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The long-run impact of Information and Communication Technology on economic output: The case of Australia

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ABSTRACT

This paper investigates the cointegration and causal relationships between Information and Communication Technology (ICT) and economic output in Australia using data for about five decades. The framework used in this paper is the single-sector aggregate production function, which is the first comprehensive approach of this kind to include ICT and non-ICT capital and other factors to examine long-run Granger causality. The empirical evidence points to a cointegration relationship between ICT capital and output, and implies that ICT capital Granger causes economic output and multifactor productivity, as does non-ICT capital.

1. Introduction

Numerous studies have examined the contribution of Information and Communication Technology (ICT) to economic output (Colecchia & Schreyer, 2002; Jorgenson & Stiroh, 1999, 2000; Jorgenson, Ho, & Stiroh, 2008; Oliner & Sichel, 2000; Parham, Roberts, & Sun, 2001). These studies have shown a varying degree of ICT contribution to economic output in different stages of economic development. For example, Colecchia and Schreyer (2002) found that the contribution of ICT capital accumulation to output growth varied between 3% and 9% during the 1990s as compared to 2% and 5% during the 1970s and 1980s, respectively, for nine OECD countries. In a recent study, Jorgenson et al. (2008) found a less important role of ICT on economic performance in the US in the post-2000 period as compared to the 1990s. Van Ark and Inklaar (2005) argued that the productivity gains of ICT capital are relatively higher at the early stage due to ICT's increasingly wide diffusion throughout the economy during the phase. In a recent study, Shahiduzzaman and Alam (2014) found the evidence of less impressed role of ICT capital on economic growth and productivity in Australia in recent years as compared to the 1990s. Therefore, the roles of ICT capital on economic output may change over time.

Studies exploring the causal direction between ICT investment and economic output generally found evidence to support the viewpoint that greater ICT investment Granger causes economic growth (e.g., Cronin, Parker, Colleran, & Gold, 1991). Yet, causality results have often been derived using a bivariate model consisting only ICT investment and a measure of economic output. Generally, the share of ICT capital to total capital stock is substantially lower than that of non-ICT capital. Accordingly, a large contribution to output growth comes from non-ICT related capital and other factors of production such as labour and technical progress. Furthermore, ICT is seen as a general purpose technology which means that investment in complementary non-ICT capital and labour quality may take place along with the investment in ICT capital. Therefore, ICT

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capital often interacts with other factors in the production process. Accordingly, a multivariate model that controls for the additional channels through which ICT investment can cause economic growth is preferable to a bivariate model.

The purpose of this paper is to revisit the role of ICT on economic output by utilising a multivariate approach and recent advances of econometric techniques on cointegration and causality analyses. A multivariate application of cointegration and causality analyses has received succinct focus in the ICT–output literature as most of the existing studies are based on bivariate models. The economic interpretation of cointegration implies that a long-run equilibrium relationship exists between the variables. ICT investment and economic output can be co-integrated as, over the long term, ICT investment can boost economic growth through capital deepening and the enhancement of multifactor productivity. A test of cointegration also has important implications for subsequent modelling and inferencing, especially in the context of analysing causal relationship. Test for Granger (1969) causality requires the variables in a model to be stationary. However, like most macro-variables, both ICT capital and economic output tend to follow a non-stationary process and a stationarity condition is typically met in the existing literature by the appropriate degree of differencing of the variables (Beil, Ford, & Jackson, 2005; Cronin et al., 1991; Cronin, Parker, Colleran, & Gold, 1993; Dutta, 2001). However, a problem with differencing is that it leads to a loss of information on long-run relationship. The role of ICT as general purpose technology implies that its productive impacts are fully materialized in the long-run. Therefore, it is useful to investigate the impact the ICT investment on economic growth from a long-run perspective.

Engle and Granger (1987) determined a way to run a model with non-stationary variables, that contains both short- and long-run information, popularly known as the error correction model (ECM). The formulation of the ECM requires variables of interest to be cointegrated. Toda and Yamamoto (TY; 1995) provided an alternative approach to determine long-run causality, which obviates the need to test for cointegration. The added advantage of the TY approach is that it controls the possible endogeneity among the variables – an issue that has not been addressed adequately in the earlier literature in the ICT–output nexus.

The dataset used in this study for about five decades (47 years) – a longer sample than most of the previous studies. Like many others advanced countries including the much noted US, the impact of ICT on economic output in Australia sparked interest to the researcher for long. The country sustained a remarkable growth performance during the period of financial crisis in the 1990s – quoting the country a 'miraculous' economy (Krugman, 1998). Once again, the Australian economy performed markedly better growth outcome than most other advanced countries during the period of Global Financial Crisis emerged around the middle of 2007 (ABS, 2010). Previous research has documented the strong contribution of ICT investment on economic output in Australia in the 1990s (e.g., Banks, 2001; Parham, 2005; Parham et al., 2001). Cross-country studies identified a very strong and positive role of ICT capital on economic output in Australia during the 1990s as compared to other advanced countries (Colecchia & Schreyer, 2002). There is less knowledge, however, on the long-term contribution of ICT capital on economic growth in Australia.

The paper is organised as follows. Following this introduction, Section 2 provides a brief review of literature. Section 3 discusses the methodology and data. Section 4 presents the empirical results and Section 5 provides conclusions and policy implications.

2. Review of literature on cointegration and causality between ICT and economic output

While the relationship between ICT investment and economic output has been a topic of empirical research since the 1960s (e.g., Jipp, 1963), a more formal causality analysis using standard econometric techniques began in the early 1990s.[1] Cronin, Colleran, Herbert, and Lewitzky (1993) and Cronin et al. (1991, 1993) were the earliest attempts to examine the Granger causality and found evidence of a bidirectional relationship between ICT investment and economic output in the US. Evidence of a bidirectional relationship between the two variables was also found by, among others, Yoo and Kwak (2004) for Korea, Wolde-Rufael (2007) for the US and Dutta (2001) for a sample of 30 industrial (including Australia) and developing countries. The evidence of bidirectional causality indicates that any shock to ICT investment transmits to economic output and via economic output to ICT investment again through the feedback effects. The policy implication of this causality result is that a reduction in telecommunication investment would be detrimental to economic growth. On the other hand, Beil et al. (2005) found evidence of unidirectional causality running from Gross Domestic Product (GDP) to ICT investment and not in the opposite direction.

In a study of 20 countries Lee, Gholami, and Tong (2005) found mixed results regarding the direction of causality. For example, they found evidence of bidirectional causality between ICT investment and GDP only for Australia, but for majority of other countries, including the US, they found evidence of unidirectional causality running from GDP to ICT investment. For Italy, Japan, Finland, France, the UK and China they found no evidence of causality between the two variables. Therefore, the causality results from prior research remain inconclusive.

Table 1 provides an overview of selected time series studies on the causality between ICT investment and economic output. As shown in the table, the findings from the studies are conflicting. Moreover, a large body of literature is based on

[1] The literature on ICT investment and economic growth is, by now, voluminous. Mainstream research in this domain has utilised the growth accounting framework to examine the contribution of ICT on economic growth (e.g., Jorgenson, 2001; Jorgenson & Stiroh, 1999; Parham et al., 2001). There are some other studies using panel data analysis (e.g., Datta & Agarwal, 2004; Lee, Levendis, & Gutierrez, 2012). For the sake of brevity the literature review section here only focuses on the time series studies with particular reference to the co-integration and causality analysis. A comparison of results with the growth accounting studies is discussed in Section 4.