A Revisit to the Incremental Capital-Output Ratio: The Case of Asian Economies and Thailand

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Abstract

This paper aims to examine the trend in the incremental capital-output ratio (ICOR) and its relationship with per capita GDP and GDP growth rate by utilizing the panel data of a number of Asian economies and the historical time-series data of Thailand. It might be significant to know the linkage between growth and investment through the ICOR level, since Asian economies have faced serious needs for heavy investments to attain a targeted growth. The panel-data analysis confirmed that the gross ICOR had a positive correlation with per capita GDP and a negative association with GDP growth rate as expected in a theoretical model. The time-series analysis verified that the net ICOR was positively correlated with per capita GDP. Both analyses showed that industrial shares did not affect the level of the gross and net ICORs.

Keywords: Incremental capital-output ratio (ICOR), Asian economies, Thailand, investment requirement, per capita GDP, GDP growth rate, panel data, historical time-series data, gross ICOR and net ICOR.

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1. Introduction

This paper aims to examine the trend in the incremental capital-output ratio (hereafter ICOR) and its relationship with per capita GDP and GDP growth rate by utilizing the panel data of a number of Asian economies and the historical time-series data of Thailand.

The ICOR is one of the most important concepts and analytical instruments of both economic growth theory in academic circles and development planning in policy makers. The ICOR is defined as a ratio between incremental changes in capital over incremental changes in output. As a traditional literature, the Harrod-Domar Growth model[1], in which the rate of growth of output is determined by the rate of saving and the ICOR, suggested that the ICOR could be a key variable to link investment requirements with targeted rates of economic growth. Kuznets (1960) also presumed an association between the two variables in such a way that "the additions to output require the additions to reproducible capital stock, or the latter permit (not necessarily guaranteeing) the additions to output", and "the association between reproducible capital and output may be sufficiently strong to warrant an interest in and examination of the ratio between the two". Thus, a number of studies on the regularities in variations of the ICOR have been conducted as described in the following section. The use of the ICOR appears to be still valid in present times, in particular, in less-developed countries. It is because less-developed countries regard capital stock as an important factor in explaining economic growth due to its scarcity in their economies and also because they often suffer the lack of data appropriate for sophisticated model construction for economic projections.

This paper revisits the ICOR issue by focusing on the case of a number of Asian economies and Thailand historical trends. Asia has recently been a growth center in the world. For its future, the Asian Development Bank (ADB) presented the scenario called the "Asian century", in which Asian share of global GDP will nearly double from 27 percent in 2010 to 51 percent by 2050.[2] One of the driving forces for Asian economic growth has been the development of international production and distribution networks in manufacturing sectors (see e.g. Kimura, 2006), and the formation of the networks has required intensive investments in terms of infrastructure and production facilities. The linkage between growth and investment, therefore, has been of great concerns for policy makers as well as academic circles in recent times.[3] In particular, such latecomer's economies as Cambodia, Lao PDR and Myanmar in Mekong region have faced serious needs for heavy investments under their conditions of scarce capital stocks to attain a targeted economic growth. Here comes the necessity to explore and signify the ICOR levels whose variations are standardized by such theoretically-related variables as per capita GDP and GDP growth rate among Asian economies. Knowing the standard ICOR levels may also contribute to assessing the investment efficiency and the productivity of capital stock in specific economies. In this sense, the ICOR would be an old but still new issue for economic growth theory and development planning.

The paper is structured as follows. Section 2 outlines the literature focusing mainly on the relationship between the ICOR and both of per capita income and growth rate. Section 3 provides empirical evidence on the levels and trends of ICOR and their relationship with growth and income factors, in a number of Asian economies and Thailand. Section 4 summarizes the analytical results and concludes.

2. Literature

There have been a number of the studies to investigate the international variations in the ICOR as we stated in the introduction, and we herein summarize main literature on these studies. It seemed to be a study by the U.N. Economic Commission for Latin America in 1955[4] that the ICOR was utilized for the first time mainly to obtain estimates of the productivity of capital and of the investment required to attain a targeted level of income in the economy. Since then, most of the efforts have been concentrated on the investigation of the relationship between the ICOR and both of per capita income and growth rate.

Kuznets (1960) verified the existence of a positive association between the ICOR and the level of per capita income, as a part of his intensive works on "quantitative aspects of the economic growth of nations". Based on the observation on international variations in the ICOR in the period of 1951-57, it found that the gross ICOR tended to be lower in the lower-income group of countries and higher in the higher-income group ranging from 2.5 to 7.3; the net ICOR showed the same tendency ranging from 1.8 to 5.3; and the inter-income-group differences in the ICOR was not coming from the intergroup differences in their industrial weights, but from the intergroup differences in each industrial ICOR, i.e., the ICOR of agriculture, manufacturing and services. Kuznets (1961) also observed a general tendency of the gross and net ICOR to rise over the changes of time. These findings imply that the ICOR is an increasing function of the level of per capita income across counties and times.

With regard to the relationship between the ICOR and growth rate, several studies provided the evidence on their inverse relationship. Ohkawa and Rosovsky (1962) identified their inverse association by showing a series of graphs on the annual growth rate of GDP and the ICOR for Japan in the period from 1931 to 1980 with seven-year moving average. Leibenstein (1966) also confirmed the existence of an inverse relationship between the ICOR and growth rate as a general tendency across 18 countries, while Beckerman (1965) identified this inverse association in 10 European countries and the U.S.A. during the period from 1956 to 1962.

The relationship between the ICOR and both of per capita income and growth rate were examined systematically in the theoretical and empirical senses by Vanek and Studenmund (1968) and Sato (1971). Vanek and Studenmund (1968) constructed the simple theory on which the two variables – the gross ICOR and growth rate should be functionally related with two parameters – the net ICOR and the average life of capital stocks, and derived the empirical values of the two parameters by fitting the function to a sample of 62 country-observations. They also attempted by regressions methods to explain the gross ICORs through growth rate and other independent variables such as per capita income, shares of agriculture and industry and others. Through these analyses, they could get the highly realistic values of the two parameters: an average life-span of all capital assets of some seventeen years and a net average ICOR of somewhere just below 2.0. They also found that in the estimated regressions of the gross ICORs, the growth rate was the most significant explanatory variable with an inverse impact; the per capita income was positively correlated in less-developed countries presumably due to diminishing returns; and the rest of the variables included indicated unexpected or insignificant impacts on the gross ICORs.

Sato (1971) attempted a quantitative assessment of the growth and income factors as explanatory variables of variations in the gross ICOR, by making econometric specifications more precise, on the basis of a cross-country sample of 73 countries representing the experiences of the 1950s and early 1960s. His findings and interpretations were as follows: first, the ICOR and the income level were positively correlated, due to shifts of production to more capital-using sectors and to overall capital deepening; second, for production shifts, the relative contraction of agricultural production exerted a positive influence on the aggregate ICOR, due to the capital requirement differential between agriculture and non-agriculture, and third, the influence of the growth rate on the ICOR is notable in economies with medium income, but is not significant in economies with very low income. The study focusing on developing countries as to the determinants of the ICOR and its policy impacts was conducted by Wai (1985). As far as the determinants of ICOR are concerned, it confirmed the positive association between the ICOR and the level of per capita income, although his determinants did not include the growth rate.

3. Empirics

This section turns to the empirics on the ICOR estimations. Among the fore-mentioned literature, we basically extend the outcomes of Vanek and Studenmund (1968) and Sato (1971), by modifying their models in accordance with our analytical interests. We first specify the model for the estimations of the gross and net ICOR, and then conduct the gross-ICOR estimation for a number of Asian economies and the net-ICOR one for Thailand. The data availability of capital stock in Thailand enables us to estimate directly the net ICOR.

3.1 Model for Estimation

We first present a simple identity equation on the gross ICOR description as follows.

The gross ICOR = $I/\Delta Y = (\Delta K + \delta * K)/\Delta Y = \Delta K/\Delta Y + \delta/g * K/Y$
$$= \text{the net ICOR} + \delta/g * K/Y \quad \text{(I.1)}$$

where I is gross investment; Y is output; K is capital stock; δ is depreciation ratio of capital stock (thus I = $\Delta K + \delta * K$); and g is growth rate of output (= $\Delta Y/Y$). This identity equation simply shows that the gross ICOR is inversely related with the growth rate of output, and this relation is in line with Vanek and Studenmund (1968) stating that with an infinite rate of growth the relative difference between the gross and net ICOR becomes zero, while with a zero rate of growth the gross ICOR become infinite. It implies that the replacement component in total investment is less important at a higher growth rate of output.

We also assume that the net ICOR is positively associated with per capita income y, in accordance with the observation of Kuznets (1960), Vanek and Studenmund (1968) and Sato (1971). Taking the logarithm of per capita income, the relation is specified as:

$$\text{The net ICOR} = \text{const.} + \alpha * \log y, \quad \alpha>0 \quad \text{(N.1)}$$

Alternatively, we attempt to add such explanatory variables as output shares of industrial sectors in the net-ICOR equation. The previous studies have represented ambiguous impacts of industrial shares on the ICOR; Kuznets (1960) and Vanek and Studenmund (1968) did not extracted clear-cut or expected effects of industrial shares on the ICOR, while Sato (1971) emphasized that changes in industrial structure are more important than changes in income level as the factor to explain the ICOR. Thus, it seems to be significant in this study to re-confirm the industrial-share impacts on the ICOR. When we let sh the industrial sector's share in output, the alternative equation will be as follows.

$$\text{The net ICOR} = \text{const.} + \alpha * \log y + \gamma * sh, \quad \alpha>0 \quad \text{(N.2)}$$

When we then simply combine the equation (I.1) and (N.1) or (N.2) for the gross-ICOR estimation under the assumption that the depreciation ratio δ and capital-output ratio K/Y are stable in the long run among the sample economies, we can get the following equations.

$$\text{The gross ICOR} = \text{const.} + \alpha * \log y + \beta * g, \quad \alpha>0, \beta<0 \quad \text{(G.1)}$$

$$\text{The gross ICOR} = \text{const.} + \alpha * \log y + \beta * g + \gamma * sh, \quad \alpha>0, \beta<0 \quad \text{(G.2)}$$

The equation (G.1) and (G.2) will be used for the estimation of a number of Asian economies, and the (N.1) and (N.2) will be for Thailand time-series estimation.

3.2 Gross-ICOR Estimation for Asian Economies

This section focuses on the gross-ICOR estimation by utilizing the panel data of a number of Asian economies. We first describe the data for estimation and then present the estimation outcomes with discussions.

Data for Estimation

The sample areas are 21 economies in east, south-east and south Asia, where international production networks have been or will be penetrated: Bangladesh, Bhutan, Brunei, Cambodia, China, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, Mongolia, Myanmar, Nepal, Pakistan, Philippines, Singapore, Sri Lanka, Taiwan, Thailand and Vietnam (see Table 1).

The sample periods are three periods: 1983-1989, 1990-1996 and 2001-2007. We choose these periods since in these period the regional and world economic conditions were rather stable in the sense that the periods do not include the Asian financial crises in the late 1990s and the world Lehman Shock in the late 2000s. If we calculated tentatively the seven-year moving average of the gross ICOR for Indonesia, Korea and Thailand (see Figure 1)[5], we can observe the irregularly high level of the gross ICOR due to the sharp GDP declines for 1997-2004 in Indonesia and Thailand, and for 2009-2011 in Korea and Thailand. The sample periods cover rather long time-span as seven years since the gross ICOR, if averaged in shorter time span, were also affected by business cycles and fluctuations. We follow Kuznets (1960) that calculated the ICOR in terms of the seven-year average between 1951 and 1957.

With regard to the sample data other than per capita income, they are retrieved from the "Key Indicators for Asia and the Pacific" by Asian Development Bank (ADB) in various issues. The data for Thailand, however, come from Office of the National Economic and Social Development Board, Government of Thailand[6], since it provides the data with longer range for 1980-2011 than ADB. We specify each estimated variable by the data sources as follows. For "gross investment (I)", we use "Gross fixed capital formation at constant prices".[7] For "output (Y)", we adopt "Gross domestic product (GDP) at constant prices".[8] Thus, we calculate "the gross ICOR" in 2001-2007, for instance, in such a way as dividing the sum of "Gross fixed capital formation" for seven years of 2001-2007 by the increase in GDP from 2000 to 2007. As for "growth rate of output (g)", we show an annual growth rate of GDP at constant prices averaged for seven years.[9] Regarding with the industrial sector's share in output, we pick up such sectors as agriculture and manufacturing, and extract the percentage ratios of agriculture and manufacturing as the components of GDP by industrial origin at constant prices in terms of seven-year average.[10] As for the per capita income, the data are retrieved from "World Economic Outlook Database April 2013" by International Monetary Funds in terms of "Gross domestic product per capita, current prices, U.S. dollars"[11], and are shown as seven-year average.

We expect the positive correlation of the gross ICOR with per capita income and its negative association with growth rate. These relationships are roughly shown in bilateral forms as expected in Figure 2. The next section will put the equations of (G.1) and (G.2) in statistical tests through multiple regression analysis.

Estimation Outcomes with Discussions

Table 2 reports the outcomes of estimating the equation (G.1) and (G.2). We estimate their equations by excluding Japan as (G.1') and (G.2'), since the gross ICOR of Japan, 16.22 for 2001-2007, is extremely high (see Table 1) and it appears to be an outlier (see Figure 2).[12]

Main findings are as follows. First, the coefficient of per capita income, log(y) is significantly positive except in equation (G.2') and the one of growth rate, g, is discernibly negative in all the equations. As far as these two variables are focused on in equation (G.1) and (G.1'), the gross ICOR is positively related with per capita income and negatively associated with growth rate as expected in the theoretical model. Second, the coefficients of output shares of agriculture and manufacturing are insignificant in either equation (G.2) or (G.2'). It seems to come from multicollinearity between output share and per capita income since the structural change which is implicitly measured by the per capita income changes may occur simultaneously with the structural change from agriculture to manufacturing and service. Alternatively, it may mean that the differences in industrial shares do not give any impacts on the differences in the level of the gross ICOR, which seems to be consistent with the outcome of Kuznets (1960). Third, as far as the equations, (G.1) and (G.1') are concerned, the coefficient of constant term is significantly positive. It may imply the long-run and cross-economy constancy of the depreciation ratio and capital-output ratio.

We next conduct another grouping test by the epochal arrangement of the sample cases according to their levels of economic development for examining the 'within and between' group results. Specifically, we divide the sample cases into four quartiles according to per capita income and then attach a dummy variable to differentiate each category in the previous ICOR regression model of (G.1'). Table 3 describes the arranged quartiles with dummy variables and Table 4 denotes the estimation outcome for ICOR with a dummy variable for each group. The estimation outcome tells us that there are no significant dummy variables in any category of groups, i.e. no group-specific ICOR, which is rather different from Sato (1971) that argued that the influence of the growth rate on the ICOR differs according to income group. Thus, we can say that the gross ICOR simply follows the linear combination with per capita income and growth rate.

Now that we could identify the linear relationship of the gross ICOR with per capita income and growth rate, we can present the gross ICOR standardized by both variables in Asian economies, which is one of the purpose of this study (see Table 5). Among the estimated equations in Table 2, we choose the equation (G.1') to extract the standardized gross ICOR, since that equation showed the better performance in terms of the adjusted R-squared and T-value in each coefficient. Under the equation (G.1'), we calculate the actual, fitted, and residual values of the gross ICOR in all the sample economies (see Table 6). We find that all residuals but those of Bhutan (2001-2007) and Brunei (1990-1996) are within the double ranges of the standard error of the regression, 1.179*2.[13] The standardized gross ICOR in Table 5 ranges from 1.14 at minimum to 5.35 at maximum, within rather reasonable levels, under the combination of per capita income (500-9,000 US dollar) and growth rate (1.0-10.0%).

The trends in the standardized ICOR above imply that such latecomer's economies as Cambodia, Lao PDR and Myanmar would face the serious requirement for investment if they moved up the development-ladder as the forerunners has so far experienced. It is because the correlation between per capita income and the ICOR means that development process essentially involves the shifts of production to more capital-using sectors and to overall capital deepening as Sato (1971) suggested. The standardized ICOR may, therefore, provide some benchmark for investment requirement to attain a target growth for the policy makers, especially, of the latecomer's economies. At the same time, if heavy investment did not lead to higher per capita income, the actual ICOR might exceed the standardized ICOR, which implies inefficient investment. Thus, the standardized ICOR may also provide another benchmark to judge the efficiency of actual investment and the productivity of existing capital stock in a specific economy.

3.3 Net-ICOR Estimation for Thailand

This section focuses on the net-ICOR estimation shown as the (N.1) and (N.2) equations by utilizing the historical time-series data of Thailand. We first state the data for estimation and then present the estimation outcomes with discussions.

Data for Estimation

All the data come from Office of the National Economic and Social Development Board (NESDB), Government of Thailand, and the sample period is from 1970 to 2011. We specify each estimated variable by the data sources as follows. For "capital stock (K)", we use "Table 8 Net Capital Stock of Thailand at 1988 Prices" in "Capital Stock of Thailand 2011".[14] For "output (Y)", we choose "Gross Domestic Product at 1988 Prices" in "National Income of Thailand".[15] Then we calculate "the net ICOR" for 1977-2011 in such a way as dividing the seven-year increase in capital stock by the seven-year increase in GDP.[16] The per capita income is shown as the seven-year average of the "Per Capita GDP at 1988 Prices" in "National Income of Thailand". As for the industrial sector's share in output, we classify it into three sectors: agriculture (*ag*), industry (*id*) and service sector (*sv*) in GDP at 1988 Prices by Economic Activities in "National Income of Thailand"[17], and show their percentage ratios as seven-year average.

Before estimating the (N.1) and (N.2) by Thailand time-series data, we test the stationarity of all the series by using the unit root test as a usual procedure. In this study, we conduct the Ng and Perron test[18] on the null hypothesis that the level and the first difference of each variable has a unit root by choosing to include only an intercept in the test equation. This test constructs four test statistics that are based upon the de-trended data. These test statistics are modified forms of Phillips and Perron statistics (MZa, MZt), the Bhargava (1986) statistic (MSB), and the ERS Point Optimal statistic (MPT). Table 7 reports that the null hypothesis on a unit root was rejected at more than 95 % significance level in the level and first difference of the net ICOR, the first difference of per capita GDP and the level of GDP share of service sector (*sv*). Thus, to make a regression valid, we modify the (N.1) and (N.2) for their estimation into the following ones by using only stationary time-series data.

$$d\,(\text{The net ICOR}) = \text{const.} + \alpha * d\,(\log y), \quad \alpha>0 \qquad \text{(N.1')}$$

$$d\,(\text{The net ICOR}) = \text{const.} + \alpha * d\,(\log y) + \gamma * sv, \quad \alpha>0 \qquad \text{(N.2')}$$

Estimation Outcomes with Discussions

Table 8 indicates the results of estimating the equation (N.1') and (N.2'). We insert the dummy variable for the period of 1997-2002, in which the impacts of the 1997 currency crisis entailed the abnormally high level of the net ICOR, more than 4.0.

Main findings are as follows. First, the coefficient of the first difference of per capita GDP, *d* (log(*y*)) is significantly positive in both equation (N.1') and (N.2') as expected in the theoretical model. Second, the coefficient of GDP shares of service sector, *sv*, is insignificant in equation (N.2'). Though it may include multicollinearity problem like the Asian analysis, it may mean that the difference in service-sector share does not give any impacts on the difference in the level of the net ICOR, which is also consistent with the outcome of Kuznets (1960).

We herein investigate further the impacts of sector's shares on the net ICOR by the more direct way that Kuznets (1960) adopted, since Thailand has the data of sector's capital stocks[19], thereby enabling us to calculate the sector's net ICOR. We can verify whether the trend in total net ICOR was affected by the change in each sector's GDP share or by the change in each sector's ICOR. The former can be identified by fixing each sector's ICOR at its average and allowing the change in each sector's share, and the latter can be confirmed by fixing each sector's share at its average and allowing the change in each sector's ICOR. We focus on the period for 1977-1996 with monotonous upward trend in the total net ICOR. Figure 3 depicts the trends in the total net ICOR, sector-share-fixed net ICOR and sector-ICOR-fixed net ICOR, which are produced by using the data of each sector's ICOR and GDP share for 1977-1996 and their averages for that period in Table 9. We found that the total net ICOR was traced well by sector-share-fixed net ICOR, but not by sector-ICOR-fixed net ICOR. Thus, we can say that the change in each sector's GDP share did not have any impacts on the trend in the total net ICOR.

4. Concluding Remarks

This paper set out to examine the trend in the incremental capital-output ratio (ICOR) and its relationship with per capita GDP and GDP growth rate by utilizing the panel data of a number of Asian economies and the historical time-series data of Thailand. It might be significant to know the linkage between growth and investment through the ICOR level, since Asian economies, in particular, latecomer's economies in Mekong region, have faced serious needs for heavy investments under their conditions of scarce capital stocks to attain a targeted economic growth.

The panel-data analysis confirmed that the gross ICOR had a positive correlation with per capita GDP and a negative association with GDP growth rate as expected in a theoretical model. The time-series analysis verified that the net ICOR was positively correlated with per capita GDP. Both analyses showed that industrial shares did not affect the level of the gross and net ICORs. We also extracted the gross ICOR standardized by per capita GDP and GDP growth rate, ranging from 1.14 to 5.35 under the combination of per capita GDP (500-9,000 US dollar) and GDP growth rate (1.0-10.0%). This standardized gross ICOR might be expected to be referred to in the case that policy makers and academicians consider investment requirements to attain a targeted economic growth. Despite the fact that ICOR is relatively an old concept—being dominated now by the more recent concept of total factor productivity (TFP)—this paper shows that ICOR is still a useful method. Particularly in countries with rather moderate stage of economic development, there may be some data constraints for calculating complex indicators. Given that the TFP concept requires more sets of data than the ICOR, it is therefore easier to calculate the latter. For instance, data for Myanmar are quite limited that it is not possible to calculate the TFP but suffice for ICOR. Nonetheless, the concept of ICOR may have to be used with some cautions as the new growth model argued that increase in capital can only stimulate growth in the short run. In the long run, the economic growth is determined by technological change or the TFP (Easterly, 2002). Accordingly, careful consideration is recommended when choosing between ICOR and TFP as a growth determinant.

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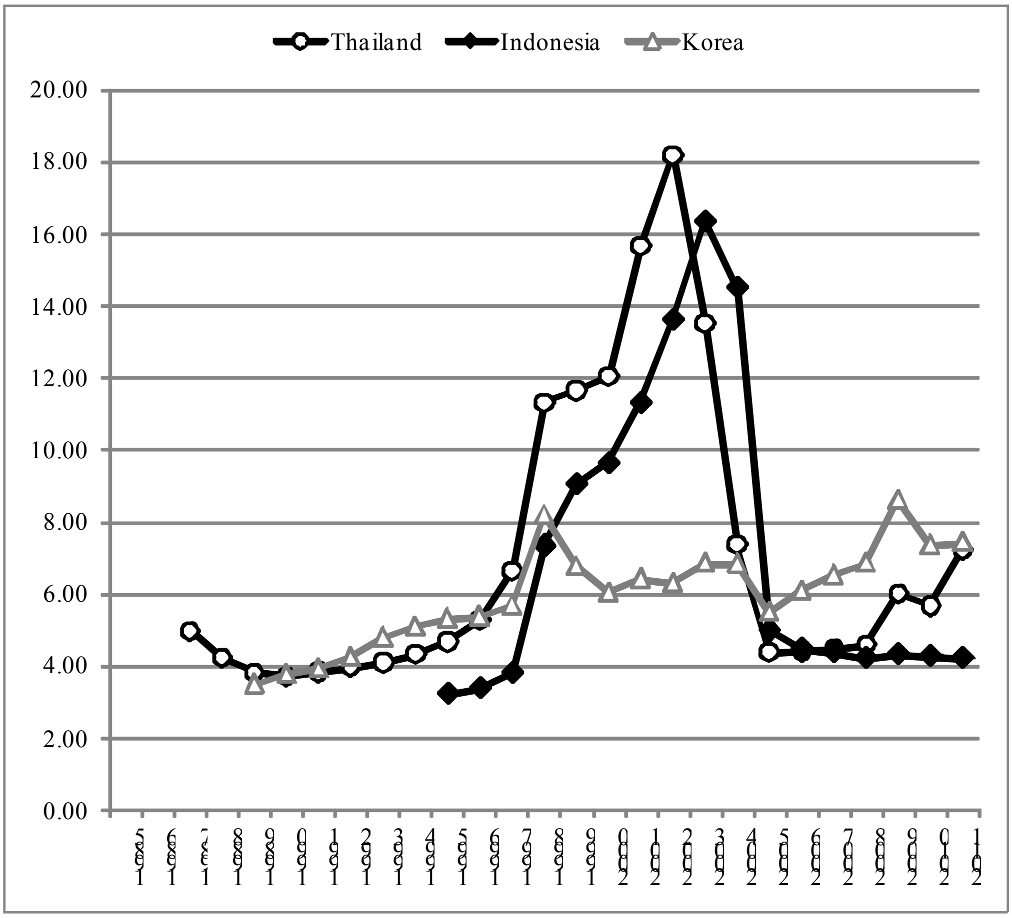
Footnotes

1. See Harrod (1939) and Domar (1946).
2. See ADB (2011).
3. There are many analyses on the linkage between growth and investment in the different terms from ICOR. See e.g. Kare and Sinkovia (2013), Tsaurai and Odhiambo (2013), and Pradhan (2011).
4. See Naciones Unidas, Secretaria de la Comision Economica para America Latina (1955).
5. The way of their calculation is the same as the one for the estimation.
6. See http://eng.nesdb.go.th/Default.aspx?tabid=94.
7. We exclude "Increase in stocks" from our specification due to its fluctuation. Due to the constraint in the data source, however, it is combined as "gross investment" in Bangladesh.
8. We should use the time series at constant prices for both gross investment and GDP since the changes in current prices affect differently both variables (see Kuznets, 1960). The benchmark year at constant prices varies according to the time-series and the economies. Due to the constraint in the data source, both of gross investment and GDP are at current prices in China and Mongolia.
9. For China and Mongolia, the data source for the growth rate is World Economic Outlook Database April 2013 by IMF instead of ADB due to its data constraint.
10. As industrial classifications, "Mining" and "Electricity, gas, and water" are combined into "Manufacturing" in China, and "Mining" is combined into "Agriculture" in Singapore. The ratios at current prices are in China, Hong Kong and Mongolia.
11. We use "current prices" here, since the description by U.S. dollar enables us to compare the GDP per capita in different economies and their degrees of inflation are usually reflected in their currency values.
12. Japan has suffered the continuous stagnation in her economy since the 1990s, and thus her capital stock may have been not fully utilized under the GDP gap coming from the lack of demands. This is considered to be one of the causes of the high gross ICOR in Japan.
13. In Brunei, the high share of mining may affect her high level of the gross ICOR.
14. See http://eng.nesdb.go.th/Default.aspx?tabid=98.
15. See http://eng.nesdb.go.th/Default.aspx?tabid=94. We combine "GDP 1996 (1951-1996)", "NI 2001 (1980-2001)", "NI 2009 (1993-2009)" and "QGDP 1st quarter 2013" (in http://eng.nesdb.go.th/Default.aspx?tabid=95).
16. The reason for setting seven years as time-span is the same as the one in the previous section.
17. The "Mining and Quarrying", "Manufacturing" and "Construction" are classified into the "industry" sector.
18. See Ng and Perron (2001). As for the unit root tests for ordinary time series, the augmented Dickey-Fuller (ADF) test (Said & Dickey, 1984) and the Philips-Perron (PP) (Philips & Perron, 1988) test have often been used. It is well-known, however, that both the ADF and PP suffer from severe size and power problems depending on the nature of the process (highly persistent but stationary series, negative MA terms, etc). Accordingly, Ng and Perron (2001) introduces a new unit root test, which uses de-trended data and a lag selection procedure that improves on previous methods. The description of this test is shown in details in the EViews 7 Users' Guide.

19. See http://eng.nesdb.go.th/Default.aspx?tabid=98.

Figure 1 Trend in Gross ICOR with 7-Year Moving Average



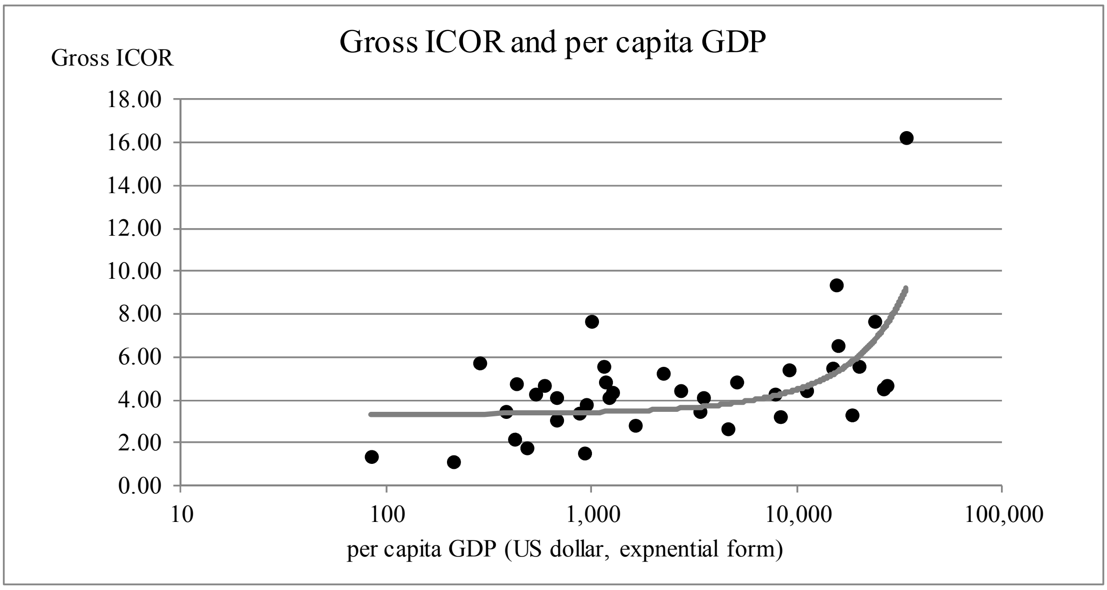
Source: the same as the one in Table 1

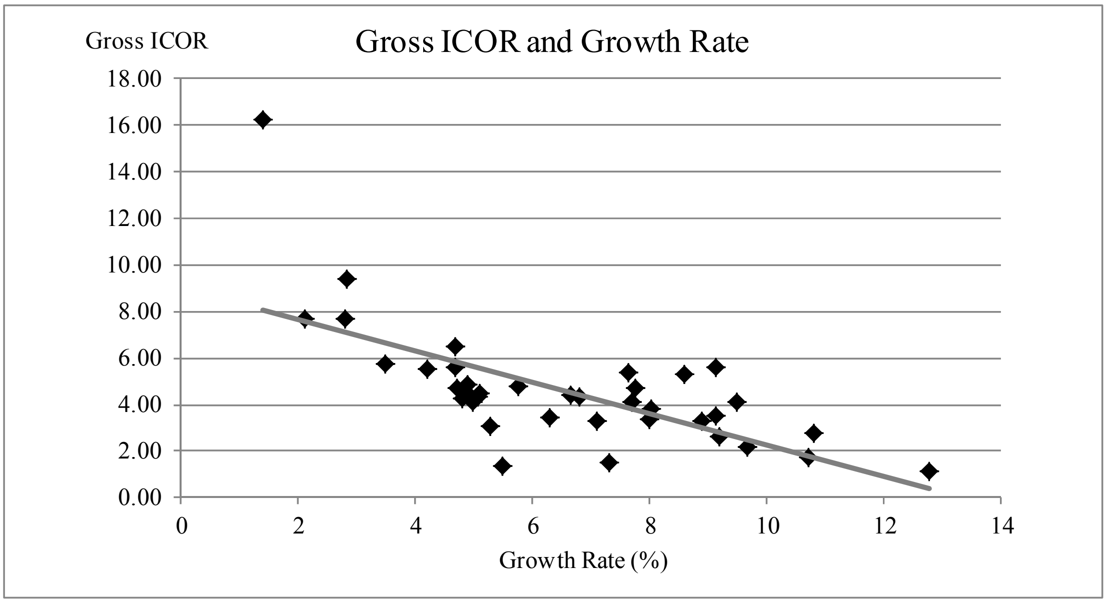
Table 1 Data Description

		Gross ICOR	*g* (%)	*y* (US dollar)	*ag* (%)	*mn* (%)
Bangladesh	1983-89	-	-	-	-	-
	1990-96	-	-	-	-	-
	2001-07	4.80	5.74	428	22.1	15.8
Bhutan	1983-89	-	-	-	-	-
	1990-96	-	-	-	-	-
	2001-07	5.57	9.13	1,135	22.5	7.7
Brunei	1983-89	-	-	-	-	-
	1990-96	9.37	2.82	15,314	0.8	13.9
	2001-07	7.67	2.12	23,777	1.2	14.8
Cambodia	1983-89	-	-	-	-	-
	1990-96	-	-	-	-	-
	2001-07	2.21	9.66	422	30.2	19.4
China	1983-89	-	-	-	-	-
	1990-96	1.75	10.70	485	21.7	39.3
	2001-07	2.80	10.79	1,623	12.6	39.6
Hong Kong	1983-89	3.28	7.11	8,273	0.4	21.0
	1990-96	5.59	4.67	19,728	0.2	10.9
	2001-07	4.55	4.86	26,246	0.1	3.0
India	1983-89	-	-	-	-	-
	1990-96	-	-	-	-	-
	2001-07	4.14	7.70	668	19.8	15.4
Indonesia	1983-89	-	-	-	-	-
	1990-96	3.38	8.00	862	17.7	22.5
	2001-07	4.36	5.07	1,253	14.8	27.9
Japan	1983-89	-	-	-	-	-
	1990-96	-	-	-	-	-
	2001-07	16.22	1.41	34,001	1.3	19.7
Korea	1983-89	3.49	9.11	3,323	10.9	26.4
	1990-96	5.38	7.63	9,124	6.0	24.2
	2001-07	6.52	4.68	15,721	3.1	23.9
Malaysia	1983-89	-	-	-	-	-
	1990-96	4.09	9.48	3,469	12.9	26.4
	2001-07	4.84	4.89	5,100	8.4	29.3
Mongolia	1983-89	-	-	-	-	-
	1990-96	-	-	-	-	-
	2001-07	1.50	7.31	923	20.9	5.4
Myanmar	1983-89	-	-	-	-	-
	1990-96	1.36	5.49	84	46.3	9.1
	2001-07	1.11	12.77	211	50.0	11.0
Nepal	1983-89	-	-	-	-	-
	1990-96	-	-	-	-	-
	2001-07	5.73	3.48	283	35.7	7.9
Pakistan	1983-89	3.48	6.28	383	27.1	16.8
	1990-96	4.27	4.80	535	25.3	17.6
	2001-07	3.05	5.26	671	23.2	17.3
Philippines	1983-89	-	-	-	-	-
	1990-96	7.66	2.81	997	22.2	25.2
	2001-07	4.09	4.97	1,200	13.6	23.8
Singapore	1983-89	4.31	6.78	7,727	0.7	24.2
	1990-96	3.33	8.89	18,475	0.2	24.6
	2001-07	4.70	4.71	27,067	0.1	24.8
Sri Lanka	1983-89	-	-	-	-	-
	1990-96	-	-	-	-	-
	2001-07	4.86	4.89	1,159	14.0	17.9
Taiwan	1983-89	2.64	9.18	4,601	6.0	34.8
	1990-96	4.43	6.64	10,977	3.5	26.7
	2001-07	5.50	4.20	14,972	1.7	24.6
Thailand	1983-89	3.83	8.02	938	16.2	26.0
	1990-96	5.27	8.59	2,212	10.6	31.3
	2001-07	4.46	5.09	2,683	9.6	38.2
Vietnam	1983-89	-	-	-	-	-
	1990-96	-	-	-	-	-
	2001-07	4.68	7.75	585	20.3	22.0

Sources: For the data except per capita GDP, “Key Indicators for Asia and the Pacific” by ADB in various issues, but for Thailand, NESDB. For per capita GDP, World Economic Outlook Database April 2013 by IMF.

Figure 2 Gross ICOR Relation with per capita GDP and Growth Rate





Source: the same as the one in Table 1

Table 2 Estimation Outcome for Gross ICOR

Dependent variables	Gross ICOR			
	Equation (G.1)	Equation (G.2)	Equation (G.1') (excluding Japan)	Equation (G.2') (excluding Japan)
Const.	4.295 **	-2.665	4.363 ***	4.260
	(1.935)	(5.556)	(1.286)	(3.946)
log(y) : per capita income	0.510 **	1.161 **	0.353 ***	0.354
	(0.192)	(0.537)	(0.129)	(0.388)
g : growth rate	-0.559 ***	-0.601 ***	-0.418 ***	-0.426 ***
	(0.119)	(0.129)	(0.082)	(0.092)
ag : output share of agriculture		0.096		0.001
		(0.072)		(0.051)
mn : output share of manufacturing		0.037		0.006
		(0.040)		(0.028)
Adjusted R-squared	0.521	0.519	0.540	0.513
S.E. of regression	1.774	1.778	1.179	1.213
Number of observations	39	39	38	38

Note: ** and *** indicate significance at the 5% and 1% level, respectively. The figure in parenthesis denotes standard error.

Table 3 Grouping the Sample Cases into Four Quartiles

			y (US dollar)	Dummy		
1st Quartile	Singapore	2001-07	27,067	*D01*	*D12*	
	Hong Kong	2001-07	26,246			
	Brunei	2001-07	23,777			
	Hong Kong	1990-96	19,728			
	Singapore	1990-96	18,475			
	Korea	2001-07	15,721			
	Brunei	1990-96	15,314			
	Taiwan	2001-07	14,972			
	Taiwan	1990-96	10,977			
2nd Quartile	Korea	1990-96	9,124	*D02*		*D23*
	Hong Kong	1983-89	8,273			
	Singapore	1983-89	7,727			
	Malaysia	2001-07	5,100			
	Taiwan	1983-89	4,601			
	Malaysia	1990-96	3,469			
	Korea	1983-89	3,323			
	Thailand	2001-07	2,683			
	Thailand	1990-96	2,212			
3rd Quartile	China	2001-07	1,623	*D03*	*D34*	
	Indonesia	2001-07	1,253			
	Philippines	2001-07	1,200			
	Sri Lanka	2001-07	1,159			
	Bhutan	2001-07	1,135			
	Philippines	1990-96	997			
	Thailand	1983-89	938			
	Mongolia	2001-07	923			
	Indonesia	1990-96	862			
	Pakistan	2001-07	671			
4th Quartile	India	2001-07	668	*D04*		
	Vietnam	2001-07	585			
	Pakistan	1990-96	535			
	China	1990-96	485			
	Bangladesh	2001-07	428			
	Cambodia	2001-07	422			
	Pakistan	1983-89	383			
	Nepal	2001-07	283			
	Myanmar	2001-07	211			
	Myanmar	1990-96	84			

Table 4 Estimation Outcome for Gross ICOR with Group-Dummy Variables

Dependent variables				Gross ICOR			
Const.	4.097 **	4.360 ***	4.277 ***	4.285 **	3.738 *	4.353 ***	3.410
	(1.507)	(1.377)	(1.396)	(1.731)	(2.034)	(1.307)	(2.714)
log(y) : per capita income	0.404 **	0.354 **	0.361 ***	0.362 *	0.449	0.353 **	0.449
	(0.194)	(0.140)	(0.138)	(0.181)	(0.272)	(0.131)	(0.272)
g : growth rate	-0.427 ***	-0.417 ***	-0.416 ***	-0.417 ***	-0.411 ***	-0.420 ***	-0.411 ***
	(0.087)	(0.087)	(0.083)	(0.083)	(0.084)	(0.084)	(0.084)
D01	-0.260						
	(0.739)						
D02		-0.003					
		(0.498)					
D03			0.080				
			(0.462)				
D04				0.042			
				(0.620)			
D12					-0.327		
					(0.818)		
D23						0.056	
						(0.394)	
D34							0.327
							(0.818)
Adjusted R-squared	0.528	0.526	0.527	0.526	0.529	0.527	0.529
S.E. of regression	1.194	1.196	1.196	1.196	1.193	1.196	1.193
Number of observations	38	38	38	38	38	38	38

Note: *, ** and *** indicate significance at the 10%, 5% and 1% level, respectively. The figure in parenthesis denotes standard error.

Table 5 Gross ICOR Standardized by per capita Income and Growth Rate (G.1')

	Growth Rate (%)									
	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0	10.0
per capita Income (US dollar)										
500	4.90	4.48	4.07	3.65	3.23	2.81	2.39	1.98	1.56	1.14
1,000	5.01	4.59	4.17	3.75	3.34	2.92	2.50	2.08	1.66	1.25
1,500	5.07	4.65	4.23	3.82	3.40	2.98	2.56	2.14	1.73	1.31
2,000	5.11	4.70	4.28	3.86	3.44	3.02	2.61	2.19	1.77	1.35
2,500	5.15	4.73	4.31	3.89	3.48	3.06	2.64	2.22	1.80	1.39
3,000	5.18	4.76	4.34	3.92	3.50	3.09	2.67	2.25	1.83	1.41
3,500	5.20	4.78	4.36	3.95	3.53	3.11	2.69	2.27	1.86	1.44
4,000	5.22	4.80	4.38	3.97	3.55	3.13	2.71	2.29	1.88	1.46
4,500	5.24	4.82	4.40	3.98	3.57	3.15	2.73	2.31	1.89	1.48
5,000	5.26	4.84	4.42	4.00	3.58	3.17	2.75	2.33	1.91	1.49
5,500	5.27	4.85	4.43	4.02	3.60	3.18	2.76	2.34	1.93	1.51
6,000	5.28	4.87	4.45	4.03	3.61	3.19	2.78	2.36	1.94	1.52
6,500	5.30	4.88	4.46	4.04	3.62	3.21	2.79	2.37	1.95	1.53
7,000	5.31	4.89	4.47	4.05	3.63	3.22	2.80	2.38	1.96	1.54
7,500	5.32	4.90	4.48	4.06	3.65	3.23	2.81	2.39	1.97	1.56
8,000	5.33	4.91	4.49	4.07	3.66	3.24	2.82	2.40	1.98	1.57
8,500	5.34	4.92	4.50	4.08	3.66	3.25	2.83	2.41	1.99	1.57
9,000	5.35	4.93	4.51	4.09	3.67	3.26	2.84	2.42	2.00	1.58
9,500	5.35	4.94	4.52	4.10	3.68	3.26	2.85	2.43	2.01	1.59
10,000	5.36	4.94	4.53	4.11	3.69	3.27	2.85	2.44	2.02	1.60

Table 6 Gross ICOR: Actual, Fitted and Residual (G.1')

		y (US dollar)	g (%)	Gross ICOR		
				actual	fitted	residual
Bangladesh	2001-07	428	5.74	4.80	4.11	0.69
Bhutan	2001-07	1,135	9.13	5.57	3.04	2.53
Brunei	1990-96	15,314	2.82	9.37	6.60	2.77
	2001-07	23,777	2.12	7.67	7.04	0.63
Cambodia	2001-07	422	9.66	2.21	2.47	▲ 0.26
China	1990-96	485	10.70	1.75	2.08	▲ 0.33
	2001-07	1,623	10.79	2.80	2.47	0.33
Hong Kong	1983-89	8,273	7.11	3.28	4.58	▲ 1.30
	1990-96	19,728	4.67	5.59	5.91	▲ 0.32
	2001-07	26,246	4.86	4.55	5.93	▲ 1.38
India	2001-07	668	7.70	4.14	3.45	0.69
Indonesia	1990-96	862	8.00	3.38	3.41	▲ 0.03
	2001-07	1,253	5.07	4.36	4.77	▲ 0.41
Korea	1983-89	3,323	9.11	3.49	3.43	0.06
	1990-96	9,124	7.63	5.38	4.40	0.98
	2001-07	15,721	4.68	6.52	5.83	0.69
Malaysia	1990-96	3,469	9.48	4.09	3.29	0.80
	2001-07	5,100	4.89	4.84	5.34	▲ 0.50
Mongolia	2001-07	923	7.31	1.50	3.72	▲ 2.22
Myanmar	1990-96	84	5.49	1.36	3.64	▲ 2.28
	2001-07	211	12.77	1.11	0.92	0.19
Nepal	2001-07	283	3.48	5.73	4.91	0.82
Pakistan	1983-89	383	6.28	3.48	3.84	▲ 0.36
	1990-96	535	4.80	4.27	4.58	▲ 0.31
	2001-07	671	5.26	3.05	4.47	▲ 1.42
Philippines	1990-96	997	2.81	7.66	5.63	2.03
	2001-07	1,200	4.97	4.09	4.80	▲ 0.71
Singapore	1983-89	7,727	6.78	4.31	4.70	▲ 0.39
	1990-96	18,475	8.89	3.33	4.12	▲ 0.79
	2001-07	27,067	4.71	4.70	6.01	▲ 1.31
Sri Lanka	2001-07	1,159	4.89	4.86	4.82	0.04
Taiwan	1983-89	4,601	9.18	2.64	3.51	▲ 0.87
	1990-96	10,977	6.64	4.43	4.88	▲ 0.45
	2001-07	14,972	4.20	5.50	6.01	▲ 0.51
Thailand	1983-89	938	8.02	3.83	3.43	0.40
	1990-96	2,212	8.59	5.27	3.50	1.77
	2001-07	2,683	5.09	4.46	5.03	▲ 0.57
Vietnam	2001-07	585	7.75	4.68	3.38	1.30

Table 7 Ng-Perron Test for Time-series Data for Regression

Variables	Ng-Perron, Intercept			
	MZa	MZt	MSB	MPT
Net ICOR				
Level	-11.12**	-2.35**	0.21**	2.20**
First difference	-13.74**	-2.60***	0.18**	1.83**
log(*y*) : per capita GDP				
Level	-1.92	-0.73	0.37	10.08
First difference	-13.45**	-2.55**	0.19**	1.95**
ag : GDP share of agriculture				
Level	-3.70	-1.19	0.32	6.65
First difference	-2.11	-0.91	0.43	10.55
id : GDP share of industry				
Level	-4.22	-1.24	0.29	6.06
First difference	-4.76	-1.34	0.28	5.54
sv : GDP share of service sector				
Level	-10.01**	-2.10**	0.21**	2.94**
First difference	-5.49	-1.62	0.29	4.56

Note: ** and *** indicate significance at the 5% and 1% level, respectively.

Table 8 Estimation Outcome for Net ICOR

Dependent variables	*d* (Net ICOR)	
	Equation (N.1')	Equation (N.2')
Const.	-0.908 **	3.350
	(0.339)	(5.012)
d (log(*y*)) : per capita GDP	17.421 **	20.708 **
	(6.535)	(7.614)
sv : GDP share of srvice sector		-0.088
		(0.104)
dummy 1997-2002	1.046 ***	1.151 ***
	(0.364)	(0.386)
Adjusted R-squared	0.202	0.195
S.E. of regression	0.709	0.712
Durbin-Watson stat	1.341	1.381
Number of observations	34	34

Note: ** and *** indicate significance at the 5% and 1% level, respectively. The figure in parenthesis denotes standard error.

Table 9 Sectors' Net ICORs and GDP Shares

	Net ICOR			GDP share		
	ag	*id*	*sv*	*ag*	*id*	*sv*
1977	1.135	0.736	2.320	23.2	27.5	49.3
1978	0.978	0.743	2.175	22.6	28.1	49.3
1979	0.923	0.823	2.232	21.9	28.6	49.5
1980	1.177	0.916	2.600	21.2	29.0	49.8
1981	0.782	0.975	2.888	20.5	29.5	50.0
1982	0.594	1.073	2.963	19.8	29.9	50.3
1983	0.773	1.146	3.426	19.1	30.3	50.6
1984	0.685	1.301	3.927	18.7	30.6	50.7
1985	0.726	1.547	4.116	18.2	30.7	51.1
1986	1.057	1.421	4.129	17.8	30.9	51.4
1987	1.155	1.181	3.731	17.3	31.3	51.5
1988	0.894	1.143	3.234	16.7	31.8	51.5
1989	0.743	1.096	3.256	16.2	32.5	51.2
1990	1.337	1.119	3.116	15.4	33.3	51.3
1991	1.523	1.211	3.430	14.6	34.2	51.2
1992	1.783	1.277	3.738	13.7	35.3	51.0
1993	2.509	1.367	3.884	12.8	36.4	50.7
1994	2.623	1.484	4.139	12.1	37.4	50.5
1995	3.756	1.525	4.370	11.3	38.3	50.3
1996	5.366	1.731	4.847	10.6	39.1	50.2
Average for 1977-1996	1.526	1.191	3.426	17.2	32.2	50.6

Source: NESDB, Government of Thailand

Figure 3 Net ICOR by Fixing Sector-Share and Sector-ICOR