



## Economic research and economic growth: Evidence from East Asian economies

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### ARTICLE INFO

#### Article history:

Received 13 July 2008

Received in revised form 31 October 2008

Accepted 20 December 2008

#### JEL classification:

O40

C32

#### Keywords:

Research productivity

Economic growth

Granger causality

### ABSTRACT

Based upon page counts of articles published in 60 quality economics journals, the role of economic research is examined for five East Asian economies. In Hong Kong, causality runs bi-directionally between research productivity and economic growth; in Japan, the causal effects tend to be one direction from economic growth to research publications; in Korea and Taiwan, causality runs the other way around from publications to growth; and in Singapore, the causal effects are small and insignificant. Socioeconomic differences in each economy help to explain the various causal directions found.

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### 1. Introduction

East Asian economies, which are highly dependent on international trade, were not only hit hard by the Asian financial crisis in 1997/1998, but also vulnerable to the worldwide high-tech crisis in 2001. Confronted with such economic crises, many Asian governments recognized the importance of education for sustaining high economic growth. In particular, education would increase the number of competent workers and enable the creation of new technologies domestically and facilitate the absorption of advanced technologies from overseas, and hence economies with more educated human capital would grow faster than other countries. The theoretical foundation of the role of human capital is discussed in Nelson and Phelps (1966), and further discussions of the role of human capital in the model of endogenous growth are found in Romer (1986, 1990), Lucas (1988), and Becker, Murphy, and Tamura (1990).

Theoretical agreement on the role of education in economic growth is matched by solid empirical evidence. Barro (1991), for example, used secondary and primary school enrollment rates as a proxy for the quantity of human capital, and the two quantity proxies were found to raise real economic growth. More recently, quality measurement is another important aspect of human capital in the literature. Hanushek and Kimko (2000) employed high school students' test performances in international competitions of mathematics and science in order to directly measure the skills and knowledge of the future labor force. This quality measure was also found to raise real economic growth.

The aim of this paper is, however, to focus attention on the measurement of the cognitive ability of teachers, rather than students. Professors, in particular, pass on their creative attributes and knowledge to their students and thereby improve the

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quality of the future labor force. It is also widely observed that highly developed countries normally have the most active and productive research universities. Hence, we can make a conjecture that high economic growth is caused by an improvement of new technology that can be achieved in part through effective education at the university level. The education quality is further enhanced if more professors are active in research. Jin and Jin (2007) estimated the effect of research publications on economic growth using cross-country data that included many developed countries, and found that the growth effects of publications were significantly positive.

The role of research publication is, however, less clear regarding the growth of East Asian economies. Most East Asian economies grew fast in the 1960s and 1970s and increased investment in tertiary education afterwards, thus implying that economic growth is a primary cause of the increased research productivity. The larger purchase of overseas publications by hiring established scholars with good publishing records would be another reason for the increased publications in East Asia.<sup>1</sup> Therefore, a co-movement between a rise in research productivity and a rapid economic growth over the past decades does not necessarily warrant the conclusion that research publications caused the growth of East Asian economies. The causal effects may run the other way around from economic growth to research productivity. No consensus has emerged on the appropriateness of the directions of causality between academic research and economic growth, and no such causal directions have been identified yet in the literature. This paper thus aims to investigate the Granger-causal directions between research productivity of economics and real economic growth using time series data for five East Asian economies. This would shed light on the ongoing debate on education and economic growth.

## 2. The publication data

The EconLit CD-ROM was used to track page counts of articles published in 60 quality economics journals (out of more than 750 tracked journals) that have appeared in the *Journal of Economic Literature*. The 60 quality journals included the top-8 'blue ribbon' journals (Dusansky & Vernon, 1998), the best 11 general journals published by economic associations/societies, the best 2–3 field journals in each economics field depending on perceived popularity among economists, and three best regional journals in Asia. Although one might object to this type of journal selection with an Asian emphasis, top-24 journals that were used in Graves, Marchand, and Thompson (1982) and top-36 journals that were selected in Scott and Mitias (1996) are all included. Total pages counted were then converted to *American Economic Review* (AER)-equivalent length pages. Impact factors that assign quality weights to each journal (Kalaitzidakis, Mamuneas, & Stengos, 2003; Laband & Piette, 1994) were not used here because impact factors may turn out to be nearly zero for some journals and hence lower-rank schools in East Asia that publish in less quality journals will be penalized more than double. More details about this selection method are available in Jin and Hong (2008).

Total publications in our sample have been summed up for each economy in each year. Fig. 1 presents historical data for publication over the period 1969–2004 for five East Asian economies: Hong Kong, Japan, Korea, Singapore and Taiwan. Most recent years were not included here because a complete publication of the years did not appear due to publication lag. In Hong Kong, for example, the economics profession began to publish papers in the early 1970s, achieved a sharp rise in the late 1990s, peaking in 2000. A similar pattern is observed in Japan. Although an emphasis on research began a decade earlier than in Hong Kong, Japan's research emphasis seems to be reduced recently. For the rest of the economies in the sample, research performance appears to be relatively low, and occurring in fewer years. Universities in Korea and Taiwan are less prolific in quality English-language journals, but much of their research works are published in their own native-language journals. The small number of universities in Singapore also limits aggregate research outputs there. Mainland China was not included here since the research-active period of the last 10–15 years was too short for the analysis.

For each economy, total publication (PUB) was used as a proxy for the quality of education at the university level, while economic growth was measured using real GDP in 2000 prices (GDP). Except for Taiwan, the data for nominal GDP and GDP deflator (year 2000 = 100) were obtained from *International Financial Statistics* produced by International Monetary Fund. Taiwan data for real GDP in 2001 prices were obtained from the government's website of *National Statistics*, Republic of China (Taiwan).

## 3. Empirical results

Prior to estimation of the model for Granger causality, a unit root test has been conducted to ascertain whether each individual series is integrated of order one. The test for integration is conducted employing the unit root test developed by Dickey and Fuller (1979). For the augmented Dickey–Fuller unit root test, each variable is regressed on a constant, a linear deterministic time trend, a lagged dependent variable, and  $q$  lags of first differences:

$$\ln X_t = \alpha + \beta t + \rho \ln X_{t-1} + \sum_{i=1}^q \delta_i \Delta \ln X_{t-i} + u_t, \quad (1)$$

<sup>1</sup> Recently, Kalaitzidakis, Mamuneas, and Savvides (2004) found that 'research spillovers' from North America to Europe such as short-term visiting programs across the Atlantic Ocean and European economists' formal education in North America were the most important determinants of increasing research productivity in Europe.

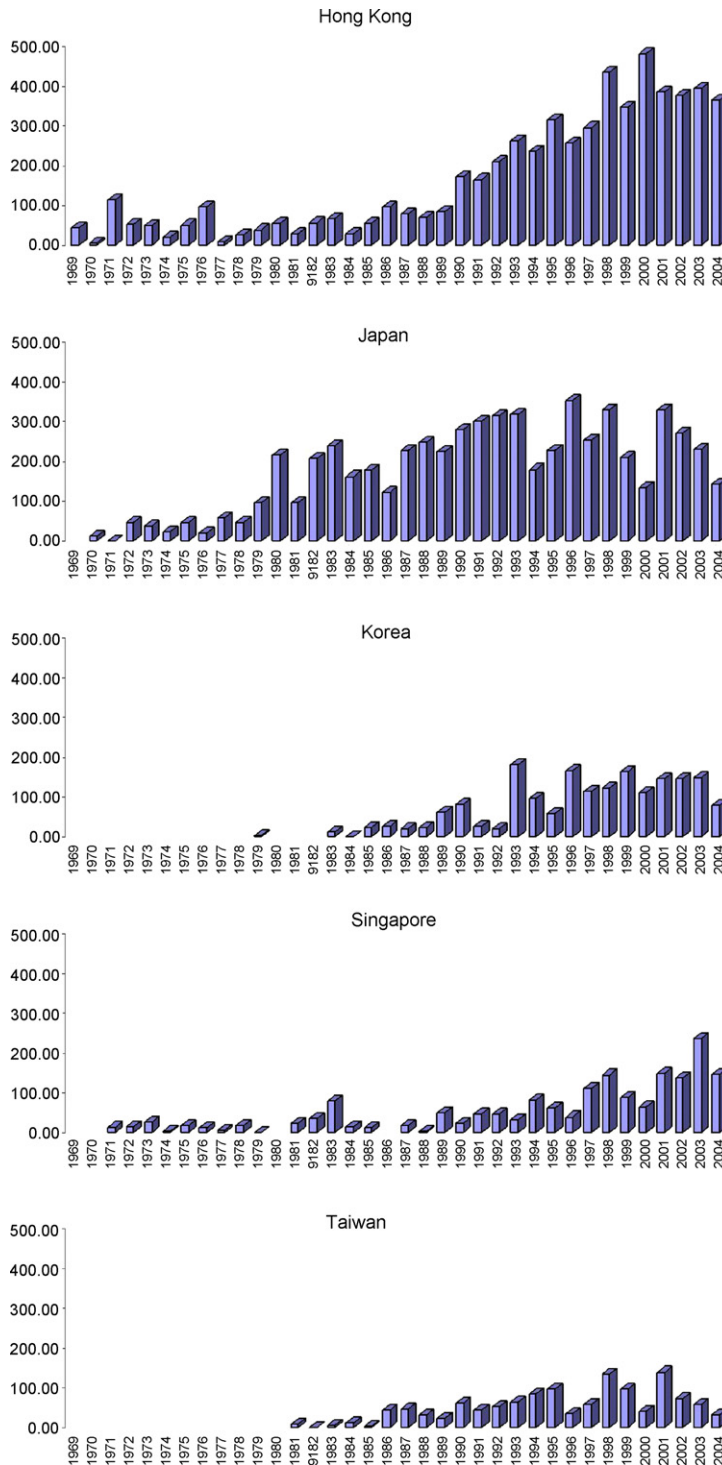


Fig. 1. Research publications in top-60 economics journals, 1969–2004.

where  $\ln X_t$  is the log level of the variable under consideration at time  $t$ . Following Schwert (1987) that takes a nearest integer of  $0.769 (=1.0 * (35 \text{ obs}/100) ** 0.25)$ , the lag length  $q$  is set at one year, so that residuals  $u_t$  can be white noise. The marginal significance levels of the Ljung-Box Q statistics range between 0.13 and 0.97, which indicates that the serial correlation of residuals does not appear to be serious. Choice of other lag lengths merely reduces the significance levels of the Q statistics.

Table 1 presents the results of the unit root test in log levels. All series are transformed to natural logs, and the model for each series is estimated by least squares. The numbers are  $t$ -values under the null hypothesis  $H_0: \rho = 1$ . For GDP, the null

**Table 1**  
Test for integration.

Variables	Hong Kong	Japan	Korea	Singapore	Taiwan
GDP	−1.10	−1.31	−1.25	−2.01	−0.29
PUB	−3.80*	−5.00*	−4.32*	−3.54*	−2.14

Notes: The numbers are  $t$ -values under the null hypothesis  $H_0: \rho = 1$ . The critical value for the augmented Dickey-Fuller unit root test is approximately  $-3.50$  at the 5% significance level (Fuller, 1976, Table 8.5.2).

\* Significant at the 5% level.

hypothesis of one unit root cannot be rejected at the 5% significance level, which suggests that GDP in log levels are nonstationary and the nonstationarity is properly characterized as stochastic trends rather than deterministic trends. PUB, however, appears to be stationary in log levels. A similar pattern has been observed for all economies in the sample, except for Taiwan. Therefore, Granger-causal models were estimated with first differences of the logs of GDP and the log levels of PUB. But for Taiwan, both series were measured in log differences.

Granger (1969, 1988) defines the causal orderings such that  $X$  Granger-causes  $Y$  if the current value of  $Y$  can be predicted more accurately, in the sense of mean square error, with the use of past values of both  $X$  and  $Y$  rather than past values of  $Y$  only. Based upon the definition of Granger causality, a simple bivariate autoregressive model is specified as:

$$\Delta \ln \text{GDP}_t = a + \sum_{i=1}^p \alpha_i \Delta \ln \text{GDP}_{t-i} + \sum_{j=1}^q \beta_j \ln \text{PUB}_{t-j} + \lambda D_t + \mu_t, \quad (2)$$

$$\ln \text{PUB}_t = b + \sum_{i=1}^r \gamma_i \ln \text{PUB}_{t-i} + \sum_{j=1}^s \delta_j \Delta \ln \text{GDP}_{t-j} + \tau D_t + v_t, \quad (3)$$

where  $\Delta \ln \text{GDP}_t$  represents the growth rate of real gross domestic product, and  $\ln \text{PUB}_t$  stands for research publication in log levels;  $p$ ,  $q$ ,  $r$ , and  $s$  are lag lengths for each variable in each equation; and  $\mu_t$  and  $v_t$  are serially uncorrelated white-noise residuals. In addition, the model includes a dummy variable  $D_t$  for structural changes. In particular, East Asian economies in the sample have experienced the Asian financial crisis in 1997/1998, and also suffered from the worldwide high-tech crisis in 2001. If structural shifts were omitted from the specification of the model, estimation results would be biased and misleading. To avoid the structural shift bias, a dummy variable was assigned 1's to the two time periods 1998 and 2001. For Japan, the dummy was assigned to a decade-long recession period 1993–2002 in which the Japanese economy was suffered most.

Using the same lag length for each variable in each equation, the model is estimated by least squares. To help infer the causal orderings, the Granger test employs  $F$ -statistics within a framework of restricted and unrestricted models. For the Granger-causal links from publication to economic growth, past values of publication are used as a zero restriction, and vice versa.  $F$  statistics are computed as:

$$F = (\text{RSS}_r - \text{RSS}_u) \text{df}_u / \text{RSS}_u (\text{df}_r - \text{df}_u), \quad (4)$$

where  $\text{RSS}_r$  and  $\text{RSS}_u$  are the residual sums of squares in restricted and unrestricted models, respectively; and  $\text{df}_r$  and  $\text{df}_u$  are, respectively, the degrees of freedom in restricted and unrestricted models.

Table 2 shows the estimation results of Granger causality. For each economy, the sample periods used were different depending on the availability of the publication data. The Granger test might also be sensitive to the use of different lag lengths, and hence estimation results were all reported for the alternative lags used. For Hong Kong, Granger-causal directions are found bi-directional between GDP and PUB. While there may well be other interpretations of this exotic behavior, one explanation for this finding would be that although the quality of tertiary education importantly contributed to the service-oriented Hong Kong economy in the short run, Hong Kong is a small and perhaps the world's most open economy and thus human capital conducive to long-term economic growth was frequently imported from developed regions. A significant portion of GDP growth in Hong Kong was also granted for higher education to catch up with other industrialized countries, and hence publications and economic growth are reinforcing to each other.

In contrast, GDP in Japan tends to Granger-cause PUB when longer lags are used. This is broadly consistent with a general belief that Japan's investment in tertiary education has been the primary cause for a subsequent rise in research productivity. More specifically, the Japanese economy grew rapidly during a reconstruction period of the 1950s with the help of a war experience. The advanced war technology developed during WWII was transformed to an industrial technology for the development of heavy industries. Afterwards, the technology was improved further because of an increase in domestic R&D which was done primarily by private firms rather than by the government. It was not until the late 1970s that the Japanese government began to raise investment in education, especially at the university level. Many Japanese scholars overseas also returned home in the 1980s. Therefore, research publications were notably increased in the 1980s and early 1990s, which seemed to follow a rapid rise of Japan's economy in earlier decades. The results also imply that a recent drop in research publications was caused by an economic recession in Japan over the past 15 years.

**Table 2**  
Test for Granger causality.

Country/economy	Lags (years)	H <sub>0</sub> : GDP $\nless\neq$ PUB	H <sub>0</sub> : GDP $\nless\neq$ PUB	Causal inferences
Hong Kong (1970–2004)	1	0.01 (0.98)	13.39 (0.01) <sup>*</sup>	GDP $\Rightarrow$ PUB
	2	4.16 (0.02) <sup>*</sup>	8.61 (0.01) <sup>*</sup>	GDP $\Leftrightarrow$ PUB
	3	5.51 (0.01) <sup>*</sup>	3.95 (0.02) <sup>*</sup>	GDP $\Leftrightarrow$ PUB
	4	4.86 (0.01) <sup>*</sup>	7.73 (0.01) <sup>*</sup>	GDP $\Leftrightarrow$ PUB
	5	5.18 (0.01) <sup>*</sup>	1.94 (0.13)	GDP $\Leftarrow$ PUB
Japan (1970–2004)	1	4.97 (0.03) <sup>*</sup>	0.11 (0.74)	GDP $\Leftarrow$ PUB
	2	2.12 (0.13)	0.72 (0.49)	GDP ... PUB
	3	2.94 (0.05) <sup>*</sup>	3.48 (0.03) <sup>*</sup>	GDP $\Leftrightarrow$ PUB
	4	0.95 (0.45)	2.62 (0.06) <sup>†</sup>	GDP $\Rightarrow$ PUB
	5	0.95 (0.47)	1.68 (0.19)	GDP ... PUB
Korea (1983–2004)	1	0.14 (0.71)	2.56 (0.12)	GDP ... PUB
	2	0.93 (0.41)	0.92 (0.41)	GDP ... PUB
	3	3.72 (0.04) <sup>*</sup>	0.29 (0.83)	GDP $\Leftarrow$ PUB
	4	5.34 (0.02) <sup>*</sup>	0.16 (0.95)	GDP $\Leftarrow$ PUB
	5	n.a.	n.a.	n.a.
Singapore (1971–2004)	1	0.04 (0.82)	0.32 (0.57)	GDP ... PUB
	2	0.49 (0.61)	0.75 (0.47)	GDP ... PUB
	3	0.16 (0.91)	0.43 (0.73)	GDP ... PUB
	4	0.15 (0.96)	0.32 (0.85)	GDP ... PUB
	5	1.81 (0.16)	0.24 (0.93)	GDP ... PUB
Taiwan (1981–2004)	1	1.22 (0.28)	0.07 (0.78)	GDP ... PUB
	2	3.36 (0.06) <sup>†</sup>	0.91 (0.42)	GDP $\Leftarrow$ PUB
	3	1.70 (0.21)	1.38 (0.29)	GDP ... PUB
	4	2.61 (0.10) <sup>†</sup>	1.21 (0.36)	GDP $\Leftarrow$ PUB
	5	3.77 (0.06) <sup>†</sup>	1.27 (0.38)	GDP $\Leftarrow$ PUB

Note: *p*-values are in parentheses. n.a. stands for not available due to a degrees of freedom problem.

<sup>\*</sup>Significant at the 5% level. <sup>†</sup>Significant at the 10% level.

For Korea and Taiwan, research publications tend to cause economic growth when longer lags are used, perhaps due to the fact that many universities in both countries have recently been compelled to change their attitude toward school reputations, particularly research publications in internationally recognized journals. For example, many domestic universities tend to 'buy' overseas publications by hiring foreign scholars to short-term contracts to become more competitive with foreign universities in terms of international publications. Many scholars overseas with good publishing records have also returned to their home countries. In this case, their past publications are credited to their home countries although their research was actually done while in other countries.

Finally, economic growth in Singapore does not show any significant causal effect on research publications. The growth effect of publications is also small and insignificant. One explanation for this finding is that there are a small number of universities in Singapore and thus a limited tertiary education domestically cannot exert a significant effect on an expanding Singaporean economy. Singapore, like Hong Kong, has an open labor market and thus high-tech experts especially in biotechnology, medical services, logistics, and even in education are regularly imported from all over the world.<sup>2</sup>

#### 4. Concluding remarks

This paper has investigated the causal relationships between rising research productivity and rapid economic growth for five East Asian economies. Research productivity in Hong Kong was found to have bidirectional causal relations with economic growth, perhaps due to the fact that Hong Kong is a small but highly open economy focusing mainly on service sectors such as trading, financial services, and tourism to name a few. Thus, tertiary education in Hong Kong may have an immediate effect on service-related technology such as management and marketing skills, and the improved economy in turn reinforces tertiary education. However, for Japan, a one-way causal relationship from economic growth to research productivity appeared to be non-trivial when longer lags are used. The results are, in general, consistent with the observation that Japan, which experienced fast growth in the 1960s and 1970s, was a relatively closed economy, and hence its increase in investment in tertiary education domestically has long been believed to be the primary cause for a subsequent rise in research productivity.

Unlike in Japan, research publications in Korea and Taiwan tend to cause the growth of the two economies. This finding is a bit surprising given their shorter experiences of publishing papers in English journals but the results are generally

<sup>2</sup> Future research could identify the importance of a fluid and open labor market for economic growth.

consistent with their recent trends of purchasing overseas publications to compete with foreign universities. In this case, causality may run from publications to economic growth but the growth effect of publications is debatable because the past publications purchased from overseas may not have a direct influence on a home country's past economic activities. Moreover, publications in Singapore no longer show significant causal effects on economic growth. The insignificant causal effects are, perhaps, linked to the small number of universities in Singapore.

Finally, the investigation of short-run causal relations based solely on a standard Granger test may reach its limit. Further investigation on long-run causal relations by estimating a cointegrated vector autoregressive model that emphasizes inferences more on causal effects in the long run would be a topic for future research.

## Acknowledgements

The author would like to thank David Ahlstrom and Eden Yu for valuable discussions, anonymous reviewers of this journal for their helpful comments and suggestions, and Jin-heon Hong for able research assistance. The author alone is responsible for any omissions and errors.

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