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Can small and medium enterprises benefit from skill-biased technological change?☆

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ABSTRACT

This research addresses the contribution that technical skills and cognitive abilities make toward technological efficiency in small and medium enterprises. While most of the literature on skill-biased technological change focuses on large corporations, this exploratory research tries to close the gap in the literature and addresses the impact of technical training, age, and educational level of the workforce on the fit between technological change and organizational innovation in small and medium-sized enterprises. The results suggest that the impact of the workforce structure on efficiency is a function of the level of technological change.

1. Introduction

The most recent technological transformation of modern economies is the adoption of information technology (IT). A central question in management theory is how to deal with organizational adaptation to IT-led technological change. A growing body of empirical evidence shows that proper adaptation to this technological change has a positive impact on firms' efficiency (Dedrick, Gurbaxani, & Kraemer, 2003). However, heterogeneity in organizational characteristics can explain the differences in the outcomes of this adaptation process (Bresnahan, Brynjolfsson, & Hitt, 2002; Brynjolfsson & Hitt, 2000). Starting with the paper by Milgrom and Roberts (1990), a large body of literature supports the complementarity hypothesis between technology, skills and organization, and suggests that modern technological and organizational changes are complementary with skilled workers.

The main aim of this study is to understand the nature of the skill-biased technological change (SBTC) in small and medium enterprises (SMEs). While several studies explain the complementarities between technological change, organizational innovation and skills for large organizations, few studies address the role of these complementarities in SMEs. SMEs are enterprises which employ fewer than 250 persons and whose annual turnover does not exceed EUR 50 million, or whose annual balance-sheet total does not exceed EUR 43 million (European Commission, 2003). These small businesses make a significant contribution to gross domestic product (GDP) and employment in many economies of the world.

The differences between SMEs and large corporations in terms of resources and organizational sophistication cast some doubts on the applicability of previous SBTC research on SMEs. Compared to large firms, small businesses tend to have simple and centralized structures, lower levels of specialization, less standardized procedures, less financial resources and less managerial and professional expertise (Thong, Yap, & Raman, 1996). These limitations suggest that SMEs do not have the same skills and capabilities to profit from SBTC. The main contribution of this paper is the study of the impact on SMEs' efficiency of the complementarities between skills and technological change. The main hypothesis of this research is that technology adoption and the skill composition of the workforce of SMEs are complementary factors in the production function.

More specifically, this study proposes that technological change in SMEs causes a shift in the demand for both cognitive and technical skills. Technological change reduces the costs of communication and supervision, fosters organizational innovations, and flattens organizational structures (Bertschek & Kaiser, 2004; Bresnahan et al., 2002; Brynjolfsson & Hitt, 1998; Garicano & Rossi-Hansberg, 2006). In these flattened organizations, workers are less likely to perform repetitive, specialized tasks, but rather are responsible for a wider range of tasks within teams. Further, the decentralization of organizational decision-making increases the tasks' variability and complexity. Following technological change,

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the redefinition of tasks and responsibilities fosters firms' demand for cognitive and technical skills (Bartel, Ichniowski, & Shaw, 2007; Black & Lynch, 2001; Bresnahan et al., 2002; Nielsen & Lassen, 2012). More advanced technical skills facilitate the absorption of new technology, while cognitive abilities help workers to make better decisions through more accurate mental models. Consequently, these new skills affect the impact of technological change on firm's performance (Acemoglu, 2002; Autor, Levy, & Murnane, 2003; Garicano & Rossi-Hansberg, 2006). However, previous literature provides little evidence of the effect of technological change, and cognitive and technical skills on the efficiency of SMEs. To close this gap in the literature, the main contribution of this paper is to explore the interactions between cognitive and technical skills and IT-led technological change in SMEs.

The next section reviews the key literature dealing with the fit between skills and technological change with a special focus on SMEs. Section 3 describes the data and the empirical methodology. Section 4 presents the results obtained and Section 5 discusses the results. Finally, Section 6 presents the main conclusions of this research.

2. Theoretical framework

SBTC favors the relative demand for workers at the high end of the skill distribution. In a knowledge economy, IT-led technological change leads to organizational innovation. In the first instance, this change facilitates an increased span of control and can reduce organizational layers. Adoption of IT-driven management tools reduces both information processing and communication costs between the different levels of the hierarchy and allows top managers to control a larger number of employees (Garicano & Rossi-Hansberg, 2006). Firms with these flattened hierarchies are more likely to adopt organizational innovations such as increased delegation of authority to line workers or new lateral communication links (Bertschek & Kaiser, 2004; Bresnahan et al., 2002; Brynjolfsson & Hitt, 1998; Gera & Gu, 2004; Yu, To, & Lee, 2012). Secondly, these new technologies facilitate process innovation through the automation of repetitive tasks. A result of this automation is the reduction in numbers of unskilled workers (Autor et al., 2003; Francalanci & Galal, 1998).

Organizational innovations such as flattened hierarchies and IT adoption have a positive impact on firms' efficiency. Empowered workers may be more motivated and consequently more productive (Bresnahan et al., 2002; Caroli & Van Reenen, 2001; Yu & Ting, 2012). The reduction in the number of middle managers and unskilled employees should decrease labor input while maintaining organizational output (Autor, Levy, & Murnane, 2001; Francalanci & Galal, 1998). Reduction in the number of organizational layers, and the enhanced lateral communication links may also contribute to efficiency by increasing the speed of both the dissemination of information and decision-making (Gera & Gu, 2004).

Workers in flat, interconnected and decentralized organizations have more responsibilities and more difficult decision-making. In the process of making decisions, workers developmental models, which are cognitive representations of external reality (Jones, Ross, Lynam, Perez, & Leitch, 2011; Renko, Shrader, & Simon, 2012). The ability to build complex and accurate mental models depends on individuals' cognitive abilities (Anderson, 1990). SBTC literature suggests a positive correlation between higher levels of formal education and cognitive abilities (Acemoglu, 2002; Bekman, Bound, & Machin, 1998; Huarng, Mas-Tur, & Yu, 2012; Reed, Storrud-Barnes, & Jessup, 2012; Silva da Rosa, Ensslin, Ensslin, & Lunkes, 2012). Workers with higher educational levels develop accurate mental models and effective strategies and plans better adapted to a changing external reality. As a result, a highly educated workforce with stronger cognitive abilities will be more adaptable to non-routine tasks and more well versed at multi-tasking activities. Consequently, technological change will increase the need for highly educated workers.

Prior empirical research on skill-biased technological change provides little specific evidence on the complementarities between technological change, skills and organizational innovation in SMEs. Most of the studies do not differentiate between large corporations and SMEs and often neglect micro enterprises in their samples. For instance, in a study of large American Fortune 1000 corporations, Bresnahan et al. (2002) find substantial and positive complementarities between IT and human capital with college education. Black and Lynch (2001) observe that human capital investments have an important impact on labor productivity based on a survey of American establishments with more than 20 employees, which oversamples establishments in the manufacturing sector with more than 100 employees. Caroli and Van Reenen (2001) report strong evidence for skill-biased organizational change in a sample of British and French firms with more than 10 employees. In a sample of German firms with more than five employees in the business related and distribution service sector, Hempell (2003) finds that technological change affects the firms' performance in the training efforts of college employees but not of other skill-level groups. Gera and Gu (2004), in a sample of Canadian establishments with more than one employee, observe that service firms shifting from low levels to high levels of human capital education can expect an improvement in firm performance where high levels of IT implementation occur. For the Canadian manufacturing sector, however, these authors do not find any evidence of complementarities between technological change and skills.

Kanamori and Motohashi (2006) find that the effect on productivity of the complementarities between technological change and organizational innovation is greater for large firms compared to SMEs for a sample of Japanese service firms with more than 50 employees. These findings are comparable to Gera and Gu's (2004) findings, in that the productivity of Japanese firms in the manufacturing industry does not benefit from the complementarities between technological change and organizational innovation. Using the same data sources, Moshiri and Simpson (2011) observe that education levels have positive and significant effects on computer productivity of Canadian firms.

Giuri, Torrisi, and Zinovyeva (2008) study Italian firms with more than 10 employees. Interestingly, this research also provides differentiated results for large and small businesses. Their findings suggest that rather than technological change, organizational innovations explain the higher productivity of highly educated workers in SMEs. Furthermore, their empirical results suggest that the simultaneous adoption of technological change and organizational innovations may have a negative impact on performance. These authors conjecture that structural difficulties of SMEs in dealing with the complexity of multiple innovations explain this negative interaction. Neirotti and Raguseo (2012) hypothesize that intensive technological change and new organizational practices are not necessary in SMEs with simple organizational structures and may unnecessarily overburden the educated employees. In a theoretical paper, Dupuy and de Grip (2006) suggest that larger substitution parameters between skilled workers and capital explain the larger rates of the increase of the demand for skilled workers associated with technological change in large firms. The research by Caroli and Van Reenen (2001) also observes that the effects of skill-biased technological change depend on firm size. These authors find that the introduction of organizational change in larger skill-intensive plants leads to significantly faster productivity growth than the introduction of similar organizational change in non-skill-intensive firms. Thus, skill-biased technological change is more likely to enhance productivity in large firms with complementary assets. Following this initial evidence, the first hypothesis supports the complementarity hypothesis in the production function and suggests that IT adoption and skilled labor are relatively more complementary than IT adoption and unskilled labor. The greater the technological change of the firm, the stronger the impact of employees' cognitive abilities on firm productivity. Large corporations