	0.3601	0.5880	0.3044	0.1240	0.7848	0.8012***	0.5023	0.6935**	0.4402	0.9273**	0.4695	0.3097	0.8086*	0.4126	0.1556
	(0.2835)	(0.3342)	(0.3921)	(0.3283)	(0.3987)	(0.4310)	(0.3102)	(0.3119)	(0.3400)	(0.3324)	(0.4027)	(0.3633)	(0.4304)	(0.4234)	(0.3760)	(0.4510)
R&D	26.1994	15.4635	-0.7603***													
	(15.5818)	(9.8886)	(0.2255)													
Research				1.0240	1.5527	-0.1044										
							0.7096	0.7190			1.8906	0.7019*	-0.9608			
R&D_hat							(0.6728)	(0.5816)			(3.8043)	(0.3691)	(0.7062)			
									0.4642	0.2728				0.6017	0.2797	0.2271
Research_hat									(0.4044)	(0.2600)				(0.4537)	(0.2543)	(0.3050)
	-2.7184**	-2.3407*	-3.0864*	-2.5650*	-2.1681	-3.3033*	-2.3115**	-3.1834***	-2.2894**	-3.1851***	-2.5337**	-3.0001**	-1.5791	-2.5149**	-3.0222**	-1.4542
Constant	(1.0414)	(1.0311)	(1.4799)	(1.1521)	(1.1262)	(1.6471)	(0.9610)	(1.0255)	(0.9662)	(1.0269)	(1.2237)	(1.2226)	(1.4661)	(1.2326)	(1.2172)	(1.4447)
							0.6934***		0.6933***		0.6069***			0.6030***		
Rho21							(0.1720)		(0.1724)		(0.1880)			(0.1891)		
											0.2297			0.2146		
Rho31											(0.1829)			(0.1838)		
											-0.1977			-0.2124		
Rho32											(0.1827)			(0.1826)		
	241	243	154	207	204	130	254		254		171			171		
Observations	-769.1	-768.4	-455.4	-704.4	-681.8	-373.5										
Log-like	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
ISIC-2digits dummies																

*Robust standard errors in parentheses *** p<0.001, ** p<0.01, * p<0.05*

A4.3 Innovation and productivity

The final stage to determine the impact of innovation on performance is to estimate equation (8). As productivity measure, we use two proxies of labor productivity: the logarithm of sales per worker and the logarithm of value added per worker. Although value added per worker is a better measure of labor productivity, the existence of missing observations for material inputs in some firms reduces significantly the sample when using this variable. In order to control for potential endogeneity of innovation decisions to firm performance when trying to estimate causality in equation (8), we instrument the different type of innovations using the predicted values of the multivariate framework described in the previous section and correct the standard errors of the regression as proposed in Greene (2012). Table A4.3 shows the results of the OLS estimates without instrumenting for comparison and Table A4.4 shows the instrumental variables estimates using the logarithm of sales per workers. Columns (1) to (4) in Table A4.4 show the results when using R&D intensity as knowledge input to predict innovation, while columns (4) to (8) uses the instruments of innovation estimated using research, training and equipment for innovation intensity to explain innovation.

The main result that emerges from the table is that innovation is not statistically significant in increasing productivity for our sample of Kenyan firms, with or without instrumenting. Only column (6) in table A4.3 show statistically significant signs for a positive impact innovation on value added per worker. However, these results are likely to be biased given the endogeneity problems discussed above. When we introduce instruments and correct the standard errors in Tables A4.4 and Table A4.5, these increase significantly and only capital intensity appear to be statistically significant in the sales per worker specifications using R&D to predict innovation.

Also, we introduce interactive innovation dummies to capture complementarities between different types of innovation. However, the coefficients are not statistically significant.

As proposed in the previous section, as a robustness test we estimate stages 2 and stage 3 simultaneously as a system of equations by maximum likelihood and allowing for correlations in the innovation decisions. Table A4.6 shows the results for sales per worker. The results confirm the lack of statistically significant impact of innovation on productivity. One difference, however, is that when estimating the innovation equation and the productivity equation jointly, the knowledge intensity coefficients are statistically significant in explaining innovation outcomes. The estimates using research, equipment and training investment intensity also show a positive and statistically significant impact of knowledge capital investments on innovation outcomes, but no impact of innovation on productivity.

One needs to interpret these results with caution, given the low number of observations and the lack of panel structure of the dataset. However, overall, the main result of the estimates is that firm-level productivity appears to be largely unexplained and there is no statistically significant impact of innovation on productivity.

TABLE A4.3 PRODUCTIVITY EQUATION – NO INSTRUMENTS

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	sales per worker-R&D	sales per worker-R&D	sales per worker-R&D	sales per worker-R&D	sales per worker-Research	sales per worker-Research	sales per worker-Research	sales per worker-Research
Log(K/L)	0.3290***	0.3299***	0.4081***	0.4147***	0.1539	0.1472	0.2522**	0.2423**
	(0.1124)	(0.1133)	(0.1535)	(0.1509)	(0.1085)	(0.1014)	(0.1104)	(0.1107)
Log(L)	0.2131*	0.2103*	0.3482***	0.3809***	0.0631	-0.0036	0.3379**	0.2290
	(0.1130)	(0.1132)	(0.1256)	(0.1394)	(0.1437)	(0.1506)	(0.1300)	(0.1390)
Prod inno	0.2729	0.3556	0.1784	-0.2102	0.3462	1.4266**	0.0362	0.8901*
	(0.2802)	(0.4262)	(0.3766)	(0.5958)	(0.4203)	(0.6319)	(0.3755)	(0.4726)
Process_inno	0.2484	0.3284	0.0849	-0.4315	0.2331	1.2825***	0.4177	0.9011
	(0.2875)	(0.4270)	(0.3717)	(0.8309)	(0.4412)	(0.4416)	(0.3810)	(0.5822)
Organ inno			0.5323	0.3323			0.6470*	0.0092
			(0.3465)	(0.5003)			(0.3620)	(0.5011)
Prod*process		-0.1544		0.6262		-1.9904***		-1.5143**
		(0.6023)		(1.0476)		(0.7423)		(0.7623)
Prod*organ				-0.1423				0.7510
				(0.9476)				(0.7756)
Process*org				-0.0408				1.9237
				(1.3106)				(1.2475)
Prod*proc*org				0.7792				-2.0019
				(1.7080)				(1.4699)
Constant	9.2779***	9.2938***	7.6303***	7.4771***	11.4409***	11.9913***	8.6913***	9.6091***
	(1.6373)	(1.6468)	(2.0813)	(2.0726)	(1.4891)	(1.4357)	(1.6690)	(1.6858)
Observations	270	270	182	182	178	178	126	126
R-squared	0.2437	0.2441	0.3527	0.3586	0.1589	0.2238	0.4460	0.4829
ISIC-2 digits dummies	YES	YES	YES	YES	YES	YES	YES	YES

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

TABLE A4.4 PRODUCTIVITY EQUATION – INSTRUMENTED (SALES PER WORKER)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Sales per worker-R&D	Sales per worker-R&D	Sales per worker-R&D	Sales per worker-R&D	Sales per worker-Research	Sales per worker-Research	Sales per worker-Research	Sales per worker-Research
Log (K/L)	0.4328**	0.4196*	0.4349***	0.3794	0.4299**	0.4267	0.4292**	0.3902
	(0.1852)	(0.2426)	(0.1559)	(0.2958)	(0.2156)	(0.2726)	(0.1915)	(0.3579)
Log (L)	0.2120	0.1991	0.1902	-0.0219	0.1291	0.0921	0.0843	-0.1115
	(0.2586)	(0.3608)	(0.2301)	(0.5047)	(0.2971)	(0.3905)	(0.2949)	(0.6158)
Prod inno	2.2484	5.6757	2.8650	14.4861	3.5300	7.0117	4.7432	16.4024
	(3.3423)	(6.1733)	(3.1705)	(13.7158)	(3.6970)	(7.1267)	(4.0873)	(15.4963)
Process_inno	-2.8134	-1.1129	-3.0536	1.9590	-3.6382	-2.6428	-4.0233	2.1472
	(3.3593)	(4.9941)	(2.9182)	(8.7362)	(3.8614)	(5.2075)	(3.4685)	(10.0153)
Organ inno			-0.5815	7.4873		-4.9673		-18.1962
			(1.5020)	(16.8481)		(6.5904)		(16.6713)
Prod*process		-5.6822		-14.5134			-1.1916	8.8638
		(5.8074)		(13.6501)			(2.4414)	(19.9464)
Prod*organ				-19.5423				-22.5378
				(29.4896)				(33.4257)
Process*org				-20.1862				-24.1821
				(28.3072)				(32.3929)
Prod*proc*org				35.0909				44.9991
				(41.1207)				(47.3746)
Constant	7.7424***	7.0384*	7.8599***	6.0715	7.8743**	7.2271	8.1619***	5.7949
	(2.7880)	(3.8907)	(2.4044)	(5.4318)	(3.2472)	(4.3824)	(2.9935)	(6.6872)
Observations	255	255	255	255	255	255	255	255
R-squared	0.2698	0.2946	0.2704	0.3314	0.2742	0.2928	0.2760	0.3464
ISIC-2 digits dummies	YES	YES	YES	YES	YES	YES	YES	YES

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

TABLE A4.5 PRODUCTIVITY EQUATION – INSTRUMENTED (VALUE ADDED PER WORKER)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	va per worker-R&D	va per worker-R&D	va per worker-R&D	va per worker-R&D	va per worker-Research	va per worker-Research	va per worker-Research	va per worker-Research
Log (K/L)	0.1853	0.1881	0.1809	0.1719	0.1863	0.1844	0.1623	0.1611
	(0.2422)	(0.2284)	(0.2526)	(0.2296)	(0.2775)	(0.2610)	(0.3165)	(0.2815)
Log (L)	-0.1219	-0.1445	-0.2428	-0.2043	-0.1921	-0.1762	-0.3979	-0.3512
	(0.4389)	(0.4312)	(0.5192)	(0.5073)	(0.4939)	(0.4939)	(0.7267)	(0.7106)
Prod inno	4.0846	1.9006	6.7359	3.7043	5.1212	2.3905	9.4091	7.9512
	(6.1594)	(6.5831)	(7.7282)	(11.3843)	(6.4799)	(7.8157)	(10.0681)	(13.6423)
Process_inno	-3.8705	-5.6990	-5.0826	-3.7461	-4.7933	-5.8482	-6.2040	-4.8717
	(6.4531)	(7.0526)	(7.3639)	(8.8384)	(7.1312)	(7.2267)	(8.8627)	(10.6555)
Organ inno			-2.1091	-2.0674		4.4144		-0.5167
			(2.7269)	(13.7208)		(5.8644)		(12.7700)
Prod*process		4.5975		1.0111			-3.5725	-1.3169
		(5.0404)		(9.8612)			(5.2847)	(16.2605)
Prod*organ				3.1682				-2.3093
				(22.1971)				(24.3128)
Process*org				-5.5222				-5.6661
				(23.8885)				(27.4785)
Prod*proc*org				5.6589				8.7958
				(31.6299)				(36.5690)
Constant	11.5887***	12.3021***	12.2890***	12.6803***	11.7448***	12.3742***	13.0301***	12.7338**
	(3.2668)	(3.0843)	(3.4363)	(4.0388)	(3.7672)	(3.6001)	(4.4971)	(5.1224)
Observations	172	172	172	172	172	172	172	172
R-squared	0.1502	0.1660	0.1627	0.1759	0.1606	0.1744	0.1824	0.1900
ISIC-2 digits dummies	YES	YES	YES	YES	YES	YES	YES	YES

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

TABLE A4.6 STRUCTURAL MODELLING - INNOVATION AND PRODUCTIVITY

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	lsales_l	prod_inno	process_ inno	organ_ inno	lsales_l	prod_inno	process_ inno	organ_ inno
Log (K/L)	0.2195**	0.0229	0.0188	0.0328	0.2179**	0.0229	0.0188	0.0328
	(0.1016)	(0.0158)	(0.0168)	(0.0200)	(0.0989)	(0.0158)	(0.0168)	(0.0200)
Log (L)	0.0181				-0.0050			
	(0.1059)				(0.1112)			
Prod inno	0.3586				-0.2209			
	(0.3003)				(0.4726)			
Process_inno	0.2845				-0.0029			
	(0.2811)				(0.4821)			
Organ inno					0.8691			
					(0.7135)			
Prod*process	0.1809				0.1653			
	(0.2895)				(0.4793)			
Prod*organ					0.4386			
					(0.7345)			
Process*org					-0.6918			
					(1.1689)			
Prod*proc*org					0.3186			
					(1.4281)			
R&D_hat		0.1231**	0.1696***	-0.1626***		0.1231**	0.1696***	-0.1626***
		(0.0510)	(0.0484)	(0.0548)		(0.0510)	(0.0484)	(0.0548)
Education-obstacle		-0.0088	-0.0148	-0.0476		-0.0088	-0.0148	-0.0476
		(0.0233)	(0.0240)	(0.0297)		(0.0233)	(0.0240)	(0.0297)
Medium		0.1974***	0.1248*	0.1852*		0.1974***	0.1248*	0.1852*
		(0.0733)	(0.0721)	(0.0957)		(0.0733)	(0.0721)	(0.0957)
Large		0.2977***	0.2183***	0.1809*		0.2977***	0.2183***	0.1809*
		(0.0848)	(0.0845)	(0.1025)		(0.0848)	(0.0845)	(0.1025)
Constant	10.6130***	-0.0688	-0.0276	-0.2152	10.8843***	-0.0688	-0.0276	-0.2152
	(1.5121)	(0.2270)	(0.2430)	(0.2913)	(1.4613)	(0.2270)	(0.2430)	(0.2913)
Rho21		0.0796***				0.0796***		
		(0.0128)				(0.0128)		
Rho31		0.0158				0.0158		
		(0.0153)				(0.0153)		
Rho32		-0.0139				-0.0139		
		(0.0151)				(0.0151)		
Observations	255	255	255	255	255	255	255	255
ISIC-2 digits dummies	YES	YES	YES	YES	YES	YES	YES	YES

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

A4.4 Innovation and employment

As a further check for the impact of innovation on employment, we use the retrospective information in the survey on full-time employment and sales and estimate a model of employment growth. We follow Harrison et al. (2008) and decompose sales growth into the share linked to new products and the share linked to old products using the share of sales attributed to product innovation. We assume that this share accounts for the growth of the entire three years period and estimate equation (9) below, where the change in permanent employment is determined by: the growth in sales of old products and product innovation (new), process innovations; and a set of controls X that include region to control for labor market conditions, whether the firm is a two-way trader, the size of the firm, the age and sector dummies.

$$\Delta L_i = \alpha_0 + \alpha_1 old_i + \alpha_2 new_i + \alpha_3 process_i + \beta X_i + e_i \qquad (9)$$

Table A4.7 shows the OLS estimates of equation (9). We start estimating in column (1) the specification considering only sales growth and province and sector dummies. Surprisingly, we find that the coefficient on sales growth is not statistically significant affecting employment growth in the period. In columns (2) we add a specification with more controls: including firm characteristics such as ownership, trading status, age and size, in order to better capture the impact of sales growth. However, the coefficient is still not statically significant. Equations (3) and (4) apply the decomposition of sales growth between old and new products and also introduce process innovation, but the coefficients associated to innovations remain statistically not significant.

TABLE A4.7 EMPLOYMENT AND INNOVATION

	(1)	(2)	(3)	(4)
Sales growth	0.0018	0.0015		
	(0.0013)	(0.0012)		
Sales growth old products			0.0015	0.0009
			(0.0020)	(0.0019)
Sales growth new products			0.0013	0.0011
			(0.0027)	(0.0024)
Process_inno2			0.0504	0.0419
			(0.0453)	(0.0474)
Age		-0.0024**		-0.0035***
		(0.0010)		(0.0013)
Two_way traders		0.0356		0.0163
		(0.0679)		(0.0778)
Foreign		0.1326		0.1022
		(0.0834)		(0.0946)
Nyanza	0.3046***	0.2998***	0.2677***	0.2561***
	(0.1008)	(0.1061)	(0.0940)	(0.0974)
Mombasa	0.1393***	0.1310**	0.1310**	0.1194*
	(0.0522)	(0.0576)	(0.0571)	(0.0608)
Nairobi	0.1766***	0.1649***	0.1693***	0.1576**
	(0.0525)	(0.0590)	(0.0603)	(0.0655)
Nakuru	0.1166	0.1215	0.1912	0.1976
	(0.1123)	(0.1161)	(0.1561)	(0.1586)
Medium		-0.0172		-0.0290
		(0.0532)		(0.0604)
Large		0.0064		0.0446
		(0.0574)		(0.0661)
Constant	0.0002	0.0547	-0.0117	0.0747
	(0.0395)	(0.0512)	(0.0441)	(0.0539)
Observations	568	554	440	429
R-squared	0.0856	0.0981	0.0984	0.1164
ISIC-2 dummies	YES	YES	YES	YES

*Robust standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$. Dependent variable change in permanent employment in the last 3 years*

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