Information Economics and Policy 25 (2013) 126–141

Contents lists available at SciVerse ScienceDirect

Information Economics and Policy

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

Mobile communication networks and Internet technologies as drivers of technical efficiency improvement

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ARTICLE INFO

Article history:
Received 2 March 2011
Received in revised form 6 November 2012
Accepted 8 November 2012
Available online 7 December 2012

Keywords:
Technical efficiency
Mobile communications
Internet technologies
Stochastic production frontier
Government effectiveness
Political risk

ABSTRACT

Empirical research on the determinants of technical efficiency (TE) is essential for policy formulation, in particular in low-income countries.

In this study, we estimate the variations of TE between 1980 and 2009 in 23 low-income countries and 18 high-income countries, and demonstrate that TE has increased in both country groups in view of the deployment of mobile communication networks and Internet technologies. For low-income countries, we also prove that the causal relation is from the deployment of mobile networks and Internet technologies towards the increase of TE.

More specifically, by estimating the stochastic production frontier for a flexible transcendental logarithmic production function under the assumption of fixed effects, we show that the increase in TE per additional mobile phone and Internet subscriber is the highest in Latin American and Asian countries, but the accrued TE increase in response to Internet usage is the largest in high-income countries due to an overly higher Internet diffusion.

Having established that modern information and communication technologies improve the TE, we conclude discussing policies that lead to the spread of such technologies, particularly in low-income countries.

1. Introduction

Differences in income levels across countries are determined by the stock of production inputs such as physical capital, labor force, and human capital, as well as by the efficiency of input allocation, also known as the technical efficiency (TE). In this context, empirical research unveiling the determinants of income and TE most conducive to economic growth is required for policy formulation, in particular in the context of low-income countries (Easterly and Levine, 2001).

This study quantifies the variations of TE in 23 low-income and 18 high-income countries between 1980 to 2009 with respect to the deployment of two specific types of infrastructure: mobile communication networks and Internet technologies. To address the impact of a more general type of infrastructure, the contribution of freight railways is also taken into account. Furthermore, two institutional performance measures are considered: government effectiveness (i.e., the quality of public services and policy implementation), and political risk (i.e., the level of economic planning, corruption, law enforcement, and bureaucracy quality).

Our econometric method is based on estimating the stochastic production frontier for a flexible transcendental logarithmic (translog) production function and a technical efficiency equation under the assumption of fixed effects (Kumbhakar and Lovell, 2000). In order to reflect the particular situation of low-income countries, we classify these into the following four geographical regions: Asia, Latin America, Middle East and North Africa (MENA), and Sub-Saharan Africa.

Our results are threefold. At first, it is shown that the deployment of mobile communication networks and

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http://dx.doi.org/10.1016/j.infoecopol.2012.11.004

Internet technologies improves TE in both low-income and high-income countries. In particular, the TE improvement per additional subscriber to mobile communication networks and Internet technologies is the highest in Latin American and Asian countries. However, the overall TE improvement in view of the deployment of Internet technologies is the highest in high-income countries owing to an overly better penetration during the analyzed period.

Secondly, it is shown that the deployment of mobile communication networks and Internet technologies causes the estimated TE improvement in low-income countries, i.e. the causal relation is from the diffusion of mobile communication networks and Internet technologies towards the TE improvement in low-income countries. For high-income countries, the causality between telecommunication technologies and TE improvement could not be confirmed, since the relevant coefficients are not statistically significant.

Lastly, we demonstrate further TE improvements in response to (i) higher freight railways usage in all countries, (ii) improved government effectiveness in Europe and Sub-Saharan Africa, and (iii) lower political risk in high-income countries as well as, to a lesser extent, in MENA and Asia.

Our findings highlight the importance of future deployments of next-generation technologies for mobile communications and broadband Internet. In this regard, we conclude by discussing effective telecommunication policies, focusing especially on the context of low-income countries. Some of these policies include privatization, granting regulator independence, guaranteeing market access to new entrants, and regulating final-user price.

The remainder of the paper is organized as follows. Section 2 surveys related previous studies on telecommunications and economic growth, and Section 3 summarizes our main contributions. Section 4 introduces the employed stochastic production frontier method, while the panel data and empirical model strategy are explained in Section 5. Section 6 presents the summary statistics of infrastructure and institutions of countries by income and region. Section 7 presents the estimated TE coefficients and rankings for low-income and high-income countries, as well as the model robustness checks. Finally, concluding remarks are offered in Section 8.

2. Previous work on telecommunications and economic growth

In general, previous works investigate the contribution of infrastructure deployment to national income, as well as the causality of the relationship between infrastructure and income. To our best knowledge, research on the effects of infrastructure on TE is still scarce, and studies on the causality relation between infrastructure and TE have not been addressed previously.

2.1. Telecommunications as determinants of national income level

National income level and GDP growth have been shown to partially depend on various types of infrastructure. In high-income countries, these include mainlines (Roller and Waverman, 2001), mainlines and transportation (Esfahani and Ramirez, 2003), mobile communication networks (Waverman et al., 2006), information technologies (Lin and Chiang, 2011; Lin, 2009; Shao and Lin, 2001), and broadband Internet (Qiang et al., 2009, Czernich et al., 2011). In low-income countries, an improvement of market efficiency has been demonstrated in view of the deployment of information and communication networks (Jensen, 2007; Aker, 2008; Jensen and Oster, 2007). The studies by Roller and Waverman (2001), Esfahani and Ramirez (2003), and Czernich et al. (2011) have also addressed the problem of the causality relation between income levels and infrastructure in developed countries.

In the context of the causality between telecommunications and income, it is well known that the relationship is of a two-way nature (Roller and Waverman, 2001). On one hand, infrastructure investments lead to a higher income, but on the other hand, income raises the demand for infrastructure and induces a greater supply. The mutual coupling makes it difficult to define the dominating causality.

Some country-level studies examined the causality between income and infrastructure, in particular mainlines (Roller and Waverman, 2001), mainlines and railways (Esfahani and Ramirez, 2003), and broadband Internet (Czernich et al., 2011). The first two studies employ models that estimate simultaneous equations of demand and supply, but Roller and Waverman (2001) only addresses the case of developed countries for which there are available data on infrastructure investment. In comparison, Czernich et al. (2011) employ pre-existing networks (voice telephony and cable TV) as instruments for the supply of broadband in order to isolate the causal effect of broadband Internet on economic growth in OECD countries.

However, neither the determinants of TE nor their causal relation to TE have been addressed in the above studies. The focus on telecommunications infrastructure in both developed and developing countries as well as the investigation of the role of institutions and their quality are missing entirely.

2.2. Telecommunications as determinants of technical efficiency

Few recent studies have attempted to identify several infrastructure/institution types as the determinants of country TE. Thompson and Garbacz (2007) used the stochastic frontier model based on a Cobb-Douglas function to show that improved telecommunications and economic freedom increase TE, especially in Africa and Latin America. However, the employed econometric model suffers from an unrealistic assumption of errors being uncorrelated to the regressors, so-called random effects. This assumption may cause the by-definition positive coefficients of human capital to become negative. Thus, the credibility of the obtained results is weak (Kumbhakar and Lovell, 2000).

Using a similar model, Lin and Chiang (2011) have found that Eastern European countries gain more productive efficiency than the G7 countries if the IT capital is considered as a production input. The study also analyzes the