

Growth
Research
Programme

Innovation
in low income
countries:
A survey report

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Funded by an ESRC-DFID grant, the DILIC project has had international breadth with investigators and advisors from Oxford University, the United Nations University – Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT), the Ghanaian Science and Technology Policy Research Institute (STEPRI), the University of Cape Town, Tshwane University of Technology, and the United Nations Conference on Trade and Development (UNCTAD). The survey questionnaire has benefited greatly from constructive discussions and comments from Anne Miroux, Marc Ventresca, David Kaplan, Mammo Muchie, Calestous Juma, Jorge Katz, Dirk Willem te Velde, Christopher Adam and colleagues of the DFID-ESRC Growth Research Programme (DEGRP). The invaluable support and assistance in the field of Mavis Akuffobe, Portia Adade and numerous enumerators are greatly acknowledged.

Executive summary

The Diffusion of Innovation in Low Income Countries project (DILIC), an ESRC-DFID funded research project involving a team of investigators and advisors from various universities and international organisations in Europe and Africa led by Prof Xiaolan Fu at the University of Oxford (UK), was designed to investigate the determinants of — and transmission channels for — the dissemination of innovations in firms under severe institutional and resource constraints. From a survey of more than 500 formal and informal firms in Ghana, six key findings have emerged:

- Firms in Ghana undertake relevant innovation activities, both in technological and non-technological fields, and within the formal and informal sector. Most of the innovations are incremental in nature, demand driven, and mainly based on learning, adoption and adaptation.
- The majority of the innovations in LICs are about appropriate technologies and processes in or for the base of the development pyramid. That fact reflects the instrumental nature of innovation as a means for development and not the outcome of development.
- Innovations in Ghana are mainly originated and diffused within Ghana, although some are sourced directly from a range of foreign countries, mainly in formal firms. The current role of universities and research institutions for innovation creation and knowledge transfer appears to be limited.
- International knowledge is mainly acquired via imports, internet, multi-national enterprises (MNEs) in the same industry, and participating in export markets. Innovations originated by foreign firms are of higher novelties compared to innovations achieved by local firms, suggesting potential positive spillovers.
- Lack of specific skills and access to credit, as well as market constraints, are the main bottlenecks firms face during the process of knowledge adaptation and innovation.
- Although firms in LICs are innovative and government is regarded as important innovation partner, they go very largely unsupported. On the one hand firms have scarce knowledge of policy instruments in place, on the other hand innovations are rarely recognised and innovation efforts within the firms are not properly underpinned.

For countries at the bottom of the development pyramid, technological innovation is decisive for industrialisation and catch-up. Technological innovation has, however, been traditionally concentrated in a few developed countries, given the costs and risks involved in fomenting technological innovation. Foreign sources of technology account for a large part of productivity growth in most countries. Therefore the development process in low income countries (LICs) can be supported by tapping existing knowledge and know-how. The transfer, adoption and adaptation of knowledge to LICs hence constitute an important issue for economic growth and global development. Innovative capacity in LICs is, however, critical for the successful transfer and adaptation of knowledge. Yet several constraints and obstacles prevent firms from innovating. Addressing these constraints, to build functional innovation systems and enhance innovative capacity, is fundamental to socio-economic development in LICs.

The DILIC survey of the diffusion of innovation in Ghana is the first survey in LICs dedicated to the origin and diffusion of innovation within and to these countries. The unique design of the survey provided unprecedented insights into the transmission mechanisms of innovation, expanding our understanding and going beyond the traditional input and output indicators. Such a survey is not only

unique for LICs but also for middle and high income countries, where transmission mechanisms have not been receiving the attention the issue deserves. This carefully designed pioneering survey offers distinctive evidence on the form and nature of innovations in the LICs context, the origins and the effective channels for the diffusion of innovation within the country and from foreign sources to these countries, the barriers to innovation creation and diffusion, and the space for innovation policy in these economies.

The survey gathered data from 500 firms from the formal and informal sectors in all the 10 regions of Ghana. Key sub-sectors of industry were purposively selected, including textiles and garments, metal work and food processing, on the basis of their innovative activities. Sampling in these sub-sectors was, however, random with the sampling frame drawn from industry information sources such as the National Industrial Census, the register of the Association of Ghana Industries and other databases.

The data show that firms in LICs are innovating, and innovation activities are taking place in both formal and informal sectors. During the three-year period 2011 – 2013, almost 80 per cent of the Ghanaian firms surveyed had introduced some innovations, both technological and non-technological in nature. Most innovation in LICs is local learning-based innovation, being diffused mainly within country and based on adoption and adaptation. This is normal behaviour in an environment in which research and development departments are extremely rare. The majority of the innovations in LICs are about appropriate technologies and processes in or for the base of the pyramid. That fact reflects the instrumental nature of innovation as a means for development and not the outcome of development.

Our data show that innovations are primarily developed in response to customer needs and they emerge and are developed in accordance to customer requirements. Clients and customers are also one of the main sources of innovation from within Ghana, together with members of clusters and associations and the use of Internet. Networks of SMEs often enable small firms to enter the value chain and produce something that they otherwise would not be able to produce. International knowledge is mainly acquired via imports, internet, MNEs in the same industry, and participating in export markets. Moreover, we captured how innovations originated by foreign firms are of higher novelties compared to innovations achieved by local firms, suggesting potential positive spillovers.

Lack of specific skills and access to credit, as well as market constraints, are the main bottlenecks during the process of knowledge adaptation and innovation. The successful and sustainable innovations fit the economic, social, and cultural environment and technical status of the LICs by addressing the resource, skill and institutional constraints and affordability and accessibility typical of these countries.

Finally, the survey showed that, although firms in LICs are innovative and government is regarded as important innovation partner, they go very largely unsupported. Innovations are rarely recognised and innovation efforts within the firms are not properly assisted, for example by mitigating financial and skill constraints that firms face. Firms in many cases have scarce knowledge of policy instruments in place. New thinking and policies to recognise and support innovation are needed in the context of LICs for long-term growth and development.

Table of Contents

Contributors and acknowledgements.....	iii
Executive summary.....	v
1. Introduction.....	3
Why study innovation in LICs.....	4
The DILIC Innovation Survey.....	5
2. The state of play: firms' environment and innovation activities.....	7
The firms' environment in Ghana.....	7
The innovation activities.....	9
The nature of innovation.....	11
Innovation strategies.....	12
3. Sources of innovation in LICs.....	13
Country of origin.....	13
How innovations are born and materialise.....	14
Local sources of information.....	15
4. The diffusion of innovation in Ghana.....	17
Formal collaborations.....	17
Universities and innovation.....	19
SMEs and cluster network.....	20
5. Foreign sources of knowledge and innovation.....	22
Channels for acquiring foreign knowledge sources.....	22
Factors ensuring foreign knowledge adoption and adaptation.....	25
6. Objectives and impact of innovation.....	27
Objective of innovations.....	27
Impact of innovations.....	28
7. Constraints to innovation.....	31
The abandonment and delay of innovation in Ghana.....	31
Innovation barriers faced by firms in Ghana.....	32
8. The role of innovation policy.....	35
Participation in training and financing programmes.....	35
The role and implementation of innovation policy in Ghana.....	37

9. Innovativeness of foreign firms	40
Innovation activities	40
Sources of innovations	42
10. Conclusions	45
Innovation under the radar in LICs	45
Origin of innovations in LICs	46
Diffusion of innovations within LICs	46
Diffusion of innovations to LICs	47
Constraints to innovations and space for policy	48
Final remarks.....	49
A. Technical Appendix	50
In-depth interview	50
Questionnaire design and survey instruments	51
Sampling frame	51
Recruitment and training of enumerators.....	53
Pilot survey	53
Survey and monitoring.....	53
Firm replacement protocol	54

1. Introduction

For countries at the bottom of the development pyramid, technological innovation is decisive for industrialisation and catch-up. Technological innovation has, however, been traditionally concentrated in a few developed countries given the costs and risks involved in fomenting technological advances. Foreign sources of technology account for a large part of productivity growth in most countries. Therefore, the development process in low income countries (LICs) can be supported by tapping existing knowledge and know-how. The transfer, adoption and adaptation of knowledge to LICs hence constitute an important issue for economic growth and global development.

Technology diffusion and adoption relies on substantial and well-directed technological efforts (Lall, 1992)¹ as well as sufficient human and financial resources and absorptive capacity (Cohen and Levinthal, 1989)². It requires appropriate institutions and policies to incentivise and facilitate the process in addition to strong local capabilities to identify the right technology and appropriate transfer mechanism, and to absorb and make adaptations according to local economic, social, technical and environmental conditions (Fu et al., 2011)³. By defining innovation as a new product or process, or new management, organisational or marketing practices (where 'new' means new to the world or new to the country or the firm), the Diffusion of Innovation in Low Income Countries project (DILIC) was designed to shed light on this issue investigating the role of innovation in LICs by exploring the nature of innovation in the private sector and the determinant factors and transmission channels for effective innovation creation, diffusion and adoption in LICs under institutional, resource and affordability constraints. It analyses the determinants of knowledge diffusion in LICs from leading innovators to latecomers, in particular the role of university-industry linkage and inter-firm networks. It examines the effect of external knowledge diffusion to LICs, in particular the productivity impact of South-South trade and FDI with a special focus on Chinese trade and FDI in Africa. And, finally, it seeks to develop a SME open innovation network model to increase frugal innovation for the poorer societies in LICs.

The DILIC project investigating chose to focus its main research on Ghana in West Africa and this report presents the findings from an innovation survey carried out in Ghana between November 2013 and January 2014. The project was funded by ESRC-DFID and supported by the United Nations Conference on Trade and Development and the Ghanaian government. It included researchers from the University of Oxford (UK), UNU-MERIT (Maastricht), and the Science and Technology Policy Research Institute (STEPRI) of the Council for Scientific and Industrial Research of Ghana.

¹ Lall, S. (1992). Technological capabilities and industrialization. *World Development* 20, 165-186.

² Cohen, W. and Levinthal, D. (1989). Innovation and learning: Two faces of R&D. *Economic Journal* 99, 569-596.

³ Fu, X. and Gong, Y. (2011). Indigenous and foreign innovation efforts and drivers of technological upgrading: Evidence from China. *World Development* 39, 1213-1225.

Why study innovation in LICs

Is innovation relevant for the LICs? For some people the answer is a clear 'yes', but other people may argue that there are other more important issues in LICs, such as food safety, water, health and conflict. However, only innovation and technical progress can provide fundamental solutions to the major challenges facing LICs, such as poverty reduction, environment and resource constraints, and sustainable development. Therefore innovation should be regarded not as an outcome of development but as a means to achieve it.

The term "innovation" is often associated with patents or ground-breaking discoveries. Those are the results of costly, risky and lengthy processes which require intense knowledge and capital investment to create something "new". For those reasons, most of the patent registrations and ground-breaking innovations are concentrated in a few rich countries linked with specific forms of university science and research capacity, and amongst a small number of firms. Would this view of the world imply that in LICs, where skills and capital constraints are prevalent, innovation is not relevant and firms are hardly innovative?

What is innovation? Does innovation refer only to those laboratory-based scientific research and development activities? The classical definition of innovation comes from Schumpeter who defines innovation as creative destruction. Nowadays our understanding of innovation has evolved and the most widely accepted definition of innovation is contained in the Oslo Manual. Innovation refers to the creation or adoption to a new product or process, and new organizational and marketing practices, where 'new' means new to the world or new to the country or the firm. It also includes new business models and new sources of supply. It is important to highlight that innovation means not only laboratory-based research and development activities. It also includes the whole innovation chain, which covers both the creation and adoption of new knowledge and commercialisation process.

Innovation as a public good has several distinguished features. Innovation includes both codified and tacit knowledge. The first is knowledge that can be written and expressed, while the latter refers to the knowledge that cannot be expressed and cannot be easily shared. Tacit knowledge often has to be picked up through learning and practice over time. It cannot easily be acquired, neither can it be easily repeated and imitated. Moreover, innovation has a feature of being a non-rival good, which means the marginal cost for additional use of it is zero. In other words, the use of innovative knowledge by one additional use does not reduce the availability of the knowledge to others. Finally, innovative knowledge is likely to generate positive externalities, which means others can benefit from the newly created or diffused knowledge by learning, observation, and imitation. In other words, the new knowledge can benefit others who are neither the inventor nor the owner of the new knowledge. The characteristics of innovation shape its transmission as well. Since tacit knowledge is difficult to be written down and transferred, most of the new knowledge is geographically localised and the diffusion of innovative knowledge needs several specific channels.

How does innovation emerge then? Innovation can be developed by an original idea but also emerges from diffusion, absorption, or imitation of the new methods that are observed. The imitative innovation includes technological innovation and also non-technological innovation. Many innovations are from or for the bottom of the pyramid, the poorest socio-economic group, and to be relevant need to be economically and socially appropriate and accessible for them. It means being affordable and suitable for the poor.

Innovation in LICs can have an impact on multiple dimensions, from income growth and job creation to poverty reduction, and more generally on improving human well-being. Innovation can support poverty reduction and enhance human well-being through three main channels. Firstly, innovation can contribute to household's poverty reduction by improving medical care, supporting education, updating agricultural techniques, and providing sustainable energy. Secondly, innovation can have a direct impact on the people and production at the bottom of the pyramid. If innovations are affordable and easy enough to be used, poorer people would be provided with more goods and opportunities. In such context scenario, the so-called frugal innovation aims to reduce both the complexity of the technologies and the skills needed to use them, making them affordable to poorer people. Thirdly, at the macro-economic and structural levels innovation is a driver to improve productivity and increase the production capacity of an economy. Eventually the impact of innovation will improve competitiveness, increase sales, generate more profits, and create more employment. Improving more people's living conditions can also help others to leave poverty. It is clear from the data collected that innovation can be everywhere, even in the informal economy. Small workshops around the country are constantly trying out new ideas and better ways to deal with constraints. For example, a local Ghanaian entrepreneur told the survey "I survive because I innovate and this makes my business competitive in the market". Through different channels, innovation can support people to solve the poverty and income growth problem.

The DILIC Innovation Survey

Although the transfer, adoption and adaptation of knowledge and technologies to LICs are acknowledged to constitute an important issue for economic growth and global development, so far our understanding of innovation in developing countries has been limited. For example, which kinds of innovation are found in LICs and how are innovations transmitted to and spread within LICs? What drives formal and informal firms to innovate? The DILIC project designed and implemented a representative survey of the firm population in Ghana and collected detailed information on the innovation activities of more than 500 formal and informal firms. The data collected is giving an invaluable contribution to better understanding the role of innovation in a LICs context and will better inform policy-makers on how to support the diffusion of innovation and incentivise its adoption among firms.

The DILIC survey of the diffusion of innovation in Ghana is the first survey in LICs dedicated to the origin and diffusion of innovation within and to these countries. The unique design of the survey provided unprecedented insights on the transmission mechanisms of innovation, expanding our understanding and going beyond the traditional input and output indicators. Such survey is not only unique for LICs but also for middle and high-income countries, where transmission mechanisms have not been receiving the attention the issue deserves. This carefully designed pioneering survey offers distinctive evidence on the form and nature of innovations in the LICs context, the origins and the effective channels for the diffusion of innovation within the country and from foreign sources to these countries, the barriers to innovation creation and diffusion, and the space for innovation policy in these economies.

This report includes and comments on the main findings from the DILIC innovation survey. The results of our study challenge the opinion that innovation may not be relevant in LICs and reveal a much more diverse picture than hitherto acknowledged. Firms in LICs are shown to be innovative and to be running a wide range of creative activities. These include products and production practices as well as novel

marketing and management strategies. Most of these activities are incremental in nature and based on the diffusion of ideas across Ghana. Little knowledge comes from outside the country and the limited collaboration between businesses was also seen as stifling creativity. The role of policy-makers should therefore be geared to implementing policies that build national and international business networks, create incentives for innovators and provide funding to overcome common financial restraints.

The report covers multiple aspects of innovation in LICs, from exploring the nature and the sources of innovation (Ch. 2 and 3), to investigating the diffusion of innovation in Ghana (Ch. 4) and the foreign sources of knowledge and innovation (Ch. 5). It also discusses findings on the objective and impact of innovation (Ch. 7), the barriers to innovation that firms face (Ch. 8), and concludes with the role of innovation policy in supporting innovation activities (Ch. 9). Throughout the report, we not only report general statistics but also compare the behaviour of formal and informal firms. The latter are fundamental actors in many economies of LICs and the source of income for a large proportion of workers. The different firms' capabilities of formal and informal sectors are likely to shape the innovation adoption and diffusion.

2. The state of play: firms' environment and innovation activities

The economic and business environment of low-income countries presents peculiarities which are likely to affect the innovation activities. Moreover, the nature of innovation will be specific to this environment. For these reasons, it is critical to analyse the composition of the private sector in Ghana and understand how to capture innovation in such an environment.

At a structural level most of the low income countries present a sort of dual-economy system, in which there is an active informal sector alongside formal registered firms. Ghana is no exception, with an estimated 40 per cent of GDP produced by the informal sector. The different firms' capabilities between the two sectors are likely to shape the innovation adoption and diffusion. Formal establishments usually have the human and capital resources to undertake innovation processes with other firms' research and development institutions, or, for larger firms, with foreign institutions. Instead, informal firms are unlikely to have strong capabilities and therefore are more likely to innovate from entrepreneurs' initiatives and in response to specific constraints from the context in which they operate.

To capture this diversity of innovation in Ghana, we used a broad definition of the term "innovation". Following the so-called "Oslo Manual", it includes the adoption of a new product or process, or new organisational and marketing practices (where "new" means new to the world or new to the country or the firm). On the one hand, this accounts for the different innovation activities and isolates their impact on the business of the firms. On the other hand, we captured innovation that could simply be new to the firm and have impact because of that. Importantly, this also allows us to distinguish between ground-breaking genuinely novel innovation and imitative and incremental innovation. This emphasis on imitative and incremental innovation is more compatible with the type of evidence that is more likely to be relevant and available for Ghana, and LICs in general.

In this section, first we will describe and analyse the firms' environment in Ghana. We then go on to investigate the innovation activities, the nature of innovation, and finally the innovation strategies which formal and informal firms undertake.

The firms' environment in Ghana

The firms' environment in low income countries is characterised by a mix of informal and formal firms. The definition of the two types of firms is not unique and is sometimes context-dependent. Informal firms are firms that may avoid taxation or other mandated regulation because law enforcement is weak and uneven. They may also register only part of their workers and part of their sales – or declare only part of the salary of their workers – due to an excessive regulatory burden. While informal firms are usually the vast majority of firms and collectively employ most of the unskilled workers in the private sectors, they produce less value than the formal firms.

Formal and informal firms have different characteristics, including age, size, business model, and absorptive capacity. As a consequence, they necessarily have a different approach to innovation, and the determinants of – and transmission channels for – the dissemination of innovations amongst the

different types of firms could be different. For these reasons, in presenting the findings from the innovation survey, we often compare the two types of firms.

Given the somewhat blurred definition of formal and informal firms, and the potential sensitivity of the topic involved, we collected a self-reported view of the firm, asking the respondents “How do you define the nature of the firm?”. During the conduct of the survey, the enumerators – all local people – were trained to cross-check this specific information based on a visit to the firm’s premises and observation of its activity. So we have a strong indication of the reliability of this information.

In Table 2.1 we report some key firms’ characteristics in the sample, and compare the differences between formal and informal firms. On average, the surveyed firms have been active for 15 years, with formal firms for a longer period of time. Informal firms employ on average just over 5 employees, significantly less than the 54 employees working in formal firms. Turnover too is significantly different between formal and informal firms. While on average the former produce over two millions of Ghanaian cedis, the latter return five thousand cedis. Almost half of the informal firms predominantly trade in local and regional markets, while three-quarters of the formal firms are mostly active in national or international markets.

Absorptive capacity is also significantly different in the two types of firms. Compared to informal firms, formal firms have six and three times more employees with a University degree and a technical specialisation, respectively. Informal firms are often established in peripheral areas or far from large cities, and as a consequence they have worse access to public infrastructure than formal firms. Two out of five formal firms have access to the public grid and the Internet. The same proportion shrinks for the informal firms, with only ten and five per cent respectively connected to public electricity and the Internet. Finally, only formal firms have had access to foreign investors.

Table 2.1: Key firm’s characteristics (by nature of the firm).

	All	Informal	Formal	Difference
Age of the firm (years)	15.8	13.6	19.8	-6.2***
Active mainly in the local market (%)	31.5	46.4	23.1	23.4***
Number of employees	23.1	5.3	54.6	-49.3***
Turnover ('000 GhC)	764.3	6.7	2108.0	-2101.3*
Employees with a university degree (%)	3.9	1.4	8.2	-6.7***
Employees with a technical specialisation degree (%)	6.3	3.5	11.2	-7.6***
Foreign investor (%)	3.6	0.0	9.9	-9.9***
Access to public grid (%)	21.3	9.0	43.1	-34.1***
Access to Internet (%)	17.9	5.0	40.9	-35.9***

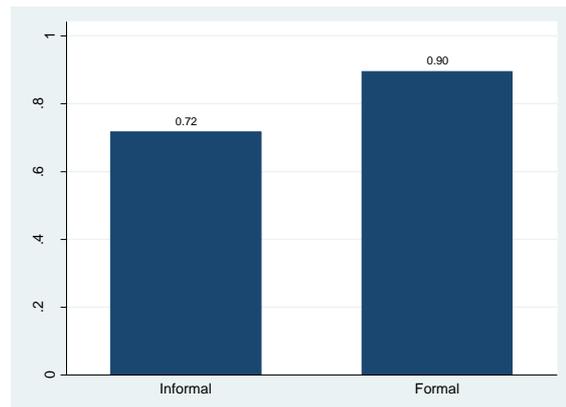
Note: Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively.

The innovation activities

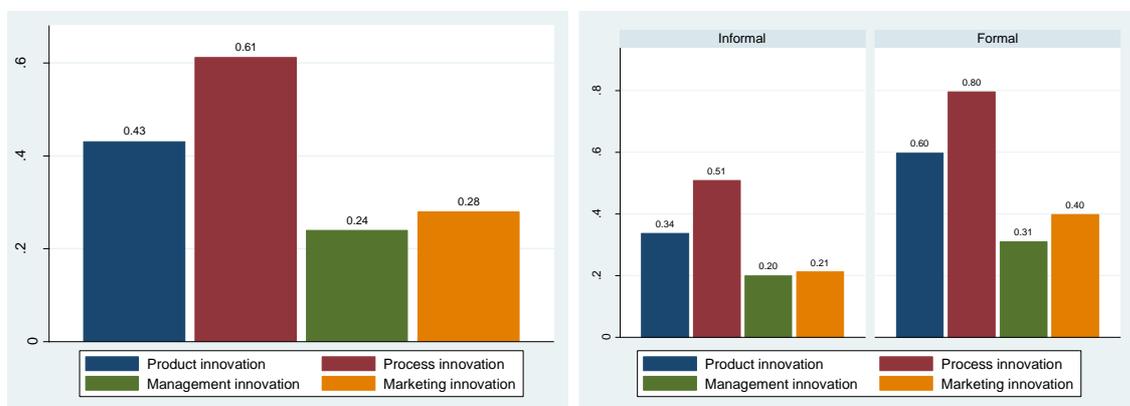
Innovation is a widespread phenomenon in the private sector in Ghana. From our sample, most of the firms (78 per cent) are active in some innovation activity. Formal firms seem to perform better than informal firms. Almost three out of four informal firms have engaged in innovation activities in the period 2011-2013, while amongst formal firms the innovative firms are ninety per cent (Graph 2.1).

Innovations can span different fields and it is relevant to understand in which fields firms are innovating. To this end, we used the definitions contained in the Oslo Manual, a standard reference for surveys of innovation in advanced economies, to define four fields of innovations. On that basis, we found innovations that cover new or significantly improved products (goods or services) with various features, such as improved user-friendliness, components, software or sub-systems, and process innovations, i.e. new or significantly improved processes or methods for the production or distribution of goods or services or supporting activity. Moreover, we have management innovations, which refer to the implementation of new management methods in the firm's business practices, workplace organisation or external relations in firm structure or management methods that are intended to improve the firm's use of knowledge, the quality of the goods and services, or the efficiency of workflows. And finally there are marketing innovations, which include marketing methods involving significant changes in product design or packaging, product placement, product promotion or pricing, or sales methods to increase the appeal of the goods and services or to enter new markets.

Graph 2.1: Proportion of innovative firms (by nature of the firm).



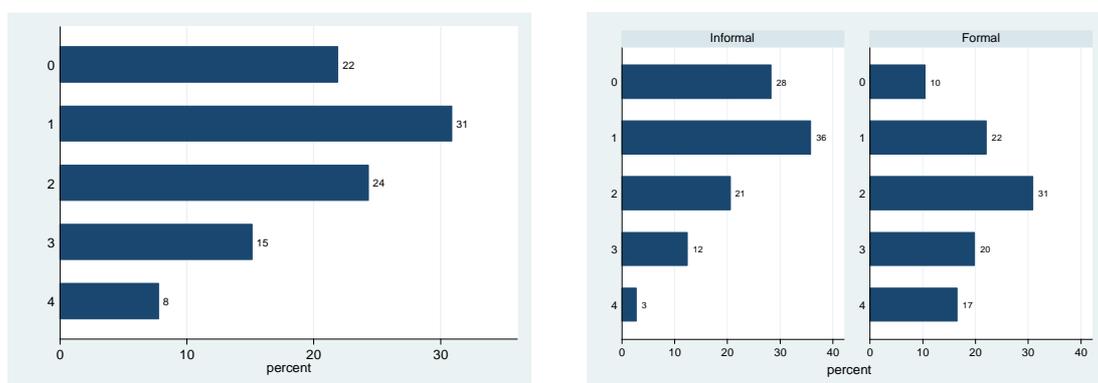
Graph 2.2: Proportion of firms active in innovations, by nature of innovation (left) and by nature of innovation and firm (right).



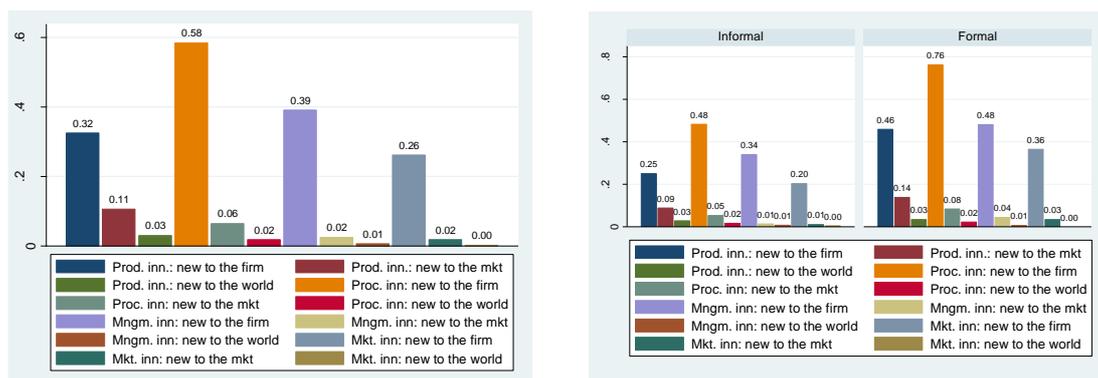
The breakdown of the different innovations is reported in Graph 2.2. Most of the firms (61 per cent) are involved in process innovation. This may reflect the fact that often firms in low income countries work far from the technological frontier, and improvement are relatively easy to implement. A little bit less than half of the firms introduced new or significantly improved goods or services between 2011 and 2013. Management and marketing innovations are covered by a minority of the firms, with respectively 24 and 28 per cent of the firm active in these fields. The pattern of innovation activities for formal and informal firms is similar, although formal firms are more active in every field than informal firms (Graph 2.2). Process innovations are more common for both groups, followed by product innovations and, further behind, we found management and marketing innovations.

Firms that are innovating may focus in multiple fields of innovations. Graph 2.3 reports what we called “intensity of innovation”, the number of different types of innovations that are undertaken by the firms. The variable can take values from ‘0’ (no innovation undertaken) to ‘4’ (firm active in all four fields of innovation). Among the innovators, most of the firms (31 per cent) are active in only one field, with a decreasing rate of firms active in two, three or four fields. This distribution is different between formal and informal establishments. While most of the informal firms (36 per cent) tend to focus on only one innovation, two out of three formal firms are active in two fields. Around twenty per cent of innovative formal firms are undertaking either one or three innovations, and almost one in six are active in all four innovations, almost six times the amount for informal firms. Formal firms are not only more likely to innovate, but are also significantly more active in innovation activities than informal firms.

Graph 2.3: Intensity of innovation, proportion of full sample (left) and by nature of firm (right).



Graph 2.4: Proportion of firms active in innovation activities, by nature of innovation (left) and nature of innovation and type of firm (right).



The nature of innovation

Not all innovations are equal, and the level of resources needed to implement different innovations can vary significantly. In order to capture the different nature of innovations, we again referred to the Oslo Manual and captured whether an innovation was new to the firm, new to the country, or new to the world. Based on these definitions, innovation does not necessarily have to be new to the country or to the world as a whole, but could simply be incremental in nature. This suggests how innovation can be either a ground-breaking novel innovation or an imitative innovation; both forms of innovation can add considerable value, albeit through different implementation processes and on different time scales. As reported in Graph 2.4, the vast majority of innovations are new to the firm, with some evidence of new to the country product and process innovations. This is more common amongst formal firms. We also found some evidence of product and process innovations that are thought to be new to the world, although the diffusion is very small. Therefore, most of the findings refer to incremental innovation, rather than innovations that leapfrog or redefine value creation processes.

For product innovations, we were able to capture the contributions of the different nature of the innovation on the total turnover (Table 2.2). For both formal and informal firms, around half of their turnover in 2013 was produced from the sale of products or services that were unchanged or only marginally modified in the past three years. Goods and services innovations that were only new to the firms accounted for around 40 per cent of the total turnover, while the contribution of product innovations new to the country provided the remaining seven per cent. It is worth noting that product innovations new to the firms and new to the country jointly account for a significantly larger part in turnover of formal than informal firms.

Table 2.2: Percentage of total turnover in 2013 of goods or service innovations introduced during 2011 to 2013 (by nature of the innovation).

	Total	Informal	Formal	Difference
Goods and service innovations new to the country	7.48	8.47	6.48	1.99
Goods and service innovations were only new to the firm	41.35	43.29	39.42	3.87*
Goods and services that were unchanged or only marginally modified	51.17	48.14	54.19	-6.45**

Note: Only for firms that introduced product innovations (n=216). Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively.

Innovation strategies

Finally, we look at the patterns of innovation activities and nature of innovations to better capture the innovating behaviours of Ghanaian firms (Table 2.3). Amongst the innovation firms, most of the informal firms are active only in process innovations, whereas half of the innovating formal firms are equally active in process and product innovations. Informal firms that are active in two innovation fields are more likely to engage in management and marketing innovations. We found similar patterns amongst formal and informal firms that are active in three fields of innovations, although the former are more likely to undertake marketing innovations in additions to process and product innovations compared to informal firms. It seems to emerge that informal firms concentrate on product innovation as a single innovation activity, while formal firms are more likely to combine product innovations with other types of innovation.

Table 2.4 reports the pattern of the different natures of innovations undertaken by innovating firms. The vast majority of the firms (80 per cent) are engaged only in innovation new to the firm, with ten per cent of firms active in innovations new to the firms and new to the country. No firm is active only in innovations new to the world. Again, formal and informal firms seem to have slightly different behaviour toward the nature of innovation activities that they are carrying out. Formal firms have a mixed nature of innovation activities in their portfolio. Finally, a marginally higher percentage of formal firms have been engaged in innovations that cover all three types.

Table 2.3: Pattern of innovation activities (percentages of innovating firms).

Product	Process	Management	Marketing	Total	Informal	Formal
✓				8.2	12.6	1.9
	✓			22.4	26.1	17.3
		✓		6.4	7.8	4.3
			✓	2.6	3.5	1.2
✓	✓			17.6	13.0	24.1
✓			✓	1.5	0.9	2.5
✓		✓		1.0	1.3	0.6
	✓		✓	6.9	7.4	6.2
	✓	✓		2.6	3.5	1.2
		✓	✓	1.5	2.6	0.0
✓	✓	✓		9.9	10.4	9.3
✓	✓		✓	6.4	4.3	9.3
✓		✓	✓	0.5	0.4	0.6
	✓	✓	✓	2.6	2.2	3.1
✓	✓	✓	✓	9.9	3.9	18.5

Table 2.4: Pattern of nature of innovations (percentages of innovating firms).

New to the firm	New to the country	New to the world	Total	Informal	Formal
✓			81.9	84.8	77.8
	✓		2.8	3.5	1.9
		✓	0.0	0.0	0.0
✓	✓		9.9	6.5	14.8
✓		✓	0.0	0.0	0.0
	✓	✓	1.0	0.4	1.9
✓	✓	✓	4.3	4.8	3.7

3. Sources of innovation in LICs

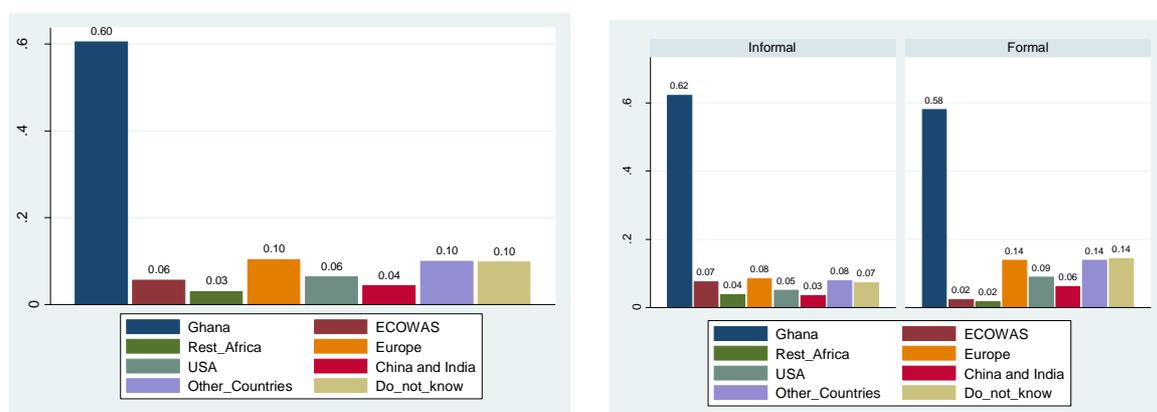
Identifying relevant channels and sources for diffusion of innovations and capturing how firms adopt innovations is relevant for contextualising the sources of innovations in LICs. Reporting the findings from our data from Ghana and comparing the behaviours of formal and informal firms, this section is divided into three complementary parts. First, we report the country of origin of the innovation, and in case of foreign origin we analyse in detail the geographical origin. We then analyse closely the process by which innovations get born and materialise. Finally, we focus on the local source of information, from sources internal to the firm to market and institutional resources, and other sources such as ICTs, conferences and publications.

Country of origin

Graph 3.1 reports the main countries of origin of the innovations adopted by the firms. The vast majority of innovations introduced during the three years 2011 - 2013 originated from within Ghana. In fact 62 and 60 per cent of informal and formal firms have respectively adopted or created innovations with resources and information found in-country. Formal and informal firms behave differently regarding the adoption of innovation from abroad. Informal firms seem to be more likely to adopt innovations from nearby countries, and Africa in general, than formal firms. The latter instead are more likely to adopt innovations from Europe and United States.

In recent times there has been an emphasis on the relevance of South-South collaboration and technology transfer. The rationale is that the knowledge transferred to Ghana is likely to be more appropriate if it comes from countries with similar factor endowment and at a similar development stage. The absorptive capacity of Ghana may also be more able to adopt technologies of a similar level to its own. Collectively, 13 per cent of the innovations introduced came from a low-or middle income country (other country in Africa, India, and China). Informal firms seem to have a greater share of innovation from those countries, highlighting the fact that adoption of innovations from a country at a similar development stage may be more easily adopted by firms with lower absorptive capacity.

Graph 3.1: Proportion of countries of origin of innovations (left), and by nature of firm (right).



Note: More than one answer allowed.

How innovations are born and materialise

Understanding how an innovation gets born and materialises provides relevant insights on the innovation behaviours of firms. In an environment in which research and development departments are hardly developed, firms need to find ways to improve the production and increase sales. The different ways in which an innovation can be materialised are reported in Table 3.1. Most of the innovations (60 per cent) get born in response to customers' requirements. This on the one hand shows how the market is an inspiration for innovation, and on the other hand how a strong connection between firms and customers can be mutually beneficial. Customers are not only a source of information but are often actively involved in the innovation process. Almost half of informal firms have developed innovation together with customers. Nonetheless, most of the innovations appear to be developed primarily within the firm. Sixty-six per cent of formal firms developed innovations in-house, with no external collaboration with other institutions. For informal firms, the proportion is significantly lower, though still relevant.

The contribution of skilled workers in the innovation process is relevant mainly for formal firms. More than one third of these introduced process innovations that were produced by skilled workers who found better ways to produce after some experiments in a trial-and-error approach. A minor concentration of skilled workers in informal firms pushes the latter to significantly rely more on adapting or modifying goods or services originally developed by other enterprises or institutions than formal firms. These initiatives are critical not only for the innovation activities of informal firms, but also for their survival.

Table 3.1: How the innovation materialised (percentages of innovating firms).

	Total	Informal	Formal	Diff.
The product or process was mainly developed within the enterprise	57.7	51.7	66.0	-14.3**
The firm developed the innovation in a research & development department	3.3	0.9	6.8	-5.9**
Technicians in the firm created the innovation as a solution to a problem that constrains the production or competitiveness of the company	9.4	7.0	13.0	-6.0*
Skilled workers in the firm find out a better way for the production process after some experiments	25.5	19.1	34.6	-15.4***
The firm modified the product in response to customers' requirement	60.5	54.3	69.1	-14.8**
The firm adapted or modified goods or services originally developed by other enterprises or institutions	23.7	27.0	19.1	7.8
The firm create the innovation together with supplier	9.9	8.7	11.7	-3.0
The firm create the innovation together with customer	45.7	48.3	42.0	6.3
The firm create the innovation together with other firm in the industry	9.7	10.4	8.6	1.8
The firm create the innovation together with universities and research institution	6.1	5.2	7.4	-2.2
The firm create the innovation together with other firm in the same company group	6.6	8.3	4.3	3.9
The firm acquired technology originally developed by others by licensing and adapted or modified it	6.6	4.3	9.9	-5.5*
The firm acquired technology originally developed by others by licensing without any adaptation and modification	7.1	6.1	8.6	-2.6
The firm observed or heard of the innovation by other companies and imitated it directly	29.8	34.3	23.5	10.9*
The firm observed or heard of the innovation by other companies and imitated it with some modification	46.2	47.0	45.1	1.9

Note: More than one answer allowed. Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively.

Beside adaption and modification, many firms innovate simply by imitating from other companies. This is a normal behaviour in a situation in which research and development departments are extremely rare. In fact, in our sample only seven per cent of formal firms (and less than one per cent of informal ones) have developed innovations in some formal research facilities. Many firms do not just imitate innovations, but adapt and modify innovations observed or heard from other firms. Again, the process of adapting materials, production, management structures, or marketing tools to the nature and the resources of the adopting firms is a critical feature of innovation in low-income countries.

Local sources of information

How do firms gather information for the innovation activities? Information, together with knowledge, is an essential component for innovation creation and transmission. Graph 3.2 reports the importance of different local sources of information, with a score of '1' when firms consider the source insignificant, and '5' if considered crucial. The sources are grouped into five categories: sources internal to the firm, membership of networks, market and institutional resources, and other sources which include ICTs, conferences and publications. The graph shows the different pattern between formal and informal firms. The former uses

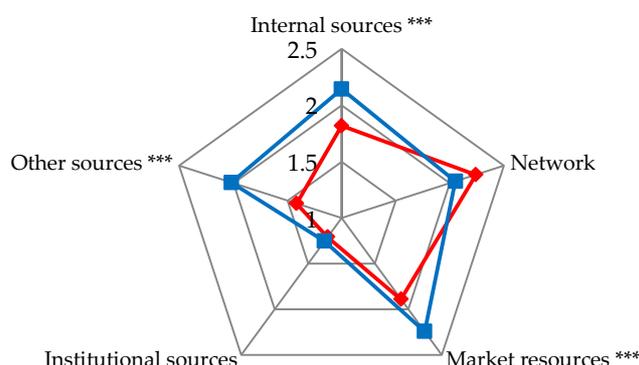
significantly more internal sources, market resources and other sources than the latter. By contrast, informal firms seem to rely most on sources within their networks.

The breakdown of the five sources is reported in Table 3.2. Clients and customers are the most important source of information for both formal and informal firms. This finding reinforces the evidence we reported that often innovations arise in response to customer requirements or together with customers. In addition to clients and customers, competitors or other enterprises in the same sector are an important source of information. Information that supports innovation activities in Ghanaian firms is mainly sourced by market agents, both from the demand side and from competitors.

Firms also rely on members of clusters and associations to gather information on innovations. The importance of networks is more evident for informal firms, which otherwise would have limited resources for gathering specific information. The relevance of clusters and associations also hinges on the fact that those institutions by nature provide information that is context- and sector-specific to the members. This finding supports the role of clusters in fostering innovation and technological transfers, through knowledge spill-overs and labour market pooling.

Internal sources, such as colleagues, are also an important source of information. Labour mobility and hiring experienced employees can boost the innovation activities of firms. This is particularly important

Graph 3.2: Importance of local sources of information for formal (blue line) and informal (red line) firms (1 = insignificant, 5 = crucial, average values).



Note: Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively.

for formal firms, which significantly attach greater value to the importance of colleagues as a source of information.

Finally, it is important to highlight the role of the Internet as a vector of information. Among the sub-sample of firms that have access to the Internet (40 and 5 per cent of formal and informal firms, respectively), the Internet is considered a significant source of information. This is relevant, considering the potential which the Internet holds to overcome the lack of information in low income countries and allow users to find specific information.

Table 3.2: Importance of local sources of information for formal and informal firms (1 = insignificant, 5 = crucial, average values).

		Total	Informal	Formal	Diff.
Internal sources	Sources within the firm (colleagues)	2.35	2.19	2.64	-0.45***
	Sources within the group (if you have subsidiary)	1.52	1.45	1.65	-0.20*
Network	Member of cluster	2.17	2.39	1.78	0.61***
	Member of associations	2.17	2.09	2.32	-0.23
Market resources	Suppliers of equipment, material, components, software	1.88	1.70	2.20	-0.51***
	Clients or customers	2.83	2.69	3.09	-0.40**
	Competitors or other enterprises in your sector	2.16	2.01	2.42	-0.41***
	Consultants, commercial labs or private R&D inst.	1.20	1.16	1.26	-0.10
Institutional sources	National universities or other higher education inst.	1.21	1.20	1.23	-0.03
	Government or public research institutes	1.24	1.22	1.28	-0.06
Other sources	Radio	1.60	1.47	1.82	-0.34***
	Internet [†]	2.82	2.56	2.88	-0.32***
	Conferences, trade fairs, exhibitions	1.98	1.76	2.36	-0.60***
	Scientific journals and trade/technical publications	1.45	1.36	1.61	-0.25**
	Professional and industry associations	1.34	1.28	1.44	-0.16*

Note: Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively. [†] Information collected only from respondents with an Internet access.

4. The diffusion of innovation in Ghana

The economic growth of low income countries is a product of ideas, skills, capital, and the organisation of society and firms. Despite the current state of technologies allowing real-time communications across the globe and worldwide movement of goods, the diffusion of knowledge and technologies from outside and within developing countries poses many challenges. In this section we focus on the drivers of diffusion of innovations. We will first describe formal collaborations firms may have with a range of different agents before moving to analyse the role of universities and how firms collaborate (or do not) with them. Finally, we conclude by reporting the collaborative dynamics within SMEs and cluster networks.

Formal collaborations

The vast majority of innovations in Ghana are created and diffused throughout informal collaborations between firms and other agents. In fact, only eight per cent of the firms in the sample (n=41) have developed or introduced innovations in the period 2011-2013 that stemmed from formal collaborations based on the active participation of different actors. The decision to engage in formal collaborations is partially influenced by the characteristics of the firms. With larger financial resources and greater absorptive capacity, formal firms are relatively more likely to engage in formal collaborations than informal firms, with respectively eleven and seven per cent the proportions of firms that co-operate in innovation activities.

To better understand the nature of the cooperation, we captured the actors involved and their geographical origins. Partners include other enterprises within the enterprise group, suppliers (e.g. equipment, materials, components or software), clients or customers, competitors or other enterprises working in the same firm's sector, consultants or private R&D institutes, universities or other higher education institutions, and government or public research institutes (e.g. research councils). For each collaboration established, we also captured whether the partner was based in Ghana or abroad.

From Table 4.1, we see that most of the firms collaborate with other companies within the group or with clients or customers. Informal firms seem to slightly favour the former, while formal firms prefer the latter. The third most common partners are the government or public research institutes, followed by nineteen firms that collaborated with universities. Lastly, only five informal and nine formal firms partnered with consultants or private R&D institutes on innovation activities. While formal and informal firms display a somehow similar pattern in the choice of partners, their locations are different between the two. Informal firms almost exclusively collaborated in activities with local or national actors, whereas formal firms tend to be better able to engage with foreign actors. In some cases, formal firms indifferently chose a local or international partner (e.g. for consultants or private R&D institutes, or suppliers), in other cases the partners are predominantly local (e.g. universities).

Why then do firms decide to co-operate with foreign actors? The most common reason is that the technology needed is not directly available in Ghana and collaborations become an effective way of technology transfer. It follows that firms are working in a broader network and therefore the connection is facilitated by common interests. Finally, for a minority of firms the collaboration was initiated by a

foreign customer/supplier or the collaborator was a relative or a friend of one of the key staff of the local firm.

The different needs and capabilities of formal and informal firms are also reflected in the rankings of the most valuable types of co-operation for the two types of firms (Table 4.2). Informal firms most value government or public research institutes, while formal firms favour clients or customers followed by suppliers. This finding is relevant in highlighting the support of public-funded initiatives in strengthening the innovation activities of informal firms. For both categories of firm, consultants and private R&D institutes are considered the least valuable partners. Nonetheless, we need to remember that the ranking is provided only by firms that co-operated in innovation activities, which are a small sample.

Table 4.1: Formal collaborations: Partners and country of origin (number of firms).

	All sample			Informal (22)			Formal (19)		
	Tot.	Ghana	Other	Tot.	Ghana	Other	Tot.	Ghana	Other
Other enterprises within the enterprise group	31	26	8	17	17	2	14	9	6
Suppliers of equipment, materials, components or software	21	17	8	10	10	3	11	7	5
Clients or customers	31	27	9	16	16	4	15	11	5
Competitors or other enterprises in the firm's sector	21	20	4	13	13	2	8	7	2
Consultants, commercial labs or private R&D institutes	14	10	5	5	5	0	9	5	5
Universities or other higher education institutions	19	19	2	9	9	0	10	10	2
Government or public research institutes	23	22	3	12	12	1	11	10	2

Note: More than one answer allowed.

Table 4.2: Most valuable types of co-operation partner for firm's innovation activities (ranking, by nature of the firm).

Informal		Formal	
1	Government or public research institutes	1	Clients or customers
2	Other enterprises within your enterprise group	2	Suppliers of equipment, materials, components or sw.
2	Competitors or other enterprises in your sector	3	Government or public research institutes
2	Universities or other higher education institutions	4	Other enterprises within your enterprise group
3	Suppliers of equipment, materials, components or sw.	4	Universities or other higher education institutions
4	Clients or customers	5	Competitors or other enterprises in your sector
5	Consultants, commercial labs or private R&D institutes	5	Consultants, commercial labs or private R&D institutes

Universities and innovation

In advanced economies universities play a key role in the innovation process and are an integrated part of a national innovation system together with the state and industry. Universities are pivotal in knowledge and technology transfer (and sharing) to industry, essential partners in collaborative research and development activities, and overall play an active role in national and regional innovation systems. In the context of low income countries, universities could have equal importance, being seen as tools for knowledge-based economic development and change through spin-off companies, licences for new technologies, and by transferring knowledge to existing businesses.

In our sample we found 19 firms that have actively collaborated with universities or other higher education institutions in developing and adopting innovation. Formal and informal firms were equally represented and the vast majority of the firms co-operated with local institutions. In 75 per cent of those cases, the collaboration was established by individual initiative and through personal connections (Table 4.3). Only one third of the collaborations were initiated due to governmental initiative. If on the one hand personal initiatives may overcome the lack of more comprehensive programmes, on the other hand they may bring uncertainty and instability to the collaboration. If strong ties are not built between the firm and university, the co-operation is largely dependent on the continued employment of key figures in both institutions.

Why are the vast majority of firms not connected to universities? Table 4.4 reports the main reasons. A large proportion of firms simply does not have the need or the interest to have such collaboration. The contribution of private-public partnership could benefit particular firms working in specific sectors. However, 68 and 58 per cent of informal and formal firms respectively also mentioned a lack of connections as a reason for not having collaborated with firms. Nonetheless, around 30 per cent of formal and informal firms have the intention to collaborate with universities. Two initiatives may support those firms willing to engage with universities. First, financial opportunities could meet the costs involved in such collaborations. Secondly, information provision of compatible university departments or staff could provide a quick way of identifying potential collaborators. Our findings suggest that such initiatives are thought to be useful in bringing firms and universities together for around 60 per cent of the firms, with no significant differences between formal and informal firms.

Table 4.3: How the connection with the University was established.

Personal network	74%
University approached us	-
Governmental initiative	26%

Table 4.4: Main reasons for not collaborating with Universities (percentages in parenthesis).

We do not have such need	205 (43%)
They are not interested	113 (24%)
We are not connected	325 (68%)

SMEs and cluster network

Evidence from low income countries suggests that simple forms of clusters and vertical production chains of SMEs allow firms and entrepreneurs to share capabilities in the existing value chain. Even if those organisations may not be established with the aim of creating new products or processes, they go farther than merely exploiting economies of scale.

A cluster is a common institution in developed and developing countries. It can be defined as a geographic concentration of interconnected businesses and suppliers that encompasses an array of linked industries and other entities important to competition. They could include, for example, suppliers of specialised inputs such as components, machinery and services. In low income countries clusters are often made up of small and informal firms that together can have a greater market power. Most of the firms in the sample are part of a cluster (62 per cent), and the percentage of informal firm members of clusters rises to 81 per cent. Friendship seems to be the main origin of the network for most firms, however this is closely followed by vertical business relationships for formal firms and collaborators, such as knowledge sharing, for informal firms.

Clusters can provide different benefits to their members. Table 4.5 reports the benefits that firms receive from being a member of a cluster and provides a breakdown between formal and informal firms. Overall, the findings suggest that clusters as institutions provide greater support and assistance to informal than formal firms. The vast majority of the informal firms reported that clusters facilitate the exchange of relevant production and technology information and a greater collaboration on pricing. Work- and resource sharing are also important benefits for cluster members. One third of formal and informal members explicitly reported that clusters are environments that facilitate the diffusion and creation of innovations. Informal firms seem to have significantly greater benefits in collaborating on pricing and work-sharing compared to formal firms.

Table 4.5: Benefits from being a member of a cluster (percentages of members of cluster).

	All	Informal	Formal	Difference
Easier to exchange or get relevant production and technology information	66.9	68.3	60.0	8.3
We can divide the labour	24.5	26.6	14.5	12.1
It provides a pool for resources	48.1	47.9	49.1	-1.2
Easier to collaborate in innovation	36.3	36.3	36.4	-0.1
Easier to collaborate in pricing	65.0	68.0	50.9	17.0*
Availability of specialist service and equipment providers	22.6	22.4	23.6	-1.2
Joint programmes to raise skills and enhance efficiency	38.9	39.0	38.2	-0.8
Work-sharing	51.0	53.7	38.2	15.5*

Note: Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively.

Vertical integration in the supply chain is an important strategy to reduce transaction costs, exploit the competitive advantage of the chain members, and secure supplies or distribution channels. While in developed countries it often involves the acquisition of smaller firms by a network leader, in low income countries the small firms that are part of a network work predominantly with a lead firm though retaining independent ownership. In the case of Ghana we found ten per cent of firms are part of a vertical production chain consisting of SMEs. The proportion is similar for formal and informal firms, although the locations of the lead and the network are usually different between the two categories. Informal firms tend to be part of a network mainly located in the region and driven by small firms, while formal firms are more likely to have a large firm as a leader and the network is spread out at the national level.

While clusters are often established based on friendship relationships between members, vertical production chains including formal and informal firms are mainly initiated for business reasons. As Table 4.6 shows, only one vertical production chain is led by a foreign firm and the remaining are almost equally divided between small and large local firms. The geographical location of the network follows a similar pattern (Table 4.7). Only in one case did we find the network having a global dimension, while in most cases firms are located in various regions of Ghana. Around four out of ten networks have a regional nature, with the firms in the network located in only one region.

However, some informal firms join a chain predominantly for knowledge sharing. Most of the networks seem to be formed to make existing products cheaper or of better quality rather than producing something that firms in Ghana would otherwise not be able to produce. Sixty-seven per cent of formal and informal firms that are part of a network are able to reduce the price of the final output thanks to the competitive advantage and lower transaction costs embedded in the network. By contrast, just less than half of the members of a network produce outputs that a single firm in Ghana is not producing, with a greater proportion of informal firms working in such networks.

Table 4.6: Nature of the leading firm in the vertical production chain (percentages in parenthesis).

Small local firm	12 (46%)
Large local firm	13 (50%)
University	- (-)
Foreign firm	1 (4%)

Table 4.7: Location of the vertical production chain (percentages in parenthesis).

Your region	Ghana	ECOWAS	Africa	Globally
23 (44%)	28 (54%)	- (-)	- (-)	1 (2%)

5. Foreign sources of knowledge and innovation

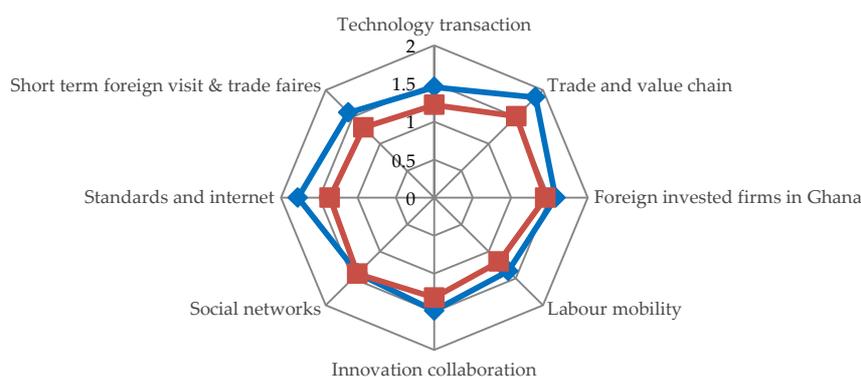
The costly, risky, and path-dependent nature of innovation pushes firms in LICs to seek external sources in order to compensate for the weak indigenous technological capability. Innovation activities carried out by them are characterised as learning and adoption of existing knowledge advances. Foreign sources of knowledge, complementing indigenous efforts, have become a substantial driver of economic growth in developing countries. Knowledge acquired from foreign channels not only helps the host economy to fill gaps in indigenous technological capability but also upgrades the existing technologies to international standards. The current chapter reviews different types of foreign knowledge sources and the factors that ensure the success in adaption of foreign know-how to the local context.

Channels for acquiring foreign knowledge sources

The DILIC survey distinguishes several different channels through which foreign knowledge sources are acquired by local firms in Ghana. Firms in our sample assessed how important the given foreign knowledge sources are to their innovation activities by responding with a 5 Likert scale measurement. We calculated the significance rates for each factor by taking the sample average value of the Likert scores reported by firms. Apart from direct market transactions, Ghanaian firms also rely on various other sources to acquire foreign technological advances as given in Graph 5.1. Measured by the average values of each foreign source, among the most important are 'trade and value chain', 'standards and internet', and 'firms in Ghana that received foreign investments'. Foreign knowledge obtained through the mobility of skilled labour is perceived as the least important channel.

Owing to the nature of informal firms, innovation activities carried out among them are often without specific financial and managerial resources and without formalised procedures. Are the foreign knowledge sources that are widely acknowledged by formal firms also appropriate for firms in the informal sector? Graph 5.1 suggests that there are substantial differences between formal and informal entrepreneurs' use of foreign knowledge sources. In spite of evident gaps in the magnitudes of mean values, both formal and informal firms recognize spill-overs through trade and value chains as the most critical channel for acquiring foreign know-how. Obtaining information via the Internet and pairing international standards with local production were acknowledged as the second important channel by

Graph 5.1: Importance of foreign sources of knowledge and innovation for formal (blue) and informal (red) firms (1 = insignificant, 5 = crucial, average values).



the formal entrepreneurs, and interaction with foreign invested firms took the third place. Social networks receive nearly the same credit as local firm that received foreign investment from entrepreneurs of informal firms and both sources are commonly used as effective means to acquire technology from other countries.

Table 5.1 presents the importance of foreign sources of knowledge in subcategories for the whole sample, formal and informal firms. Differences between formal and informal firms were tested by t-statistics and the asterisks denote the significant level. The most straightforward way to obtain foreign technology is via market transactions, i.e. payments for the use of licences, patents and copyrights. As shown in the first category of Table 5.1, the importance of licensing was more evident to firms in the formal sector than those in the informal sector. Much foreign knowledge diffusion to LICs, however, occurs not only through market transactions but also, and possibly for a large part, through spill-overs in association with various international activities.

Table 5.1: Importance of foreign sources of knowledge and innovation for formal and informal firms (1 = insignificant, 5 = crucial, average values).

		All	Informal	Formal	Diff.
Technology transaction	Foreign technology acquired through licensing	1.30	1.22	1.45	-0.23*
Trade and value chain	Imported goods in the same industry	1.73	1.59	1.99	-0.40
	Imported goods that input as intermediate goods into your production	1.72	1.56	1.99	-0.43
	Imported machinery and equipment	2.18	1.94	2.60	-0.65
	Observing and imitating competitors in export market	1.54	1.43	1.73	-0.30*
	New product or quality requirement raised by customers in export market	1.50	1.38	1.72	-0.34*
	Knowledge transferred from foreign suppliers	1.41	1.36	1.50	-0.14*
	Knowledge transferred from foreign customers in export market	1.39	1.31	1.51	-0.20*
Foreign invested firms in Ghana	Foreign firms in the same industry	1.52	1.34	1.83	-0.49*
	In upstream industry	1.46	1.49	1.41	0.08*
	In downstream industry	1.51	1.51	1.50	0.01*
Innovation collaboration	Foreign research institutions & universities	1.14	1.10	1.22	-0.12**
	Foreign competitors	1.39	1.33	1.51	-0.18*
	Foreign suppliers	1.33	1.29	1.42	-0.13*
	Foreign customers	1.64	1.54	1.80	-0.26
Labour mobility	Returnees employed in your firm	1.27	1.23	1.36	-0.13*
	Foreign workers/managers employed in your firm	1.23	1.15	1.37	-0.22*
	Local workers who have worked in MNEs before	1.25	1.19	1.36	-0.18*
Social networks	Relatives or friends working/living abroad	1.41	1.41	1.41	0.01*
Standards and internet	Information found via Internet	1.55	1.31	1.97	-0.66*
	International standards that your firm has to meet	1.47	1.41	1.58	-0.17*
Short term foreign visit & trade fairs	Visits to foreign production sites	1.28	1.18	1.46	-0.28*
	Attending international trade fairs	1.52	1.43	1.70	-0.27*

Note: More than one answer allowed. Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively

Trade brings technological spill-overs not only by allowing Ghanaian firms to learn from importing and exporting activities, also by granting firms access to foreign knowledge-embedded machinery and equipment. It is worth emphasising the substantial role of import market-related activities in assisting Ghanaian firms to gain new production and processing techniques. The top three important foreign sources reported were all in association with importing activities but the level of importance is found to be insignificant between formal and informal firms. All goods and services imported from advanced economies contain some potential technological information. Employing machinery and equipment which has been purchased from abroad is expected to improve productivity through being used in production. The statistics in Table 5.1 indicate that imported machinery and equipment were treated as the most important foreign source of knowledge for both formal and informal firms in Ghana. The other two equally important sources were imported goods in the same industry and imported intermediate goods, scored 1.73 and 1.72 respectively for the total sample. Reverse engineering of these goods in the same industry should positively affect domestic imitation and innovation, whereas the direct application of the imported intermediate goods in the production process should foster productivity gains. Activities in export market such as imitating competitors, matching customers' requirements for product or quality, and transferring knowledge from foreign customers were also bringing in foreign knowledge, and their roles were in general more substantial for formal firms.

The presence of foreign direct investments (FDI) provides domestic firms in LICs with more efficient foreign technologies and results in technological diffusion in many ways. In addition to imitating foreign firms in the same industry (demonstration effects), technology transfer may occur due to vertical linkages in both upstream and downstream industry. Moreover, interactions with Multinational Enterprises or MNEs, especially the face-to-face ones, effectively ensure that domestic imitators fully comprehend the tacit components and permit them to learn production processes more easily by inspection than by reverse engineering imported goods. Table 5.1 highlights the function of FDI-related activities in promoting innovation for formal and informal firms. Imitating foreign firms in the same industry clearly plays a more essential role in sourcing foreign knowledge for firms in the formal sector, while vertical technology transfer from multinational enterprises has been cited to be more important for informal firms.

Collaboration with foreign partners allows local firms to gain access to a broader knowledge pool at lower cost and to share the risks. Collaborative activities can take a variety of forms and the survey distinguishes four types: with foreign research institutions and universities, with foreign competitors, with foreign suppliers, and with foreign customers. As Table 5.1 shown, foreign research institutions and universities are less oriented towards international collaboration with firms in Ghana and amongst all sources of knowledge it has been reported as the least important channel to induce knowledge diffusion for both formal and informal firms. Conducting collaborative activities with foreign customers to stimulate knowledge flow received relatively more approval in this category, while collaborations with competitors and suppliers were relatively less important to Ghanaian firms.

It has long been recognized that knowledge flows from multinationals to domestic firms not only through machinery, equipment, licensing, but also through expatriate managers and technicians. Meanwhile, the skills gained while working for an MNE may spill over through labour mobility to the domestic market or by setting up one's own business. Yet it is found in Table 5.1 that the intra-national labour movement from global to domestic market was limited. A possible explanation is that the capacity of local firms was not up to absorbing knowledge brought by returnees, foreign workers or

workers with international experience. So utilising these persons as a means of technology diffusion could not be realised.

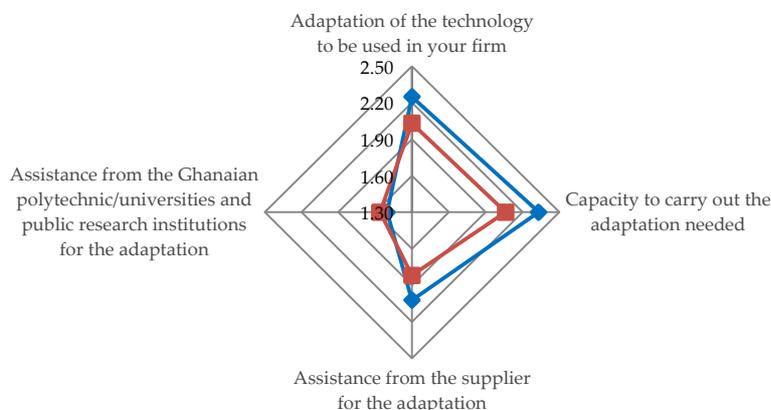
Significantly, formal firms in Ghana perceived the Internet as a crucial channel to obtain information about foreign technology whereas the same perception did not hold for informal firms - this represented the greatest disagreement in the survey between formal and informal samples. Relevant learning and imitation could also happen via networks, foreign visits or trade fairs. In general these knowledge-sourcing channels were more important for formal firms.

Factors ensuring foreign knowledge adoption and adaptation

International technology diffusion is neither costless nor unconditional. Due to inevitable social and cultural differences, foreign technologies developed in advanced economies may not fit well into the local conditions of developing countries. The further the 'technological distance' of a country from the global frontier, the more difficult it is to absorb the knowledge effectively. Accordingly, firms tend to source foreign technology more readily if internal technological capability has been established. Furthermore, asymmetric information problems can significantly reduce the incentive for knowledge adoption. Hence external conditions such as the assistance from linked partners and universities would also foster the adaptation of foreign knowledge.

The DILIC survey listed four factors in ensuring the success of foreign knowledge acquisition and a 5 point Likert index was used to measure the extent to which a Ghanaian firm was aware of the importance of each factor. As the radar pattern in Graph 5.3 depicts, 'the adaptation of the technology to be used' and 'the corresponding capacity to carry out the adaptation' were rated as the most important determinants in foreign knowledge learning by both formal and informal firms, and the levels of importance are statistically indifferent between the two groups. In addition to internal capacity building, assistance from suppliers for the adaptation would also encourage local firms to acquire more advanced knowledge. Our results confirm that assistance from suppliers was more crucial to formal firms, while the assistance from the Ghanaian polytechnic/universities and public institutions was more meaningful to the informal group.

Graph 5.2: Factors in ensuring the success of foreign knowledge absorption and adaptation for formal (blue) and informal (red) firms (1 = insignificant, 5 = crucial, average values).



To sum up, Ghanaian firms rely on a variety of channels to acquire foreign sources of knowledge and innovation. In particular, trade activities carried out with upstream value chains provide both formal and informal firms with valuable opportunities to upgrade their innovation capability. Using the Internet as another important way to obtain knowledge information was commonly acknowledged by formal firms, while establishing vertical linkages with local firms that received foreign investments tended to be more essential to firms in the informal sector. Therefore, it is important for host-country governments to differentiate between the policy needs of formal and informal firms. Meanwhile, the efficiency of the knowledge flow responds to factors such as effective infrastructure, investment regime and, most importantly, the capacity to absorb and assimilate technology. To ensure the success of international technology transfer, a fundamental challenge for host LICs is to improve the local environment and investment climate to encourage domestic firms to participate in international activities that allow them to access the international stock of knowledge, and strengthen the interactions between foreign and domestic firms that foster international knowledge diffusion.

6. Objectives and impact of innovation

As part of the broader policy agenda, innovation has not only helped to drive economic growth in developing countries, it has also addressed socio-economic challenges such as environment, health and poverty. As we have seen, most of the innovations are born out of needs or opportunities. This chapter focuses on the attitudes of firms toward innovation activities. It first starts with identifying the objectives of innovation in Ghana, then moves on to discuss the impact of different types of innovation and how Ghanaian firms perceive the success of the process.

Objective of innovations

What are the reasons behind the innovation activities of firms in LICs? Table 6.1 reports a series of objectives of innovation and their relevance for the firms. For each objective, firms ranked the importance for their innovation activities, from irrelevant ('0') to highly important ('3'). The most important objective of innovation is the improvement of the quality and range of goods and services. This reflects the state of the production of outcomes of firms in LICs. Obsolete or inappropriate technologies may compromise the quality of the final products. Moreover, it shows how the range of products is limited and there is potentially market demand for additional products. The least important objectives for innovation activities are perceived to be reducing production costs, improving working conditions on health and safety, and enhancing supervision and accountability. Again, this last reflects the economic and legal environment in LICs. Manual labour is usually inexpensive and in large supply, therefore firms may not have the priority of reducing its costs. In addition, law enforcement may be weak and firms may not be condemned for not totally complying with work legislation.

There are also some differences between the objectives of innovation activities for formal and informal firms. In general, formal firms seem to have more critical objectives for their innovation activities. In fact, they have given higher scores in all the objectives compared to informal firms. In particular, formal firms significantly awarded a higher importance to increasing the range of goods or services, improving flexibility and increasing capacity for producing goods and services, reducing production costs per unit output, improving working conditions on health and safety and supervision and accountability.

Table 6.1: Objectives' importance of innovation activities, by nature of the firm (irrelevant = 0 to high = 3, average values).

	All	Informal	Formal	Difference
Increase range of goods or services	2.36	2.23	2.54	-0.31**
Replace outdated products or processes	2.19	2.18	2.21	-0.03
Enter new markets	2.07	2.02	2.14	-0.12
Increase market share	2.08	2.06	2.12	-0.06
Improve quality of goods or services	2.53	2.47	2.60	-0.13
Improve flexibility for producing goods or services	2.13	1.98	2.35	-0.37***
Increase capacity for producing goods and services	2.21	2.07	2.40	-0.33***
Reduce production (labour, materials, energy) costs per unit output	1.95	1.77	2.22	-0.45***
Improve working conditions on health and safety	1.88	1.64	2.23	-0.59***
Improve supervision and accountability	1.59	1.47	1.77	-0.30*

Note: Conditional to any innovation introduced. Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively.

Impact of innovations

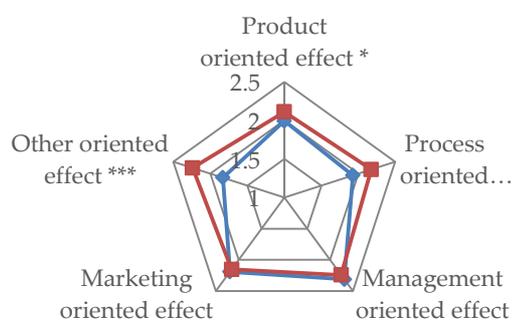
Innovation constitutes an indispensable component of the economic catch-up for LICs because the transfusion of new knowledge provides firms with competitive products, more productive manufacturing processes, efficient managerial practices, and eventually sustainable economic growth. Innovation relates not only to new products and new methods of production, but is also associated with new sources of supply, the exploitation of new markets, and new ways to organise business. In line with conventional classification, innovation in the DILIC survey was differentiated into five types: product oriented, process oriented, management oriented, marketing oriented and other oriented. Based on the perception of innovation projects undertaken, Ghanaian firms in our sample were asked to evaluate the success of innovations on a 3-point Likert scale: low (1), medium (2) or high (3). The average scores were calculated respectively for each type of innovation and the results are depicted in Graph 6.1.

Product and process oriented innovation stem from the concept of technological development. Driven by advancing technologies, product innovation normally incorporates significantly improved characteristics in goods and services that consequently induce profits and increase competitive advantages. In adopting a new or significantly improved production or delivery method, process innovation intends to increase the competitive capability of a firm by decreasing unit costs of production or increasing the quality of the existing products. Both product and process innovation seem to be more successful in formal firms, their average values of success being above 2 as shown in Graph 6.1. In contrast, due to the fact that the innovation activities initiated by informal firms were subject to higher risks due to the lack of stable funding sources and institutional constraints, innovation projects implemented under such circumstances were not so rewarding. Graph 6.1 exhibits that the informal firms' average values were below 2 for both product and process oriented innovation.

Management innovations include the implementation of new managerial methods in the firm's business practices, internal workplace or external relations. It has a tendency to increase firm performance by reducing administrative and transaction costs, improving organisational efficiency, providing access to non-tradable assets such as non-codified external knowledge. The highest score (2.31) was reported for firms in the informal sectors. Firms in the formal sector rated management innovation with a slightly smaller score, 2.24. The difference between two types of firms was not significant.

Marketing oriented innovations indicate the introduction of a new marketing strategy, for instance significant changes in product design or packaging, product placement, product promotion or pricing. The intention of adopting new marketing strategies is to address customer needs or open up new markets, which would eventually lead to increase firms' sales. Both formal and informal Ghanaian firms

Graph 6.1: The success of the innovations introduced, by formal (red) and informal (blue) firms (irrelevant = 0 to high = 3, average values)



Note: Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively.

agreed that marketing innovation was a crucial component in their business strategy and the outcomes had in general met their expectation.

Apart from the different types of innovation, the DILIC survey also addressed a variety of objectives that were expected to be achieved by Ghanaian innovators. Table 6.2 is the statistical summary (averages on a 3-point Likert scale) given by Ghanaian entrepreneurs to assess the outcomes of eighteen innovation objectives.

Product innovation has been used as a main driver to improve the competitive advantage of Ghanaian firms, generating profits by either introducing wholly new products and services or improving the features and functionality of existing products and services. For both formal and informal firms, the major benefits obtained from being involved in product innovation were improving the quality and range of goods or services. New or improved products or services had also successfully helped Ghanaian firms to gain access to new markets and increase their market shares whereas its function in promoting exports was not acknowledged. Due to its cost-cutting nature, process innovation attempted to improve flexibility, increase the capacity, and reduce the costs of production or service provision. Formal firms in our sample agreed that the introduction of process innovation had led to the improvement of production efficiency. Yet such an effect was found to be rather moderate for informal firms as shown in the 7th to 9th rows of Table 6.2.

Table 6.2: Successful of the innovations introduced, by nature of the firm (irrelevant = 0 to high = 3, average values).

	All	Informal	Formal	Difference
Increased range of goods or services	2.29	2.24	2.33	-0.09
Entered new markets	1.74	1.69	1.78	-0.08
Increased market share	1.73	1.69	1.77	-0.07
Improved quality of goods or services	2.40	2.32	2.48	-0.16
Started to export	0.70	0.78	0.62	0.16
Expanded export volumes or to new market	0.81	0.85	0.76	0.09
Improved flexibility of production or service provision	1.80	1.64	1.99	-0.35**
Increased capacity of production or service provision	1.89	1.80	2.00	-0.20*
Reduced production costs per unit of labour, materials, energy	1.84	1.61	2.10	-0.50***
Reduced organisational costs	1.82	1.95	1.66	0.29
Increased management efficiency	2.07	2.19	1.93	0.26
Improved supervision and accountability	2.15	2.34	1.93	0.42*
Targeted new customers	2.34	2.35	2.33	0.02
Entered new geographical markets	1.51	1.47	1.56	-0.09
Reduced environmental impacts	1.24	1.01	1.56	-0.55***
Improved working conditions on health and safety	1.69	1.48	1.99	-0.51***
Met governmental regulatory requirements	0.91	0.66	1.28	-0.62***
Used less energy or generated less pollution	1.18	0.97	1.48	-0.51***

Note: Conditional on innovations introduced. Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively.

Organisational innovations, which are strongly related to administrative efforts to renew managerial routines, procedures, mechanisms and systems, aim to promote information sharing, coordination and collaboration among actors within the organisation. Our results suggest that organisationally oriented innovations were more successful to the informal firms than to the formal firms, especially in improving supervision and accountability. With respect to the objective of reducing organisational costs and increasing management efficiency, no significant differences were observed for two groups. For firms participating in marketing oriented innovations, the greater success was in targeting new customers.

To explore the linkages between innovation and social challenges, the DILIC survey was designed to cover many other impacts of innovation such as reducing environmental impacts, improving working conditions on health and safety, meeting governmental regulatory requirements, and using less energy or generating less pollution. The statistics from the last four rows of Table 6.1 indicate that the impacts of innovation on the environment and governmental regulations were moderate in Ghana, although formal firms were more effective in addressing these issues.

7. Constraints to innovation

It is inevitable for firms in developing countries to encounter obstacles during the process of knowledge adoption and innovation. An innovation obstacle is perceived as a factor that potentially prevents an innovation decision or increases the difficulties, timeframe and cost of the process. Limited by their inadequate resources and experiences, firms in LICs are likely to face substantial barriers to innovation compared to firms in advanced economies. Better understanding of the types of innovation obstacles and the pattern of their appearance would be essential for the Ghanaian government to design efficient innovation strategies and policies. The aim of this chapter is therefore to relate the DILIC survey results to a practical understanding of the innovation barriers faced by Ghanaian firms.

The abandonment and delay of innovation in Ghana

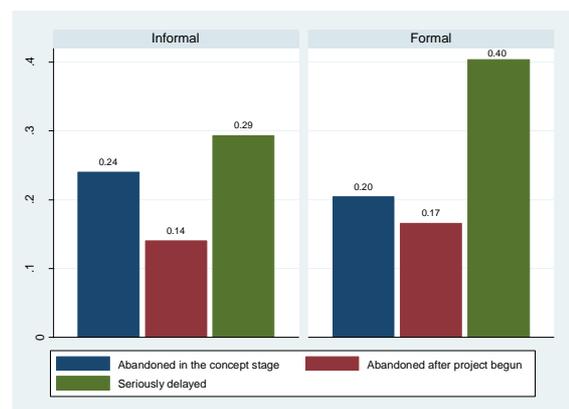
Constraints should be considered as evolving and changing during the innovation process rather than being viewed as static or pre-determined. Innovation as a complex and interactive process needs a comprehensive analysis on each of the components and stages. Barriers can then be examined at different stages starting from the innovation idea and moving up to the innovation investment decision, the invention and adaptation process, and the commercialisation. Any missteps would lead to abandonment, delay, or failure.

Graph 7.1 presents the percentage of Ghanaian firms, formal and informal respectively, that had abandoned innovation ideas or delayed on-going projects due to innovation constraints encountered.

At the initial stage, obstacles may emerge that prevent firms from engaging in innovation activities (e.g. R&D investment or acquiring technology externally). Informal firms have more of a difficulty in finding sources of funds inside and outside of the enterprise to finance their innovation. Graph 7.1 shows that giving up innovation at the concept stage happens more frequently among informal firms than formal ones as shown by the blue bars. If constraints already exist at this stage, firms will not participate in the innovation competition.

After firms pass the starting line and engage in innovation, they may face different types of obstacles throughout the knowledge creation or adaptation process. Obstacles during this process may represent a major determinant of the decision to abandon an on-going innovation project or simply delay and limit the innovation outcomes. The red bars in Graph 7.1 compare the percentages of formal and informal firms that experienced the abandonment of at least one innovation project during years 2010 to 2013. The incidence of quitting while innovating was below 18% for both groups although firms in the formal sector tended to have a slightly higher rate (3% higher). The most common scenario was to delay on-going innovation projects due to potential obstacles faced by Ghanaian firms. Graph 7.1 reveals that about 40% of formal firms delayed their innovation project whereas only about 29 per cent of informal

Graph 7.1: Proportion of Ghanaian firms that experienced innovation failure or delay, mean values for formal and informal firms from year 2010 to 2013.



firms went through a similar experience. Given that constraints faced by Ghanaian firms imposed a substantial impediment to delaying an innovation project rather than initiating an innovation project, it is crucial to differentiate between obstacles to entry and obstacles to proceeding in innovation projects. Appropriate policies should be designed on this basis.

Innovation barriers faced by firms in Ghana

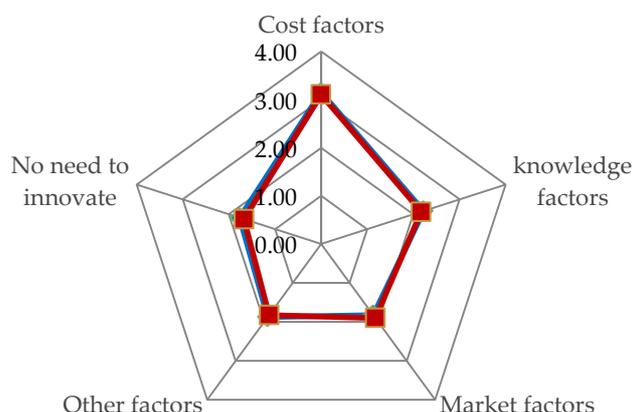
Turning to the types of innovation obstacles, the DILIC survey listed five of them among which eighteen subcategories were distinguished. These are factors that potentially hamper firms' innovation activities or projects or influence the decision not to innovate. Each firm in our sample was asked to evaluate the significance of each obstacle on a 5 point Likert scale. If innovation was not needed for a firm or the entrepreneurs had never considered becoming innovators, then '0' was given. We calculated the significance rates for each factor by taking the sample average value of the Likert scores reported by the firms that had experienced the specific constraint.

Graph 7.2 exhibits the importance of innovation obstacles perceived by Ghanaian firms which considered innovation barriers are relevant. In general, similar patterns of innovation constraints were observed with respect to formal and informal firms. Tight budgets severely impeded innovation activities among Ghanaian firms. Difficulty in securing finance for high-cost innovation was recognised as one of the toughest barriers to innovation. Inadequate knowledge resources were another group of barriers that

Ghanaian firms face and the average scores were 2.17 and 2.22 for formal and informal firms respectively. Market related factors such as the existence of strong competitors in the same industry, a weak intellectual property regime, and market uncertainties were also identified as factors discouraging innovation. The questionnaire also asked Ghanaian entrepreneurs to indicate if innovation was needed for their firm during the period under review. It is worth emphasising that firms without the desire to become innovators would not be aware of the existence of potential obstacles. Only being involved in the innovation process or at least having the need to be innovative would help firms to discover the constraints. The relatively low value for 'No need to innovate' suggests that only a small proportion of firms in our sample did not become innovators because innovation was not needed.

Descriptive statistics on the average values of importance for each factor are presented in Table 7.1. As done previously, the whole sample was divided into two groups for formal and informal firms respectively, while the differences between the rates of average importance were estimated by t-test. Asterisks indicate the level of significance. Obstacles can be classified in different ways. The most common one is to differentiate between those that are internal and external to the firm. Internal obstacles relate to organisational characteristics, the employees' acceptance of innovation and the management structure. External obstacles include supply, demand and other market related factors, for example,

Graph 7.2: Importance of obstacles to innovation for formal (blue) and informal (red) Ghanaian firms (1 = insignificant, 5 = crucial, average values).



difficulties in acquiring external technological information and finance, incorrect perception of target markets, and government regulations.

The absence of advanced financial systems and the lack of technological capabilities are contributing to the internal difficulties to innovation faced by Ghanaian firms. As the statistics in Table 7.1 show, the top three major obstacles to innovation in Ghana were all under the category of 'Cost factors'. It is a common phenomenon that the main obstacle to innovation is its economic cost and the lack of available finance. While this result can be found also in developed countries, the dimension of the problem is more serious for small and medium enterprises in LICs. Table 7.1 suggests that the lack of innovation funding represents a major weakness of the innovation system in Ghana. This obstacle was more frequently complained about by informal firms as shown by the negative signs for differences in the last column, although the differences were not statistically significant. The costly and risky nature of innovation was reported as another major deterrent of innovation and cause of failure of innovation projects.

Table 7.1: Importance of obstacles in hampering innovation for formal and informal firms (1 = insignificant, 5 = crucial, average values).

		All	Informal	Formal	Diff.
Cost factors	Lack of funds within your enterprise or group	3.93	4.01	3.79	-0.22
	Lack of finance from sources outside your enterprise	2.84	2.91	2.73	0.17
	Innovation costs too high	3.12	3.07	3.20	-0.13
	Excessive perceived economic risks	2.65	2.62	2.71	-0.09
Knowledge factors	Lack of qualified personnel	2.14	2.12	2.18	-0.06
	Lack of information on technology	2.17	2.16	2.19	-0.03
	Lack of information on markets	2.20	2.19	2.22	-0.03
	Difficulty in finding co-operation partners for innovation	2.29	2.40	2.09	0.31*
Market factors	Market dominated by established enterprises	2.17	2.18	2.17	0.01
	Uncertain demand for innovative goods or services	1.97	1.97	1.96	0.01
	Innovation is easy to imitate	1.71	1.69	1.74	-0.05
	Little competition in the market and hence no need to innovate	1.47	1.46	1.50	-0.04
	Too much competition in the market and too low perceived return of innovation investment	1.94	1.83	2.13	-0.30*
Other factors	Organisational rigidities within the enterprise	1.54	1.51	1.59	-0.08
	Workers do not have the incentive to innovate.	1.91	1.88	1.94	-0.06
	Insufficient flexibility of regulations or standards	1.72	1.73	1.71	0.02
	Limitations of science and technology public policies	1.77	1.81	1.70	0.11
	Weak intellectual property rights protection	2.43	2.49	2.34	0.15
	Practices used by informal firms	1.77	1.82	1.68	0.14
No need to innovate	No need due to prior innovations	2.10	2.17	1.98	0.20
	No need because of no demand for innovations	1.51	1.48	1.58	-0.10
	Social or cultural factors	1.58	1.64	1.46	0.18

Note: More than one answer allowed. Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively.

Knowledge related factors were another internal constraint to innovation. The success of innovation cannot be achieved without having a compatible internal technological capability to absorb and integrate various knowledge sources during production. Table 7.1 shows the awareness of four types of knowledge related obstacles by Ghanaian firms. The statistics indicate that the major hampering effects in this category were in relation to the lack of technology and market information whose collection is time-consuming, expensive and difficult to use. In addition, institutions of education and training are not producing enough graduates with the required skills to spur technological innovation for economic growth. This has been recognized as one of the major barriers to improving the technological performance in LICs. The same was observed with Ghanaian firms: the shortage of employees' skills in mastering production techniques and managerial skills were regarded as serious constraints to innovation activities. With respect to the differences between the two groups, formal firms are more aware of the lack of qualified personnel and of information on technology and information on markets while they undertake innovation activities whereas informal firms face more difficulties in finding co-operation partners to obtain external knowledge sources and technical assistance. However, the differences were not significant.

Two categories of external barriers were discussed with entrepreneurs in Ghana, market and institution related factors. The market-related barriers refer to various kinds of market failure and other market-induced innovation deterring factors. The nature and intensity of competition within markets affect the risks and profitability of innovation investment. Under the category of 'Market factors' in Table 7.1, 'Market dominated by established enterprises', 'Intense competition in the market and too low perceived return of innovation investment' and 'Uncertain demand for innovative goods or services' were rated as the major barriers to Ghanaian firms as they would crowd out many small firms and start-ups. Moreover, Ghanaian firms reported that the public good nature of innovation might lead to knowledge leakage, which undermines their incentives to invest in innovation. Only a small proportion of firms in our sample treated weak competition in the market as a potential barrier that impaired innovation.

Several factors linked to institutional constraints were also mentioned in the DILIC survey such as the insufficient flexibility of regulations or standards, limitations of science and technology public policies, weak intellectual property rights (IPR) protection, and practices used by informal firms. In general, informal firms perceived the prevailing policy and regime (with the exception of weak IPR) as an obstacle more often than formal firms. Organisational rigidities within the firms had also been addressed under the category of other factors, but they did not seem to substantially retard innovation in Ghana.

To encourage innovation and facilitate economic growth, governments in LICs should collaborate with the private sector and collectively establish an effective innovation system to overcome the potential innovation barriers. Given the substantial undermining effects induced by finance-related barriers, actions should be taken to design an effective financing scheme that enables more firms, especially the informal ones, to gain access to financing for innovation. Meanwhile, policy incentives should also consider compensating for market and institutional weaknesses.

8. The role of innovation policy

Government can effectively reduce the technological gap between LICs and advanced economies by establishing national or regional innovation systems that encourage indigenous knowledge creation, foster domestic and international knowledge transfers, and promote the upgrading of technological capabilities. Since independence, stimulating a rapid social and economic development by using knowledge and tools derived from Science and Technology (S&T) has been the ambitious plan of the Government of Ghana. To date, however, the role played by S&T policy in Ghana's development has been limited. In reviewing some of the key elements of Ghana's S&T policy from the perspective of local firms, this chapter seeks to offer an understanding of their current state and impacts.

Participation in training and financing programmes

The way public actors provide guidance and intervene in the innovation process is strongly associated with the determinants of innovation. For instance, policies to encourage open trade and investment would be suggested if trade and FDI were believed to generate knowledge spill-overs. As discussed in chapter 6, an important determinant for LICs to effectively absorb advanced know-how is the local level of technological capability. In-house knowledge creation, external technology adoption, and the process of translating knowledge into competitive advantage depend heavily on an adequate supply of engineering and management skills. In the situation that universities and institutions of education are not producing enough graduates with the required skills to spur technological innovation for economic growth, an inadequately skilled workforce has become one of the major barriers to improving the country's technological performance and to growing a national system of innovation. Attempting to overcome this shortage, the Government in Ghana introduced various educational reforms and offered opportunities for improving training outside of the formal education system such as technical education, apprenticeships, in-service training and other means intended to ensure the workforce is appropriately skilled to absorb new technologies and to meet the local industry demands.

Firms in our sample were asked if they had taken advantage of training opportunities provided by the Ghanaian government. The bar graph on the left of Graph 8.1 shows that between 2010 and 2013, 107 firms (20 per cent of the total sample) had participated in government training programmes in Ghana, among which the participation incidence for informal firms was nearly 43 per cent higher than for formal firms (63 versus 44). The first row of Table 8.1 presents the average extent to which formal firms and informal firms benefitted from public training. In general, Ghanaian firms were aware of the

Table 8.1: Benefitting from participation in training and subsidised rate loans programme for formal and informal firms: training (1 = insignificant, 5 = crucial, average values).

	Total	Formal	Informal	Difference
Training opportunities	3.37	3.25	3.46	-0.21
Subsidised rate loans	3.17	3.14	3.22	-0.79

Note: Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively.

advantages of taking part in a training service and the average beneficial rate was 3.37 out of 5. Despite the fact that informal firms had gained slightly more benefits compared to formal firms, there was no evidence that the benefits between two groups were significantly different from each other.

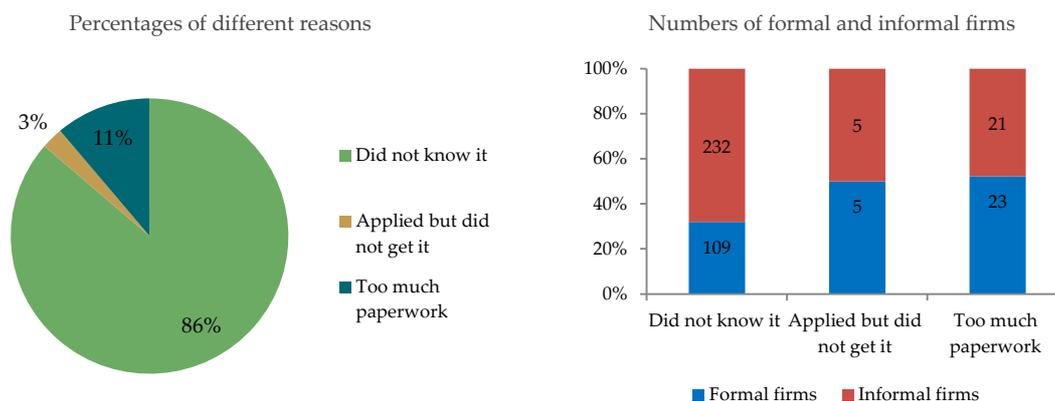
The government also aims to promote innovation in private firms via improving fiscal and legal incentives for domestic entrepreneurship. Given the 'supply-driven' nature of S&T systems in developing and least developed countries, direct funding subsidies have become one of the most commonly used incentives to encourage firms to adopt new technologies, innovate and raise productivity. Nevertheless, in Ghana the majority of domestic firms so not appear to have successfully gained benefits from government financial support programme. Only 14 formal firms and 9 informal firms had received government subsidised rate loans during 2010 – 2013, accounting for a mere 4 per cent of the total sample. In line with the participants of training programmes, firms that received the subsidised loans responded positively to such financial incentives. The average beneficial rate evaluated by the 23 firms was 3.17 out of 5 among which informal firms tended to take more advantage than formal firms from the cheap rate loans. The t-test rejected the hypothesis that the difference between two groups is statistically significant.

Among the various factors that caused Ghanaian firms to fail to participate in the public innovation programme, the survey listed the most common three categories for each firm to choose: did not know about it, too much paperwork, or applied but did not get it. Graphs 8.2 and 8.3 summarise the statistics in relation to training services and cheap rate loans respectively. The pie graph in Graph 8.2 demonstrates that many non-participants (almost 86%) did not participate because they did not know about the existence of the training services. About 11 per cent of the non-participants pointed out that it was the bureaucracy of the procedures and the paperwork that kept them away, while only 3 per cent indicated that they applied for it but did not get it. The figures on the right in Graph 8.2 try to calculate the proportions of formal and informal firms accounting for each of the reasons. There was clear evidence showing that the lack of effective channels to access the information was the main barrier for informal firms to participate in government-funded training programmes. This reason was less profound for formal firms as shown in the bar figure in Graph 8.2. For those who gave up because of the heavy paperwork entailed or did not succeed with their application, the proportions of formal and informal firms were almost equal.

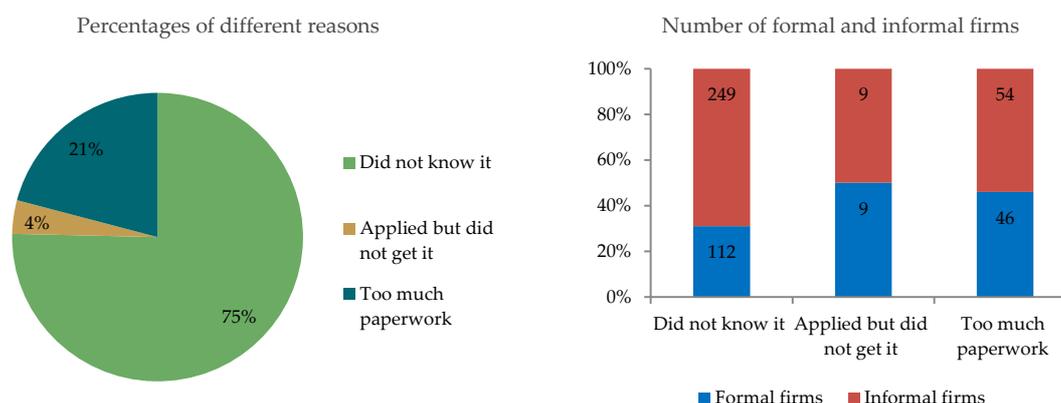
An analogous pattern was observed for firms that were absent from the subsidised rate loans programme, as exhibited in Graph 8.2. Owing to the information asymmetry, nearly three-quarters of the firms missed the opportunity to take advantage of cheap rate loans. Compared to the training programme, more firms (21 per cent) were frustrated by the heavy paperwork involved with applying for the subsidised rate loans. The remaining 4 per cent of non-participation was due to the fact that non-participants were less qualified than applicants. In total, there were 249 informal firms that did not know about the subsidised rate loans whereas 109 formal firms reported the same. Informal and formal groups are about equally represented with respect to the reason 'applied but did not get it', while two more formal firms than informal ones gave up on their applications because of excessive paperwork.

Clearly, Ghanaian firms have not been responding to the existing incentives mainly because of the absence of information. Lack of effective means to gain access to innovation policy and information had prevented local firms, especially the informal ones, from participating in the government innovation programme.

Graph 8.1: Reasons for not participating in training programmes for formal and informal firms, percentages of different types of reasons (left) and numbers of formal and informal firms (right) for each reason.



Graph 8.2: Reasons for not receiving subsidised rate loans for formal and informal firms, percentages of different types of reasons (left) and numbers of formal and informal firms (right) for each reason.



The role and implementation of innovation policy in Ghana

Recognising the important role that knowledge and innovation must play in transforming the economy and reducing poverty, the Government of Ghana has placed S&T development high on its list of priorities. This is reflected in various political and policy statements, including Vision 2020, the Growth and Poverty Reduction Strategy II, and the medium-term development plan. These policies and strategies have emphasised that the absorption and application of much more S&T is a critical ingredient for successful growth. The survey tried to help better understand the role of the innovation policy in Ghana by inviting each respondent to assess the effectiveness and implementation of a series of government innovation incentives.

A 5-point Likert scale was used to index how effective each incentive was to the firm. The corresponding statistics are presented in Table 8.2. Ghanaian firms agreed that the ten listed innovation policy initiatives were in general beneficial for their innovation activities except for 'open the economy to foreign competitors and increase competition', which was rated below the median of 2.5. Fiscal

incentives played a substantial role in stimulating knowledge creation and technology adaptation and received relatively higher rates of importance compared to other innovation policies. The top two important incentives for formal as well as informal firms were 'provide cheaper interest loans' and 'provide fiscal subsidies'. Another important policy selected by entrepreneurs of formal firms was 'lower corporate taxes' whereas informal firms were more likely to benefit from 'government funding schemes: the MSME project of the Ministry of Trade and Industry'. Other fiscal policies such as allowing duty-free exports, imposing higher duties on imported products, and the venture capital trust fund were also acknowledged by Ghanaian firms but considered less crucial to innovation than the ones mentioned above.

Table 8.2: The importance of government policies for formal and informal firms, (1 = insignificant, 5 = crucial, average values).

	Total	Informal	Formal	Diff.
Provide fiscal subsidies	3.94	3.94	3.93	0.01*
Duty-free exports	3.71	3.65	3.82	-0.17
Impose higher duties for imported products	3.37	3.38	3.35	0.04
Develop high tech industrial development zone	3.53	3.55	3.48	0.07
Lower corporate taxes	3.79	3.73	3.91	-0.18*
Provide cheaper interest loans	4.17	4.20	4.11	0.09*
Government procurement	3.57	3.57	3.56	-0.00
Open the economy to foreign competitors and increase competition	2.22	2.26	2.15	0.11
Gov. funding schemes, e.g. the Micro, Small and Medium Enterprise (MSME) Project of the Ministry of Trade and Industry	3.78	3.84	3.66	0.19
Government funding scheme, e.g. The Venture Capital Trust Fund	3.75	3.78	3.69	0.09

Note: More than one answer allowed. Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively.

Table 8.3: The implementation of government policies for formal firms and informal firms, (1 = insignificant, 5 = crucial, average values).

	Total	Informal	Formal	Diff.
Provide fiscal subsidies	1.86	1.92	1.74	0.18
Duty-free exports	1.78	1.78	1.77	0.01
Impose higher duties for imported products	1.86	1.85	1.87	-0.02
Develop high tech industrial development zone	1.77	1.85	1.64	0.22
Lower corporate taxes	1.79	1.82	1.73	0.09
Provide cheaper interest loans	1.88	1.91	1.83	0.08
Government procurement	1.88	1.89	1.87	0.01
Open the economy to foreign competitors and increase competition	1.93	1.98	1.86	0.12
Gov. funding schemes, e.g. the Micro, Small and Medium Enterprise (MSME) Project of the Ministry of Trade and Industry	2.02	2.12	1.85	0.27
Government funding scheme, e.g. The Venture Capital Trust Fund	1.99	2.07	1.86	0.22

Note: More than one answer allowed. Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively.

In addition, firms were also asked to evaluate the implementation of each policy on the same 5-point Likert scale. As the second column of Table 8.3 reports, the sampled firms in general agreed that there was still a great potential to improve the strength and coverage of innovation policies in Ghana. Except for government funding schemes, the implementation scores rated for other policies were all below 2 (2.5 being the median). In contrast to its relatively high score on its importance, fiscal related policy was seen as having been less satisfactorily implemented. According to the entrepreneurs in formal firms, the top three well-implemented policies were government procurement, imposing higher duties for imported products, and the venture capital fund during 2010-2013, while for informal firms they were the MSME project, the venture capital trust fund and increasing competition via opening the economy to foreign competitors.

As with many other economies in sub-Saharan Africa, Ghana is still in the stage of 'factor-driven' growth. Inefficient innovation financing schemes, low capacity levels for innovation and weak international linkages are still severely constraining the development of innovation capability. Policy-makers in Ghana, if they want to transform the economy from a 'factor-driven' one into an 'innovation-driven' one, must begin addressing these issues.

9. Innovativeness of foreign firms

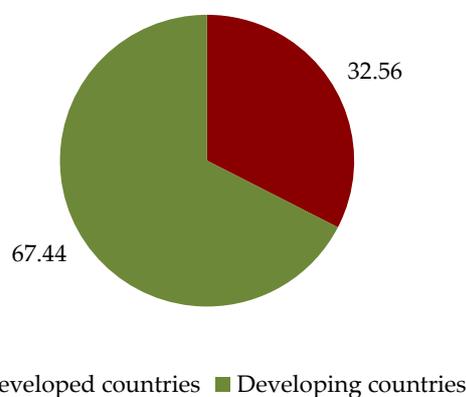
As the leading player in global economic integration, foreign firms bring key knowledge resources to host countries and facilitate knowledge diffusion across national borders. To sustain their global competitiveness, foreign firms actively engage in home-based private R&D as well as enhance technological capabilities through acquiring external knowledge sources. In the context of low-income countries, do foreign firms also participate in R&D investment in the host economies? Do they behave differently in sourcing innovation compared with domestic firms? This chapter provides a general description of the innovativeness and the technological sourcing channels of foreign firms in Ghana.

The DILIC survey received 43 valid responses from foreign invested firms that are present across various industries and regions. The data collection of foreign firms comprises two rounds: the first round had 21 responses and it was conducted together with domestic firms among the sample of 501 firms. The information of the additional 21 foreign enterprises was collected separately, a few months after the main survey. Thus the total number of foreign firms becomes 43, about 8.2 per cent of the total sample. The descriptive statistics presented in the current chapter are based on the sub-sample of 202 firms, consisting of 43 foreign firms and 159 local formal firms. The 321 domestic informal firms are not included in the following discussion.

Innovation activities

In this study, we use the origin of the largest shareholder in the firm as the indicator to determine if a firm will be classified as foreign invested firms. If the largest shareholder is a non-Ghanaian, the firm is considered a foreign firm. The origins of foreign investors are not only from neighbour countries but also from distant countries in Europe, America and Asia. About 67 per cent of the foreign firms in the sample are from developing countries, whereas 33 per cent are from developed countries, as shown in Graph 9.1.

Graph 9.1: Proportion of investor origins of the foreign firms

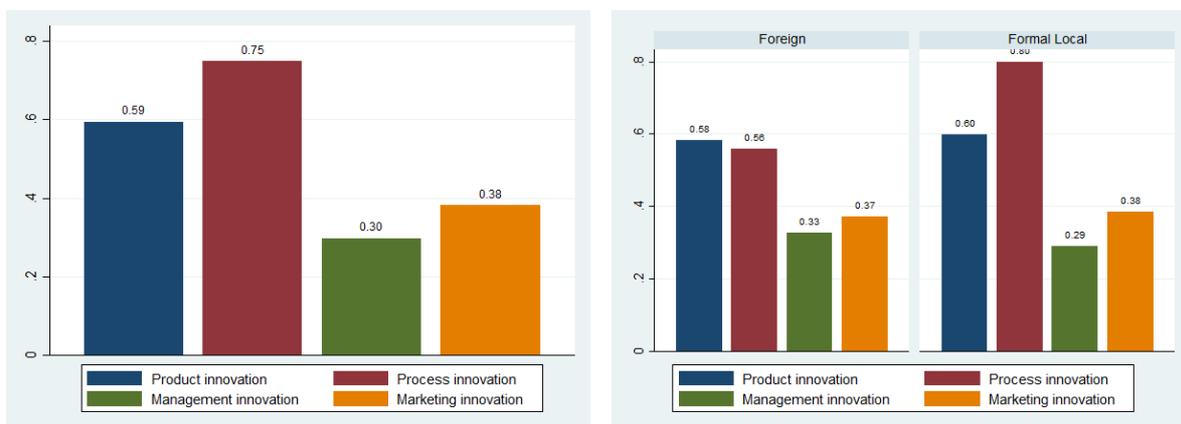


In general, foreign firms arrive in recipient countries with advanced technologies and efficient production methods. Although their relatively large size and immense resources confer them with the ability to easily compete with domestic firms, very often foreign firms still need to engage in innovation to adapt their products and production process to local market demands and conditions. Graph 9.2 shows the proportion of firms active in innovations among the sub-sample of 202 firms (excluding domestic informal firms) and the bar graph on the right compares the innovation performance between foreign firms and local formal firms. Due to the economic, cultural and societal differences in the host countries, product innovation helps foreign firms modify or create new products to best fit the host country market. Nearly 58 per cent of foreign firms reported having product innovation during the period under survey, which is slightly smaller compared to local formal firms. The largest difference

was found in process innovation which is more common to the local formal firms, at nearly 80 per cent. Foreign firms tend to be less engaged in process innovation (56 per cent), probably because the advanced production process and design have already applied within these firms. With respect to management and market innovation, similar patterns are observed for both groups.

Despite similar levels of innovativeness displayed between foreign and domestic formal firms, the content, especially the quality, of the innovation outcomes may vary strongly. Graph 9.3 reports the proportions of innovation which are new to the firm, new to the country and new to the world, respectively for foreign and domestic formal firms. In general, most of the innovations taking place in foreign firms are diffusionary innovation. About 95 to 97% of the innovations in the foreign invested firms are new to the firm or the country. Nevertheless, overall, innovations originated by foreign firms are clearly of higher novelties compared to innovations achieved by local firms. Among all product innovations within foreign firms during the period under survey, 33 per cent of them are new to in the Ghanaian market and 2.3 per cent were never found before globally, making a total of at least 34.9 per cent new to the country. The corresponding proportion of innovation in the local formal firms is 11.9 per cent, only one third the proportion of foreign firms. The same pattern can be found for process, management, and marketing innovation. Innovation originated in foreign firms contains higher levels of novelties whereas local firms tend to adopt and imitate the existing technologies.

Graph 9.2: Proportion of firms active in innovations, by nature of innovation (left) and by nature of innovation and firm (right)



Graph 9.3: Proportion of firms active in innovation activities, by nature of innovation and type of firms



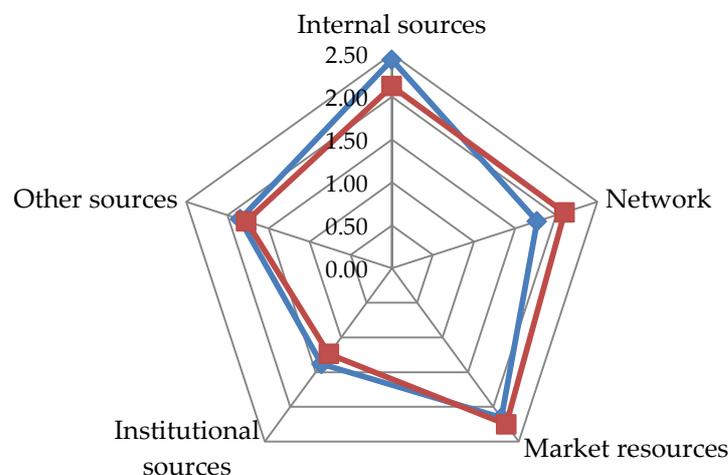
Sources of innovations

Owing to the nature of foreign firms, their innovation behaviours are often different from those of the domestic firms. How do the innovations in foreign invested firms come to fruition in low income countries? What are the major sources of innovation in MNE subsidiaries in low income countries? Do the sources of innovation that are commonly acknowledged by domestic formal firms also transmit useful information to foreign firms? Graph 9.4 suggests that the use of innovation sources by foreign firms is in general consistent with that used by domestic firms in spite of differences in magnitudes. Both foreign and domestic firms recognise sources originated from the market and within organisations as the most important sources to help firms innovate. It is worth noting that the network is perceived as another equally critical innovation source for local formal firms while foreign firms tend to reply less on it. Institutional sources are ranked as the least important for both foreign and domestic firms.

Table 9.1 presents the summary statistics of the importance of fifteen local sources of information for foreign and local formal firms. Managers of sample firms were asked to give a 5-point Likert scale to rate the importance of each innovation source. Differences between foreign and local formal firms are tested by t-statistics and the results are displayed in the last column. The asterisks indicate the level of significance. As Table 9.1 shows, foreign firms can efficiently initiate innovation internally because of accumulated knowledge and rich human and financial resources. The importance of internal sources was less evident to firms with domestic ownership than those with foreign ownership.

Meanwhile, much innovation occurs not only internally but also, especially for domestic firms, through various external channels. Messages delivered by the market are valuable for firms to formulate business plans and innovation strategies. The local market has always been a pivotal channel to learn and acquire innovation sources for both foreign and domestic firms. Obtaining information from the market can be achieved via various forms. Interactions with customers allow firms to gain direct and profound understandings about the needs of the local market. Both foreign and domestic firms rated the information obtained from customers as the most important source of innovation. Learning and imitating the competitors or other enterprises in the same sector is another way to acquire innovation sources for domestic formal firms. Significantly, foreign firms in Ghana perceived the internet as another

Graph 9.4: Importance of local sources of information for foreign (blue line) and local formal (red lines) firms (1 = insignificant, 5 = crucial, average values)



important channel to receive sources of innovation where the same perception did not hold for domestic formal firms. The difference found between two groups is the greatest disagreement among all local sources of innovation.

Table 9.2 reports the summary statistics of the channels through which innovations are created. Overall, modifying the existing products in response to customers' requirement, achieving innovation through efforts within the firm, collaborating with customers, and imitating innovations introduced by other firms with some modification are reported to be the main mechanisms through which innovations come to fruition. However, comparing the foreign invested firms to the domestic firms, domestic firms rely significantly more on imitation, while innovations in foreign invested firm are created significantly more by internal technicians and via collaborations than the domestic firms do.

Table 9.1: Importance of local sources of information for foreign and local formal firms (1 = insignificant, 5 = crucial, average values)

		Total	Foreign	Local formal	Diff.
Internal sources	Sources within your enterprise (colleagues)	2.64	2.84	2.58	0.25
	Sources within your group (if you have subsidiary or associated companies)	1.74	2.02	1.66	0.36*
Network	Member of cluster	1.79	1.72	1.81	-0.09
	Member of associations	2.27	1.81	2.39	-0.58**
Market resources	Suppliers of equipment, materials, components or software	2.20	2.12	2.23	-0.11
	Clients or customers	3.06	2.84	3.13	-0.29
	Competitors or other enterprises in your sector	2.39	2.21	2.43	-0.22
	Consultants, commercial labs or private R&D institutes	1.28	1.47	1.23	0.24*
Institutional sources	National universities or other higher education institutions	1.24	1.26	1.23	0.02
	Government or public research institutes	1.30	1.51	1.25	0.26**
Other sources	Radio	1.79	1.51	1.86	-0.35*
	Internet	1.77	2.33	1.62	0.70***
	Conferences, trade fairs, exhibitions	2.29	2.00	2.37	-0.37*
	Scientific journals and trade/technical publications	1.62	1.70	1.60	0.10
	Professional and industry associations	1.46	1.70	1.39	0.31*

Note: Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively.

Table 9.2: How the innovation materialised (percentages of innovating foreign and formal firms).

	Tot.	Foreign	Local formal	Diff.
The product or process was mainly developed within the enterprise	63	60	65	-5
Your company has a research & development department. Scientists and engineers working in this R&D department created it.	7	12	5	7
Technicians in your companies created this as a solution to a problem that constrains the production or competitiveness of the company.	14	26	10	16***
Skilled workers in the company find out a better way for the production process after some experiments.	32	26	34	-8
You modified the product in response to customers' requirement.	63	52	66	-14
Your enterprise adapted or modified goods or services originally developed by other enterprises or institutions	17	19	17	2
Your enterprise created it together with other enterprises or institutions:				
With supplier	11	19	9	10*
With customer	40	36	42	-6
With other firm in the industry	9	10	9	1
With universities and research institution	8	7	8	1
With other firm in the same company group	8	19	4	15***
Your firm acquired technology originally developed by others by licensing and adapted or modified it	10	12	9	3
Your firm acquired technology originally developed by others by licensing without any adaptation and modification	9	14	7	7
Your firm observed/or heard of new products or production process or new ways of organising production and marketing by other companies and imitated it directly	21	7	26	-18*
Your firm observed/or heard of new products or production process or new ways of organising production and marketing by other companies and imitated it with some modification.	42	14	50	-35***

Note: Significance at the 10 per cent, 5 per cent and 1 per cent levels are indicated by one, two and three asterisks respectively.

To sum up, foreign firms are slightly less oriented towards innovation, in particular process innovation, probably because of the already-built efficient production process and design. Evidence of gaps is observed between the novelty contents of the innovation originated by foreign firms and domestic formal firms, and differences in innovation sourcing are also exhibited. Overall, sources within the company group, internet, private R&D institutes as well as government and research institutes played a more important role in innovation in foreign invested firms; while membership of industry associations and conferences and trade fairs played a more significant role in innovation in the domestic formal firms. Customers, competitors, suppliers as well as internal creative ideas are of significant importance to both the foreign and domestic firms. Finally, while the domestic firms rely more significantly on imitation for innovation, innovations in foreign invested firm are created significantly more by internal technicians and via collaborations than the domestic firms do.

10. Conclusions

The DILIC survey of the diffusion of innovation in Ghana is the first survey in LICs that is dedicated to the origin and diffusion of innovation within and into these countries. The unique design of the survey provides unprecedented insights into the transmission mechanisms of innovation, expanding our understanding and going beyond the traditional input and output indicators. Such a survey is not only unique for LICs but also for middle and high income countries, where transmission mechanisms have not been receiving the attention the issue deserves. This carefully designed pioneering survey offers distinctive evidence on the form and nature of innovations in the LIC context, the origins and the effective channels for the diffusion of innovation within the country and from foreign sources to these countries, the barriers to innovation creation and diffusion, and the space for innovation policy in these economies.

The transfer, adoption and adaptation of knowledge to LICs constitute an important issue for economic growth and global development. Technological innovation has been traditionally concentrated in a few developed countries, given the costs and risks involved in fomenting technological innovation. Therefore, the development process in LICs can be supported by tapping existing knowledge and know-how. Innovative capacity in LICs becomes critical for the successful transfer and adaptation of knowledge. Yet several constraints and obstacles prevent firms from innovating. Addressing these constraints, building functional innovation systems and enhancing innovative capacity, is fundamental to socio-economic development in LICs.

Innovation under the radar in LICs

Firms in LICs are innovating, and innovation activities are taking place in both formal and informal sectors. In the formal sector, 80 per cent of the firms we surveyed reported having had a process innovation in the past three years. Sixty per cent of the firms reported having had a product innovation, either new to the country or new to the firm. Seventy per cent of the firms answered that they had introduced a management innovation and forty per cent of them reported that they had new marketing practices. Remarkably, more than fifty per cent of the surveyed informal establishments reported that they had introduced new process innovations, thirty-four per cent product innovations, and twenty per cent of these firms reported management and marketing innovations in the past three years.

Most of these innovations are not lab-based R&D. They are based on learning and are incremental in nature. The majority of these innovations are new to the firm, with a small proportion of them new to the country. A very small minority of innovations -- around two per cent of them -- are claimed to be new to the world. Therefore, according to the data from the survey, the majority of them are diffusion-based innovations. It is also important to note that the innovations in LICs are not only technological innovations, but we found substantial non-technological innovations, which are related to new management and marketing models and practices.

Finally, most of those innovations are created for the base of the development pyramid and are also taking place at the base of the pyramid. They are about appropriate technology, in a way that is technically, economically and socially appropriate to the local context. This allows firms to address the affordability constraints and also the affordability issue of innovation in the context of LICs and in the

context of lower income groups. Of course, innovations in LICs are overlapping with the notions of frugal, 'jugaad' innovation and inclusive innovations. Innovations are cost-cutting and cost-efficient and are created to meet the diverse demands of consumers and customers in the market. There are also innovations in the high-tech sector, which do not necessarily aim at frugal innovation cost-cutting, and resemble the inclusive innovation notion.

Origin of innovations in LICs

The vast majority of innovations introduced during the three years 2011 - 2013 originated from within Ghana. In fact 62 and 60 per cent of informal and formal firms have respectively adopted or created innovations with resources and information found in-country. Formal and informal firms behave differently regarding the adoption of innovation from abroad. Informal firms seem to be more likely to adopt innovations from nearby countries, and Africa in general, than formal firms. The latter instead are more likely to adopt innovations from Europe and United States. In recent times there has been an emphasis on the relevance of South-South collaboration and technology transfers and we found that collectively 13 per cent of the innovations introduced came from a low-or middle income country (other countries in Africa, India, and China). Informal firms seem to have a greater share of innovation from those countries, highlighting the fact that adoption of innovations from a country at a similar development stage may be easier for firms with lower absorptive capacity.

Most of the innovations in LICs are of a different nature than those in more developed countries. Research and Development (R&D) departments are available only in the larger firms in Ghana, and most of the firms need to rely on different ways to innovate. Our data show that innovations are primarily responses to customer needs and they emerge and are developed in accordance to customer requirements. The second most important source of innovation is through observing or hearing from other firms of some new product or production processes, or new ways of doing marketing and production organisation. Price competition often drives firms to imitate, adapt or develop new ways of production. Imitation and adaptation account for 46 percent of innovations in our sample. Beside adaptation and modification, many firms innovate simply by imitating other companies. This is a normal behaviour in a situation in which R&D departments are extremely rare. Instead, the contribution of skilled workers to the innovation process is highly relevant, mainly for formal firms. More than one third of these firms introduced process innovations that came from skilled workers who had found a better way for the production process after some experiments, in a trial-and-error approach. The information gathered in the survey suggests that innovation in LICs do not necessarily require large investments or advanced R&D laboratories. Innovation emerges to meet the requirements of customers and help firms to become more competitive. Imitation of other firms, with or without changes, is a way to become innovative. It is demand-driven, progressive, and absorptive innovation.

Diffusion of innovations within LICs

The main sources of innovation from within Ghana are clients and customers for both formal and informal firms. This finding reinforces the evidence that in many cases innovations originate in response to customers' requirements or together with customers. In addition to clients and customers, competitors or other enterprises in the same sector are an important source of information. Information that supports innovation activities in Ghanaian firms is mainly sourced by market agents, both from the demand side and from competitors. Firms also rely on members of clusters and associations to gather

information on innovations. The importance of networks is more evident for informal firms, which otherwise would have limited resources for gathering specific information.

The vast majority of innovations in Ghana are created and diffused throughout informal collaborations between firms and other agents. In fact, only eight per cent of the firms in the sample have developed or introduced innovations in the period 2011-2013 that stemmed from formal collaborations based on the active participation of different actors. The decision to engage in formal collaborations is partially influenced by the characteristics of the firms. With larger financial resources and greater absorptive capacity, formal firms are relatively more likely to engage in formal collaborations than informal firms, with respectively eleven and seven per cent the proportions of firms that co-operate in innovation activities.

In low income countries, universities could have a pivotal role for knowledge-based economic development and change through spin-off companies, licences for new technologies, and by transferring knowledge to existing businesses. In our sample we found 19 firms that have actively collaborated with universities or other higher education institutions in developing and adopting innovation, and in most cases the collaboration was established by individual initiative and through personal connections. If on the one hand personal initiatives may overcome the lack of more comprehensive programmes, on the other hand they may bring uncertainty and instability to the collaboration. If strong ties are not built between the firm and university, the co-operation is largely dependent on the continued employment of key figures in both institutions. In fact, the lack of connections is the main reason that prevented willing firms to collaborate with universities.

Finally, we found ten per cent of firms are part of a vertical production chain consisting of SMEs. The proportion is similar for formal and informal firms, although the locations of the lead and the network are usually different between the two categories. Informal firms tend to be part of a network mainly located in the region and driven by small firms, while formal firms are more likely to have a large firm as a leader and the network is spread out at the national level. Vertical integration in the supply chain is not only a vector for innovation diffusion but also an important strategy to reduce transaction costs, exploit the competitive advantage of the chain members, and secure supplies or distribution channels.

Diffusion of innovations to LICs

Most of the innovations in Ghana have emerged from domestic sources; however we have seen some innovation being imported from abroad or resulting from spill-overs emanating from multinational companies. International knowledge is mainly acquired via networks, imports and exports. Trade is a critical channel for local firms to come across and potentially adopt innovations. In addition, more formal firms can engage in the global value chain via the downstream manufacturing sectors, which is a very effective way to obtain innovation from abroad. Spill-overs from multinationals are an increasingly relevant source of innovation diffusion. Not only technology transfers can occur between multinationals and local firms, but also non-technological innovations. Multinationals often provide training for local employees and knowledge can be transferred via the mobility of labour. Skilled workers in multinationals often move to another company or start their own business at some point in their career. Some technological and non-technological innovation transfer processes occur deliberately, but most are spontaneous. Using the Internet as another important way to obtain knowledge information was commonly acknowledged by formal firms, while establishing vertical linkages with local firms that received foreign investments tended to be more essential to firms in the informal sector.

Due to inevitable technological but also social and cultural differences, foreign technologies developed in advanced economies may not fit well into the local conditions of developing countries. Therefore external conditions such as the assistance from linked partners and universities can foster and support the adaptation of foreign knowledge. The most relevant factors in ensuring the success of foreign knowledge acquisition for both formal and informal firms is the adaptation of the technology to be used and the corresponding capacity to carry out the adaptation. In addition to internal capacity building, assistance from suppliers for the adaptation would also encourage local firms to acquire more advanced knowledge. Our results confirm that assistance from suppliers was more crucial to formal firms, while the assistance from the Ghanaian polytechnic/universities and public institutions was more meaningful to the informal group.

We captured a different behaviour of formal and informal firms towards the adoption of innovation from abroad. Therefore, it is important for host-country governments to differentiate between the policies needs of formal and informal firms. Meanwhile, the efficiency of the knowledge flow responds to factors such as effective infrastructure, investment regime and, most importantly, the capacity to absorb and assimilate technology. To ensure the success of international technology transfer, a fundamental challenge for host LICs is to improve the local environment and investment climate to encourage domestic firms to participate in international activities that allow them to access the international stock of knowledge, and strengthen the interactions between foreign and domestic firms that foster international knowledge diffusion.

As the leading player in global economic integration, foreign firms bring key knowledge resources to host countries and facilitate knowledge diffusion across national borders. From the comparison between foreign owned and formal firms we found that the former are slightly less oriented towards innovation (in particular the process innovation) probably because of the already-built efficient production process and design. Nonetheless, evidence of gaps is observed between the novelty contents of the innovation originated by foreign firms and domestic formal firms, and differences in innovation sourcing are also exhibited. Innovations originated by foreign firms are clearly of higher novelties compared to innovations achieved by local firms. Moreover foreign firms tend to rely more on internal resources and collaboration with government or public research institutes for innovation activities.

Constraints to innovations and space for policy

Inevitably firms in developing countries encounter significant obstacles during the process of knowledge adaptation and innovation. The main bottlenecks for innovation in these countries include financing and knowledge, as well as market constraints. Our research also reveals the substantial challenges to innovation in LICs. These include constraints in finance, such as access to credit, and lack of skills. Financial resources are needed to acquire new technologies. The lack of skills is also a very important factor because most of the innovations in LICs are incremental and learning-based, and therefore skills actually determine the capacity to learn. The political environment plays an important role as well. Politicians want to win elections, and very often they would prefer to introduce policies or make efforts toward those policies that could deliver quick changes in the short run. While innovation is not only risky and costly, it also takes time, which conflicts with the objectives of some politicians.

In LICs there is also a traditional perspective in which many people think innovation is the business of somebody else and the business of advanced countries, and that innovation does not have an important role to play for growth and development in LICs. Such a vision constrains people's efforts and the

investment and dedication to innovation and it also ignores the contribution of technical progress and innovation to growth in these low income countries.

The fourth challenge comes from weak intellectual property rights (IPR) protection in low income countries. In many LICs overall institutional development still lags behind and so protection of IPR is still weak. This has clear implications for the diffusion of innovation; however, the issue is still a matter of ongoing debate amongst scientists, academics, and policy makers. On the one hand, the lack of protection of IPR weakens incentives for inventors and for innovators. This therefore could be detrimental to innovation. On the other hand, too strict an IPR protection may inhibit the diffusion of innovation, especially in LICs where firms, people, and the government lack financial resources to pay royalties. Therefore the solution probably has to be on a case-by-case and sector-by-sector basis. For some of the technologies and innovations and in some countries there may be a need to encourage protection and incentivise the innovators. In some sectors, especially for luxury goods and in areas not directly affecting people's welfare, strong IPR protection could be put in place. The results from our survey indicate that cost factors and knowledge factors are the top two constraints for the firms in Ghana.

Policies play a critical role in accelerating the diffusion and creation of innovation and mitigating the obstacles LICs face. Recognizing the important role that knowledge and innovation must play in transforming the economy and reducing poverty, the Government of Ghana has placed S&T development high on its list of priorities. The current policies and strategies emphasise that absorption and application of much more S&T is a critical ingredient for successful growth. However, the survey revealed that firms need even more support, and policies should be followed by a strong commitment by the Government. Incentivising external transfer of innovation, facilitating cluster participation, easing access to credit, and further strengthening education and the capacity to use research are all critical actions that can mitigate some of the current constraints and drive economic growth in the long run.

Final remarks

From our results, five important conclusive points can be drawn. First, innovation is not the outcome of development but a means for development. Without innovation, there will be no transition from low income to middle income. In the past we have witnessed the prosperity of business leading this transition, but in retrospective it has been only a short-term boom and not a sustainable prosperity. Hence, innovation is a driving force to achieve sustainable development. In addition, innovation should occur among LICs over a wider range, in both the formal and informal firm sectors and include technological and non-technological innovations. Third, most of the innovations in LICs are learning-based innovations; they are adoptions and adaptations based and diffused mainly from within the country. Moreover, most of these innovations are about appropriate technology and processes in or for the base of the development pyramid. Innovation must be appropriate in economic and technical aspects, and socially appropriate for the characteristics of the LICs. That means they should address the resource, skill and institutional constraints and affordability and accessibility in these countries. Finally, the survey showed that firms in LICs are innovative but they are very largely unsupported. Innovations are not recognised and the innovation efforts in the firms are not properly supported, for example by mitigating financial and labour skills constraints. New thinking and policies to recognise and support innovation is needed in the context of LICs for long-term growth and development.

A. Technical Appendix

Preparatory work and data collection spanned a period of 11 months (Feb. 2013 – Jan. 2014). It involved eight stages:

- In-depth case study
- Questionnaire design and survey instruments
- Sampling Frame
- Recruitment and training of enumerators
- Pilot survey
- Survey and monitoring
- Firm replacement protocol

In-depth interview

A preliminary study was conducted between February and March 2013 to collect in-depth case studies about firms' responses to the constraints on innovation, and how and when innovation policies can overcome these barriers. This guided the research team in the sample frame and the designing of the questionnaire. In the preliminary study, a total of ten firms were surveyed and 32 in-depth interviews were carried out among managers from different divisions and workers. The firms were selected across sectors and categories. These sectors were garment and textiles, food processing and construction. Under each sector, firms were selected from both the formal and informal sectors, four from the textile and food sectors, and two from the construction business. To capture the different nature of innovation, for the textile and food sector two firms were selected under a formal setting, and two from the informal sector. The firms were selected using a purposive sampling technique to identify and approach innovative firms. We selected textile, food processing and construction firms from the Association of Ghana Industries database which in a previous Innovation Survey in Ghana had identified themselves as innovators. Amongst the subsample, we then randomly selected the firms to visit. This allowed us to approach only innovative firms.

The data was collected through in-depth interviews. The interviews covered four main dimensions: innovation activities, process of innovation, barriers to innovation transmission and space for innovation policies. The interviews were recorded and later transcribed. On occasion, some relevant findings came out during informal discussion with the respondents – before or after the interview. In order to have a comprehensive understanding of the nature and constraints to innovation, interviewees included a range of actors: senior managers, departmental managers (production, marketing, and human resources), R&D staff, technicians, and workers. For the firms in the informal sectors, the managers and workers were the main source of information since those firms did not have complex functional departments.

Questionnaire design and survey instruments

The design of the survey was based on previous innovation surveys and tailored to the Ghanaian environment based on the findings from the in-depth interviews and discussion with key local policy makers.

The data were collected with the aid of a Personal Digital Assistant (PDA). PDAs are increasingly used for data collection in developing countries and bring several benefits. The use of PDAs supports the work of enumerators, allowing them to code consistency checks during the interview and systematic skips. Since the data is already entered in a digital format, no other data entry is needed, which saves time and as a system is less prone to mistakes. However, PDAs bring some disadvantages compared to paper-based surveys, mainly in terms of the reliability of the devices and the computer skills needed to use them. We took extensive precautions to mitigate these potential drawbacks. The devices we used had already been used in previous data collections and their reliability in term of battery life and failures had already been tested. Besides the extensive training of the enumerators we also put in place a protocol to make sure data were constantly backed up and devices constantly charged. In the whole survey, we did not experience any PDA failure at all and no data were lost.

Sampling frame

We use a different sampling framework for formal and informal firms. The rationale for this hinges on the fact that informal firms may not be recorded on databases for official firms, and therefore we could have under-represented the whole informal sector. We therefore sampled half of the sample from sources that were likely to mainly capture informal firms, and the other half from sources containing mainly formal firms.

For informal firms, we randomly sampled 25 firms in 10 clusters spread in five regions. Cluster activities ranged from the food and textile sectors to metal and wood working (Table A.1). The choice of clusters and regions was determined by the need to have a sectoral and geographical representation of the Ghanaian informal economy.

We compiled a comprehensive population of firms from which we drew the sample of the formal firms. Three main sources were used:

- The latest available National Industrial Census (2003) by the Ghana Statistical Service
- The Micro, Small and Medium Enterprises database from the Ministry of Trade and Industry
- The D&B database of Ghanaian firms
- The list of members of the Association of Ghana Industries (AGI)

The lists of firms from the different sources were merged and the duplicated firms removed. A total of 4,658 firms were included. The sample was then randomly selected with three levels of stratification: industry sector, size, and regional location (see Table A.2, Table A.3, and Table A.4).

Table A.1: Clusters details (region and sector).

Region	Sector
Greater Accra	Handicraft producers
Greater Accra	Sawmill
Greater Accra	Metal working
Greater Accra	Mushroom production
Greater Accra	Garment and textiles
Ashanti	Wood workers
Ashanti	Automotive industry and metal working
Central	Garment and textile
Eastern	Oil Palm processors
Northern	Shea butter production

Table A.2: Geographical distribution of the firms in the sample.

	Full Sample	Informal	Formal
Greater Accra	249	159	90
Ashanti Region	104	69	35
Brong-Ahafo Region	8	0	8
Central Region	42	27	15
Eastern Region	41	34	7
Northern Region	34	26	8
Upper East Region	4	0	4
Upper West Region	2	0	2
Volta Region	8	6	2
Western Region	10	0	10

Table A.3: Sectorial distribution of the firms in the sample.

	Full Sample	Informal	Formal
Manufacture of food products	124	90	34
Manufacture of beverages	2	0	2
Manufacture of textiles	23	15	8
Manufacture of wearing apparel	102	52	50
Manufacture of leather and related products	1	1	0
Manufacture of wood and of products of wood and cork	51	36	15
Manufacture of paper and paper products	10	0	10
Printing and reproduction of recorded materials	9	4	5
Manufacture of chemicals and chemical products	1	1	0
Manufacture of basic pharmaceutical products	1	0	1
Manufacture of rubber and plastics products	8	0	8
Manufacture of fabricated metal products	65	45	20
Manufacture of electrical equipment	2	2	0
Manufacture of machinery and equipment	1	0	1
Manufacture of furniture	74	51	23
Other manufacturing	5	4	1
Repair and installation of machinery	21	20	1
Construction of buildings	2	0	2

Table A.4: Size distribution of the firms in the sample.

	Total sample	Informal	Formal
Micro (< 9 empl.)	367	269	99
Small (10-29 empl.)	86	48	38
Medium (30-99 empl.)	21	4	17
Large (> 99 empl.)	27	0	27

Recruitment and training of enumerators

Ten enumerators were recruited and trained specifically for data collection. The enumerators were selected amongst Science and Technology Policy Research Institute (STEPRI) staff or were derived from previous experience of data collection in other projects coordinated by STEPRI. In designing the enumerator team we made sure enumerators were able to speak local languages. Table A.5 reports the names of the enumerator employed.

The purpose of the training was to impart skills to the enumerators, in particular to explain the concepts and terms of the survey and the use of the PDA. It was also to train the enumerators in the process of data collection. The training was facilitated by a team of Research Officers from Oxford University and STEPRI. During the three-day training the facilitators reviewed the questionnaire with the enumerators, offering a platform for the enumerators to interact with facilitators to allow for a possible review of the questionnaire. The enumerators were also taken through the use of the PDAs and were allowed to conduct mock interviews with PDAs to familiarise themselves with a PDA and build their confidence in using PDAs. A discussion of the results from the mock interview was held to help review the questionnaire.

The enumerators were evaluated through a short written test to find out their level of understanding of the survey terms and concepts. The results of the test were critically examined. The enumerators who needed further assistance were given the needed support.

Pilot survey

In September 2013 a pilot survey was conducted to ensure that the survey design and materials would capture the data necessary to meet the survey objectives. A sample of fifty firms was chosen from the sampled firms located in the Greater Accra Region and each enumerator surveyed five firms, with a mix of formal and informal firms. The data from the pilot were then analysed and feedback from the enumerators collected. We did not find any major issues and only minor changes to the coded questionnaire in the PDA were made.

Survey and monitoring

The data collection spanned a period of 7 weeks, from Nov. 2013 to Jan. 2014. During this period, survey managers visited several locations (Greater Accra, Eastern region, Ashanti region, and Central region) to monitor the progress of the data collection and support the work of the enumerators. The data were downloaded from the PDAs every week and analysed for consistency checks. In a few cases, the enumerators re-visited the firms to double-check the reliability of the data. Most of those cases involved unreliable or data entry mistakes on the number of employees, turnover, or fixed asset variables.

Firm replacement protocol

A third of the firms originally sampled needed to be replaced (Table A.6). Most of those could not be located by the enumerators (24 per cent), others had closed down (8 per cent), and a few firms were not willing to participate in the survey (1 per cent). Firms often are located in part of cities which do not have street names and tracking down their exact location can be a challenge. This is the case for most small and informal businesses. During the development, firms may also change location and name, or sometime move to a different business.

The replacement firms were randomly selected between the firms working in the same sector and region, and with the same size as the missing firms.

Table A.5: List of enumerators.

Name of enumerator	Qualification
Asabo Rankine	BA Sociology and Psychology
Ampong Henry Gyekye	BSc Agribusiness Management
Marilyn Yeboah	BA Social Sciences
Sarfo Micheal Asante	BA Economics and Political Science
Opoku Benedicta	BSc Marketing
Yirenkye Nana Joshua	MA Social Policy Studies
Owusu Johnny	BSc Molecular Biology and Biotechnology
Yarboye Annang Elliott	BA Integrated Development Studies
Kuuguu Eric	BSc Agricultural Technology
Asafu-Adjaye Stephanie	BSc Agricultural Science

Table A.6: Total number of firms replaced.

Reasons for replacement	Number of firms	Percentage (%)
Cannot be located	122	24.4
Closed down	38	7.6
Uncooperative	5	1.0
Total	165	33.0

Growth Research Programme

The Diffusion of Technology in Low Income Countries (DILIC) Project was funded from the DFID-ESRC Growth Research Programme (DEGRP) and supported by UNCTAD and the Ghanaian government. The DILIC project examined the determinants and impact of technology transfer in and to low income countries. Led by the University of Oxford, the project partners included UNU-MERIT and the Science and Technology Policy Research Institute (STEPRI) of the Council for Scientific and Industrial Research, Ghana.

The Technology and Management Centre for Development (TMCD) is a research centre of Oxford University's Department of International Development (ODID). Founded by Prof Xiaolan Fu, it aims to promote interdisciplinary research into the development of technology and management in the developing world as well as address some of the most important issues related to technology and management facing public and private policymakers today. The TMCD is an outgrowth of ground-breaking work since the 1970s by ODID's world-leading development economists including Frances Stewart, Sanjaya Lall, Adrian Wood and Valpy FitzGerald on trade/foreign direct investment, technology and competitiveness.

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