ARTICLE IN PRESS

Telecommunications Policy xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Telecommunications Policy

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

Impact of modern communication infrastructure on productivity, production structure and factor demands of US industries: Impact revisited

M. Ishaq Nadiri[a], Banani Nandi[b,*,1], Kemal Kivanc Akoz[a]

[a] New York University, USA
[b] AT&T Laboratories, USA

ARTICLE INFO

Keywords:
Communications
Broadband
Infrastructure
Marginal benefits
Productivity

JEL classification:
D2
D24
L86
L96
O47

ABSTRACT

This study investigates the contribution of modern communication infrastructure characterized by high speed broadband access network on the productivity growth, production structure and factor demands for US industries and for the aggregate economy. To evaluate such contribution, we modify the traditional cost function by incorporating communication infrastructure as input in production process in conjunction with other public infrastructures. The network externality and spillover effect of broadband access technology are captured by introducing broadband penetration rate as a shift factor in industry level production function. Empirical results show that the increased use of modern communications infrastructure increases the productivity of all industries with wide variations across industries. Estimated impacts on input demands show that increase in use of communications infrastructure service saves labor and materials and increase the demand for private capital. Finally, aggregate social rate of return on such investment has been estimated for policy implications.

1. Introduction

Existing literature on endogenous growth theory suggests that efficient transfer of knowledge and information, because of its spillover effects, is a key factor to achieve high economic growth. Rapid diffusion of existing knowledge, ideas and information helps acceleration of innovation, economic growth and structural changes in most industries in all countries at all stages of development. Modern communication infrastructure, enriched with its wired and wireless broadband features,[2] is facilitating this process in a very revolutionary way.

Since the introduction of the Internet, the World Wide Web and widespread adoption of wireless communications, accessibility of the Internet via broadband (high speed) is another revolutionary phenomenon of information and communication technology (ICT). With progressive improvement in speed and quality of broadband connections together with ongoing innovation and automation in information technology, the role of modern communication infrastructure in achieving higher rates of economic growth and development is expanding. However, building such infrastructure requires a substantial amount of investment and, therefore, a proper

* Corresponding author.
E-mail addresses: m.ishaq.nadiri@nyu.edu (M.I. Nadiri), bn3158@att.com (B. Nandi), kka227@nyu.edu (K.K. Akoz).

[1] The authors wish to thank Sun Bae Mun, Mary MacCarthy, Rebecca Coffman and Ramen Nandi for their valuable suggestions regarding this paper. The views and opinions expressed in this paper are solely those of the author(s), and are not endorsed or attributable to AT&T.

[2] According to modern endogenous growth theorists (e.g., Romer, 1990), technology should accelerate economic growth and increase productivity by facilitating a rapid diffusion of ideas and information. It also fosters the development and adoption of new products and processes.

https://doi.org/10.1016/j.telpol.2018.03.008
Received 11 May 2015; Received in revised form 19 March 2018; Accepted 19 March 2018

evaluation of the contribution of such investment is crucial for national strategic policy decisions.

Even though the contribution of communication infrastructure has been extensively evaluated by many researchers in the past, including our studies (e.g., Nadiri and Nandi, 2001; Nadiri, Nandi and Chakraborty, 2009), the nature and characteristics of such technology are changing very rapidly and quite radically. The availability of high speed fixed and mobile broadband (BB) communication technology is significantly improving the efficiency of many activities at both micro and macro economy level. It is generating strong positive impact on productivity and rapidly changing the structure of production in many industries. In the face of such a dynamic role for communication technology, it is a constant challenge for policy makers to adopt the right path to extract the maximum benefits from such technology and to minimize any adverse impacts. Therefore, continuous assessment and understanding of the effects of evolving role of communication infrastructure is critical for ongoing policy decisions, which is the primary motivation for this paper.

To conduct such a study, we first modify the traditional cost function by introducing infrastructure capitals as separate inputs in the production function. This formulation is similar to the cost model used by Nadiri and Nandi (2001) in an earlier research paper with extension of incorporating the role of broadband (BB) technology into the production process. The basic contribution of BB infrastructure capital at the disaggregate level is captured by using communication infrastructure capital as a separate input in the industry level production function. However, due to limitation of BB infrastructure data (issue is addresses in Flamm, Friedlander, Horrigan and Lehr, 2007 and Lehr, Osorio, Gillett and Sirbu, 2005),[3] we could not separate the impacts of BB vs. non-BB part of communications infrastructure [4] on production. Additionally, the current model introduces an exponential growth factor in the production function, which is a function of both 'time' (index of general purpose technological progress) and 'the BB penetration rate' (number of BB subscribers per 100 inhabitants). The rationale behind such a formulation is based on the assumption that the BB technology has the characteristics of general purpose technology (GPT),[5] a concept which is already mentioned by many researchers and is thus likely to affect the exponential growth factor. Together with other technology, this leads to an upward shift in the production function. This formulation facilitates the capture of the network externality and spillover effects of BB networks.

A cost model is estimated using data set for a panel of 41 individual US industries (excluding the communication industry) for the period that spans 1987 to 2008. The study identifies the incremental benefits from BB technology as a general purpose technology (GPT) by the type of industry, which are not already captured through the estimated contribution of communication infrastructure capital as a direct input in industry level production process.[6] A social rate of return on communication infrastructure investment is also estimated. The most important conclusion of our study is that there are sizeable differences in the impacts of communication infrastructure on productivity and production structure of various industries. The new communication technology is generally reducing demand for labor and materials and increasing the demand for capital. These impacts vary in magnitude and direction over time and across industries. *This aspect is very important for understanding the consequence of increasing use of communication infrastructure service on aggregate demand for labor, composition of labor skills and the type of capital formation*.

The present paper is organized in the following manner. Section 2 summarizes the findings of various researches in this area. Section 3 outlines the basic econometric model and Section 4 provides a short description of the data used for estimation. Estimated model parameters are reported in section 5. A summary of the industry-level estimated results is presented in section 6. The implications of these results at the aggregate economy level are discussed in section 7 together with concluding remarks in the last section.

2. Related literature

Communication infrastructure technology is highly dynamic with the possibility of generating a wide range of economic and social impacts. In the existing literature, several studies (Bebee & Gilling, 1976, Hardy, 1980, Cronin, Parker, Colleran, and Gold (1991 & 1993) and Dholakia and Harlam, 1994; Röller and Waverman, 2001) have already established the contribution of telecommunication infrastructure capital on growth and productivity. However, most of these studies did not address the network externality and spillover effects of such infrastructure. In more recent studies, a group of researchers focused on this aspect. Utilizing an input-output framework, Cronin, Colleran, Herbert, and Lewitzky (1997) reported that, though heterogeneous across industries, investment on Information and Communication Infrastructure capital generates substantial amounts of consumption and production externalities. On the other hand, by incorporating communication infrastructure capital as an input in the industry-level production function,[7] Nadiri and Nandi (2001) captured the externality effects of such networks across US industries and reported *a strong linkage* between access to such infrastructure and productivity gains.

Another branch of researchers studied the contribution of information technology and equipment to the aggregate economy

[3] The difficulties of measuring contribution of broadband infrastructure due to lack of proper data is recognized by many researchers and many of them addressed that issue in their research papers (i.e., Flamm et al., 2007; Lehr et al., 2005).

[4] This infrastructure represents all kinds of traditional and modern communications and broadcasting networks, which include Internet, wired and wireless networks and broadband access networks.

[5] see Czernich et al., 2011, OECD paper, 2008. A caveat of such formulation is that the measured contribution of BB is likely to be biased to the extent that progress/adoption of ICTs co-varies with BB penetration; however, disentangling the effects of two is difficult.

[6] To avoid bias in estimation, infrastructure capital needs to be adjusted for quality improvement. It is not an easy task with the continuous change in communications and information technology.

[7] The incorporation of infrastructure capital in the production process evolved into a standard practice in productivity literature after the pioneer work of Aschauer (1989), and Munnell (1990, 1992), Munnell and Cook, 1990, Nadiri and Mamuneas (1994) in this area.