Economic growth: The role of knowledge economy in the context of selected Asian countries

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ABSTRACT

This study examines the role of different knowledge economy components in economic growth as well as the simultaneous effects of information and communication technology (ICT) infrastructure, education, and innovation on economic growth of selected Asian countries over the 1990–2014 period, using Driscoll-Kraay estimation method and seemingly unrelated regression (SUR) and three stage least squares (3SLS). The results confirm that there exists a positive association between economic growth and four components of the knowledge economy framework. Furthermore, there is also evidence of the multidimensional effects of ICT infrastructure, education, and innovation on economic growth. As a result, policy makers should pay more attention to improving innovation, education, information and communication infrastructure, and institutional regime systematically to achieve sustainable economic growth.

1. Introduction

Economic growth is based on capital, labor, technology (Solow, 1956, 1957), natural resources (Sachs & Warner, 1995, 1999, 2001; Labra et al., 2016) and other "new" factors of growth such as knowledge and innovation (Lucas, 1988; Romer, 1990; Mankiw et al., 1992; Powell & Snellman, 2004; World Bank, 2007). In the 21th century, the engines of growth, especially in developed countries, tend to shift to knowledge, innovation factors (WEF, 2015). As a result, knowledge economy model is regarded as a new growth model to achieve the quality of growth and sustainable development (Powell & Snellman, 2004; Suh & Chen, 2007; World Bank, 2007).

Asia consists of more than 40 countries with GDP (PPP) accounting for approximately 40% of the world (IMF, 2016). Asian economies are focusing more and more on new determinants of growth including improving education, information and communication infrastructure, innovation besides traditional engines of natural resources and labor intensive production so as to sustain long-term economic growth (ADB, 2016). Some questions may arise following this trend: "Does these factors have an impact on economic growth?" and "How do they take effect?" Hence, this study aims to: (i) examine the role of different knowledge economy components in economic growth of selected Asian countries; and (ii) investigate the simultaneous effects of ICT infrastructure, education, and innovation on economic growth of selected Asian countries.

Knowledge economy has received much attention in recent times. Many studies focused on the conceptual framework of knowledge economy such as OECD (1996), World Bank (1999), Powell & Snellman (2004), Suh and Chen (2007), and World Bank (2007). Several studies, including Karagiannis (2007), Sundać and Fatur Krmpotić (2011), and Labra et al. (2016), investigated the impacts of multiple components of knowledge economy framework on economic growth. Moreover, a majority of empirical studies focused on the impacts of individual components of knowledge economy framework on economic growth (Education: Barro, 1991; Hanushek & Kimko, 2000; Cohen & Soto, 2007; Suri et al., 2011; Barro, 2013; Hanushek, 2013; Hassan & Cooray, 2015; Innovation system: Lederman & Maloney, 2003; Agénor & Neanidis, 2015; Inekwe, 2015; Castellacci & Natera, 2016; Information and communication infrastructure: Jorgenson & Vu, 2005; Inklaar et al., 2008; Vu, 2011; Erumban & Das, 2015; Jorgenson et al., 2015; Pradhan et al., 2015; Institution: Barro, 1991; Barro, 1996; Knack & Keefer, 1995; Mauro, 1995; Kaufmann et al., 1999; Acemoglu et al., 2001). However, most previous studies have put a stress on this issue in developed countries. To the best of our knowledge, there is a lack of studies on this topic in the context of Asian countries. Therefore, this study contributes to the literature as a comprehensive study for the case of Asian economies. In terms of research methodology, our study has a significant contribution by employing Driscoll and Kraay's (1998) estimation approach, which may capture most of the diagnostic problems including heteroscedasticity, autocorrelation, and cross-sectional dependence (Hoechle, 2007). Furthermore, we employ the SUR technique, which accounts for cross-equation error correlation, estimates the full information estimators of different equations simultaneously, and correct the problem of endogeneity (Zellner, 1996; Baltagi, 2008; Greene, 2012).

The rest of the study is structured as follows. Section 2 presents the literature review, which covers the roles of different components of knowledge economy as well as natural resources in economic growth. In section 3, we describe the econometric method and data used for estimation. Section 4 discusses main estimation results. Finally, Section 5 concludes and suggests some policy implications.

2. Literature review

2.1. The concept of knowledge economy

The concept of "knowledge economy" is widely mentioned in development literature (OECD, 1996; World Bank, 1999; Powell & Snellman, 2004; Suh & Chen, 2007; World Bank, 2007); it can be defined as *"production and services based on knowledge-intensive activities that contribute to an accelerated pace of technical and scientific advance, as well as rapid obsolescence. The key component of a knowledge economy is a greater reliance on intellectual capabilities than on physical inputs or natural resources"* (Powell & Snellman, 2004). Knowledge economy can also be defined as *"one that uses knowledge as the key engine of economic growth. It is an economy in which knowledge is acquired, created, disseminated, and used effectively to enhance economic development"* (Suh & Chen, 2007). In general, knowledge economy considers knowledge as the main resource and driver of the economy compared to other material resources. It is also as important as land and labor in the agricultural economy, or natural resources and machinery in the industrial economy, and is even more important due to the continuous innovation and creativeness to increase labor productivity and the quality of growth.

2.2. Structure of knowledge economy

To establish a benchmark for measuring the progress of a country toward knowledge economy and increase policy markers' awareness, the World Bank Institute introduces the project "Knowledge for Development" (K4D) using the "Knowledge Assessment Methodology – KAM" (www.worldbank.org/kam) to establish the World Bank's Knowledge Economy Index (KEI). According to World Bank (2007), the knowledge economy consists of four pillars: (i) Economic and institutional regime; (ii) Education; (iii) Innovation system; (iv) Information and communication infrastructure. "Economic and institutional regime" refers to the macroeconomic, legal framework that supports the efficient distribution of resources and fosters entrepreneurship as well as the generation, diffusion, and utilization of knowledge. "Education" involves the process of educating and training an educated and skilled workforce so that they can use knowledge effectively. "Innovation system" includes companies, research institutes, universities, and other organizations that can access and keep up with technology to acquire new knowledge and adapt it for specific demand. Finally, "Information and communication infrastructure" facilitates the exchange, process, and dissemination of information effectively. Information and communication technologies (ICT), including telephone networks and the Internet, is the essential infrastructure of the global economy based on information and knowledge in the 21st century (World Bank, 2007).

2.3. Roles of components of knowledge economy and natural resources in economic growth

Empirical studies on the impacts of the components of knowledge economy on economic growth are extensive. Regarding the pillar of "Education," some distinguishing studies include Barro (1991), Hanushek and Kimko (2000), and Cohen and Soto (2007), which present the positive impacts of education on economic growth. Recent studies such as Suri et al. (2011), Barro (2013), Hanushek (2013), and Hassan and Cooray (2015) mostly find evidence of the crucial role of education in growth. For example, Barro (2013), using data of 100 economies during the period from 1960 to 1995, finds that economic growth has a positive association with years of attending school for adult males at secondary and higher levels, but it is insignificant given the case of females. Regarding the quality of education, using comparable test scores among countries, it is found that science tests scores have a positive association with growth. A study by Hanushek (2013) shows that developing countries have made significant advancement to catch up with developed ones regarding school enrollment. However, in terms of educational quality—cognitive skills, developing countries have not achieved much compared to developed economies. Hassan and Cooray (2015) investigated the impacts of school enrolment on economic growth with different gender groups in Asian context, and the results reveal that the impacts of education are significantly positive for both males and females at all educational levels including primary, secondary, and tertiary ones.

Regarding "Innovation system," a variety of studies show that innovation has a considerable positive impact on economic growth. For instance, Lederman and Maloney (2003), employing the data from 1975 to 2000 of 53 countries, find that when the proportion of R&D expenditure in GDP goes up by 1 percentage point, GDP growth rate increases by 0.78 percentage point. Similarly, Agénor and Neanidis (2015), using data from 38 countries (mostly OECD) from 1981 to 2008, also show that more innovation performance boosts economic growth directly. Inekwe (2015) examined the role of R&D spending in economic growth of developing economies during the period 2000 - 2009 with the sample of 66 countries including both upper middle-income and lower middle-income countries. The findings show that R&D expenditure has a positive impact on growth in upper middle-income countries, but it is insignificant in the case of lower income countries. Moreover, dealing with simultaneity and endogeneity by simultaneous equation models reveals that R&D expenditure is still advantageous for growth. Castellacci and Natera (2016) adopted Johansen cointegration method with data from 1970 to 2010 of 18 Latin American economies, demonstrating that the countries with strong innovation policies achieved higher growth rates than those only focusing on imitation policies.

As for the pillar of "Information and communication infrastructure," the impacts of ICT on economic growth were investigated in several studies including Jorgenson and Vu (2005), Inklaar et al. (2008), Vu (2011), Erumban and Das (2015), Jorgenson et al. (2015), and Pradhan et al. (2015), and there is strong evidence that ICT has a positive impact on economic growth. Jorgenson and Vu (2005) documented the effect of investment in information technology (IT) on the economic growth of the global economy. With the data of 110 countries from 1989 to 2003, they find that the role of IT investment in growth is significant, especially in industrialized and developing Asian countries. Inklaar et al. (2008) also reveals that more investment in ICT raises labor productivity in service markets (such as wholesale/retail trade, hotels, and restaurants, etc.) considerably in both Europe and the US. Vu (2011) examined the impacts of ICT on economic growth in 102 countries during 1996–2005. The estimation results confirm that ICT, namely personal computers, mobiles phones, and the Internet, has a positive impact on growth. Recent evidence from Pradhan et al. (2015) also shows that there is a causal relationship between ICT infrastructure and economic growth in Asian countries during 2001–2012.

A large body of studies investigated the relationship between institution and economic growth. Some seminal papers include Barro (1991), Barro (1996), Knack and Keefer (1995), Mauro (1995), Kaufmann et al. (1999), and Acemoglu et al. (2001). Barro (1991) shows that political instability (represented by a number of coups/years and the assassination of political figures/one million people/year) has a negatively effect on economic growth. Mauro (1995) studied the impact of corruption on growth, indicating the negative association between these two factors. Because there is the possibility of reverse causation from growth to institution, Mauro used ethnolinguistic fractionalization index (the probability of two people chosen randomly in a country does not belong to the same cultural language group) as an instrumental variable for institutions to control endogeneity. Knack and Keefer (1995) surveyed the impact of property rights on economic growth. By using the risk assessment criteria of potential foreign investors (namely contract enforceability and risk of expropriation) to represent property ownership, they find that property ownership has a significant impact on growth. Therefore, protection of property rights plays an important role in promoting growth.

Barro (1996) examined the factors affecting economic growth in about 100 countries in the period 1960-1990. The results show that rule of law has a statistically significant and positive impact on economic gr owth;

the countries following the rule-of-law principle reflect better economic growth. Moreover, the relationship between democracy and growth has an inverted U-shape, with the degree of political freedom maximizing growth locating between democracy and dictatorship. Kaufmann et al. (1999) studied the impact of governance on per capita income, using a dataset covering more than 150 countries with the aggregated data of more than 300 indicators from various sources, divided into six major groups of indicators including: (i) voice and accountability; (ii) political instability and violence; (iii) government effectiveness; (iv) regulatory burden; (v) rule of law; and (vi) graft. Their results show that governance has a strong and positive impact on per capita income, implying that better governance leads to higher per capita income.

Acemoglu et al. (2001) studied the impact of institution on per capita income. To control for the endogenous problems, the authors used European settler mortality rates, namely the death rate of soldiers, bishops, and sailors arrived in the colony from the 17th century to the 19th, as an instrument for existing institution. Their empirical results show that institutions have a significant effect on current per capita income. Recent evidence was accumulated by Flachaire et al. (2014), who re-examined the role of institution in economic growth by applying data from both developed and developing countries during 1975–2005. The findings show that political institutions lead to economic institutions, and economic institutions have a direct effect on growth, supporting the argument that political institutions are one of the root causes of economic growth.

Existing literature also revealed the impacts of multiple components of knowledge economy framework on economic growth (Karagiannis, 2007; Sundać & Fatur Krmpotić, 2011; Labra et al., 2016). Karagiannis (2007) examined the impacts of knowledge-based economy factors on economic growth. Employing the data of 15 economies of the EU from 1990 to 2003, the estimation results indicate that R&D expenditure from abroad, public expenditure on education, and ICT have significantly positive effects on GDP growth rates. As a result, in the long run, investments in knowledge-related pillars by both the government and private sectors are several main engines of economic and productivity growth in EU countries. Sundać and Fatur Krmpotić (2011) considered the impacts of various knowledge economy components on economic growth in 118 economies (divided into three income groups based on GDP per capita—PPP in 2006). The knowledge economy indicators are from World Bank KAM 2007 and 2008. The study shows that there is a statistically positive association between Education, ICT, and GDP per capita in low-income countries, while Law and Institutions, Education, and ICT affect positively GDP per capita in middle-income countries. In the case of high-income economies, labor-force quality and ICT have beneficial effects on GDP per capita. Labra et al. (2016), in addition, find a positive nexus between innovation capabilities and GDP growth in natural resource-driven economies.

Overall, a wide variety of empirical investigations has demonstrated the role of different components of knowledge economy in the growth process: better institutions, education, innovation system, and information and communication infrastructure altogether lead to higher economic growth. The evidence, in general, is relatively robust with different datasets in different countries and time spans as well as different research methods.

3. Data and methodology

3.1. Data

We construct a panel of 37 countries in Asia from 1990 to 2014. The data are collected from World Development Indicators (WDI), Worldwide Governance Indicators (WGI), International Financial Statistics (IFS), UN Comtrade. The dependent variable is natural logarithm of per capita GDP, PPP, at 2011 constant USD. Independent variables include four pillars of knowledge economy, namely innovation, education, information and communication infrastructure, and institutional regime. Other control variables cover conditions for economic growth such as labor force, capital, FDI, and so on. Detailed definition, sources of variables, and summary statistics are presented in Table A.1. in Appendix.

Table A.2. in Appendix describes the correlation matrix of main variables. It is apparent that there are strong correlations among six different institutional indicators, which suggests that they should be estimated separately in different regressions to avoid the problem of muticollinearity.

Figure 1 shows the scatter plot of economic growth and each of four pillars of knowledge economy. Seemingly, there exist positive correlations between the natural logarithm of GDP per capita and innovation, education, information and communication infrastructure, and institutional regime in selected Asian countries in the period 1990-2014, which is a good trend in the path toward knowledge economy. Further investigation by econometric methods to understand the nature of these relationships will be conducted in later parts of the study.

3.2. Methodology

3.2.1. The Driscoll-Kraay estimation

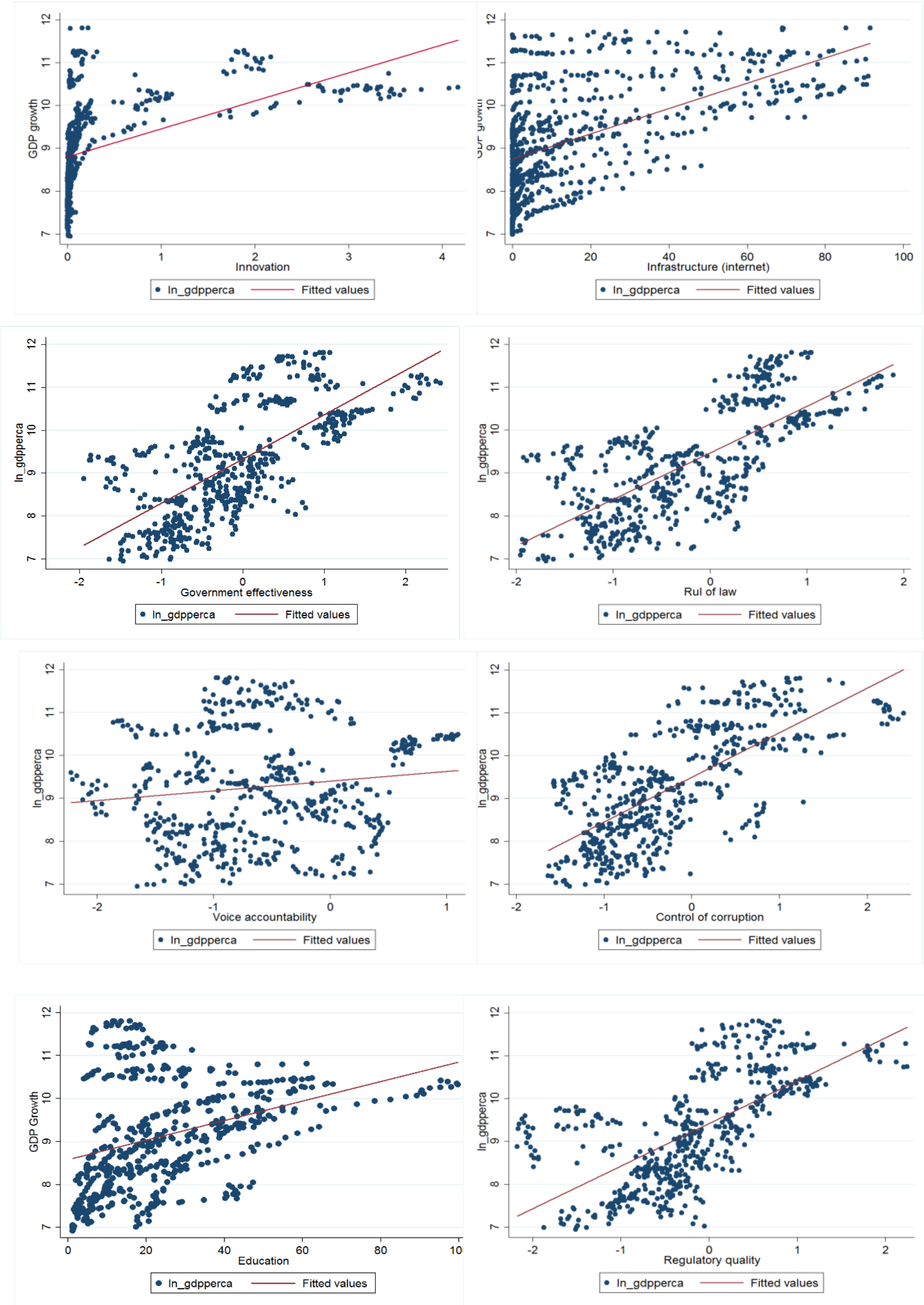
It is common to rely on fixed effects model (FEM) or random effects model (REM) in panel data regression. Nevertheless, the problems of heteroscedasticity, autocorrelation, and cross-sectional dependence may arise. Concerning this issue, in this paper, we employ Driscoll and Kraay's estimation approach. Driscoll and Kraay (1998) clarified the mechanism of standard error estimation and corrected the problems of heteroscedasticity and autocorrelation (Hoechle, 2007; Baltagi, 2005). The asymptotic characteristic from the diagonal element in the mechanism of covariance matrix is defined as follows:

$$V(\hat{\theta}) = (X'X)^{-1}\hat{S}_T(X'X)^{-1} \quad (1)$$

where $\hat{S}_T$ is denoted by Newey and West (1986) as:

$$\hat{S}_T = \hat{\Omega}_0 + \sum_{j=1}^{m(T)} w(j,m)[\hat{\Omega}_j + \hat{\Omega}_j'] \quad (2)$$

In this way of analysis, Driscoll-Kraay


GDP growth
Innovation
ln_gdpperca
Fitted values
Infrastructure (internet)
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Fitted values
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Government effectiveness
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Fitted values
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Rul of law
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Voice accountability
ln_gdpperca
Fitted values
ln_gdpperca
Control of corruption
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GDP Growth
Education
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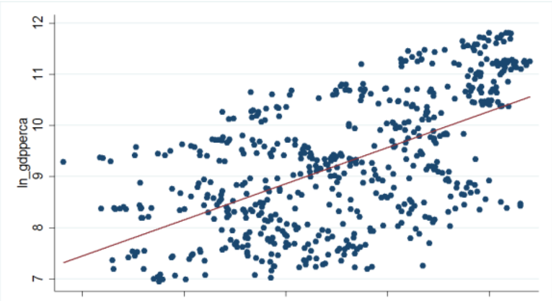

Figure 1. Correlations between economic growth and all four pillars of knowledge economy

measurement can capture most of the diagnostic problems including heteroscedasticity, autocorrelation, and cross-sectional dependence (Hoechle, 2007).

3.2.2. Simultaneity and econometric estimations

Since Haavelmo's (1943) initial research on the issue of simultaneity in economic equations, the modeling framework of simultaneous equation regression has developed remarkably as a cornerstone in econometric literature (Hausman & Taylor, 1983; Greene, 2011; Paxton, 2011). We consider the two following structural models:

$$y_1 = \gamma_{11}x_1 + \gamma_{12}x_2 + \zeta_1 \quad (3)$$

$$y_2 = \beta_{21}y_1 + \gamma_{22}x_2 + \zeta_2 \quad (4)$$

We have a series of equations that present joint determination of causal effect and recursive models (Wooldridge, 2010; Greene, 2011; Paxton et al., 2011). It means that the first estimation of the equation is a completely causal effect of a group of exogenous variables. Then, in comparison with the first equation, the second is explained by another group of variables that could include some factors in the previous one. As a result, the mechanism of mediation effect may appear; the following figure illustrates the causal (direct) effects and mediation (indirect) effects mechanism:

We use seemingly unrelated regression (SUR) and three stage least squares (3SLS) in our analysis of the simultaneous effects of ICT infrastructure, education, and innovation on economic growth of selected Asian countries. Zellner and Theil (1962) constructed the mechanism of the structural

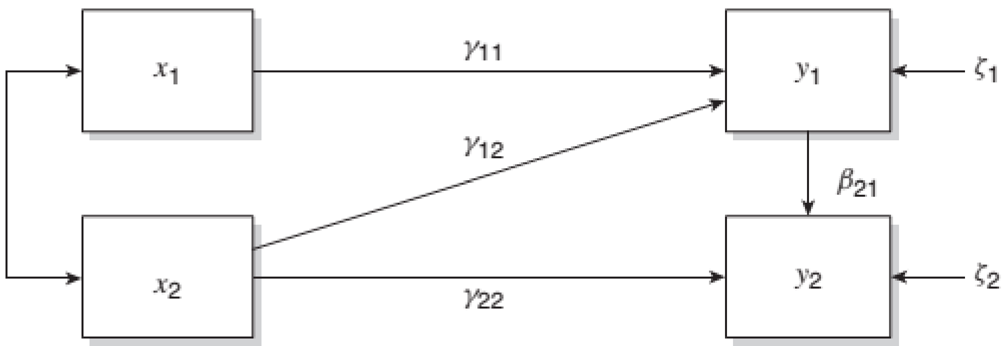

Figure 2. Causal and mediation effects

Source: Paxton et al. (2011)

equation that forms the common idiosyncrasy of simultaneity in the seemingly unrelated regression (SUR) and the regression of three-stage least square (3SLS). A statistical framework and conditions have been presented for the simultaneous estimation that satisfied most of the causal and mediation analysis (Baltagi, 2005; Greene, 2011).

The advantage of SUR technique is that it will account for cross-equation error correlation and estimate the full information estimators as well as all N equations simultaneously. As a result, it could be more consistent in comparison with the limited information estimation (such as two stage least squares – 2SLS) which constructs a single equation in each stage of measurement (Zellner, 1996; Baltagi, 2008; Greene, 2012). The primary conditions of SUR model are as follows:

$$E\left[\varepsilon_t \mid x_t\right] = 0 \; \& \quad E\left[\varepsilon_t \varepsilon_t^{'} \mid x_t\right] = \Omega = \Sigma \otimes \mathrm{I} \tag{5}$$

The idiosyncrasy of the multiplication between the sum of squares and identity matrix will give the efficient coefficients of the generalized least square (GLS) estimation as follows:

$$\hat{\beta}_{GLS} = \left[X'\left(\Sigma^{-1} \otimes I\right)X\right]^{-1} X'\left(\Sigma^{-1} \otimes I\right)y \tag{6}$$

In addition, the regression of 3SLS obtains both the 2SLS and GLS techniques. In nature, the final coefficient of cross-measurements of this technique is quite similar with the SUR methods:

$$\hat{\beta}_{3SLS} = \left[\hat{Z}'\left(\Sigma^{-1} \otimes I\right)Z\right]^{-1} \hat{Z}'\left(\Sigma^{-1} \otimes I\right)y \tag{7}$$

The main difference here is that the Z-hat components are derived from the 2SLS estimation, then added in the GLS mechanism. (Zellner & Theil, 1962; Baltagi, 2005; Greene, 2011).

3.3. Model specification

We estimate the growth model that concerns the impact of the four pillars of knowledge economy including innovation, education, information and communication technologies (ICT), and institutional regime. As shown in Stern et. al. (2000), Bilbao-Osorio and Rodríguez-Pose (2004), Schneider (2005), Gyimah-Brempong (2006), Schiffbauer (2007), Agénor (2012), Agénor and Neanidis (2015), and Suri et al. (2011), it is possible that there are reciprocal relationships and multidimensional effects between innovation, education, infrastructure, and economic growth. Besides, as shown in the correlation matrix, it is apparent that there are strong correlations among six different institutional indicators. Hence, they should be estimated separately in different regressions to avoid the problem of muticollinearity. Due to these reasons, we construct the impacts of four pillars of knowledge economy on economic growth in separate equations as follows:

Ln (GDP per capita)$_{it}$ = β_0 + β_1 *(innovation)*$_{it}$ + β_2 *(NR, intensity)*$_{it}$ + β_3 *(labor force)*$_{it}$ + β_4 *(gross fixed capital formation)*$_{it}$ + β_5 *(FDI inflow)*$_{it}$ + β_5 *(trade openness)*$_{it}$ + β_6 *(Inflation)*$_{it}$ +ε_{it}.

Ln (GDP per capita)$_{it}$ = β_0 + β_1 *(education)*$_{it}$ + β_2 *(NR, intensity)*$_{it}$ + β_3 *(labor force)*$_{it}$ + β_4 *(gross fixed capital formation)*$_{it}$ + β_5 *(FDI inflow)*$_{it}$ + β_5 *(trade openness)*$_{it}$ +

β_6 *(Inflation)*$_{it}$ +ε_{it}.

Ln (GDP per capita)$_{it}$ = β_0 + β_1 *(ICT)*$_{it}$ + β_2 *(NR, intensity)*$_{it}$ + β_3 *(labor force)*$_{it}$ + β_4 *(gross fixed capital formation)*$_{it}$ + β_5 *(FDI inflow)*$_{it}$ + β_5 *(trade openness)*$_{it}$ + β_6 *(Inflation)*$_{it}$ +ε_{it}.

Ln (GDP per capita)$_{it}$ = β_0 + β_1 *(aspects of institutional regime)*$_{it}$ + β_2 *(NR, intensity)*$_{it}$ + β_3 *(labor force)*$_{it}$ + β_4 *(gross fixed capital formation)*$_{it}$ + β_5 *(FDI inflow)*$_{it}$ + β_5 *(trade openness)*$_{it}$ + β_6 *(Inflation)*$_{it}$ +ε_{it}.

Next, we will investigate the reciprocal and multidirectional relationships between innovation, education, ICT infrastructure, and economic growth. Based on Agénor (2012) and Agénor and Neanidis (2015), we compute the following equations:

Ln (GDP per capita)$_{it}$ = β_0 + β_1 *(innovation)*$_{it}$ + β_2 *(education)*$_{it}$ + β_3 *(ICT)*$_{it}$ + β_4 *(labor force)*$_{it}$ + β_5 *(gross fixed capital formation)*$_{it}$ + β_6 *(FDI inflow)*$_{it}$ + β_7 *(trade openness)*$_{it}$ + β_8 *(Inflation)*$_{it}$ +ε_{it}.

(Innovation)$_{it}$ = β_0 + β_1 *(ln of GDP per capita)*$_{it}$ + β_2 *(education)*$_{it}$ + β_3 *(ICT)*$_{it}$ + β_4 *(government expenditure)*$_{it}$ + β_5 *(education expenditure)*$_{it}$ + β_6 *(non_tax_rev)*$_{it}$ + β_7 *(bud_balance)*$_{it}$ + ε_{it}.

(Education)$_{it}$ = β_0 + β_1 *(ln of GDP per capita)*$_{it}$ + β_2 *(ICT)*$_{it}$ + β_3 *(government expenditure)*$_{it}$ + β_4 *(education expenditure)*$_{it}$ + β_5 *(non-tax revenue)*$_{it}$ + β_6 *(budget balance)*$_{it}$ + β_7 *(life expectancy)*$_{it}$+ β_8 *(ln_population)*$_{it}$ + β_9 *(rate of urbanization)*$_{it}$ + ε_{it}.

(ICT)$_{it}$ = β_0 + β_1 *(government expenditure)*$_{it}$ + β_3 *(education expenditure)*$_{it}$ + β_4 *(non-tax revenue)*$_{it}$ + β_5 *(budget balance)*$_{it}$ + β_6 *(rate of urbanization)*$_{it}$ + β_7 *(ln of initial GDP per capita)*$_{it}$ + ε_{it}.

However, unlike Agénor (2012) and Agénor and Neanidis (2015), which did not consider the reverse impacts of the economic growth on innovation and education, we take into account these relationships. Actually, Bilbao-Osorio and Rodríguez-Pose (2004) and Schneider (2005) explored the two-way relationship between the economic growth and innovation. Also, Gyimah-Brempong et al. (2006) and Suri et al. (2011) examined the reciprocal relationship between the economic growth and education. As a result, besides the analysis of direct and indirect effects mechanism, we take a further step of analyzing the reverse effects from economic growth toward two factors—innovation and education.

Compared with the study of Agénor and Neanidis (2015), this study has a significant difference by employing SUR technique besides 3SLS. The reason is that Agénor and Neanidis (2015) employed initial GDP on a system of equations as a substitute for the real instrumental variable (which should be constructed based on literature and be strictly exogenous variables). In this case, 3SLS model would become SUR model when the form of the adjusted value—the Z elements in the initial step of 2SLS—gets the weak instrumental variable since the instrumental variable in nature is not found. Therefore, the beta estimation in the step of GLS in the 3SLS will be biased, as the predicted value in the initial step is inconsistent (Hausman, 1983; Baltagi, 2008; Greene, 2012). As a result, the mechanism of full information estimation from the SUR model should be employed, while the 3SLS model is just considered a reference in this case.

4. Findings and discussion

Table 1 presents nine different models that capture the impacts of four knowledge economy pillars on economic growth. The first three models examine the effects of three pillars—innovation, education, and ICT infrastructure. As shown in Table 1, all these three pillars have positive impacts on economic growth at 1% level, which is consistent with most of previous literature (Education: Barro, 1991; Hanushek & Kimko, 2000; Cohen & Soto, 2007; Suri et al., 2011; Barro, 2013; Hanushek, 2013; Hassan & Cooray, 2015; Innovation system: Lederman & Maloney, 2003; Agénor & Neanidis, 2015; Inekwe, 2015; Castellacci & Natera, 2016; Information and communication infrastructure: Jorgenson & Vu, 2005; Inklaar et al., 2008; Vu, 2011; Erumban & Das, 2015; Jorgenson et al., 2015; Pradhan et al., 2015).

The next six models investigate the impacts of various aspects of institutions on economic growth. These indicators come from Worldwide Governance Indicators (WGI) that summarizes different views on the institution in a country. The estimation results verify the significant positive effects of better institutional quality on economic growth in all six models (at 1% level). In general, our study confirms the positive influences of all the four pillars of knowledge economy on economic growth.

In addition, there is evidence of a significant contribution of natural resources intensity toward the growth of a country. This result may be due to the fact that most Asian countries, especially Middle East ones in the studied period relied on natural resources export for national development. However, too much dependence on natural resources causes unsustainability due to the possible problems of over-exploration, rent-seeking behaviors, low competitiveness of manufacturing industries, or a number of issues related to environment (Corden & Neary, 1982; Joya, 2015; Labra et al., 2016).

We also include some macro control variables in the nine presented models. The negative effect of labor factor is found in most of these models. There could probably be a situation of the inefficient employment of labor force in economic progress. The effects of remaining macro variables are inconsistent across the models, which could lie in a case of erroneous coefficients due to the endogenous problem that will be investigated in the next section.

Table 2 presents a system of simultaneous equations including four models: Model 1 presenting the impacts of three pillars of knowledge economy (i.e. education, innovation, ICT infrastructure) on economic growth; Models 2 and 3 exhibiting the reverse effects of economic growth on innovation and education; Model 4 concerning the determinants of ICT infrastructure. At the same time, the indirect impacts of ICT infrastructure on economic growth are investigated in the education and the ability to innovate (Models 2 and 3); additionally, the education's indirect effect on growth is examined via the innovation channel in Model 2.

Table 1.
Impacts of four pillars of knowledge economy on economic growth using Driscoll and Kraay's (1998) estimation approach

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8	Model 9
pat_1000	0.618***								
	(0.000)								
gro_tertiary		0.024***							
		(0.000)							
inter_100			0.014***						
			(0.000)						
rul_law				0.869***					
				(0.000)					
re_qual					0.969***				
					(0.000)				
cont_corr						0.855***			
						(0.000)			
gov_effect							0.982***		
							(0.000)		
pol_stab_a~o								0.388***	
								(0.000)	
voi_acc									0.505***
									(0.000)
NR_inten100	8.860***	9.559***	6.855***	6.802***	7.234***	6.640***	7.703***	7.088***	9.623***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
laborpop100	-0.020***	-0.008***	-0.004	-0.005*	-0.012***	-0.005	-0.010***	-0.009***	-0.004
	(0.000)	(0.002)	(0.231)	(0.090)	(0.000)	(0.167)	(0.000)	(0.003)	(0.133)
gfcf	0.013**	0.006	0.005	-0.009	0.013**	-0.011**	-0.009*	-0.009**	0.005
	(0.021)	(0.254)	(0.138)	(0.127)	(0.030)	(0.045)	(0.052)	(0.044)	(0.147)
fdi_inf	-0.022**	-0.025	-0.017	0.012*	-0.007	0.012*	0.015**	-0.009	0.003

	(0.018)	(0.131)	(0.106)	(0.098)	(0.434)	(0.058)	(0.049)	(0.243)	(0.775)
trade	0.003***	0	0.003***	-0.001**	-0.002***	-0.002***	-0.003***	0.001**	0.002***
	(0.000)	(0.882)	(0.007)	(0.022)	(0.000)	(0.000)	(0.000)	(0.042)	(0.002)
inflation	-0.008	-0.012**	-0.011*	-0.003	-0.003	-0.006	0.002	-0.027***	-0.028***
	(0.231)	(0.049)	(0.072)	(0.740)	(0.755)	(0.430)	(0.833)	(0.001)	(0.000)
_cons	8.970***	8.481***	8.620***	9.516***	9.377***	9.760***	9.738***	9.781***	9.045***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
N	443	416	528	409	409	409	409	409	409
R-squared	0.6803	0.6077	0.5388	0.7596	0.7405	0.7559	0.7728	0.5853	0.6046

Notes: Standard deviations are in parentheses. ***, ** and * respectively represent significance at 1%, 5% and 10%.

Table 2

Simultaneous impacts of education, innovation, and ICT infrastructure on economic growth

	(model 1)		(model 2)		(model 3)		(model 4)	
	depend=growth		**depend=patent**		**depend = gro_tertiary**		**depend = inter_100**	
	3SLS	SUR	3SLS	SUR	3SLS	SUR	3SLS	SUR
Ln_gdpperca			0.568***	0.470***	2.609	3.170*		
			(0.000)	(0.000)	(-0.357)	(0.086)		
Pat_1000	0.634***	0.450***						
	(0.000)	(0.000)						
Gro_tertiary	0.013**	0.015***	0.005	0.019***				
	(0.003)	(0.000)	(0.991)	(0.000)				
Inter_100	0.005	0.008***	0.024***	0.010***	0.291	0.301***		
	0.476	(0.004)	(0.000)	(0.000)	(0.100)	(0.000)		
Gov_ex			0.028**	0.024**	0.789	1.016***	-0.656*	-0.872**
			(0.027)	(0.039)	(0.023)	(0.000)	(0.091)	(0.022)
Edu_ex			-0.219***	-0.274***	1.303	1.495**	3.239***	3.060**
			(0.000)	(0.000)	(0.173)	(0.049)	(0.007)	(0.010)
Non_tax_rev			-0.001	0.009	-1.370	-1.354***	-1.276***	-1.024***
			(0.964)	(0.476)	(0.000)	(0.000)	(0.001)	(0.007)
Bud_balance			-0.012	-0.031**	1.500	1.463***	-0.259	-0.470
			(0.600)	(0.027)	(0.000)	(0.000)	(0.561)	(0.282)
Laborpop100	-0.012*	-0.013**						
	(0.060)	(0.023)						

Gfcf	0.025***	0.028***						
	(0.000)	(0.000)						
Fdi_inf	-0.012	-0.019						
	(0.436)	(0.221)						
Trade	0.000	0.002*						
	(0.764)	(0.070)						
Inflation	0.001	0.000						
	(0.675)	(0.913)						
Life_expect					0.357	0.230		
					(0.575)	(0.423)		
Ln_pop					-1.670**	-1.705***		
					(0.015)	(0.022)		
Urban					0.280	0.272***	0.707***	0.723***
					(0.032)	(0.001)	(0.000)	(0.000)
Ln_ini_gdp							1.344	3.155
							(0.664)	(0.309)
Cons.	8.011***	7.927***	-4.843***	-3.786***	-11.806	-40.110**	-29.646	-44.590**
	(0.000)	(0.000)	(0.000)	(0.000)	(0.730)	(0.022)	(0.163)	(0.036)
R-squared	0.5002	0.5732	0.6262	0.6944	0.7367	0.7319	0.4253	0.4195
Breusch-Pagan test of independence: chi2(6) = 51.116, Pr=		0.000		0.000		0.000		0.000

Notes: Standard deviations are in parentheses. ***, **, and * respectively represent significance at 1%, 5%, and 10%.

As shown in Models 1, 2, and 3, there is a significant positive two-way nexus between two pillars of knowledge economy and economic growth. First, the reciprocal relationship between economic growth and innovation are positively significant, implying: (i) the economic growth of Asian country will be increased when it obtains more capacity to innovate; and (ii) the activities of innovation could be improved when the economy progresses. A robust confirmation is that innovation is a key determinant in stimulating the growing process of a country (Lederman & Maloney, 2003; Bilbao-Osorio & Rodríguez-Pose, 2004; Agénor & Neanidis, 2015; Inekwe, 2015; Castellacci & Natera, 2016). Additionally, the latter relationship has been verified by some papers such as Stern et al. (2000), Bilbao-Osorio and Rodríguez-Pose (2004), and Schneider (2005). They regard GDP growth as a representation of national wealth, and a proxy for the country's knowledge stock that in turn can have a positive effect on the capacity to innovate. Second, there exist reciprocal effects between economic growth and education: (i) the positive contribution of education on economic growth; and (ii) a slightly reverse effect of economic growth on education. Again, the former result confirms the results of the above regression (Driscoll-Kraay estimation). This is similar to Barro (1991), Hanushek and Kimko (2000), Cohen and Soto (2007), Suri et al. (2011), Barro (2013), Hanushek (2013), Hassan and Cooray (2015), which confirms that education is one of agents fostering the growth of a country. Nevertheless, the latter outcome is rather unconvincing since it statistically insignificant coefficients can be detected in the 3SLS model. Actually, we employ the results of SUR model due to the problem of the above-mentioned unreal instrumental variables[1]. Following Suri et. al. (2011) and Gyimah-Brempong (2006) discussion of the endogenous problem in educational variables and confirmation of the significant feedback effects from economic growth on human development, we also find a positive reverse effect of the economic growth on education.

Besides the reciprocal relationship, this section involves addressing the mediation effects of various pillars of knowledge on growth. The impacts of ICT infrastructure on economic growth are illustrated indirectly through the education and the ability to innovate (Models 2 and 3). The significant coefficients in Models 2 and 3 confirm the positive impacts of ICT infrastructure on economic growth via indirect channels. Additionally, education indirectly affects growth via the innovation channel with positive effects in Model 2.

In general, the evidence of multidimensional simultaneity in this study show the

[1] We conduct the full information tests for the SUR model (the Breusch-Pagan test of independence – the presence of simultaneous relationships and reverse impacts of economic growth and the pillars of knowledge economy). The test results show that there exists correlation among the mentioned variables. This test is constructed based on the mechanism of full information likelihood which is considered more advantageous in comparison with the limited information likelihood test of the 3SLS models (Hausman, 1983; Baltagi, 2008; Greene, 2012). Furthermore, as mentioned above, there are not actual real instrumental variables based on the literature review. Hence, 3SLS model is just a reference in our study and tests for endogeneity in our 3SLS model is not necessary because it is just for the weak instruments only, not for the real nature of instrumental variables.

mechanism of stimulating economic growth: (i) public infrastructure (ICT) has positive effect on education and innovation that in turn promote economic growth; (ii) improving educational outcome enhances innovation, which indirectly foster economic growth; and (iii) innovation, education, and ICT infrastructure altogether directly contribute positively to the growth process.

In addition, as constructed in the papers of Agénor and Neanidis (2015) and Labra et al. (2016), a set of control variables are included in the system of equations. First, Model 1 verifies the significant impact of some macro control variables on economic growth including: (i) the negative effect of the labor force variable which may due to the inefficient allocation of labor force in the growth progress; and (ii) the positive effect of gross fixed capital formation and trade openness. Second, Models 2, 3, and 4 employ several fiscal indicators, including: (i) government expenditure and education expenditure; and (ii) non-tax revenue and budget balance. With respect to the former group, government expenditure has positive contribution to innovation and education in Asian countries in the period of this research. However, government expenditure exhibits negative impact in the model of infrastructure. The possible explanation is that the components of government spending on the ICT infrastructure have been inefficiently used. Regarding education expenditure, it has significant positive impact on education and ICT infrastructure, but not innovation. The reasonable explanation is that there is still a gap between education expenditure and innovation. The latter group shows the negative impact of non-tax revenue on ICT infrastructure and education, and the significant positive contribution of budget balance to education. Third, Models 3 and 4 include some demographic variables such as life expectancy, population growth, and rate of urbanization. Regression results show the negative impact of population growth on education and the significantly positive contribution of urbanization to ICT infrastructure and education.

5. Conclusion and policy implications

The study employs Driscoll-Kraay estimation method and seemingly unrelated regression (SUR) and three stage least squares (3SLS) to investigate the role of different knowledge economy components and natural resource factor in economic growth as well as the simultaneous effects of ICT infrastructure, education, and innovation on economic growth of selected Asian countries over the 1990–2014 period. The results show that there is a positive association between economic growth and four components of the knowledge economy framework. Moreover, there is also evidence of the simultaneous effects of ICT infrastructure, education, and innovation on economic growth.

Given the empirical results, it is suggested that the development toward a fine knowledge economy is critical to gaining higher and sustainable economic growth; therefore, policy makers should concentrate on improving all the four pillars of the knowledge economy. First, improving the quality of education, especially the quality of university system is essential for building up well-trained labor force to operate in different sectors of the economy, especially high-tech ones. There should be more cooperation between university and industry, which helps update students with state-of-the-art development in the real world. Second, more resources should also be paid to innovation, R&D at firms level as well as the macro perspective of the government to increase global competiveness. It also includes the improved relationship between university and firms to conduct R&D activities. Third, investments should also be channeled more on developing ICT infrastructure, especially Internet coverage, which boosts existing industries as well as new industries such as e-commerce, and application in all fields of society, especially e-government. Finally, a simultaneous strategy to foster economic growth toward knowledge economy is to: (i) enhance ICT infrastructure to support innovation which may result in higher economic growth; and (ii) improve education quality to foster innovation which may also contribute positively to economic growth■

References

Acemoglu, D., Johnson, S., & Robinson, J. A. (2001). The colonial origins of comparative development: An empirical investigation. *American Economic Review*, *91*(5), 1369–1401.

Agénor, P. R. (2012). *Public capital, growth and welfare: Analytical foundations for public policy*. Princeton University Press.

Agénor, P. R., & Neanidis, K. C. (2015). Innovation, public capital, and growth. *Journal of Macroeconomics*, *44*, 252–275.

Baltagi, B. (2005). *Econometric analysis of panel data* (3rd Edition). John Wiley & Sons.

Barro, R. J. (1991). Economic growth in a cross section of countries. *The Quarterly Journal of Economics*, *106*(2), 407–443.

Barro, R. J. (1996). *Determinants of economic growth: A cross–country empirical study*. NBER Working Paper 5698.

Barro, R. J. (2013). Education and economic growth. *Annals of Economics and Finance*, *14*(2), 301–328.

Bilbao-Osorio, B., & Rodríguez-Pose, A. (2004). From R&D to innovation and economic growth in the EU. *Growth and Change*, *35*(4), 434–455.

Castellacci, F., & Natera, J. (2016). Innovation, absorptive capacity and growth heterogeneity: Development paths in Latin America 1970–2010. *Structural Change And Economic Dynamics*, *37*, 27–42.

Cohen, D., & Soto, M. (2007). Growth and human capital: Good data, good results. *Journal of Economic Growth*, *12*(1), 51–76.

Corden, W. M., & Neary, J. P. (1982). Booming sector and de-industrialization in a small open economy. *Economic Journal*, 825–848.

Driscoll, J. C., & Kraay, A. C. (1998). Consistent covariance matrix estimation with spatially dependent panel data. *Review of Economics and Statistics*, *80*(4), 549–560.

Erumban, A. A., & Das, D. K. (2015). Information and communication technology and economic growth in India. *Telecommunications Policy*.

Flachaire, E., García–Peñalosa, C., & Konte, M. (2014). Political versus economic institutions in the growth process. *Journal of Comparative Economics*, *42*(1), 212–229.

Greene, W. H. (2011). *Econometric analysis* (7th Edition). Pearson.

Gyimah–Brempong, K., Paddison, O., & Mitiku, W. (2006). Higher education and economic growth in Africa. *The Journal of Development Studies*, *42*(3), 509–529.

Haavelmo, T. (1943). The statistical implications of a system of simultaneous equations. *Econometrica, 11*(1), 1–12.

Hanushek, E. A. (2013). Economic growth in developing countries: The role of human capital. *Economics of Education Review, 37*, 204–212.

Hanushek, E. A., & Kimko, D. D. (2000). Schooling, labor–force quality, and the growth of nations. *American Economic Review*, 1184–1208.

Hassan, G., & Cooray, A. (2015). Effects of male and female education on economic growth: Some evidence from Asia. *Journal of Asian Economics*, *36*, 97–109.

Hausman, J. A. (1983). Specification and estimation of simultaneous equation models. *Handbook of Econometrics, 1*, 391–448.

Hoechle, D. (2007). Robust standard errors for panel regressions with cross-sectional dependence. *Stata Journal*, *7*(3), 281.

IMF. (2016). *IMF data mapper*. International Monetary Fund.

Inekwe, J. N. (2015). The contribution of R&D expenditure to economic growth in developing economies. *Social Indicators Research*, *124*(3), 727–745.

Inklaar, R., Timmer, M. P., & Van Ark, B. (2008). Market services productivity across Europe and the US. *Economic Policy*, *23*(53), 140–194.

Jorgenson, D. W., & Vu, K. (2005). Information technology and the world economy. *The Scandinavian Journal of Economics*, *107*(4), 631–650.

Jorgenson, D. W., Ho, M. S., & Samuels, J. D. (2015). The impact of information technology on postwar US economic growth. *Telecommunications Policy*.

Joya, O. (2015). Growth and volatility in resource-rich countries: Does diversification help? *Structural Change and Economic Dynamics, 35*, 38–55.

Karagiannis, S. (2007). The knowledge-based economy, convergence and economic growth: Evidence from the European Union. *The Journal of Economic Asymmetries*, *4*(2), 65–85.

Kaufmann, D., Kraay, A., & Mastruzzi, M. (2010). *The worldwide governance indicators methodology and analytical issues*. Policy Research Working Paper 5430. World Bank.

Kaufman, D., Kraay, A., & Zaido–Lobaton, P. (1999). *Governance matters*. World Bank Working Paper No. 2196. Washington, DC.

Knack, S., & Keefer, P. (1995). Institutions and economic performance: Cross-country tests using alternative measures. *Economics and Politics*, *7*, 207–227.

Labra, R., Rock, J. A., & Álvarez, I. (2016). Identifying the key factors of growth in natural resource-driven countries: A look from the knowledge-based economy. *Ensayos sobre Política Económica*.

Lucas, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics*, *22*, 3–42.

Mankiw, N. G., Romer, D., & Weil, D. (1992). A contribution to the empirics of economic growth. *Quarterly Journal of Economics, 107*(2), 407–437.

Mauro, P. (1995). Corruption and growth. *Quarterly Journal of Economics, 110*, 681–712.

Newey, W. K., & West, K. D. (1986). *A simple, positive semi–definite, heteroskedasticity and autocorrelation consistent covariance matrix*. NBER Technical Working Papers No.55.

OECD. (1996). *The knowledge economy*. Paris: OECD.

Paxton, P., Hipp, J. R., Marquart–Pyatt, S., & Marquart–Pyatt, S. T. (2011). *Nonrecursive models: Endogeneity, reciprocal relationships, and feedback loops* (Vol. 168). Sage Publications.

Powell, W. W., & Snellman, K. (2004). The knowledge economy. *Annual Review of Soci-*

ology, 30(1), 199–220. doi: 10.1146/annurev.soc.29.010202.100037

Pradhan, R. P., Arvin, M. B., & Norman, N. R. (2015). The dynamics of information and communications technologies infrastructure, economic growth, and financial development: Evidence from Asian countries. *Technology in Society*, *42*, 135–149.

Romer, P. M. (1990). Endogenous technological change. *Journal of Political Economy*, *98*(5), S71–S10.

Sachs, J. D., & Warner, A. M. (1995). *Natural resource abundance and economic growth*. NBER Working Paper No.5398.

Sachs, J. D., & Warner, A. M. (1999). The big push, natural resource booms and growth. *Journal of Development Economics, 59*, 43–76.

Sachs, J. D., & Warner, A. M. (2001). Natural resources and economic development: The curse of natural resources. *European Economic Review, 45*, 827–838.

Schiffbauer, M. (2007). *Calling for innovations: Infrastructure and sources of growth*. Working Paper No. 18. Economic and Social Research Institute.

Schneider, P. H. (2005). International trade, economic growth and intellectual property rights: A panel data study of developed and developing countries. *Journal of Development Economics*, *78*(2), 529–547.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, 65–94.

Solow, R. M. (1957). Technical change and the aggregate production function. *The Review of Economics and Statistics*, 312–320.

Stern, S., Porter, M. E., & Furman, J. L. (2000). *The determinants of national innovative capacity*. NBER Working Paper No. 7876.

Suh, J., & Chen, D. H. C. (2007). *Korea as a knowledge economy: Evolutionary process and lessons learned*. World Bank Institute Development Studies. World Bank.

Sundać, D., & Fatur Krmpotić, I. (2011). Knowledge economy factors and the development of knowledge-based economy. *Croatian Economic Survey*, (13), 105–141.

Suri, T., Boozer, M. A., Ranis, G., & Stewart, F. (2011). Paths to success: The relationship between human development and economic growth. *World Development*, *39*(4), 506–522.

Vu, K. M. (2011). ICT as a source of economic growth in the information age: Empirical evidence from the 1996–2005 period. *Telecommunications Policy*, *35*(4), 357–372.

WEF. (2015). *World Economic Forum's global competitiveness report, 2014–2015*. World Economic Forum.

Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT University Press.

World Bank. (1999). *World development report 1998/99: Knowledge for development*. Oxford.

World Bank. (2007). *Building knowledge economies: Advanced strategies for development*. World Bank Institute Development Studies, World Bank.

Zellner, A., & Theil, H. (1962). Three–stage least squares: Simultaneous estimation of simultaneous equations. *Econometrica*, 54–78.

Appendix

Table A.1.

Variable definitions and summary statistics

Variables	Signs	Definitions	Sources	Obser-vations	Mean	Std. Dev.
Dependent variable						
Economic Growth	ln_gdpperca	Natural logarithm of per capita GDP, PPP, at 2011 constant USD.	WDI	860	9.162	1.282
Independent variables						
Four pillars of Knowledge Economy						
Innova-tion	patent_1000	Patent application (nonres-ident + resident) per 1000 people.	WDI	567	0.393	0.865
Education	gro_tertiary	Gross enrolment tertiary, both sexes (%): “Gross en-rollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown. Tertiary education, whether or not to an advanced research qualification, normally re-quires, as a minimum con-dition of admission, the successful completion of education at the secondary level.”	WDI	614	24.993	18.798
Infor-mation and com-munica-tion infra-structure	inter_100	“Internet users (per 100 people)”	WDI	770	16.740	23.437
Institu-						

Variables	Signs	Definitions	Sources	Observations	Mean	Std. Dev.
tional regime						
Rule of law	rul_law	"Perceptions of the extent to which agents have confidence in and abide by the rules of society, and in particular the quality of contract enforcement, property rights, the police, and the courts, as well as the likelihood of crime and violence. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5."	World-wide Governance Indicators (WGI)	590	-0.218	0.853
Regulatory quality	re_qual	"Perceptions of the ability of the government to formulate and implement sound policies and regulations that permit and promote private sector development. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5."		589	-0.204	0.876
Control of corruption	cont_corr	"Perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests. Estimate gives the country's score on the aggregate indicator, in		589	-0.250	0.875

Variables	Signs	Definitions	Sources	Obser-vations	Mean	Std. Dev.
		units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.”				
Government effectiveness	gov_effect	“Government Effectiveness captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government’s commitment to such policies. Estimate gives the country’s score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.”		589	-0.105	0.870
Voice & accountability	voi_acc	“Perceptions of the extent to which a country’s citizens are able to participate in selecting their government, as well as freedom of expression, freedom of association, and a free media. Estimate gives the country’s score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5.”		590	-0.661	0.727
Political stability	pol_stab_ab_vio	“Political Stability and Absence of Violence/Terrorism measures perceptions		590	-0.460	1.069

Variables	Signs	Definitions	Sources	Observations	Mean	Std. Dev.
		of the likelihood of political instability and/or politically-motivated violence, including terrorism. Estimate gives the country's score on the aggregate indicator, in units of a standard normal distribution, i.e. ranging from approximately -2.5 to 2.5."				
Control variables						
Natural resources intensity	NR_inten100	"Natural resources exports as share of GDP (% of GDP)". Natural resources data are collected with the following classified codes in the SITC list: 2(27-28), 3, and 6(68).	UN Comtrade	643	5.208	8.048
Labor force	laborpop100	"Labor force (total) as share of total population (% of population)"	WDI	922	42.244	10.971
Capital	gfcf	"Gross fixed capital formation (% of GDP): including land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings."	WDI	836	25.003	8.898
Foreign direction investment	fdi_flow	"Foreign direct investment, net inflows (% of GDP)"	WDI	833	3.268	4.673

Variables	Signs	Definitions	Sources	Obser-vations	Mean	Std. Dev.
Trade openness	trade	"Trade (% of GDP)"		859	93.465	61.445
Inflation	inflation	"Inflation, GDP deflator (annual %)"		775	11.540	72.331
Govern-ment ex-penditure	gov_ex	"General government final consumption expenditure (% of GDP)"		859	15.906	13.162
Govern-ment ex-penditure on educa-tion	edu_ex	"Government expenditure on education as % of GDP (%)"		443	3.975	1.670
Non-tax revenue	non_tax_rev	"Non-tax revenue (% of GDP)"	IFS	608	5.974	6.755
Budget balance	bud_bal-ance	"Budget balance (% of GDP)"	IFS	628	-2.423	10.213
Life ex-pectancy	Life_expect	"Life expectancy at birth, total (years)"	WDI	925	69.587	6.670
Popula-tion	ln_pop	Natural logarithm of total population		922	16.468	1.970
Urban	urban	"Urban population (% of total)"		925	54.543	26.799
Initial GDP	ln_ini_gdp	Natural logarithm of initial per capita GDP (in 1990)		775	8.947	1.206

Table A.2.

Correlation analysis

	ln_gdpperca	pat_1000	gro_tertiary	inter_100	rul_law	re_qual	cont_corr	gov_effect	pol_stab_ab_vio	voi_acc
ln_gdpperca	1.000									
pat_1000	0.501	1.000								
gro_tertiary	0.350	0.690	1.000							
inter_100	0.556	0.531	0.555	1.000						
rul_law	0.712	0.656	0.300	0.598	1.000					
re_qual	0.695	0.670	0.445	0.674	0.916	1.000				
cont_corr	0.584	0.456	0.152	0.399	0.677	0.616	1.000			
gov_effect	0.672	0.609	0.456	0.616	0.830	0.904	0.529	1.000		
pol_stab_ab_vio	0.727	0.670	0.417	0.611	0.930	0.930	0.669	0.876	1.000	
voi_acc	0.126	0.600	0.480	0.254	0.485	0.548	0.212	0.554	0.554	1.000

Table A.3.

List of selected Asian countries in the study

No.	Country	No.	Country
1	Afghanistan	19	Lebanon
2	Bahrain	20	Malaysia
3	Bangladesh	21	Mongolia
4	Bhutan	22	Nepal
5	Brunei Darussalam	23	Oman
6	Cambodia	24	Pakistan
7	China	25	Philippines
8	India	26	Qatar
9	Indonesia	27	Saudi Arabia
10	Iran, Islamic Rep.	28	Singapore
11	Iraq	29	Sri Lanka

12	Israel	30	Syrian Arab Republic
13	Japan	31	Tajikistan
14	Jordan	32	Thailand
15	Kazakhstan	33	Timor-Leste
16	Korea, Rep.	34	Turkmenistan
17	Kuwait	35	United Arab Emirates
18	Kyrgyz Republic	36	Vietnam
		37	Yemen, Rep.