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The impact of ICT development on the global digital divide

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ABSTRACT

Information and communication technology (ICT) has accelerated the growth of the global economy and improved the quality life of the world's inhabitants. ICT has brought new ways of creating livelihoods for people. The diffusion of ICT has also increased year by year and made it possible to reduce poverty. The opportunities created by ICT also may eventually decrease the "distance" between countries in many other ways. Because access to ICT plays a key role in defining the global digital divide, it is important to study how the ICT gaps among countries have changed. This study examines global ICT development in the last decade. We collected secondary data for 136 countries from 2000 to 2008. Four relevant variables are used as proxies for the ICT development status of a country. Because of this multivariate nature of the data, most previous studies have applied a composite index approach to represent the ICT status of a country. For this study, we developed a framework to reduce multivariate raw data into an ordinal number representing a country's ICT development level. The methodology behind the framework involves data clustering and multi-dimensional data ranking. After applying this data reduction procedure, we explored ICT development paths of different countries, and also conducted panel data analysis based on gross national income and various fixed effects.

1. Introduction

Information and communication technology (ICT) has fostered economic growth and social progress in the past few decades. Prior studies have shown that ICT plays a critical role in the national e-commerce growth (Fathian et al. 2008, Ho et al. 2007, 2011), economic growth (Hanafizadeh et al. 2009, Andrianaivo and Kpodar 2011, Papaioannou and Dimelis 2007, Tcheng et al. 2007, Seo et al. 2009), and country development (Heeks 2008). Both developed and developing countries in the world have boosted their national investments in ICT to drive their economic growth (Dewan and Kraemer 2000, Andrianaivo and Kpodar 2011, Tcheng et al. 2007). Heeks (2008) argued that ICT development requires new technologies and new approaches to innovate and integrate. The diffusion of ICT in recent years also has surprised many analysts who serve with leading international organizations. These include the United Nations, the World Bank, the Organization for Economic Cooperation and Development (OECD), and the International Telecommunication Union (ITU), as well as the governments of many countries.

For example, benchmark progress in worldwide ICT access with an emphasis on mobile applications was realized in 2008. This was earlier than the prediction of 2015 made by the World Summit of the Information Society (WSIS) in 2005. The estimation is that more than half of the world's inhabitants will have access to ICTs by 2015. Mobile applications have been designed not only for voice communications, but also business transactions and information access (UNCTAD 2009). In developing countries, the number of users using mobile devices to access the Internet has jumped up rapidly too. As the largest developing country in the world, China had 233 million mobile Internet users with an estimated annual growth rate of 51% in 2009 (CINIC 2010).

Many countries have endeavored to develop ICT through heavy resource investments over the years. Wealthier countries are considered to have more resources at their disposal in ICT development and may have created a higher level of ICT development. Thus, it is critical to investigate the result of the ICT investments in the past decade. The objective of this paper is to explore the global ICT development trend and to examine national wealth effects on the trend. Through regional network effects, countries with spatial proximity may influence one another in their ICT development. Social influence theory (Friedkin 1998) stipulates that an individual's behavior may depend on the behavior of others to whom the individual is tied. The study of Agarwal et al. (2009) supported this social influence theory on an individual's Internet adoption behavior, which may be influenced by the Internet adoption behavior of the individual's spatial peers. In addition to national wealth effects on ICT development, we are also interested in peer effects resulting from spatial proximity on the ICT development of a country. Thus, this study provides another example of social influence theory at the entity level of countries.

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We intend to answer the following research questions. What are the trends of ICT development in a global sense for the last decade? Do countries with different gross national income (GNI) levels have different ICT development paths? Are there peer effects in the ICT development of countries with spatial proximity?

In Section 2, we review the literature related to ICT and the framework in our analysis. Section 3 illustrates our model development and analysis approach: data clustering, cluster ranking, metrics for measuring ICT gaps, and the panel study. In Section 4, we describe the secondary data collected for data analysis and data preprocessing according to our framework. Sections 5 and 6 provide analysis and discussion, and Section 7 concludes with our findings, contributions, and limitations.

2. Literature review

We first review studies in the digital divide. To analyze global ICT development, we will assess studies related to ICT that have considered it as a general purpose technology. This perspective suggests a multivariate representation of ICT development data.

2.1. Digital divide

Though more than half of the world's inhabitants have access to ICT, the distribution of resources has not been uniform throughout the world. For example, there is more communication fiber in the Asian, North American and European continents than in the African continent. Even within the same continent though, there are different levels of ICT access for different countries and regions. As ICT plays a key role in economic growth, the disparities have created many socio-economic imbalance problems in the world. The phrase *digital divide*, in particular, has caught the attention of academic researchers and policy-makers worldwide. The digital divide refers to the gap between those who have access to IT and those who do not (Rice and Katz 2003). The OECD (2001) defined digital digital divide as "the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard both to their opportunities to access information and communication technologies and to their use of the Internet for a wide variety of activities." Thus, the concept of digital divide has two key components: granularity and contents. *Granularity* refers to the level of entities such as individuals, businesses, countries and regions where the gap occurs. *Contents* refer to activities that define the gap, for example, in terms of ICT development and use of the Internet.

Alleviation of the global digital divide has been a major task of international organizations such as the United Nations (UN), the World Bank, and the G8 countries (Canada, France, Germany, Italy, Japan, Russia, the United Kingdom and the United States). These organizations have endeavored to explore how ICT impacts the development of a country. They have analyzed the *status quo* of the development of ICT in countries, and have provided practical evidence year by year. In addition, various researchers have applied different approaches to studying the digital divide (Bélanger and Carter 2009, Cuervo and Menendez 2006, Dasgupta et al. 2001, Kauffman and Techatassanasoontorn 2005a, Sacchi et al. 2009).

Research on digital disparity can be divided into the study of the *global digital divide* (the gap between countries) and the *domestic digital divide* (the gap between groups within countries). Cross-country digital divides result from social and economic inequalities among developed and developing countries. Some prior studies have focused on the extent of the *cross-country divide* (Chinn and Fairlie 2007, Crenshaw and Robinson 2006, Cuervo and Menendez 2006, Dasgupta et al. 2001, Dewan et al. 2005, Dewan et al. 2010, Emrouznejad et al. 2010, Hanafizadeh et al. 2009, Kauffman and Techatassanasoontorn 2005a, Shirazi et al. 2009, Vicente and Lopez 2011). We summarize these studies in terms of measures of digital divide, data type, research method, data period, unit of analysis, and variables examined in Table 1. These studies use wireless technology, PC, Internet, and ICT indicators to measure the digital divide. They also examine a large set of variables that may affect the digital divide across countries. Most of these studies collected secondary data and performed cross-sectional and time-series analyses (see Table 1).

Previous studies imply that opportunity to access ICT is a key component in measuring the digital divide. In addition, Internet access, PC access, user digital capability, and government policy also form a basis for measurement of the digital divide. ICT-related measures are critical indicators that show the differences between rich and poor countries (Chinn and Fairlie 2007, Cuervo and Menendez 2006). ICT opportunities and the digital divide have an interesting bidirectional relationship: ICT opportunities influence the digital divide, and the digital divide may hinder ICT opportunities as well (OECD 2005). The ICT opportunities of a country seem to be closely tied to the ICT development in that country. Instead of addressing the full set of issues related to the digital divide, we will use a broad perspective to measure ICT development in this study. We also intend to measure ICT as a general purpose technology (GPT).

2.2. ICT as a general purpose technology

General purpose technologies (GPTs) are original ideas or techniques that have the potential to significantly influence a variety of industries in a country (Guerrieri and Padoan 2007). GPTs are characterized by their pervasiveness of use, inherent potential for technical improvements and innovational complementarities (Bresnahanm and Trajtenberg 1995). An example is the steam engine. Another example is electrical systems. As GPTs improve and spread through an economy, the economy may achieve improved productivity. Since ICT is a type of GPT, measuring ICT development is a multifaceted challenge. The WSIS 2003 annual meeting provided guidelines for measuring the ICT development of a country (Sciadis 2005). The increasing penetration of ICT involves several critical indices for economic growth and technology diffusion. They include mobile phone penetration, Internet penetration, PC penetration, investment in ICT infrastructure, and so on. These indicators of ICT development have been empirically tested in previous studies (Cuervo and Menendez 2006, Ho et al. 2007, Kauffman and Techatassanasoontorn 2005a, UNCTAD 2010). In this study, we argue that the Internet and mobile phones are GPTs. We will focus on these two GPTs in this study.

Technology adoption does not take place uniformly across the world. Researchers have argued that spatial proximity is likely to result in relational proximity when there are increased interactions (Niles and Hanson 2003). Agarwal et al. (2009) examined geographical variation in Internet use by using the spatial distribution of individuals to define their reference group. An individual's social or peer group refers to everyone else living in the same region – for example, a US county. Peer effects suggest that people in the same region affect the propensity of an individual's use of the Internet (Agarwal et al. 2009). Chin and Fairlie (2007) argued that income and the telecommunication infrastructure contribute to Internet penetration. Moreover, applications of the Internet also seem to have accelerated the development of electronic commerce worldwide. The introduction of e-commerce has gradually changed the structure of global business as well (Gibbs et al. 2003). Developing countries can utilize the opportunities of e-commerce and ICTs to increase their country's competitiveness (UNCTAD 2001). The advantages of developing ICT infrastructure are beneficial; they lead to the growth of a domestic economy and also foster economic