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ICT Co-evolution and Korean ICT strategy—An analysis based on patent data ☆

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ABSTRACT

This paper investigates the interactive nature of relationships between Information and Communications Technologies (ICTs) in terms of their technological innovations and diffusion. For the purpose, the United States Patent and Trademarks Office (USPTO) database was used and Lotka-Volterra equations were applied to the patent data, resulting in a Patent Interaction Network (PIN). This matrix was employed to investigate the interaction patterns among ICT-related industries, allowing co-evolution process across ICTs to be analyzed. This paper also examined patenting activities in the Korean ICT sector, which has announced the IT839 strategy to address ICT-related services, infrastructures and growth drivers. It is judged that the evolving pattern of Koran ICT has been compatible with the PIN, facilitating the development of each other. It is also expected that promoting broadband and home-network technologies, together with technologies on digital contents and software solutions, can lead to the growth of the whole ICT industry. Such research findings will provide numerous implications for policy-making and strategic planning for ICT development.

1. Introduction

In the current knowledge economy, technological knowledge on Information and Communication Technologies (ICTs) plays a pivotal role in national growth and firm competitiveness (OECD, 2004). Actually, economic growth in such countries as Japan (Jorgenson & Nomura, 2005), Korea (Shin & Park, 2007) and Finland (Jalava & Pohjola, 2007), which are technically advanced in ICT, is dominated by investments and productivity growth in ICT, both for industries and the economy as a whole. Previous research findings show that ICT contributes to economic growth in many developed countries and newly industrialized economies, though not in developing countries (Lee, Gholami, & Tong, 2005). Accordingly, the ICT sector has received increasing interest (Colombo & Grilli, 2007) and many studies have been conducted to understand its nature in terms of technological innovations and diffusions (Chen, Watanabe, & Griffy-Brown, 2007; Vicente & López, 2006). Among these, some recent studies have focused on identifying the relationships between ICTs, based on citation analysis using patent data in the ICT sector (Corrocher, Malerba, & Montobbio, 2007; Shin & Park, 2007; Sorenson, Rivkin, & Fleming, 2006).

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Patent documents are an ample source for technical and commercial knowledge about technology progress and innovative activity (Ernst, 2003). Of the varied information that patent documents contain, patent citation is defined as the frequency that a patent is cited in subsequent patents, which reflects the impact of its technological innovation and the pervasiveness of its technological information (Karki, 1997; Narin, 1994). The number of citations per patent represents both the quantitative frequency and the qualitative importance of that particular patent, and therefore such indices as citing–cited intensity and linkage, coverage of technology, and citation cycle time may be developed in addition to simple frequency counts. If these indices are measured within and/or between technologies, patterns of technological innovation and knowledge flows can be identified and investigated (Engelsman & van Rann, 1994). Consequently, citation analysis has long been applied to understand linkages between industries, nations or technologies in terms of technological innovations and knowledge flows. When applied to the ICT sector, interactions among ICTs are emphasized, and so knowledge flows among them are investigated to define their interactions.

Such studies have provided us with useful implications for the ripple effects of technological innovation in other technologies (Hu & Jaffe, 2003; Jaffe, 1988). The positive effects of one technological innovation on others have been the main concern, since it is assumed that knowledge flows can boost innovations. However, the development of a specific technology may also arrest the development of other technologies, for the following two reasons. Firstly, within a limited R&D budget, spending on a certain technological improvement may mean missing the opportunity for the growth of other technologies. Secondly, where technologies can be substituted for each other, the growth of one technology can result in the decline of alternatives (Pistorius & Utterback, 1997). However, most previous studies have overlooked the fact that one technological innovation may inhibit the development of others, and, quite naturally, few studies deal with such negative effects when investigating patterns of technological innovation and the interrelated diffusion process between technological innovations. Thus, a new approach incorporating both positive and negative effects of innovation is needed when the interactions among technologies are to be analyzed. This approach is useful especially for ICTs, where technologies are closely connected with each other, and the advance of some technologies may well lead to the death of some others.

This study takes the competition approach to analyzing the interaction among ICTs, considering both positive and negative perspectives simultaneously. Here, the term 'competition' generally implies a confrontation between two entities, in this case, two technologies. While we are apt to associate 'competition' with only negative effects, interactions between technologies are viewed in a much wider sense in this paper. In fact, there are many cases where technologies interact in non-confrontational relationships (Pistorius & Utterback, 1997). They may interact in various modes with one another, be it predator–prey, mutualism, commensalism, amensalism or neutralism, as well as in the strictly normal sense of competition (Modis, 1999). By adopting this multi-mode approach to competition that allows for various combinations of positive and negative interactions between technologies beyond the knowledge-flow approach, we expect a much richer setting for assessing such interactions, and the subsequent plotting of offensive and defensive strategies presents itself as more complex than a simple citing–cited setting. For this purpose, taking the competition approach, we first classified ICT patents into nine industry sectors, and examined the co-evolution processes to identify the characteristics of innovations in ICT sectors. The growth of ICTs in Korea was then examined, based on patenting activities, to evaluate the effectiveness of Korean government strategies, namely, IT839 strategy.

The remainder of this paper is organized as follows. In Section 2, ICT-related industry sectors are defined and assigned the relevant USPCs (United States Patent Classifications). In Section 3, ICT co-evolution trends are analyzed using the LVC (Lotka-Volterra Competition) model and, based on these trends, ICT evolution in Korea is evaluated. Section 4 discusses some implications of the research results or ICT strategy, while Section 5 contains concluding remarks and points up future research issues.

2. ICT sector and USPC concordance

In order to analyze the patent data related to the ICT sector, the sector itself and ICT-related patents must be defined. The OECD definition of ICTs developed in 1998 consists of five categories: telecommunications; consumer electronics; computers and office machinery; measuring and control instruments; and equipment and electronic components. It also identified a list of IPC (International Patent Classification) codes associated with the sector (OECD, 2003), but since the USPTO (United States Patent and Trademarks Office) database is used in our analysis, we matched the IPC codes to USPC (United States Patent Classification) codes. In all, 37 USPC classes were identified for ICT-related patents, and data on the annual number of USPTO patent applications between 1963 and 2006 were gathered for each class (see Appendix A).

To observe the co-evolution patterns among ICT sectors, we referenced nine next-generation drivers announced by the Korean Ministry of Information and Communications to facilitate the growth of Korean ICTs. Each of the 37 USPC codes was assigned to one of the nine drivers through keywords matching. The final concordance results are shown in Table 1, which also notes the sector abbreviations used in the rest of the paper.

3. ICT co-evolution

3.1. Lotka-Volterra equations

Competition diffusion models rely primarily on evolutionary game theory, which assumes that evolution, whether biological or technological, really originates from the results of co-evolution. One of the most famous models in such theory