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Does the digital divide across countries lead to convergence? New international evidence

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ABSTRACT

We examine the convergence of information and communication technologies (ICT) among 47 developed and emerging countries using annual data from 2000 to 2012. We construct an ICT development index using a principal component analysis. The results, based on a dynamic panel data model, reveal a divergence in ICT development. This study identifies two factors that drive a country's digitalization divergence level: the growth of per capita income and the ratio of urban to rural population. In addition, ICT divergence is higher in emerging countries than in developed countries.

1. Introduction

Information and communication technologies (ICT), through various digital devices and services, are diffusing quickly yet unevenly around the world. The use of and access to ICT have a significant impact on economic growth and productivity (Cortés and Navarro, 2011; Venturini, 2009; and Cette et al., 2005). However, serious inequalities in access to and use of ICT exist within populations and also across countries (Park et al., 2015). Despite the spread of digital technology, many individuals have problems taking advantage of the various digital devices and service opportunities. As a consequence, a global digital divide in terms of ICT access and use has been recognized worldwide (Chinn and Fairlie, 2007, 2010; Erumban and de Jong, 2006; Pohjola, 2003; Kiiski and Pohjola, 2002; Caselli and Coleman, 2001; Dasgupta et al., 2005 and Quibria et al., 2003). The issue of the digital divide has become an important matter for many national policy makers and international organizations (World Bank, 2006; ITU and UNCTAD, 2007; OECD, 2008). The cross-country digital divide has motivated researchers to examine the contribution of technology, including ICT, to economic growth using the convergence hypothesis (Castellacci, 2008; Castellacci, 2011; and Park et al., 2015).

While the convergence hypothesis is widely tested on economic growth and productivity, few studies have examined the convergence hypothesis using a technology indicator as one of the determinants for economic growth (Benhabib and Spiegel, 1994, 2005; Papageorgiou, 2002; Galor, 2005; Howitt and Mayer-Foulkes, 2005;, Castellacci, 2008, Castellacci and Archibugi, 2008; Castellacci, 2011a,b; Park et al., 2015). Most of these studies investigate the dynamics of technology by focusing on the evolution of innovative activities and absorptive capacity using a large sample of countries. Castellacci (2008, 2011) first analyzes unconditional convergence for technology indicators including patents, scientific articles, mobile telephony, internet users and some indicators related to human capital. Then, in a later stage, this study examines the linkages between technology and economic growth using a dynamic panel model. The study finds that the indicators that have experienced the most rapid pace of technological convergence are those measuring ICT-related infrastructures, i.e., the Internet and mobile telephony. Innovation intensity and human capital have been converging only for middle income countries, not for low income countries. The results of the conditional convergence analysis show that technology plays a major role for per capita income convergence. Similarly, Park et al. (2015) test the convergence of digitalization by constructing an ICT development index using a principal component analysis (PCA). They employ a new form of convergence developed by Phillips and Sul (2007), referred to as the PS log t test, and found that digitalization divergence exists among countries as a whole, while digitalization

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convergence occurs in subgroups. They found that the first group with the highest level of convergence showed the slowest speed of convergence, while the results for the third group displayed the lowest level of convergence and the highest speed of convergence.

1.1. Motivation for ICT convergence

While most studies on ICT convergence have considered whether technology indicators or ICT development lead to divergence or convergence in economic growth, few studies examine the convergence of per capita ICT development. The studies that connect the convergence literature to non-economic growth indicators, such as health expenditures, financial markets and tourism, were performed by Brada et al. (2005); Kim et al. (2005, 2006); Narayan (2007); Fung (2009); Eun and Lee (2010); Su et al. (2010); Narayan et al. (2011) and Park et al. (2015).

This paper contributes to the literature in three ways. First, while most studies examine the determinants of ICT growth and address the digital divide between rich and poor countries, few examine the convergence of ICT development between developed and emerging economies. The convergence of ICT development (defined as ICT access and ICT use per 100 people) between developed and emerging countries is important because a societal digital divide is likely to aggravate existing economic and social inequalities (Strover et al., 2004; Jeffrey, 2007; and Park et al., 2015). Therefore, if emerging countries 'catch-up' to developed countries in per capita ICT development, then the existing digital divide will be reduced in the long run. This reduction will, in turn, reduce poverty in emerging countries.

Second, though few studies examine technology convergence in a dynamic panel framework, Castellacci and Archibugi (2008); Castellacci (2008, 2011) consider technology as a determinant of economic growth dynamics. That is, he examines the conditional convergence of per capita income in a growth accounting framework and tests whether technology reduces the per capita income growth gap between rich and poor countries. Similarly, a group of studies by Chinn and Fairlie (2007); Erumban and De Jong (2006); Pohjola (2003); and Caselli and Coleman (2001) examine the determinants of ICT development both across and within countries and, comparing developed and developing countries, found that per capita income and high levels of educational attainment are the most important determinants of ICT diffusion. Our study goes one step further. We compare the rate of spread of ICT in emerging and developed countries. If ICT spreads more quickly in emerging countries, then what are the factors responsible for this convergence or divergence?

Third, this paper expands upon the work of Park et al. (2015), who examine the digital divide in 108 countries using the concept of club convergence and explores the factors responsible for the digital divide. There are opportunities to extend this research. First, they construct their ICT index using four indicators; however, it is unclear whether those four indicators truly represent the ICT development index. The International Telecommunication Union (ITU) has outlined a methodology for constructing the ICT development index by taking 11 indicators with a detailed weighting scheme (ITU, 2009; pp. 18). Second, in the study by Park et al. (2015), three variables are defined as per 100 people; however, one variable, secure internet server, is measured per one million people. The PCA estimation with loading factors will be biased when the variables are in different units. Third, on the one hand, they find divergence for all of the countries combined, but on the other hand, they find convergence in all three subgroups. This finding generates some contradictions for readers. Moreover, following the Phillips and Sul (2007) methodology for assigning countries to subgroups does not give the correct economic justification for selecting the countries. For example, the ITU ICT 2015 development index ranking shows that England is ranked fourth among 167 countries, but England is not in any of the subgroups. Japan is advanced in ICT and ranked eleventh by the ITU's ICT 2015 development index; however, Park et al. (2015) placed Japan in group 3, where the majority of the countries are either developing or under-developed countries. Finally, the authors claim that the Phillips and Sul (2007) approach has merit over conventional convergence tests based on a neo-classical growth model because it examines the existence of group convergence. However, this approach may not capture country-specific effects.

This paper extends the work of Park et al. (2015) by considering two indicators of ICT access and ICT use. We not only construct an ICT development index using PCA but determine whether there is divergence or convergence with regard to ICT access and use. This study additionally examines the factors that lead to divergence or convergence using a dynamic panel data model. Further, this study creates two groups, developed and emerging countries, based on economic development and tests whether there is divergence or convergence in the subgroups. This test informs whether a homogeneous set of countries supports the convergence hypothesis.

This paper is organized as follows: Section 2 presents the analytical framework and estimation procedure. Data sources and variables are presented in Section 3. Estimation results and their interpretation appear in Section 4. In the final section, we provide some concluding remarks.

2. Analytical framework

The concept of convergence originates in traditional neoclassical growth theory. The central notion is a transitional growth path to a steady state. The introduction of new or endogenous growth theories generated controversy around the issue of convergence. The Solow–Swan neoclassical growth model (Solow, 1956; Swan, 1956) postulates the convergence of per capita output, driven by the assumption of diminishing returns to capital accumulation for the overall economy. The dynamics of the model imply that initial differences in per capita output and capital endowments vanish in the long run due to declining growth rates as countries approach the steady state. In the steady state, diminishing returns are offset by technological progress, the principal source of long-run economic growth. New or endogenous growth theory (see, e.g., Lucas, 1988 and Romer, 1990) generates a more diverse picture of convergence. In this view, economic growth is ultimately driven by the accumulation of knowledge or human capital, which is (at least partially) a public good. Hence, cross-country convergence depends on the extent of international knowledge spillovers, allowing less productive countries to catch-up with more advanced economies. In the next section, we explain the framework for σ-convergence and β-convergence following Barro and Sala-i-Martin (1995).

2.1. β Convergence

This section addresses the notion of convergence in terms of ICT growth rates. β convergence refers to whether the ICT development of a poor economy tends to grow faster than a rich one, so that the countries that lack ICT 'catch up' to rich countries. The following equation measures the β convergence, assuming that ICT development converges towards a unique steady-state for all countries.

$$\ln\left[{}^{y_{i,t}}/_{y_{i,t-1}}\right] = a - \left[\left(1-e^{-\beta}\right)\right] \ln\left(y_{i,t-1}\right) + u_{it} \tag{1}$$

The subscript t denotes the year, and the subscript i denotes the country. The theory implies that the intercept, a, equals $x + (1\text{-}e^{-\beta}).[\ln(y_i^*) + x.(t-1)]$, where y_i^* is the steady state level of $\hat{y}_i$.[1] The parameter β can be estimated in both a linear (see, Islam, 1995; and Baumol, 1986) and nonlinear (Barro and Sala-i-Martin, 1995) form. In general, if $\beta < 0$, then the equation implies convergence. Following Islam (1995),

[1] Taken from Barro and Sala-i-Martin, 1995, pp. 384.