

**Economic Convergence in Context of
Knowledge Economies in Asia:
Instrumental Variable Estimation**

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Abstract: *Traditional convergence empirics overlook the role of knowledge as a contributor to economic convergence. This paper incorporates knowledge as a factor contributing towards economic convergence in Asian countries. In addition to knowledge, capital formation, interaction effects of tertiary education with ICT and knowledge and finally electricity consumption are also used in the said regression. Instrumental Variables estimation is used to test convergence hypothesis for sample Asian countries for data of time period 2001-2010. Empirical results are in favor of knowledge-augmented convergence, inferring that knowledge participates in convergence process across sample Asian countries. Factors like capital accumulation and interaction effects of ICT and knowledge with human capital and electricity consumption show their positive role in contributing to income per capita. Recommendations are made to improve the tertiary education sector and to promote economically productive research for advancing towards economic convergence in Asian region in particular and for UDCs in general.*

Keywords: *Convergence, Knowledge, Information and Communication Technology, Instrumental Variables, Human Capital.*

Introduction

The debate in development economics has taken its shift from traditional economy to knowledge-based economy. In this era of post-industrialization, knowledge has become a vital factor for continuous uplift of all sectors of an economy. This paper empirically investigates the role of knowledge in achieving economic convergence. Economic convergence refers to the process by which relatively poorer regions or countries grow faster than their rich counterparts. The convergence hypothesis is advanced by Solow (1956) and is documented by Baumol (1986) and Barro and Sala-i-Martin (1995). This study includes knowledge stock in economic convergence regression (hence forth, knowledge-augmented convergence).

As documented in empirical literature, conditional beta convergence is a more realistic exercise because it reflects the convergence of countries after controlling for differences in steady states. Conditional convergence is simply a confirmation of a result predicted by the neoclassical growth model: those countries with similar steady states exhibit convergence. This does not imply that all countries in the world would converge to the same steady state; rather they would converge to their own steady states.

Objective

This paper inquires the role of knowledge in achieving economic convergence among Asian countries. Ability of knowledge to become economically meaningful services and goods can directly contribute to income per capita and help in achieving economic convergence. Therefore, it is pertinent to investigate the role of knowledge in the economic convergence hypothesis. This paper empirically examines the role of knowledge in economic convergence after including technology and electricity consumption as other determinants of economic convergence.

Literature Survey

In empirical literature, convergence regression has been estimated with a variety of explanatory variables. Dunaway et al. (2003) incorporates federal transfers in the convergence regression to inquire its role in growth. However results do not imply convergence. In similar veins, Bouvet (2010) attempts to explicate regional output inequality within 13 EU countries, and uses social transfers as an explanatory fiscal variable. Author does find evidence of convergence using the social transfers in reducing output inequality.

Karagiannis (2007) has tried to conduct convergence analysis for

European Union using knowledge as a determinant of convergence. His exercise of growth empirics on member states of European Union reveals that R&D expenditure initiated from abroad impacts GDP growth positively and in a statistically significant way. To augment the literature for Asian region, this paper is designed to quantitatively assess the role that knowledge play in convergence regressions for the sample countries. This paper also uses conventional determinants of growth (capital accumulation and electricity consumption) and newer factors (information and communication technology).

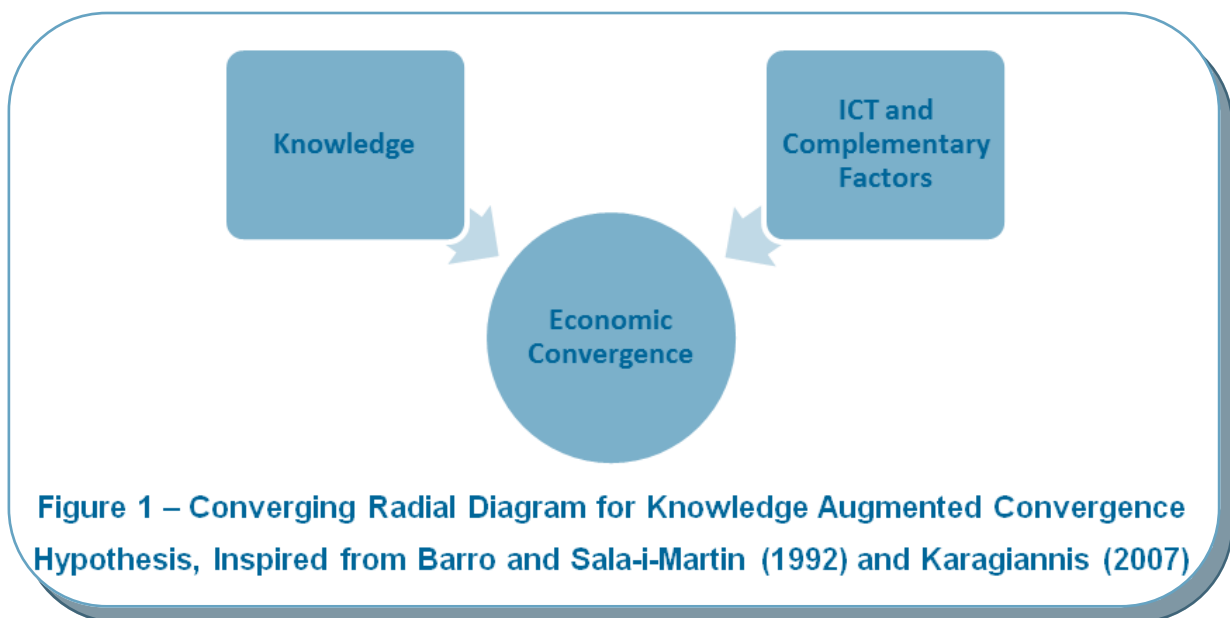


Figure 1 – Converging Radial Diagram for Knowledge Augmented Convergence Hypothesis, Inspired from Barro and Sala-i-Martin (1992) and Karagiannis (2007)

Flowchart gives a scheme of theoretical framework in this paper. There is innovation in Barro & Sala-i-Martin (1992) is the addition of knowledge as a factor contributing to economic convergence. Since knowledge is empirically evidenced as an agent of economic growth, it can be tested as a factor that enters positively into convergence regression.

Estimable Model for Knowledge Augmented Convergence Hypothesis

This paper reposes on this literature and elaborates existing findings by using a rigorous methodological approach applied at a regional level panel dataset. Foundation for the analysis is provided by Barro and Sala-i-Martin (1992) in terms of conditional convergence. The growth equation by Barro and Sala-i-Martin (1992) in this paper is augmented with knowledge. Following is the estimable model:

$$YPC_{i,t} = \phi (YPC_{i,t-1}, KM_{i,t}, ICTSERS_{i,t}, p1564_{i,t}, URBNPI_{i,t}, TRD_{i,t}, ELTKW_{i,t}, YPC_{i,t}(0)) \dots(1.1)$$

$$YPC_{i,t} = \alpha_{i,t} + \beta (YPC_{i,t-1}) + \beta_{i,t} (KM_{i,t}) + \gamma_{i,t} (ICTSERS_{i,t}) + \delta_{i,t} (p1564_{i,t}) + \kappa_{i,t} (URBNPI_{i,t}) + \lambda_{i,t} (TRD_{i,t}) + \zeta_{i,t} (ELTKW_{i,t}) + \xi_{i,t} (YPC_{i,t}(0)) + \eta_i + \epsilon_{i,t} \dots(1.2)$$

Where i shows countries and t years. $YPC_{i,t}$ is income per capita and $YPC_{i,t-1}$ is one year lagged version of income per capita, rendering the model dynamic. Role of capital formation (K) in economic growth is beyond suspicion and is rightfully included in this function. KMI is Knowledge Maturation Index. Knowledge is intangible and intermingling phenomenon. Other terms such as 'intellectual capital', 'intangibles', 'intangible assets' and 'knowledge capital' have been used in literature referring to knowledge. Accordingly, this study adopts the proximal method for measurement of knowledge. Proxies including 'research and development expenditure (% of GDI)', 'researchers in R&D (per million people)' and 'scientific and technical journal articles' are used to surrogate the level of knowledge in selected countries. This overall level of knowledge stock is calculated as the average of these three proxies and is termed as 'Knowledge Maturation Index' (KMI). For the complementary effects between knowledge and tertiary level education, $ICTSERT$ as a product of ICT and $SERT$ is included in regression. $SERT$ 'tertiary school enrollment (% gross)' as a proxy of human capital is used following Bar-

ro, Mankiw & Sala-i-Martin (1995). In lieu of 'secondary school enrollment' (SERS), SERT is chosen because knowledge created at tertiary levels of education is economically more productive. In addition to knowledge, ICT is also used in an interaction term with SERT, to incorporate the concurring effects of ICT and SERT in convergence empirics. Cette & Lopez (2008) also advocate the role of SERT in improving ICT diffusion in an economy and hence likely to be a reinforcing factor for ICT-productivity nexus. It reveals the interaction effects of ICT and school enrollment rate at tertiary level. ELTKW is the technology related determinant income growth by using the variable 'electric power consumption in kWh'. $YPC_{i,t}(0)$ is the initial condition of YPC included to test existence of the knowledge-augmented conditional convergence. In order to estimate the described scheme in panel data regressions, it is assumed that a higher level of initial per capita GDP reflects a greater stock of physical capital per capita following Barro and Sala-i-Martin (1995). Following So-to (2000), it is also assumed that the initial stock of human capital is reflected in the lagged value of per capita output in the short-run. The Solow-Swan model predicts that, for given values of the control variables, an equi-proportionate increase in the initial levels of state variables reduces the growth rate. Thus we can write the model of output per capita growth rate for this panel dataset as:

$$(y_{i,t} - y_{i,t-1}) / y_{i,t-1} \approx \alpha y_{i,t-1} + X_{i,t} \beta + v_i + \tau_t + \epsilon_{i,t} \dots (1.2)$$

where, $y_{i,t}$ is per capita gross domestic income (GDI) in sample country i ($i = 1, \dots, 10$) during the period 't' ($t = 2001, \dots, 2010$), $y_{i,t-1}$ is the initial per capita GDP in region 'i' in period 't-1', ' $\alpha < 0$ ' reflecting the convergence speed, $X_{i,t}$ is a row vector of control variables in region 'i' during period 't' with associated parameters ' β ', ' v_i ' is a country specific effect and $\epsilon_{i,t}$ is the error term. If we assume that

$$(y_{i,t} - y_{i,t-1}) / y_{i,t-1} \approx \ln(y_{i,t} / y_{i,t-1}) \dots (1.3)$$

we can approximate equation (1.2) as:

$$\ln(y_{i,t} / y_{i,t-1}) = \alpha \ln(y_{i,t-1}) + \ln X_{i,t} \beta + v_i + \tau_t + \epsilon_{i,t} \dots(1.4)$$

Moving $\ln(y_{i,t})$ from right-hand side to left-hand side, we obtain the dynamic panel data model:

$$\ln y_{i,t} = (\alpha+1) \ln(y_{i,t-1}) + \ln X_{i,t} \beta + v_i + \tau_t + \epsilon_{i,t} \dots(1.5)$$

Sampling and Estimation Techniques

The dimensions of dataset are 24 countries and 10 years (2001-2010) which are mostly dictated by the availability of data. Collection of data is done from World Development Indicators (WDI) and International Telecommunication Union (ITU) for selected Asian countries.

Panel data models with small samples produce biased coefficient estimates using ordinary least squares 'OLS', fixed effects 'FE' and random effects 'RE' (Baltagi, 2008). Moreover, endogeneity can be an issue for which following tests are employed. The statistical significance of the test statistic indicates presence of endogeneity.

Table 1: Tests for Endogeneity in Instrumental Variables (IVs)

Durbin-Wu-Hausman Tests for Endogeneity in IV estimation

Null Hypothesis (H_0): Regressor is Exogenous

| Test | Notation | Statistic | p-value |
|---------------------------------|-------------|-----------|---------|
| Wu-Hausman F test | F(1, 208) | 7.26527 | 0.00799 |
| Durbin-Wu-Hausman χ^2 test | $\chi^2(1)$ | 7.35984 | 0.00667 |

Source: Author's calculations using Stata (Special Edition) 12.0 user defined command ivendog

In presence of endogeneity IV/2SLS regression should be estimated. But if heteroskedasticity is present then GMM is suitable. To check the same, following tests are conducted. These tests reveal absence of heteroskedasticity making IV/2SLS a better estimator for this dataset.

Table 2: Tests for Heteroskedasticity in Presence of Instrumental Variables (IVs)

| IV Heteroskedasticity Tests using levels of IVs | | |
|---|-------------|----------|
| Null Hypothesis (H ₀): Disturbance is Homoskedastic | | |
| Test | $\chi^2(6)$ | p-values |
| Pagan-Hall General Test Sta- | 4.475 | 0.7237 |
| Pagan-Hall Test w/assumed | 7.328 | 0.3955 |
| White/Koenker n R_c^2 Test Sta- | 4.866 | 0.6764 |
| Breusch-Pagan/Godfrey/Cook-Weisberg | 8.356 | 0.3023 |

Source: Author's calculations using Stata (Special Edition) 12.0 user defined command ivhetttest, all

Interpretation

The estimated coefficient on the lagged dependent variable is 0.8365 which is less than 1, which means that the steady-state assumption holds. Moreover, the initial condition variable comes with a negative sign (-0.1818) and implies higher growth in response to lower starting YPC when other regressors are held constant. This coincides with the findings in Barro & Sala-i-Martin (2004) and Mankiw, Romer & Weil (1992).

KMI, K, ICTSERT, ICTKMI and ELTKW have positive relationship with economic growth as hypothesized while TRD has negative impact. ICTSERT (ICT×SERT) is also used in the regression which captures the interaction of ICT and school enrollment rate at tertiary level. SERT is used as higher levels of education invites greater 'ICT diffusion' in the economy and augments ICT-income nexus (Cette & Lopez, 2008). ICTKMI is the interaction term of ICT and KMI. It shows the complementary effects between ICT and knowledge. de Ferranti (2002) in his work, finds the association between ICT, knowledge and economic development.

Table 3: Instrumental Variable (IV)/2SLS Regression Estimates (Role of Knowledge and ICT in Convergence)Dependent Variable: Income per capita ($YPC_{i,t}$)

| | Coefficients | Standard Errors | t-statistics | p-values |
|---|--------------|-----------------|--------------|--------------------|
| $YPC_{i,t-1}$ | 0.8365 | 0.0485 | 17.26 | 0.000 |
| $KMI_{i,t}$ | 0.1430 | 0.0708 | 2.02 | 0.044 |
| $K_{i,t}$ | 1.0884 | 0.3402 | 3.20 | 0.001 |
| $ICTSERT_{i,t}$ | 0.0103 | 0.0036 | 2.91 | 0.004 |
| $ICTKMI_{i,t}$ | 0.0178 | 0.0053 | 3.39 | 0.001 |
| $TRD_{i,t}$ | -0.0116 | 0.0162 | -0.72 | 0.473 |
| $YPC_{i,t(0)}$ | -0.1818 | 0.0535 | -3.40 | 0.001 |
| C | -0.1165 | 0.1179 | -0.99 | 0.323 |
| Time Dummies | | | | |
| yrtd_02 | 0.0290 | 0.0124 | 2.34 | 0.019 |
| yrtd_03 | 0.0415 | 0.0119 | 3.48 | 0.001 |
| yrtd_04 | 0.0349 | 0.0114 | 3.07 | 0.002 |
| yrtd_05 | 0.0285 | 0.0109 | 2.61 | 0.009 |
| yrtd_06 | 0.0245 | 0.0105 | 2.34 | 0.019 |
| yrtd_07 | 0.0179 | 0.0100 | 1.78 | 0.074 |
| yrtd_08 | -0.0148 | 0.0098 | -1.51 | 0.131 |
| yrtd_09 | -0.0419 | 0.0096 | -4.37 | 0.000 |
| Other Tests and Parameters | | | | |
| Observations | | | | 135 |
| Countries | | | | 15 |
| Instruments | | | | 21 |
| F-test of Joint Significance | | | | F(15, 119) = 15593 |
| H_0 : Independent variables are jointly equal to zero | | | | |
| Sargan Test | | | | p = 0.156 |
| H_0 : Model is correctly specified & all over-identifying restrictions [all over- | | | | |

Source: Author's calculations using Stata (Special Edition) 12.0 user defined command ivreg2

Notes:

1 – Sargan-Hansen test is for overidentifying restrictions. The joint

Ho: Instruments are valid instruments. "Instruments Z_i are uncorrelated with the error term, and that the excluded instruments are correctly excluded from the estimated equation." i.e. $\text{Cor}(Z_i, \epsilon_{i,t}) = 0$.

2 – Sargan's statistic becomes consistent if disturbance is homoskedastic. For more, see Hayashi (2000).

Therefore, it is worthwhile to include this interaction term (ICTKMI) in the regression. (0.1430% increase in income per capita due to 1% increase in KMI, 1.0884% increase in income per capita due to 1% increase in K, 0.103% increase in income per capita due to 10% increase in ICTSERT, 0.178% increase in income per capita due to 10% increase in ICTKMI and -0.116% decrease in income per capita due to 10% increase in TRD). Coefficients of KMI, K, ICTSERT, ICTKMI and lagged and initial YPC are statistically significant at 1% level of significance.

Overall significance of the model is satisfactory (1%, 5% and 10% levels of significance) as revealed by F-test of joint significance. Sargan test of correct specification and over-identifying restrictions has a p-value of greater than 0.05. i.e. (p-value = 0.156 > 0.05) implying that all over-identified instruments are exogenous.

Discussion: Knowledge-Augmented Convergence Hypothesis

The contribution of knowledge stock in convergence regression is mention worthy, however, it can be improved via if the quality of knowledge creation could be improved. The creation of knowledge in most of sample (Asian) countries is based on 'retroflexed research' (and also UDCs). EMBO (2004) highlights that the 'parachute science' researches conducted in DCs are of least importance for UDCs because of their lack of application to the local environment of UDCs. The scientific

research conducted in developing countries needs to be scrutinized on the basis of their social acceptability, direct relevance and responsiveness to the local environment. Only such research can suit the needs of the UDCs and positively contribute to UDCs.

Moreover, the tendency to commercialize new ideas (knowledge creation) into innovative goods and services also determines the ability of knowledge to become economically meaningful. UDCs, in this regard, are laggards. In addition, most of the knowledge is transferred from DCs to the UDCs. Rather UDCs (most of Asian countries) are characterized by 'knowledge transfer' from DCs. Such adopted knowledge might not be as suitable for UDCs as it is in innovating DCs.

Findings in this study coincide with that in Sveikauskas (2007) who believes that in UDCs, technology is adopted and modified from advanced countries. It can be attributed to poor allocation of R&D expenditure which is not generating economically productive results (innovations). R&D expenditures can become contributive to economic growth through innovation systems which are the sets of firms, universities and public laboratories and their linkages.

Usually R&D expenditure is less effective in UDCs due to inability to select beneficial research projects, unneeded bureaucracy and barriers in importation of scientific material. R&D expenditure is a policy matter that is exogenously determined and requires the attention of policy makers. In majority of UDCs policy making is not free of vested interests. Such frictions usually render the R&D spending less efficient or some case counterproductive where the existing resources are very scarce and have high opportunity costs.

Similarly, the special encouragement of existing effective research groups and the concentration of facilities are often more a matter of wise planning rather than requiring massive additional expenditure. Apart from the direct financial support of specific projects, there is a continuing

need for international assistance through the provision of fellowships, visiting scientists, and facilities for study at well-established centers. In the future many developing countries may need to develop co-operative regional projects, if they wish to participate in more costly advanced research areas.

Conclusions

Role of knowledge is also tested in achieving convergence. The magnitude of relationship is substantial from the point of view of UDCs. Since in UDCs, ICT and knowledge stock are at their infancy stage, a strong relationship is not expected. Lack of befitting proxy for knowledge has been a limiting factor. More apt proxies for knowledge stock can provide improved results. The role of knowledge in leading to economic convergence is affirmed but with a finding that the quality of knowledge stock in sample countries suffers due to which contribution of knowledge is low.

Some of the problems of scientific research in developing countries, such as creating an increased pool of trained people, providing more resources and strengthening the whole national infrastructure, can only be solved through time. Policy makers should focus more on designing the policy in considering ICT as a phenomenon, deeply embedded into every sector of the economy.

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- [23] The jargon of Parachute science is referred to such research activities in which researchers in DCs conduct researches that have least relevance with the real life problems of people in UCSs. Such researches usually yield research papers for such researchers and benefit their research careers. Such researches might not even be useful for scientists in UDCs.
- [24] See OECD (1999) for more on innovation systems in developed countries.