



Causal relationship between ICT R&D investment and economic growth in Korea



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ABSTRACT

This study examined the Granger-causality between R&D investment and economic growth for Korea's ICT industry. Bidirectional Granger-causality was observed between ICT R&D investment and economic growth, and this result implies that ICT R&D investment is driven by economic growth and vice versa. When ICT R&D investment was classified into public sector and private sector, the results showed the private ICT R&D investment had stronger relationship with economic growth compared to public the ICT R&D investment. It means the private ICT R&D investment has stronger attribute of leading economic growth and induced investment by economic growth than the Public ICT R&D investment. The results also reported bidirectional causality between public ICT R&D investment and private ICT R&D investment. The establishment of two-way Granger-causality between public sector and private sector indicates a virtuous cycle has taken hold.

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1. Introduction

Information and communication technologies (ICTs) are key enablers of innovation throughout the economy. In most OECD economies, information industries account for the largest share of business expenditures on research and development, amounting to about 25% of total business expenditures on research and development and 0.2% to 0.4% of GDP. Especially, in Finland, Israel, Korea and the United States, information industries account for 40% to over 50% of BERD, and ICT BERD alone represents between about 0.6% to >1.8% of GDP, reflecting the high research intensity of these economies and the sector itself (OECD, 2015).

With the sector of ICT attracting vast R&D investments in various countries, many studies have been performed to determine the relationship between ICT investment and economic growth. Representative studies have been conducted by Madden and Savage (1998), Oliner and Sichel (2000), Jorgenson (2001, 2005), Colechia and Schreyer (2002), Plepys (2002), Datta and Agarwal (2004), Jorgenson and Motohashi (2005), Jalava and Pohjola (2008), Koutroumpis (2009), Martínez et al. (2010), Vu (2011, 2013), and Sassi and Goaid (2013). Many of these studies demonstrate a strong positive correlation between ICT investment and economic growth.

However, as asserted by Blomstrom et al. (1996) and Madden and Savage (1998), a strong correlation between investment and economic growth does not necessarily imply the presence of a causal relationship;

the correlation between the two variables can be either bi-directional or uni-directional. Phillips (1986) also claims that a causal relationship may be formed due to contingent regression despite the lack of correlation between the two variables. Since the establishment of a relationship dependent on correlation may invite inappropriate policies, further examination is needed on the causal relationship of the two variables.

The purpose of this study is to determine the causal relationship between R&D investment in the ICT industry and economic growth in Korea. According to the OECD (2015), OECD member countries invest about 20 to 25% of total industrial R&D investments in the ICT industry, and Korea recorded the highest investment at 56% of that. Given that the ICT industry accounts for a significant portion of Korea's R&D investment, it is essential to examine the causal relationship between ICT R&D investment and economic growth.

The characteristics of this study are as follows. First, it examines the causal relationship between R&D investment in the ICT industry and economic growth in Korea. Existing studies broadly define ICT investment as both capital investment and R&D investment due to difficulties involved in acquiring statistical data on R&D investment by industry. However, adopting this same approach to the situation in Korea would result in unreliable results since Korea's capital investment in ICT is 4 to 12 times greater than R&D investment. Second, this study analyzes the causal relationship between the two variables from multiple perspectives, and both public and private sectors are included when studying the general causal relationship between total R&D investment in ICT and economic growth. Next, ICT R&D investment is classified into public R&D investment and private R&D investment to assess the formation of a causal relation between each investment type and economic

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growth. Lastly, the causal relationship between ICT R&D investment and economic growth is reviewed based on the causal relationship between public R&D investment and private R&D investment.

This study is organized as follows. Section 2 introduces other studies covering the causal relationship between R&D investment in the ICT industry and economic growth. Section 3 examines the data and analytical model used in this study. Section 4 presents the results of analysis of the causal relationship between ICT R&D investment and economic growth. Section 5 provides a summary of the results and implications for related policies.

2. Literature review

Over the past several years, the role of telecommunications investment in economic development has been studied both using cross-section and modern advanced in time series econometrics of cointegration and causality (Wolde-Rufael, 2007). Many studies have been performed on the causal relationship between ICT investment and economic growth, from Cronin et al. (1991) to Ishida (2015). Table 1 lists representative studies in the field.

Studies focusing on the causal relationship between ICT investment and economic growth in a single country are as follows. Cronin et al. (1991), who examined the causal relationship between the two variables in the United States, found a feedback process in which telecommunications investment enhances economic activity and growth, while economic activity and growth stimulate demands for telecommunications infrastructure investment. However, Beil et al. (2005) stated that investment by telecommunications form is caused by, but does not cause, economic activity. Yoo and Kwak (2004), who analyzed the case of Korea, and Veeramacheni et al. (2008), who examined the case of India, found bi-directional causality between IT investment and economic development. Dvorjnik and Sabolic (2007), who targeted countries in Eastern Europe, found that uni-directional causality runs from IT investment to economic development. In contrast, studies by Shiu and Lam (2008) on China and by Hossein and Yazdan (2012) on Iran found that uni-directional causality runs from economic growth to telecommunication development. Meanwhile, Ishida (2015), who dealt with the influence of Japan's ICT investment on economic growth and energy consumption, found that ICT investment could ceteris paribus contribute to a moderate reduction in energy consumption, but not to an increase in GDP.

Studies on the causal relationship between ICT investment and economic growth in multiple countries are as follows. Dutta (2001) examined the causal relationship between telecommunications infrastructure and economic activity in 15 developing countries and 15 industrialized countries. He found that the evidence for causality from levels of telecommunications infrastructure to economic activity is stronger than that for causality in the opposite direction. Veeramacheni et al. (2007), whose study involved 10 countries in Latin America, found a bi-directional causal relationship between ICT and economic growth for seven countries, including Brazil. In addition,

Pradhan et al. (2014) showed a bi-directional causal relationship between the development of telecommunications infrastructure and economic growth in both the G-20 developed group and the G-20 developing group.

3. Data and methodology

3.1. Data

3.1.1. Range of the ICT industry

The Korean Standard Industrial Classification (KSIC) does not classify the ICT industry as an independent industry. This study applied the KSIC model after classifying the ICT industry as an industry on its own, using the classification method developed by Hong et al. (2012). Details of the classification of ICT industry in this study are given in Table 2.

3.1.2. Variables

This study used annual time series data from the 26 year period between 1988 and 2013. Statistical data on value-added by industry, obtained from the Korean Statistical Information Service, was used as proxy variables of economic growth. The proxy variable of ICT R&D investment was statistical data on R&D investment by industry, provided by the National Science & Technology Information Service. Table 3 gives the data used for the empirical analysis in this study. The key variables of this study are value-added of the ICT industry (IGDP) and total R&D investment (TRDI). The TRDI of the ICT industry was divided into public R&D investment (GRDI) and private R&D investment (PRDI) to allow a multi-faceted analysis of the causal relationship between variables. All data was converted into real values through the 2010 GDP deflator provided by the Bank of Korea, and substituted into the model after taking natural logs.

3.2. Methodology

According to the Monte Carlo evidence reported by Guilkey and Salemi (1982) and Geweke et al. (1983), among the many techniques Granger-causality tests provide the most reliable results in the case of small samples. Thus, this study performed Granger-causality tests to analyze the causality between ICT R&D investment and economic growth. As proven by Stock and Watson (1989), non-stationary variables in time series data can lead to spurious regression, which calls for stable time series data. Since economic time series variables tend to be non-stationary, the stability of the time series data used in this study was assessed through unit root tests and the cointegration test.

3.2.1. Unit root test

The unit root originated from when a non-stationary time series is expressed as an autoregressive model, it takes the characteristic root of 1. If a certain variable has a unit root, that variable is said to follow a random walk, and can be converted to a stable variable using the difference method. Because the test equation cannot be predetermined for

Table 1
Literature review related causal relationship between IT investment and economic growth.

Research	Country	Period	Variables
Cronin et al. (1991)	U.S.A	1958–1988	GNP, telecom investment, total output
Dutta (2001)	30 countries	1970–1993	Economic activity level, telecom infrastructure level
Yoo and Kwak (2004)	Korea	1965–1998	GDP, IT investment
Beil et al. (2005)	U.S.A	1947–1996	FDP, telecom investment
Dvorjnik and sabolic (2007)	Eastern Europe	1991–2001	GDP, degree of telecom development
Veeramacheni et al. (2007)	10 Latin American countries	1975–2003	GDP, telecom investment, foreign direct investment
Veeramacheni et al. (2008)	India	1970–2005	economic activity level, telecom infrastructure level
Shiu and Lam (2008)	China and its region	1978–2004	GDP, teledensity, penetration rate
Hossein and Yazdan (2012)	Iran	1980–2010	GDP, ICT development
Pradhan et al. (2014)	G-20 countries	1991–2012	GDP, telecom infrastructure, macroeconomic variables
Ishida (2015)	Japan	1980–2010	GDP, ICT investment, energy consumption

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