Technological Forecasting & Social Change xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

journal homepage: www.elsevier.com/locate/techfore

Technology transfer, adoption of technology and the efficiency of nations: Empirical evidence from sub Saharan Africa

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ARTICLE INFO

JEL classifications:
D24
047
055

Keywords:
Technology transfer
Absorptive capacity
Efficiency of nations
Sub-Saharan Africa

ABSTRACT

In this paper, stochastic frontier analysis is employed to examine the role of technology transfer and absorption of technology, as well as the interaction between technology transfer and absorption in explaining cross country differences in efficiency of nations in sub Saharan Africa over the period 1970–2010. The findings of the study indicate that trade openness, machinery imports, human capital and relative research and development have no empirically apparent effect on efficiency of nations in sub Saharan Africa. However, the interaction term for trade openness and human capital, and that of machinery imports and relative research and development play a significant and quantitatively important role in explaining national efficiency in sub Saharan Africa. The findings imply that policy initiatives to boost national efficiency in sub Saharan Africa must focus on the development of domestic capacity to absorb technology.

1. Introduction

Seminal papers on economic growth indicate that innovation and national efficiency are primary means for enhancing productivity growth among nations (see Solow, 1956; Romer, 1990; Lewis, 2013). Largely, the empirical literature shows that differences in national efficiency have been attributed to explaining most of the differences in productivity and economic growth among nations (see Badunenko et al., 2010; Danquah, 2012; Jerzmanowski, 2007; Prescott, 1998; Weil, 2005). National efficiency is the process whereby an economy is able to adopt and adapt already existing technology from world technology leaders and successfully apply it domestically. Some authors have suggested that an effective adoption of technology has the capacity to unlock the potential of industries, especially in Africa and foster entrepreneurial development (see Amankwah-Amoah, 2015). Given that many firms in Africa rely on foreign firms for technology transfer, it is expected that the new technology would create conditions for emerging indigenous firms to thrive (Osabutey et al., 2014).

Technology transfer and absorptive capacity appear to be some of the most important determinants that have an impact on national efficiency and productivity growth (see Danquah and Ouattara, 2015; Loko and Diouf, 2009; Van Ark et al., 2013; Wooster and Diebel, 2010). For instance, technology transfer through international trade can help in the process of productivity growth by transferring the benefits of technology and more efficient techniques of production across borders (Grossman and Helpman, 1991; Cameron et al., 2005a, 2005b; Acharya and Keller, 2009). Absorptive capacity also captures the idea that the implementation of new technologies depend on the ability and effort applied to this task (see Griffith et al., 2003; Murovec and Prodan, 2009). Human capital and domestic innovation are important factors that determine the capacity to absorb and implement new technology (see Danquah, 2012; Kneller and Stevens, 2006). Many authors have also demonstrated the explanatory power of domestic innovation (relative R&D) and absorptive capacity to growth and development (see Abramovitz, 1986; Fagerberg, 1987; Fagerberg et al., 2007; Oyelaran-Oyeyinka, 2006). For instance, using a sample of 90 countries on different levels of development during 1980–2002, Fagerberg et al. (2007) highlighted the relevance of technology, capacity, and demand competitiveness for growth and development.

Most countries acquire or import embodied technologies through capital imports from the few world technological leaders (Caselli and Coleman II, 2001; Henry et al., 2009). Many developing countries including those in sub Saharan African (SSA) are exposed to this wide range of technological opportunities which are critical for increasing productivity growth. As a result, economies that are able to adopt and adapt the already existing technology from these world technology leaders and successfully apply it domestically would stimulate their national efficiency and improve productivity growth (see Liao et al., 2012; Azomahou et al., 2013). For virtually all developing countries, the domestic pace of national efficiency is determined mainly by the speed with which these already existing technologies are adopted, adapted, and successfully applied domestically, and done so throughout the economy. Given that, firms are the basic mechanism by which technology spreads within the private sector, the extent to which

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https://doi.org/10.1016/j.techfore.2017.12.007
Received 2 December 2016; Received in revised form 28 October 2017; Accepted 9 December 2017

financing for innovative firms is available (that is, through the banking system, remittances, or government support schemes) also influence the extent to and speed with which technologies are absorbed. (Montinaria and Rochlitz, 2014; Peña-López, 2008; World Bank, 2008).

Studies on SSA largely indicate that low productivity growth is the main impediment to the poor SSA growth performance (see Bosworth and Collins, 2003; Fosu, 2011). Given the low levels of research and development (R&D) intensity and innovation in the SSA region, many SSA countries have vigorously promoted policies and investments aimed at facilitating technology transfer and adoption in order to enhance national efficiency and promote productivity growth (Danquah, 2012; World Bank, 2008). Among the most important channels through which SSA countries are exposed to foreign technologies are trade; machinery and equipments imports; foreign direct investment (FDI); and contacts with highly skilled diaspora members (nationals working abroad) and with other information networks, including those of academia and the media (see Loko and Diouf, 2009; World Bank, 2008). Trade is one of the most important mechanisms by which embodied technological knowledge (in the form of both capital and intermediate capital goods and services) is transferred across SSA countries. Imports of technologically sophisticated goods help SSA countries to raise the quality of their own products and the efficiency with which they are produced (see Danquah et al., 2013; Handoussa et al., 1986; Mayer, 2001). Following from the low R&D intensity in SSA countries, trade openness and exposure to foreign competition provide powerful inducements for countries to adopt more advanced technology. Imports of capital goods, such as machinery and equipment, enable the production of higher quality and more technologically sophisticated goods. Sub-Saharan Africa imports substantially more capital goods, although the ratio of capital goods imports to GDP has increased marginally compared to other developing regions since the mid-1990s (COMTRADE, 2012).

Sustaining an open environment to such flows into SSA countries are critical for accessing technology at least cost. However, it is vital to differentiate between the extent to which the country is exposed to foreign technology, and the ability to absorb the technology. No matter how compellingly useful a technology may be, the process by which it spreads within a country can be lengthy. The extent to which these flows are translated into technological achievement to boost efficiency and productivity depends on the technological absorptive capacity of the host economy (see Glas et al., 2015; Liao et al., 2012; Miller and Upadhyay, 2000). As indicated, absorptive capacity depends on the levels of basic technological literacy and advanced skills found in the country. These factors together dictate the country's capacity to implement technologies on the one hand and to do the research necessary to understand, implement, and adjust imported technologies on the other hand. Taken together, these components of absorptive capacity act as filters that dictate how much of the potential technological flow is actually absorbed domestically (see Castellacci and Natera, 2013; Fabrizio, 2009; Schmidt, 2010).

R&D is generally identified as a crucial ingredient in innovation. R&D facilitates the understanding and imitation of other discoveries. The role of R&D in the understanding and imitating of available technology from the world technological leaders has to do with the relative R&D (of the host country) (see Griffith et al., 2003; Becker, 2015). This is related to the absorptive capacity of the country which in turn provides for efficient technology transfer. The extent to which imported technology boosts the sophistication of domestic technological activity either directly or indirectly through spillovers from R&D intensive countries depends on the quality of absorptive capacity in the host country. R&D can be generated domestically or from international spillovers (Acharya and Keller, 2009). As pointed out earlier, empirical indicators of absorptive capacity of a country usually only include R&D and human capital. Countries with relatively weak domestic scientific capacities and human capital tend to follow a more passive approach to technology absorption. In other words, these countries are characterized by limited efforts to leverage the technology imported by foreign firms operating on their soil. Therefore, the efficiency and productivity growth of a nation "depends on its access to capital goods from around the world and its willingness and ability to use them" (Eaton and Kortum, 2001. p. 1196). Following from the connection between low productivity growth and the poor growth performance in African countries, it becomes imperative to examine how the extent of technology transfer, adoption and implementation of new technologies affect national efficiency and productivity growth.

Given the importance of technology transfer and absorptive capacity in promoting national efficiency and productivity growth, many empirical studies have focused on these channels of national efficiency. Specifically, many authors have used trade openness, machinery imports among others to represent technology transfer; and human capital, relative R&D as proxies for absorptive capacity to examine the role of these channels on national efficiency (see Griffith et al., 2003; Kneller, 2005; Christopoulos, 2007a, 2007b; Iyer et al., 2008; Henry et al., 2009; Danquah and Ouattara, 2015). Using the same representations for technology transfer and absorption, some authors have also investigated the importance of technology transfer contingent on the absorptive capacity of the host economies (see Coe et al., 2009; Glas et al., 2015; Iyer et al., 2008; Mastromarco and Ghosh, 2009; Miller and Upadhyay, 2000). It is worth noting that, albeit, the findings of these studies are mixed, these studies have largely been on OECD countries (see Griffith et al., 2003; Iyer et al., 2008; Kneller, 2005; Kneller and Stevens, 2006), developing countries as a whole (see Miller and Upadhyay, 2000; Christopoulos, 2007a, 2007b; Henry et al., 2009; Mastromarco and Ghosh, 2009; Danquah, 2012), and specific countries (see Glas et al., 2015). The few studies on this subject matter on SSA have largely focused on the determinants of productivity growth (see Danquah and Ouattara, 2014; Danquah and Amankwah-Amoah, 2017). Studies that robustly investigate the role of technology transfer and absorptive capacity as well as its interaction are lacking in the empirical literature. The lack of adequate scholarly attention on new technology, adoption and utilisation in SSA would considerably affect the role of government policy in promoting technology development and efficiency, particularly with respect to the business environment.

This study fills this gap on the role of technology transfer and absorption in promoting national efficiency in SSA. This is done by examining the effects of human capital, relative research and development (absorptive capacity), machinery imports, trade openness (technology transfer) and its interaction on national efficiency for a panel of 18 SSA countries over the 1970–2010 periods. The number of countries and the period selected for the study is due to the unavailability of data (particularly data for the construction of relative R&D) on SSA countries. The study utilises the non-monotonic version of the complex time decay model of Battese and Coelli (1995). In this way, we contribute to the literature in SSA by providing an in-depth understanding of the adoption and utilisation of new technology by SSA countries. Appropriate government policies which would support African economies to plan and enhance technological achievements, national efficiency and productivity growth can therefore be construed from the study.

The rest of the paper is organised as follows. Section 2 and 3 present the data and estimation method. In section 4, we analyse the main results and their interpretation. Concluding remarks are left to section 5.

2. Data

The dataset used in this study is a panel of 78 countries (including the 18 SSA countries) for the period 1970–2010. The dataset is expanded to include other countries in order to determine the globally efficient frontier (see Appendix A, Table A1 for list of countries). In the frontier methodology adopted for this study, the higher the observation, that is to include countries that are technological leaders, the better the