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Learning new technologies by small and medium enterprises in developing countries

Banji Oyelaran-Oyeyinka, Kaushalesh Lal*

United Nations University-Institute for New Technologies (UNU-INTECH), Keizer Karelplein 19, 6211 TC Maastricht, The Netherlands

Abstract

This paper, based on new field data, examines the ways in which small and medium enterprises in selected developing countries learn to use and augment their core capabilities with new technologies. This paper presents three findings. First, there is clear evidence of increasing complexity in the adoption and use of Information and communication technologies (ICTs) among developing country firms. Second, climbing the technological ladder requires skills upgrading through explicit learning of the new technologies. Third, firm performance is highly associated with learning capabilities, levels of technology, and a host of firm-level knowledge, skills and experience. The study found that across countries and sectors, non-formal learning is the dominant form of mastering new technologies. However, formal local and overseas training is positively associated with increasing technological complexity. There is also a close correlation between technical complexity of firms' internal ICT tools and available telecommunication infrastructure.

Keywords: Learning; New technologies; SMEs; Developing countries; ICTs

1. Introduction

In successful firms, firm level capabilities would comprise core and 'general-purpose technologies' (GPTs) competencies. The corollary is that successful firms would in turn possess both GPTs and firm-specific skills. The range of GPTs include mechanical engineering, and arguably the most pervasive to date, Information and communication technologies (ICTs) (Rosenberg, 1994) These technologies are required for and in fact are indispensable to the operation of the core routines of organizations. For instance mechanical engineering is as crucial to the automobile industry as biotechnological skill is key to pharmaceuticals and foods industries. The advent of microelectronics has not only deepened the systemic complexity of all industries; it has revolutionized the nature of industrial organization. The major technological advances in ICTs has been a major cause of the deep changes in manufacturing that underlies much of the observed patterns of process and product innovation across industries. At the center of the manufacturing changes with significant implications for processing speed, flexibility of production and high precision is the progressive inclusion of microelectronics. While much of these advances have originated in advanced industrial economies, other developing countries have taken advantage of these new technologies by building up industrial capabilities through sustained and explicit learning.

Complementary to widespread computerization and the adoption of internal electronic tools within firms is the rising skills level of the workforce in what has come to be known as the technology-skill complementarily (Goldin and Katz, 1998). In the United States, Author, Katz (1987) found substantial shifts towards tertiary education graduates in industries is strongly associated with more rapid growth rate in computer usage and computer capita per worker. Right from the advent of electricity, an equally 'wired' technology like ICTs, there has been an observed and persistent rise in the skill intensity of manufacturing. According to (Goldin and Katz, 1998, p697), 'technological shift from factories to continuous-process and batch methods, and from steam and water power to electricity, may have been at the root of an increase in the relative demand for skilled labor in manufacturing in early twentieth century'.

* Corresponding author. Tel.: +31-43-350-6300; fax: +31-43-350-6399.

E-mail addresses: oyeyinka@intech.unu.edu (B. Oyelaran-Oyeyinka), lal@intech.unu.edu (K. Lal).

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Digital technologies have led to the lowering of costs, and higher quality products, particularly in small and medium firms that could not previously compete on the basis of scale. For instance the use of computer-aided designs (CAD), computer-aided manufacturing (CAM) has revolutionised production in both the machinery sector as well as in process industries. The continuous penetration of electronic instrument in traditional sectors has led to renewed interest in, and greater competitiveness of these sectors. The use of computer integrated manufacturing (CIM) has induced greater speed of production as well as production flexibility in product and process. These changes demand complementary knowledge and skills.

The adoption of electronic business (e-business) technologies employing high-speed computers coupled with advanced telecommunications technologies has not only resulted in relatively lower transactions costs but also promoted increasing intra-firm and inter-firm integration functions. Firms earn high profit margins not only through low wage and low skills production but also through fast delivery of customized products and services to customers. The scope advantage of small firms has been significantly enhanced by new technologies be they manufacturers of batch orders or subcontractors to larger firms. These changes have led to significant shifts in the skill composition of labor and heightened the debate on technology-skill and capital-skill complementarily, (Bound and Johnson, 1992; Goldin and Katz, 1998). By this term, the authors mean that ‘skilled or more-educated labor is more complementary with new technology or physical capital than is unskilled or less educated labor’ (Goldin and Katz, 1998, p.694 footnote).

Given the technology-skill complementarities, the introduction of ICTs has significant skill implication for developing countries’ firms learning to produce for domestic and external markets. The successful adoption of e-business tools is likely to enhance individual worker’s productivity in the so-called modern sectors such as electronics and general machinery sector. In the more traditional sectors such as textiles, clothing and foods, there is a propensity for significant rise in product quality and more precise processing. To achieve the goal of better quality products, firms are obliged to undertake greater training and investment in skills and knowledge upgrading. The implications for long term industrial competitiveness in developing countries is thus evident no matter the sectors in which countries have comparative advantage.

This paper presents evidence of learning processes and investment in selected developing countries. We advance three main theses. First, there is clear evidence of increasing complexity in the adoption and use of ICTs among developing country firms. Second, climbing the technological ladder requires skills upgrading through explicit learning in the new technologies and for this reason rate of adoption had been highly differentiated. Third, firm performance is highly associated with learning capabilities, levels of technology, and a host of firm-level knowledge, skills and experience.

The remainder of the paper is organized as follows. Section 2 presents a partial survey of the literature. A theoretical framework is presented in Section 3 while hypotheses are formulated in Section 4. Data sources are also discussed in Section 4. Statistical results are presented and discussed in Section 5 whereas Section 6 presents summary and conclusions.

2. Learning, knowledge and technical change in development

Technological learning is the way organizations such as firms accumulate technological capability (Malerba, 1992). Technological capability is the knowledge, skills and experience necessary in firms to produce, innovate, and organize marketing functions (Lall and Wignaraja, 1998; Ernst et al., 1998). Much of the technological knowledge required by small and medium firms in the early stages of development in say developing Africa is incremental and could often be acquired through what (Lall, 1982) described as ‘elementary learning’ although there are exceptions within firms that have moved up in the supply chain. As firms climb the ladder of manufacturing complexity, the types of knowledge it requires, the nature of its organization and the forms of institution to support it become increasingly complex. In the last decade we have come to know much more about the nature of learning and capability acquisition in firms and in what follows, we provide a brief overview. First, learning in firms is a major source of incremental technical change and as such a firm is learning organization, and through the knowledge it accumulates, continually transform its knowledge assets to foster higher orders of operation (Lundvall et al., 2002; Malerba, 1992).

Secondly, following from above, a firm is characterized by a certain level of technical and organizational knowledge base. Third, a firm draws upon a wide variety of knowledge sources (suppliers, subcontractors, machinery suppliers) that may be within its locale and often outside the national boundary (Lundvall, 1988; Von Hippel, 1988). Fourth, there are different modes of learning and the widely known learning-by-doing, and learning through research and development (R&D) are only some of these sources. Learning-by-doing is by definition a costless, effortless process, which does not often lead to innovation. However, the sort of learning efforts that lead to dynamic productivity gains require explicit investments to alter the technical and organizational assets of the firm.

Fifth, learning processes are linked to specific sources of technological and productive knowledge such as apprenticeship, equipment manufacturers and others. Six, learning does not take place in a vacuum and firms do not innovate in isolation. External actors with whom firms interact are crucial to learning in firms. The sources of external