Structural Change and Economic Growth: Survey and Empirical Analysis for the Asian Countries

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Structural Change and Economic Growth: Survey and Empirical Analysis for the Asian Countries[1)]

Hitoshi Osaka

1. Introduction

The simultaneous occurrence of the change of industrial structure and economic growth has been observed by many researchers. Rostow (1956) argues that the change of industrial structure is induced by the process of "take-off"[2)] into self-sustained growth from his well-known historical perspectives. He emphasises that the take-off requires not only economic, but also political, social and institutional changes in the society to enable it to respond to new opportunities for productive activities.

On the other hand, Kuznets's observation over this issue is fundamentally derived from an economic consideration. In his pioneering empirical analysis, Kuznets (1957) shows that a substantial increase of the share of the manufacturing sector both in national output and in the labour force is positively associated with rising per capita income. Moreover, he suggests that economic transformation with rising per capita income is a continuous process from agriculture to manufacturing and then from manufacturing to services, even if less systematically with a shift. The less distinctive economic transformation from manufacturing to services in relation to economic growth might be well explained by Bhagwati (1985) who regards the definition of services as nebulous.[3)] The simultaneous occurrence of industrialisation and economic growth is sufficiently established as a stylised fact but economic transformation from

1) This is a revised version of a paper presented at a conference of *Nishi-Nihon Riron Keizai Gakkai*, Fukuoka University, Fukuoka, 5 June 1999. We thank conference participants for helpful comments.

2) "Take-off" is defined as the interval during which the rate of investment increases in such a way that real output per capita rises and this initial increase carries with it radical changes in production techniques and the disposition of income flows which perpetuate the new scale of investment and perpetuate thereby the rising trend in per capita output (Rostow 1956, p.25).

3) Bhagwati (1985). Bhagwati, moreover, offers some useful identifications for services which are described as "splintering process" and "disembodiment effect" of their products. Services, in nature, are born through any productive activities. However, the classification of services more than likely depends on which sector services will be identified. For example, an in-house paint job at a car factory will be considered as a part of the manufactured goods sector whilst the paint job, if it is ordered to the individual painters, will be counted as a part of the service sector. Bhagwati identifies it as "splintering process" and also shows another example from the music industry. Singing is traditionally in the service sector and technically unprogressively labour-intensive in nature. However, singing can be "disembodied" from its traditional unprogressive component of the pre-technical change sector and enter the manufacturing sector

manufacturing to services and its impact on economic expansion is not fully perceived. The development of industrialisation from the agrarian economic system and its association with economic growth, which Kuznets observed, is perfectly consistent with the case study of Japanese economic growth by Chenery, Shishido, and Watanabe (1962), and the cross-country analyses by Chenery (1960), Chenery and Taylor (1968), Chenery and Syrquin (1975), and Chenery, Robinson and Syrquin (1986).

In this paper, we empirically analyse structural change and economic growth for 6 Asian countries. First, we review the literature on structural change and economic growth, and then demonstrate the relevant stylised facts. Second, with the application of the Granger causality test, we examine the evolutionary process of industrialisation caused by population pressure which is suggested by Boserup (1965). She observes that population pressure stimulates agricultural production and hence agricultural development to support industrialisation via technological progress. The useful historical and economic perspectives for economic transformation from the predominantly agrarian economy to the industrialised economy in the contemporary Asian developing countries are found in Oshima (1987). The Granger causality test is expected to clarify to what extent the observations made by Boserup (1965) and Oshima (1987) do fit our sample countries. Third, we test the statistical association between industrialisation and other macroeconomic variables both by the cross-country and time-series regression and by the regressions for individual countries.

Data are obtained from various issues of *the International Financial Statistics* (published by the International Monetary Fund), *the International Labour Statistics* (by the International Labour Office), *the National Accounts Statistics* (by the United Nations), and the World Bank Data Source "*STARS*" for the human capital stock. Our sample countries are Indonesia, Japan, South Korea, Malaysia, the Philippines and Thailand, and our data are on an annual basis for the 1960-90 period.

2. Literature Review and the Stylised Facts

2-1. Literature Review and Empirical Perspectives

The economic literature offers explanations for the stylised facts of the change of industrial structure and industrialisation associated with rising per capita income mainly along two lines: (i) theoretical formations and explanations in models; and (ii) historical observations through empirical analyses.

The popular theoretical explanation for the linkage between the change of industrial structure and per capita income growth is derived from the dual economy models. The concept of a "dual economy" is based on various asymmetries of production and organisation that exist in developing countries (LDCs).

with the invention of gramophones and records. The music industry can provide their traditional services in the manufacturing sector. Bhagwati further states that the disembodiment effect that characterises technical change creating goods from services is accordingly responsible for a class of services where progressivity is generally considered to be low.

Although the classical concept of economic dualism can be traced back to Ricardo,[4] the organisational asymmetry is initially presented by Boeke (1953) in the sociological context of traditional and modern sectors in the colonial Indonesia. The consequences of organisational asymmetry are different initial endowment conditions of the two sectors, their spatial characteristics, their differential potential deployment of technology; and asymmetrical rules of the game are in place in the labour market in the process of economic development.[5]

In addition to organisational asymmetry, Lewis (1954) suggests production asymmetry in the two sectors in LDCs: the fixed inputs of land, little capital, unlimited supply of labour in the traditional agriculture, and on the other hand the unrequired land inputs, the accumulation of capital, and the absorption of labour as needed in the modern industrial sector. A number of models of economic dualism have been developed, since Lewis's celebrated paper, which focused on the different kinds of asymmetries. For example, Eckaus (1955) and Higgins (1968) consider technological asymmetry, Harris and Todaro (1970) consider asymmetry of the wage structure, and Myrdal (1968), Singer (1970) and Prebisch (1971) investigate international dualism, notably in the form of "North-South" models.

One of the key problematic arguments in the evolutionary process of economic development is derived from population pressure on the economy. A well-recognised economic phenomenon is that rapid population growth has a negative economic consequence. This is especially so when population growth begins to exceed the economic growth rate. Rapid population growth may lead to Nurkse's "vicious circle" (1953), and therefore to an increase in proportion of population who are in poverty. Thus, some countries who already face a population problem, notably China and India, are keen to curb population growth to attain sustainable economic growth. However, population growth may not disturb the process of economic development insofar as the supply per capita continues to expand in the economy.

A provocative challenge to the above-mentioned conventional wisdom is posed by Simon (1981) who argues that population is indeed an important long-term stimulus to economic advance through its effects on productive technology, the pace of innovation, the formation of markets, and governmental infrastructural investments.[6] This population-push model was initially proposed by Boserup in regard to technical change in agriculture. Boserup states:

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4) Ranis (1988) envisions the initial concept of economic dualism into the ***tableau economique*** of the physiocrats in the history of economic thought. He explains that the physiocrats observed the co-existence of agriculture with a small non-agricultural sector producing services and artisanal goods if the agricultural surplus was large enough to permit some labour reallocation. However, productivity is basically regarded as a fixed factor. This agrarian dualism later led to the concept of classical dualism which is represented by Ricardo. Ranis states that:

> --- classical concept *a la* Ricardo focused on the coexistence of still overwhelmingly dominant agricultural activities subject to diminishing returns to labour on the fixed land - and without benefit of technological change - and non-agricultural activities, later recognised as a consequence mainly of the accumulation of fixed capital. (Ranis 1988, p.75.)

5) Ranis (1988), p.74.

6) Working Group on Population Growth and Economic Development (1986), p.6.

--- in typical cases the cultivator would find it profitable to shift to a more intensive system of land use only when a certain density of population has been reached. In a region where this critical level of density has not yet been reached, people may well be aware of the existence of more intensive methods of land use and they may have access to tools of a less primitive kind; still they may have preferred not to use such methods until the point is reached where the size of the population is such that they must accept a decline of output per man-hour.[7)]

Her analysis is derived from the agricultural revolution in the 18th century's Western Europe and the agricultural changes in many developing countries in the 1960s. Pingali and Binswanger (1985) support Boserup's argument from their cross-sectional study of agricultural production in 52 specific locations around the world, and find that increases in the amount of labour applied per unit of land are associated with greater intensification of agricultural production, which is, in turn, hypothesised to be a response to population pressure.[8)] Their findings may suggest that the positive effect of population pressure on agriculture is in the process of market creation and of increase in domestic demand.

Apart from the above-mentioned evolutionary process for economic development caused by population pressure, Kuznets (1957) empirically observes that the transition of industrial structure, *i.e.* industrialisation, associated with economic growth simultaneously causes the migration of labour and capital from agriculture (*i.e.* traditional sector) to non-agricultural industry (*i.e.* modern sector) in the concept of economic dualism. The driving force behind this transition lies in technological development and productivity enhancement in the production function which may lead to the productivity asymmetry. The focal point of Kuznets's perspective is that economic duality must be developed to a one-sector modern economic system as well as the productivity asymmetry disappears at the end of the economic transformation.[9)]

His notion is largely supported by the experiences of the current developed countries (DCs) who are still conceptually in the state of economic dualism in a view of Kuznets. Initially, economic duality emerged from the agrarian society with the introduction of new technologies. The productivity asymmetry between two sectors will be gradually reinforced and be associated with rising per capita income. However, it will start diminishing over time as a result of the spill-over effect on technology between two sectors from the particular point. New technologies will be more quickly and efficiently utilised in the modern industrial sector if there are economies of scale whilst the traditional agricultural sector will benefit from the established industrial sector later with some time lags. For example, the agricultural sector can improve its productivity by employing advanced farming machines.

7) Boserup (1965), p.41.
8) Working Group on Population Growth and Economic Development (1986), p.27-28.
9) The two-sector growth model can be regarded as a more generalised form of the dual economy model.

Empirically, this phenomenon had been supported in the development process of the current DCs.[10] Economic dualism should be regarded as a transitional process from the agrarian system to the modern economic system.[11] This transition could be observed by means of the structural change of industry in terms of value added, as the agriculture sector declines relative to the industrial sector, or in terms of the reallocation of labour and capital from agriculture to industry until agriculture ultimately becomes a mere appendage to the system as a whole.[12] In a sense, the Ricardian-Malthusian notion of agricultural production still plays a crucial role, especially in a closed economy, perhaps even in the modern economic growth system.

2-2. The Stylised Facts

Figure 1 from the empirical analysis by Chenery and Syrquin (1975) for the period of 1950-70 confirms the findings by Kuznets (1957) on industrialisation and economic dualism, which are consistent with Figure 2 for 6 Asian countries[13] for the period of 1960-90: the decrease of the share of the agricultural sector, and the increase of that of the industrial sector and of the service sector in GDP are associated with rising per capita income. Figures 1 and 2 clearly indicate that the decline of the share of the agricultural output in total GDP (LAGRRAT, in the natural logarithms, hereafter it is only indicated as "log") is much larger than the increase of that of other sectors (LINDRAT for the industrial sector[14] and LSERRAT for the service sector, both in logs). Moreover, the declining share of agricultural output is substantially offset by the increasing share of the industrial and service sectors' output. Although our finding for 6 Asian countries is consistent with Chenery and Syrquin, it is somewhat different from that of Kravis, Heston and Summers (1983) who observe that the share of the service sector in national income remains relatively constant across countries regardless of per capita income for 34 countries for the year 1975.[15]

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10) See Kuznets (1957), and Chenery, Shishido and Watanabe (1962).

11) Myint issues a caution in regard to the current biased industrialisation policies in LDCs. The crucial point in his analysis is that government in LDCs should not employ the biased industrialisation policy in order to pursue rapid economic expansion by offering too many subsidies. In his view, economic dualism in the current LDCs is strengthened by the unequal access to the scarce economic resources between two sectors. Myint (1970, p.128) states that:

> Our interpretation of dualism emphasises the importance of domestic economic policies to promote internal economic integration between the modern and the traditional sectors of the under-developed countries by removing as far as possible the causes of unequal access to the scarce economic resources by the two sectors.

Myint also recognises the existence of the various sociological and technological rigidities together with the problem of under-employment and factor disproportionalities in LDCs. Although economic dualism is unavoidable in the process of economic development as most of the current DCs have experienced, the structural difficulties of "official" economic dualism may hinder the internal integration of the underdeveloped economies as they proceed towards Kuznets's one-sector modern economic system. Moreover, he observes"official"dualism as a species of distortion in the allocation of resources arising out of the unequal terms on which economic resources such as capital, foreign exchange and public economic services should be made available to the two sectors, although he accepts the incentives of governments in LDCs to create such "official" economic dualism.

12) Ranis (1988), p.76.

13) Indonesia, Japan, South Korea, Malaysia, the Philippines, and Thailand.

14) In this paper, the industrial sector does not only indicate the manufacturing industry, but also includes the mining and construction industries.

In this paper, we more focus on structural change in a sense of industrialisation and economic growth so that Figure 2 is modified into Figure 3 by defining the term of industrialisation: the ratio of industrial output (GDP) to agricultural output (LINDAGR, in logs).[16] Figure 3 also shows the sectoral share of the financial sector in total GDP,[17] which may suggest the role of financial development[18] on industrialisation. Figure 2 and the correlation matrix demonstrate the substantial correlations among GDP per capita (LGDPH85, in logs at the 1985 US price), LINDAGR, and the share of the financial sector's output in total GDP (LFINRAT, in logs) across our sample countries between 1960 and 1990[19]: the correlation between LGDPH85 and LINDAGR is 0.909, and that between LGDPH85 and LFINRAT and that between LINDAGR and LFINRAT are both about 0.8, which are very substantial.

The similar observations in the employment structure are found in Figure 4.[20] The correlation

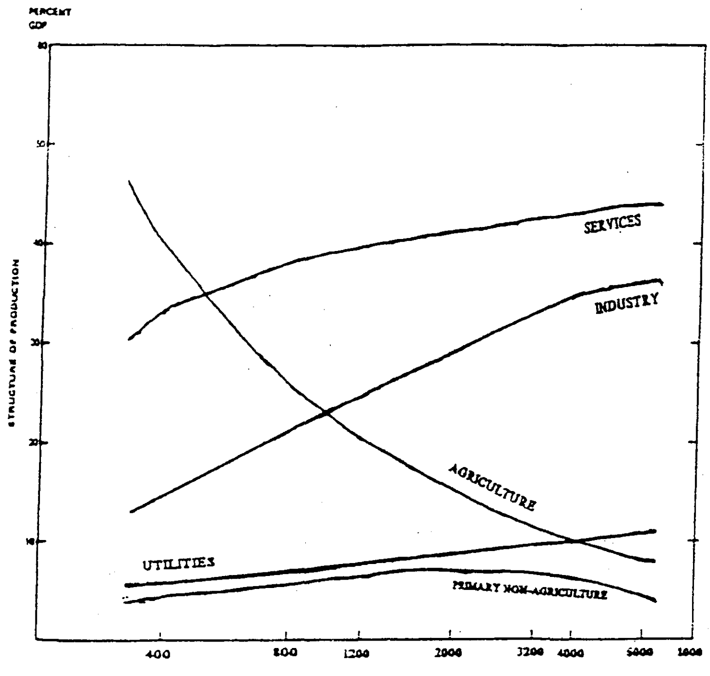


Figure 1: Evolution of Sectoral Shares of GDP with Economic Development (adapted from Chenery and Syrquin, 1975)

15) The estimation of Kravis, Heston and Summers (1983) is based on PPP (purchasing power parity) conversion of expenditure. It should be noted, moreover, that Kravis *et al* is a cross-section study which is different from a cross-section and time-series analysis of Chenery and Syrquin (1975).

16) INDAGR = (industrial output / agricultural output) × 100.

17) It should be noted that the role of the service sector for industrialisation is out of our scope due to the nebulous nature of services as we have already discussed.

18) Financial sector is here defined as the financial institutions and the related financial service industries and hence financial development here simply signifies the development of the financial sector in terms of its sectoral output share in total GDP.

19) It excludes the Indonesian data for 1960-62 due to its unavailability. The total number of observations is 183.

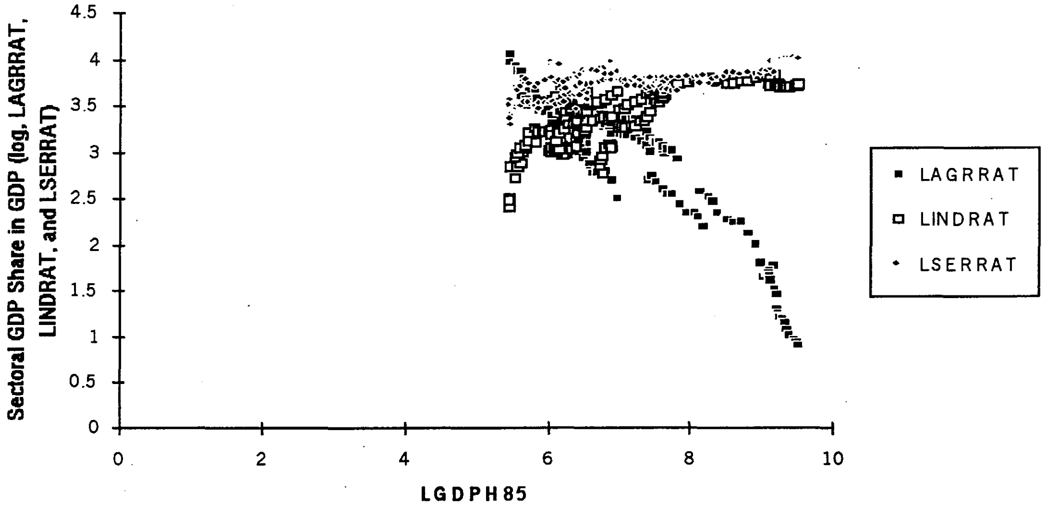
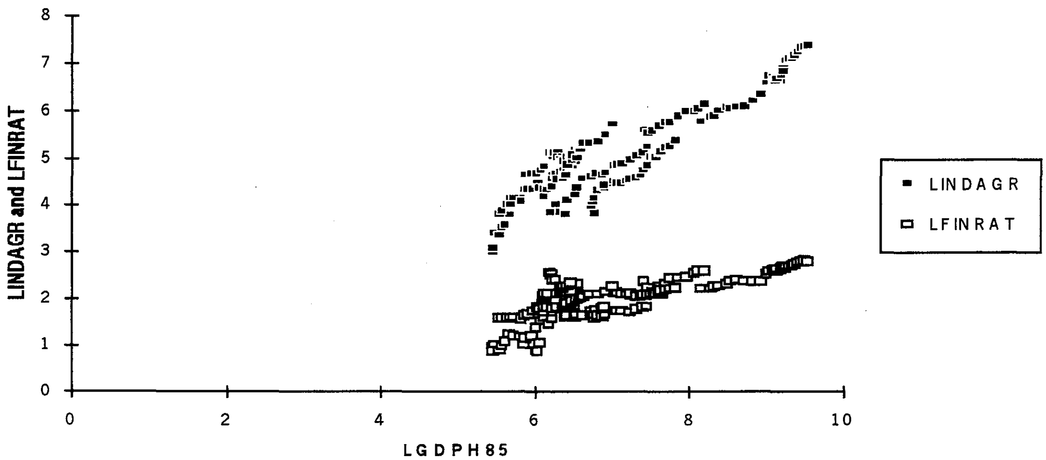


Figure 2: LGDPH85 and Sectoral GDP Share in GDP (log)



Correlation Matrix (183 observations)

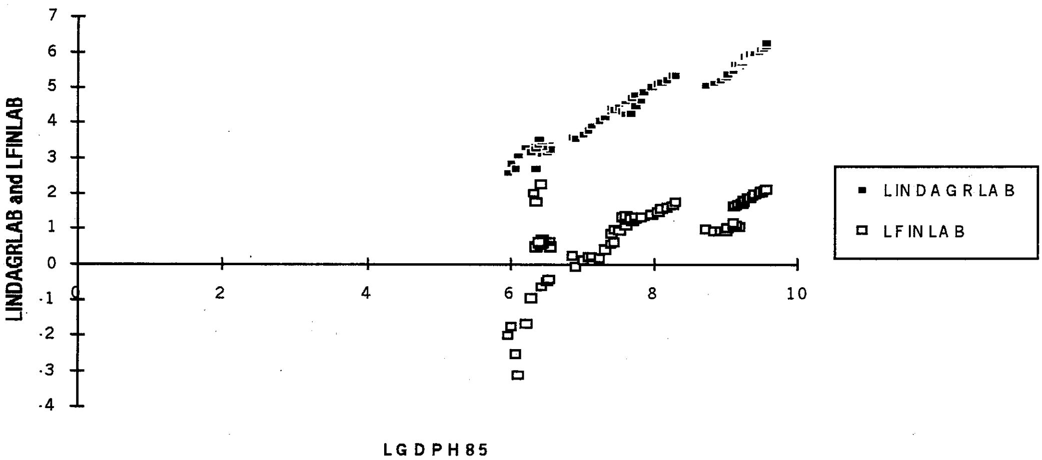
	LGDPH85	LINDAGR	LFINRAT
LGDPH85	1.000		
LINDAGR	0.909	1.000	
LFINRAT	0.771	0.807	1.000

Figure 3: LGDPH85, LINDAGR, and LFINRAT

20) The sample period is between 1960 and 1992, and the total number of observations is 84 due to the data unavailability. The following data are missing: Indonesia (1960-75, 80-81, 88, and 92), Japan (1960-66), South Korea (1960-70), Malaysia (1960-81, and 91-92), the Philippines (1960-75, and 79), and Thailand (1960-92). It should be noted, moreover, employment is synonymous to labour in this paper.

between LGDPH85 and LINDAGRLAB (the ratio of industrial employment to agricultural employment, in logs)[21] is close to unity (0.983). A larger labour employment in the industrial sector can be clearly found in the highly industrialised economy. The correlation between LGDPH85 and LFINLAB (the employment share of the financial sector in the total employment, in logs) and that between LINDAGRLAB and LFINLAB are very high, however less than those in output in Figure 3. Although some correlations are more impressive than those in Figure 3, they need to be treated with caution since the number of observations is largely reduced in Figure 4 since the adequate data are not available. Moreover, several outliers of LFINLAB in Figure 4 are all from Indonesia.

Lastly, Figure 5 exhibits the correlation between LGDPH85 and LINAGYL (the ratio of output per labour in the industrial sector to that in the agricultural sector, in logs).[22] The correlation matrix is not impressive in contrast to Figures 3 and 4 and indicates about 0.5 between the two variables. Figure 5 interestingly suggests that our sample countries can be subdivided into two groups: LINAGYL1 for Group 1 (Japan, South Korea and Malaysia) and LINAGYL2 for Group 2 (Indonesia, the Philippines and Thailand). Although GDP per capita for 3 countries in Group 1 is substantially higher than that in



Correlation Matrix (84 observations)

	LGDPH85	LINDAGRLAB	LFINLAB
LGDPH85	1.000		
LINDAGRL	0.983	1.000	
LFINLAB	0.677	0.694	1.000

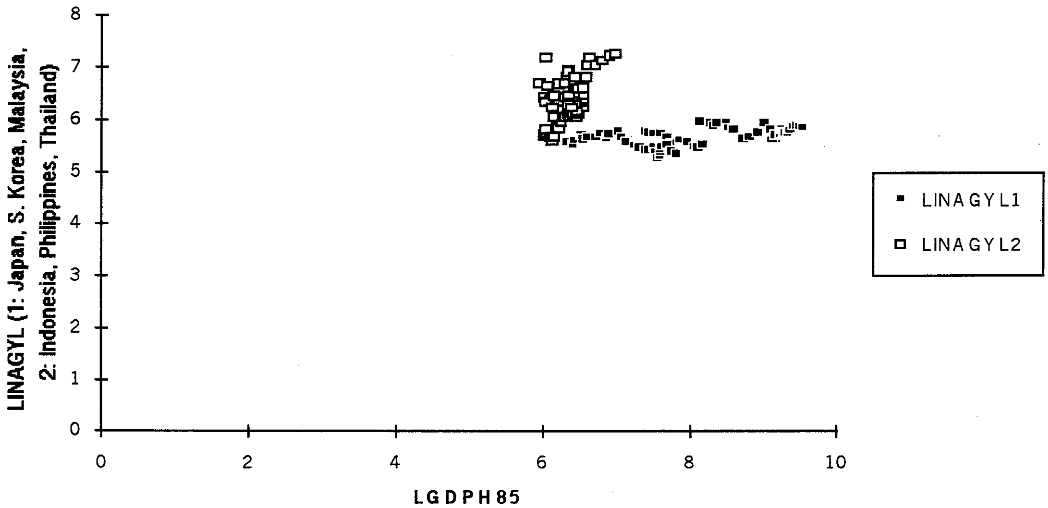
Figure 4: LGDPH85, LINDAGRLAB, and LFINLAB

21) INDAGRLAB = (industrial employment / agricultural employment) × 100.

22) INAGYL = (output per labour in the industrial sector / output per labour in the agricultural sector) × 100. The sample period is between 1960 and 1990, and the total number of observations is 130: 70 for Group 1 (Japan, South Korea, and Malaysia) and 60 for Group 2 (Indonesia, Thailand, and the Philippines). The data missing as follows: Indonesia (1960-75, 80-81, and 83-84), South Korea (1960-62), Malaysia (1960-79), Thailand (1960-70) and the Philippines (1971 and 79).

Group 2,[23] the correlation between LGDPH85 and LINAGYL for Group 2 is much higher than that for Group 1, which is in fact consistent with Kuznets's observation (1957): the larger productivity gap between two sectors, which is shown as the higher figure of LINAGYL, is more distinctive in the catching-up developing countries.[24] Kuznets suggests that the productivity gap between agriculture and industry widens during the transition period towards industrialisation and hence narrows as the state of economic maturity is approached.

In a nutshell, we reaffirm the stylised facts, initially observed by Kuznets and others, for our 6 Asian sample countries in this brief descriptive data analysis: the decreasing share of the agricultural sector and the increasing share of the industrial sector both in GDP and in employment as per capita GDP increases. Moreover, the productivity difference between two sectors more explicitly exists in the lower income countries, in terms of GDP per capita, than in the higher income countries.



Correlation Matrix (70 observations for LINAGYL1 and 60 for LINAGYL2)

	LGDPH85	LINAGYL1	LINAGYL2
LGDPH85	1.000		
LINAGYL1	0.451	1.000	
LINAGYL2	0.562	-	1.000

Figure 5: LGDPH85 and LINAGYL

23) GDP per capita for 1990, for example, as follows: Japan (US$ 13476), South Korea (US$ 3526), Malaysia (US$ 2436), Thailand (US$ 1067), Indonesia (US$ 659) and the Philippines (US$ 627) at the 1985 price.

24) It should be noted that the relevant Malaysian data are only available since 1980.

3. The Change of Industrial Structure for Industrialisation: the Granger Causality Test[25)]

We initially employ the Granger causality test in order to investigate the causal directions associated with the change of industrial structure for our sample countries. We subsequently proceed to the cross-country and time-series regressions and the regressions for individual countries whose econometric model heavily depends on the stylised facts but not the firm theoretical model mainly due to the unavailability of data on the aforementioned dual economy models, especially the data for the rural and agricultural sectors.

Prior to the Granger causality test, we examine the order of integration for all variables by the unit roots test. Appendix 1 exhibits the Dickey-Fuller (DF) and the augmented DF (ADF) unit roots test results, which indicate the possible I(1) property for all variables across sample countries. It should be noted, however, that the unit roots test results also reveal the contradictory results at various levels. For example, the ADF test shows the possible order of integration for LHUM for Indonesia either at I(0), I(1) or I(2), depending upon the inclusion of trend and constant variables in the unit roots test. These contradictory test results of unit roots at various levels might be due to the small sample bias or it may suggest the fractional process of integration of these variables.[26)] Based on these unit roots test results, we presume that all variables for our sample countries are I(1). We then examine the co-integrating relationships between the pairs of series which are used for the Granger causality test. If the pairs of series appear to be co-integrated, our Granger causality test takes the form:

$$X_t = c + \sum_{i=1}^{m} \gamma_i \Delta X_{t-i} + \sum_{j=1}^{n} \delta_j Y_{t-j} + u \qquad (1)$$

On the other hand, if the pairs of series do not appear to be co-integrated, the Granger causality test takes in difference form below in order to avoid obtaining the potentially spurious results:

$$\Delta X_t = c + \sum_{i=1}^{m} \gamma_i \Delta X_{t-i} + \sum_{j=1}^{n} \delta_j \Delta Y_{t-j} + u \qquad (2)$$

25) PcGive 8.0 and Econometric Views 2.0 are used for the regression analyses in this paper.

26) There has been a growing literature which studies the source of non-stationarity in macroeconomic series in terms of fractionally differenced time series. For example, the fractional process of integration of times series can be shown as follows:

$(1-L)^d \, y_t = \mu + \gamma t + u_t, \quad t = 1, 2, \text{---},$

If $\mu = \gamma = 0$, if u_t is an I(0) series, and if $0<d<1/2$, then y_t is a covariance stationary I(d) series, having autocovariances which decay much more slowly than those of an ARIMA process, in fact so slowly as to be nonsummable (Gil-Alana and Robinson, 1997, p.245). Moreover, the fractional process of integration of time series can be also found, for example, when $1<d<3/2$, which might be the case in our unit roots tests. See Gil-Alana and Robinson (1997) for the recent literature survey for the fractional process of integration of time series.

Appendix 2 shows the co-integration test results by the Solved Static Long-run Equation by Doornik and Hendry (1994) for all the pairs of series which indicate the possible co-integrating relationships for 10 pairs of series across our sample countries: Indonesia (LINDAGR and LHUM), Japan (LPOP and LAGR, LIND and LAGR, LHUM and LINDAGR, and LINDAGR and LHUM), the Philippines (LAGR and LPOP, LAGR and LIND, and LINDAGR and LHUM) and Thailand (LAGR and LPOP, and LINDAGR and LHUM). Therefore, these 10 pairs of series of co-integrating relationships take the Granger causality test in levels in equation (1) whilst other pairs of series take the difference form in equation (2).

We, moreover, take 3 different lags in equations (1) and (2), *i. e.* $n = m = 1, 2, 3$. Our decision for taking 3 continuous lags is somewhat conventional. We highlight our investigation for 4 different causal directions: (i) population → agricultural output; (ii) agricultural output → industrial output; (iii) population → the level of industrialisation; and (iv) human capital → the level of industrialisation. The causal investigation for (i), (ii) and (iii) are stimulated by Boserup (1965) and Oshima (1987). The causality test for (iv) is inspired by Lucas (1988) who postulates the endogenous economic growth caused by human capital. Concerning the endogeneity of human capital for economic growth in the Lucasian Model, we hypothesise the simultaneous emergence of human capital and industrialisation so that the test results should exhibit non-causality for both causal directions if our sample period adequately fits the emergence of a dual economy for any of our sample countries. What is more interesting for the causality test between human capital and industrialisation is the comparison with the causality test (iii) whose causal direction should be from population to industrialisation, suggested by Boserup[27] and Oshima. The averaged years of schooling per labourer is a proxy for human capital stock taken from the World Bank Database "*STARS*".[28]

3-2. The Granger Causality Test: Results

The results of the Granger causality test are shown in Appendix 3. Our results do not fully accommodate the observation by Oshima: the monsoon Asian countries, mainly the Southeast and East Asian economies, are following the pattern of Japan's pre-World War 2 economic development. Our results are somewhat consistent with Kalirajan and Kapuscinski (1990): agricultural development does not necessarily lead to industrial development across sample countries. It does not mean, however, that our test results can reject Oshima's observation for economic development of the Asian countries. Two issues can be raised for further considerations and researches. First, our test results are derived from the same sample period across countries without making allowance for the development stage of each economy.

27) Boserup (1965) does not argue the direct causality from population to industrialisation but the causal direction from population to the agricultural development with some implications of the spill-over effect of technological development on industrialisation.

28) Human capital data are only available between 1960 and 1987 in "*STARS*" so that the rest of the data between 1988 and 1990 are interpolated by the trend projection by the author.

For example, the Philippines were already on the road to industrialisation in 1960 just after Japan although this did not eventually succeed (at least until about 30 years later). On the other hand, Indonesia was still regarded as a predominantly agrarian economy during the same period.[29] The second consideration relates to the different initial natural endowments and the influence of the non-economic factors in the development process. Moreover, the causality test between the macroeconomic aggregates does not take account of the social or political factors underlying these data.

Boserup's notion that population pressure stimulates agricultural development and hence industrial development is only found for the Philippines and Thailand by our causality test. Boserup seemingly placed her observation about population pressure on economic development as the natural outcome without having considered the government intervention in the development process. In fact, our 6 sample countries adopted government-led industrialisation policies in the 1960s and 1970s which may appear to have disrupted Boserup's observation on the natural process of economic development.

We list the test results below from Appendix 3 which indicate statistical significance at the 10 % level and show the Granger causality (A → B: A Granger-causes B):

Indonesia			
Agriculture	→	Population	(2 lags)
Japan			
Population	→	Agriculture	(1 lag, 2 lags, 3 lags*[30])
Industry	→	Agriculture	(1 lag)
Industrialisation	→	Population	(1 lag, 2 lags and 3 lags)
South Korea			
Agriculture	→	Industry	(2 lags)
Human Capital	→	Industrialisation	(1 lag, 2 lags and 3 lags)
Industrialisation	→	Human Capital	(1 lag*)
Malaysia			
Agriculture	→	Population	(3 lags)
Population	→	Industrialisation	(1 lag)
The Philippines			
Population	→	Agriculture	(1 lag* and 2 lags)
Agriculture	→	Industry	(1 lag, 2 lags and 3 lags)

29) Our measures for the level of industrialisation, the ratio of industrial output to agricultural output (%), for 6 Asian countries in 1960 are as follows: Indonesia (11.7), Japan (332.2), South Korea (53.6), Malaysia (47.4), the Philippines (76.3), and Thailand (46.7).

30) * denotes the serial autocorrelation problem in the relevant equation of the Granger-causality test, which is detected by the Lagrange multiplier (LM) test (2nd order) and indicates the possibility of spurious regressions.

Industry	→	Agriculture	(1 lag*, 2 lags and 3 lags)
Industrialisation	→	Human Capital	(1 lag*)

Thailand

Population	→	Agriculture	(1 lag, 2 lags and 3 lags)
Agriculture	→	Industry	(1 lag, 2 lags and 3 lags)
Industry	→	Agriculture	(1 lag)
Population	→	Industrialisation	(2 lags and 3 lags)
Industrialisation	→	Human Capital	(1 lag, 2 lags and 3 lags)

which provides five interesting observations. First, that Boserup notion of population growth exerts pressure on agricultural development is only found for Japan, the Philippines and Thailand. Interestingly, Indonesia and Malaysia exhibit the opposite causal direction from agriculture to population. Japan and Thailand, moreover, emphasise agricultural development Granger-caused by population growth which is eventually indicated by all lagged (up to 3 lags) causality tests.

Second, the Philippines and Thailand show both causal directions (population → agriculture) and (agriculture → industry). Industrialisation for these countries thus appears to be Granger-caused by population growth which well supports Boserup.

Third, as Boserup alludes, Malaysia and Thailand exhibit that their industrialisation is Granger-caused by population growth (population → industrialisation) though the previous investigation for (agriculture → industry) does not accommodate it for Malaysia. On the other hand, the causal direction from industrialisation to population for Japan suggests that Japan's industrialisation and economic growth has the negative impact on population growth. However, we are not able to detect further details of this causal linkage from this causality test.

Fourth, South Korea, the Philippines and Thailand show the possibility of agriculture-led industrial development (agriculture → industry). This is in line with Oshima's observation that the post-World War 2 monsoon Asian countries follow Japan's pre-World War 2 development pattern whose industrialisation was substantially led by agricultural development. This observation, however, should be treated with caution since our sample size for countries and period might be too small to examine Oshima's observation as we have already discussed. On the other hand, Japan, the Philippines and Thailand demonstrate the industry-led agricultural development which may imply the spill-over effects of technological development from industry to agriculture. Moreover, the Philippines and Thailand indicate the feedback system by showing the two way causal directions between agriculture and industry.

Lastly, human capital, in terms of the averaged years of schooling per labourer, appears to be a causal factor for industrialisation only for South Korea (human capital → industrialisation). Moreover, the statistically substantial reverse causal direction (industrialisation → human capital) is only found for

Thailand.[31] The insignificant causal relations between these two variables for other countries may suggest the endogeneity of human capital for economic growth hypothesised in Lucas.

In a nutshell, our Granger causality test shows that population and agriculture are the major determinants of causal relations (for either direction) among variables that we have considered. Moreover, as Boserup has suggested, agricultural development appears to be Granger-caused by population growth for Japan, the Philippines and Thailand whilst industrialisation is Granger-caused by population for Malaysia and Thailand.

4. The Cross-country and Time-series Data Analysis and the Individual Country Data Analysis

4-1. The Cross-country and Time-series Data Analysis

The data sets that combine time-series and cross-country are common in economics and are expected to provide a rich source of information. In this section, we conduct a cross-country and time-series data analysis for investigation on economic association between the change of industrial structure and other macroeconomic variables based upon the stylised facts as we have previously discussed. We presume the industrialisation variable, the ratio of industrial output to agricultural output, as a proxy for structural change in the economy. We employ two different kinds of panel estimates: (i) those based simply on the pooled data regressions; and (ii) those whose parameters are restricted to be common across countries over the same time period in a system equation.[32]

In this section, we compare 3 different parameter estimates for determining economic associations between industrialisation and other macroeconomic variables:

(i) the pooled data regression (OLS) in equation (A-9) in Appendix 5
(ii) the parameter estimates in a system equation (OLS) in equation (A-10) in Appendix 5
(iii) the time-series regression for individual countries (OLS)

We employ the following variables for this regression analysis:

LINDAGR:	the level of industrialisation (the ratio of industrial output to agricultural output, in logs)
LGDPH85:	real output (GDP) per capita (US$ at the 1985 price, in logs)
LFINRAT:	the ratio of the output of the financial institutions and the relevant business services in total output (in logs)

31) Our causality test also suggests its possible causal direction of (industrialisation → human capital) for South Korea and the Philippines, however the LM test indicates the possibility of their spurious regressions.
32) See Appendix 5 for details.

LHUM: the averaged years of schooling per labourer (in logs)

LPOP: total population (million, in logs)

LOPEN: the openness of trade (the ratio of the total sum of exports and imports to total output, in logs)

LGDPH85 is output per capita and is hypothesised as domestic demand per capita. It is expected to show the positive association with industrialisation as Chenery and Syrquin (1975) demonstrated. Moreover, LFINRAT in the regressions may provide the statistical support for the stylised fact in Figure 3: the positive association between LINDAGR and LFINRAT as well as that between LGDPH85 and LFINRAT. LFINRAT highlights the financial development for industrialisation by showing its statistical significance in the regressions. LHUM is our proxy for human capital which is hypothesised as a consequent factor for industrialisation. Employing the population variable, LPOP, in the regressions is hinted at by Chenery and Syrquin (1975), and by doing so, we are able to examine the role of population on industrialisation, implied by Boserup (1965). Lastly, LOPEN is a proxy for assessing the impact of international trade on industrialisation.

As we have previously investigated in the unit roots test, all variables for our sample countries appear to be I(1), which may suggest the I(1) property of pooled cross-section time series data and the related inference problems in the regressions with variables in levels as suggested by Funke, Hall and Ruhwedel (1997). We, therefore, follow Funke, Hall and Ruhwedel (1997) and our pooled regression (A-9) takes the form in first difference:

$$\Delta LINDAGR = c + \alpha_1 \Delta LGDPH85 + \alpha_2 \Delta LFINRAT + \alpha_3 \Delta LHUM + \alpha_4 \Delta LPOP + \alpha_5 \Delta LOPEN \qquad (3)$$ [33]

Moreover, the system equation (A-10) and the individual country estimates are also examined in first differences for comparison.

4-2. Regression Results for the Cross-country and Time-series Data

Table 1 exhibits the regression results for the pooled cross-country and time-series data (P1), the system equation (P2) and the individual countries. P1 and P2 show the similar parameter estimates for ΔLGDPH85 (0.458 and 0.451), ΔLFINRAT (0.178 and 0.180) and ΔLOPEN (0.251 and 0.265) whilst the parameter for ΔLPOP provides the different results (-0.714 and -0.132, the former parameter for P1 and the latter parameter for P2, respectively). However, these parameter values are not well supported by those of individual countries. Only the parameter for ΔLGDPH85 for Japan and the parameter for

33) Δ in front of each variable denotes the first differenced operation.

ΔLOPEN for Indonesia, Japan and South Korea show the similar values with those of P1 and P2 though some of these parameter estimates do not enter the regressions significantly. Consequently, each country appears to provide a unique regression result, which is different from both the panel estimates in equation (A-9, P1) and the result in the system equation (A-10, P2). For example, the parameter values for ΔLHUM for P1 and P2 indicate 0.753 and 0.522, respectively. However, the same parameter value for

Table 1: The Parameter Estimates for the Pooled Data Regression, the System Equation and the Individual Countries

Dependent Variable: ΔLINDAGR (1961 - 1990)

	P1	P2	Indonesia	Japan	S. Korea	Malaysia	Philippine	Thailand
Constant	0.028	N	-0.289	0.069	-0.040	0.090	-0.015	-0.006
(S.E.)	(0.024)	-	(0.181)	(0.042)	(0.083)	(0.097)	(0.110)	(0.122)
ΔLGDPH85	0.458	0.451	1.845	0.439	0.815	0.076	0.842	-0.222
(S.E.)	*(0.199)	*(0.213)	+(1.073)	(0.324)	+(0.486)	(0.330)	*(0.355)	(0.612)
ΔLFINRAT	0.178	0.180	-0.152	0.670	0.645	-0.152	0.040	1.503
(S.E.)	**(0.066)	**(0.067)	(0.334)	+(0.355)	**(0.151)	(0.198)	(0.058)	**(0.369)
ΔLHUM	0.753	0.522	6.942	3.993	0.086	1.800	-1.222	6.212
(S.E.)	(0.539)	(1.125)	+(4.113)	(6.073)	(2.368)	(1.825)	(2.327)	(6.759)
ΔLPOP	-0.714	-0.132	2.804	-6.327	1.688	-3.689	1.632	-2.619
(S.E.)	(0.955)	(1.319)	(3.567)	(5.083)	(3.618)	(3.007)	(3.722)	(2.199)
ΔLOPEN	0.251	0.265	0.299	0.209	0.278	0.142	0.051	0.121
(S.E.)	**(0.065)	**(0.066)	(0.222)	+(0.120)	*(0.136)	(0.188)	(0.120)	(0.193)
R^2	0.149	N	0.348	0.224	0.525	0.099	0.275	0.434
σ	0.097	N	0.155	0.065	0.081	0.062	0.063	0.082
F	**6.088	N	+2.560	1.385	**5.306	0.528	1.819	*3.688
DW	1.940	N	2.430	1.475	2.263	1.356	2.383	1.971
log likelihood	167.065	-	-	-	-	-	-	-
AUTO (2,22)	-	-	1.495	1.037	0.757	0.922	1.878	0.267
ARCH(1,22)	-	-	0.022	0.083	1.635	0.568	0.133	0.287
NORM Chi^2	-	-	**11.558	1.355	0.874	1.636	**12.486	0.138
RESET(1,23)	-	-	0.016	2.312	0.033	0.758	1.198	0.903

Note: same as Appendix 4 and additionally;

Δ:	the first differenced operation
(S.E.):	standard error of coefficients
N:	individual countries show each own estimates and statistical significance in the system equation (A-10)
P1:	the estimates in the pooled data regression (A-9)
P2:	the estimates in the system equation (A-10)
R^2:	the goodness of fit
σ:	the standard error of regression
F:	F-test, (5, 174) for P1 and (5, 24) for the individual country results
DW:	the Durbin-Watson test for the serial autocorrelation
AUTO:	LM autocorrelation test
ARCH:	ARCH heteroscedasticity test
NORM:	Jarque-Bera Normality test
RESET:	Ramsey specification test
[prob]:	p (probability) value
**:	the statistical significance at the 1 % level
*:	the statistical significance at the 5 % level
+:	the statistical significance at the 10 % level

ΔLHUM varies from -1.222 for the Philippines to 6.942 for Indonesia and these statistical consequences are also various among sample countries. These different outcomes may suggest that each country is at a different stage of economic development. We, therefore, more focus on the regression results for individual countries in the following section.

4-3. Regression Results for Individual Countries

As we have previously mentioned, Table 1 highlights idiosyncrasies of individual countries. In this section, we attempt to more clarify similarities and differences for industrialisation among our sample countries by examining the co-integrating relationships among variables in levels and the regressions for the first differenced variables for individual countries.

First of all, in our previous unit roots test, all variables for our sample countries appear to be I(1) so that we first examine the long-run associations among variables in levels for individual countries by the co-integration test. We employ the Solved Static Long-run Equation technique of Doornik and Hendry (1994) for the co-integration investigation. With LINDAGR as the dependent variable in the regressions, we examine all the possible co-integrating relationships among variables for our sample countries. Indonesia and South Korea only show the co-integrating relationships among variables whilst Japan, Malaysia, the Philippines and Thailand do not exhibit any co-integrating relationships at the 5 % significance.

Appendix 6 exhibits the details of co-integrating relationships among variables in levels for Indonesia and South Korea. The co-integration test reveals that LPOP and LOPEN have the long-run associations with our industrialisation variable, LINDAGR, for Indonesia whilst LFINRAT and LHUM have the long-run associations with LINDAGR for South Korea. In other words, international trade and population growth have shown the long-run positive impacts on Indonesia's industrialisation whilst the increase of financial activities in total output and human capital have led to South Korea's industrialisation. The positive association between LINDAGR and LPOP for Indonesia can be seen as the evidence for Boserup.

We then proceed to analyse the regressions for the first differenced variables. Since only Indonesia and South Korea indicate the co-integrating relationships among variables in levels, we use them as the error correction terms in their regressions for the first differenced variables. For other countries, we do not include any error correction terms in the regressions for the first differenced variables since no co-integrating relationships among variables in levels are found in their co-integration tests. Moreover, we also include all the differenced variables with one lag in the regressions and the regression results are then nested unless these results reveal any diagnostic problems. Appendix 7 exhibits the regression results for the first differenced variables, which are also summarised in Table 2. There are four interesting findings.

First, ΔLGDPH85 significantly enters the regressions for Indonesia, the Philippines and Thailand with

Table 2: Summary Table: Parameter Values for the Individual Countr

Dependent Variable: LINDAGR (levels and first differenced variables)

	Indonesia		Japan		South Korea		Malaysia		Philip		Thailand	
	L	Δ	L	Δ	L	Δ	L	Δ	L		L	Δ
$LINDAGR_{-1}$	-		-		-		-	+0.306	-		-	
LGDPH85		+1.278		(0.287)				(0.446)		989		(-0.703)
$LGDPH85_{-1}$	-		-		-	+-0.586	-		-		-	+1.449
LFINRAT				+0.720	**0.362	**0.540		+0.275				+0.908
$LFINRAT_{-1}$	-	*0.457	-		-		-		-		-	
LHUM				(5.624)	**1.965							
$LHUM_{-1}$	-		-		-		-		-		-	
LPOP	**3.158	*5.276						**7.194				(-2.298)
$LPOP_{-1}$	-		-	(-7.678)	-		-		-		-	
LOPEN	**0.649	**0.629		+0.214		*0.259						
$LOPEN_{-1}$	-		-		-		-		-	212	-	

Note: the above table is based on Appendices 6 and 7

- L: the long-run parameter values (co-integrating relationships) by the Solved Static Long-rι uation (variables in levels, in logs)
- Δ: the short-run parameter (the first differenced variables)
- **: the statistical significance at the 1 % level
- *: the statistical significance at the 5 % level
- +: the statistical significance at the 10 % level
- ( ): statistically insignificant variables at the 10 % level

the large parameter values which are about 1.0. Only for South Korea, its lagged variable enters the regression with the negative parameter value. Second, ΔLFINRAT appears to be consequent in the regressions with the positive sign for all sample countries with the only exception of the Philippines. Japan and Thailand indicate the higher parameter values for ΔLFINRAT and show 0.720 and 0.908, respectively. On the other hand, the parameter value for ΔLFINRAT indicates 0.457 for Indonesia ($\Delta LFINRAT_{-1}$), 0.540 for South Korea and 0.275 for Malaysia, respectively. Third, ΔLOPEN positively enters the regressions for Indonesia (0.629), Japan (0.214) and South Korea (0.259), but negatively does for the Philippines (-0.212, $\Delta LOPEN_{-1}$). Fourth, ΔLPOP demonstrates the substantial impacts on industrialisation for Indonesia and Malaysia with the parameter values of 5.276 and 7.194, respectively, whilst ΔLHUM does not enter any regressions significantly. The insignificance of the differenced variable of LHUM in the regressions is somewhat reasonable since human capital in nature tend to grow with small fluctuations over time compared with other macroeconomic variables.

In sum, each country appears to provide a unique regression result, which may suggest that each country is at a different stage of economic development. However, we can still find some similarities between the industrialisation variable and other macroeconomic variables across our sample countries. ΔLFINRAT appears to be consequent for ΔLINDAGR for all countries with the exception of the Philippines. ΔLGDPH85 and ΔOPEN also appear to be substantial for ΔLINDAGR for many sample countries. Only Malaysia shows both insignificant variables of ΔLGDPH85 and ΔOPEN in the regressions. Interestingly, the human capital variable is only significant in the co-integrating relationship for South Korea. Moreover, LPOP and LOPEN appear to be statistically consequent both in the co-integrating relationships and in the regressions for the first differenced variables for Indonesia.

Consequently, our test results for the panel data do not appear to be well supported by the regression results for individual countries, whose similarities appear to be rather modest and whose differences may more highlight the distinctive properties among variables across sample countries.

5. Concluding Remarks

This paper surveys the economic literature for structure change and economic growth, exhibits the stylised facts and conducts the econometric analysis for 6 Asian countries.

Our Granger causality test reveals that agricultural development does not generally lead to industrial development and our sample countries do not necessarily follow the pattern of Japan's pre-World War 2 economic development. Boserup's notion of population growth exerts pressure on agricultural development is only found for Japan, the Philippines and Thailand. The Philippines and Thailand moreover show both causal directions (population → agriculture) and (agriculture → industry). Industrialisation for these countries thus appears to be Granger-caused by population growth which well supports Boserup. On the other hand, Indonesia and Malaysia exhibit the opposite causal direction from agriculture to population. Moreover, only South Korea, the Philippines and Thailand show the possibility of agriculture-led industrial development in line with Oshima's observation. The insignificant causal relations between human capital and industrialisation for our sample countries except South Korea may suggest the endogeneity of human capital for economic growth hypothesised in Lucas. It is important to note, however, that two issues can be raised for further considerations and researches: (1) our test results are derived from the same sample period across countries without making allowance for the development stage of each economy; and (2) our results may imply the different initial natural endowments and the influence of the non-economic factors in the development process among sample countries.

Moreover, per capita output, the consequence of financial institutions in terms of its output share in total output, and international trade generally appear to be the determinants of the economic transformation from agriculture to industry, *i.e.* industrialisation, across sample countries in our regression analysis. However, the comparison between the cross-country and time-series regression results and the regression results for individual countries more highlights the idiosyncracies of individual countries rather than the similarities by demonstrating the distinctive properties of the parameter values and statistical significance among variables across our sample countries. It may consequently suggest that the similarities for the patterns of the structural change associated with economic growth demonstrated by the stylised facts are not statistically robust and our empirical results provide little policy implications especially in view of individual countries. Therefore, we need to further proceed our investigation towards the causal factors behind the relations between the change of industrial structure and economic growth.

Finally, as we have reviewed, there is a gap among economic literature of the dual economy models, including the two-sector models, and the economic perspectives by Kuznets for the explanations for the economic transformation of industrialisation associated with economic growth. The dual economy models are essentially static in nature and are not able to demonstrate effectively the inter-sectoral factor movements of capital and labour in the course of economic expansion and the associated change of industrial structure due to their restrictive asymmetry assumptions and factor immobilities. We thus may not theoretically find the internal integration and the end of economic dualism in the dual economy models, which are consequently different from the empirical perspectives of Kuznets for economic dualism and hence for the one-sector economic system. On the other hand, two-sector models do not highlight the idiosyncrasies which exist in LDCs such as social rigidities and bottlenecks whilst they focus well on the inter-sectoral factor transformation of labour and capital from agriculture to industry associated with economic development. Therefore, we need to close these gaps among theoretical and empirical analyses in our future research.

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Appendix 1: Unit Roots Test (1960-90)

Indonesia

	DF			ADF			Order of Integration
	T, C	C	N	T, C	C	N	
LPOP	-1.700	-1.777	12.428	-1.619	-1.782	2.429	
Δ LPOP	**-4.863	**-4.497	-1.555	-2.751	-2.945	-1.094	1
Δ_2 LPOP	**-8.088	**-8.208	**-8.331	**-5.428	**-5.511	**-5.580	
LAGR	-2.716	0.436	1.814	-1.255	1.215	2.223	
Δ LAGR	**-7.120	**-6.861	**-5.765	**-5.487	**-4.875	-1.889	1
Δ_2 LAGR	**-8.923	**-9.094	**-9.286	**-7.886	**-8.048	**-8.181	
LIND	-1.297	-1.019	3.481	-1.363	-1.014	2.225	
Δ LIND	**-5.085	**-5.064	**-3.645	-3.093	*-2.999	*-2.169	1
Δ_2 LIND	**-8.835	**-8.937	**-9.114	**-4.735	**-4.741	**-4.819	
LINDAGR	-1.256	-1.482	2.123	-1.086	-1.513	1.566	
Δ LINDAGR	**-5.530	**-5.416	**-4.588	-3.050	*-3.500	**-2.793	1
Δ_2 LINDAGR	**-9.173	**-5.896	**-9.452	**-5.834	**-9.278	**-5.996	
LHUM	**-6.159	**-12.325	10.726	*-3.721	-2.712	0.343	
Δ LHUM	-2.874	-1.663	*-2.183	-2.338	-1.710	*-2.579	0 or 1
Δ_2 LHUM	**-6.077	**-6.036	**-5.250	**-4.866	**-4.008	**-2.745	

Japan

	DF			ADF			Order of Integration
	T, C	C	N	T, C	C	N	
LPOP	3.135	**-5.664	14.808	-1.126	*-3.161	-1.027	
Δ LPOP	-1.512	0.570	-1.318	-1.559	0.054	-1.174	1 or 2
Δ_2 LPOP	**-4.068	**-3.727	**-3.477	-2.733	-2.549	*-2.308	
LAGR	-2.187	-1.289	-0.266	-2.602	-1.740	-0.239	
Δ LAGR	*-4.218	**-4.138	**-4.225	**-4.481	**-4.257	**-4.347	1
Δ_2 LAGR	**-6.035	**-6.164	**-6.295	**-5.607	**-5.725	**-5.850	
LIND	-1.989	-2.789	4.788	-2.239	-2.263	2.222	
Δ LIND	-3.493	*-3.220	*-2.284	-1.544	-1.584	-1.192	1
Δ_2 LIND	**-6.734	**-6.842	**-6.968	**-7.030	**-7.137	**-7.284	
LINDAGR	-1.945	-1.167	4.007	-3.527	-1.255	1.934	
Δ LINDAGR	-3.106	*-3.180	*-2.596	*-3.943	**-4.008	*-2.596	1
Δ_2 LINDAGR	**-5.244	**-5.369	**-5.481	*-3.792	**-3.887	**-3.973	
LHUM	0.025	-2.726	5.383	-0.809	-2.093	1.984	
Δ LHUM	*-3.640	-2.735	-1.799	-3.344	-1.988	-1.167	1
Δ_2 LHUM	**-6.073	**-6.123	**-6.250	*-4.335	**-4.239	**-4.334	

South Korea

	DF			ADF			Order of Integration
	T, C	C	N	T, C	C	N	
LPOP	-1.817	**-9.689	12.215	-1.825	**-4.046	1.492	
Δ LPOP	**-4.872	-2.172	-1.373	-2.456	-1.112	-1.550	0 or 1
Δ_2 LPOP	**-7.946	**-8.059	**-7.948	**-6.542	**-6.610	**-6.124	
LAGR	-2.786	-2.022	1.884	-2.767	-1.938	1.820	
Δ LAGR	**-5.455	**-5.566	**-5.227	*-3.962	**-4.034	**-2.809	1
Δ_2 LAGR	**-8.513	**-8.627	**-8.749	**-6.307	**-6.328	**-6.414	
LIND	-1.434	-1.502	11.676	-1.238	-1.517	3.942	

Δ LIND	**-5.219	**-4.689	-1.223	**-5.112	**-4.169	-0.485	1
Δ_2 LIND	**-6.656	**-6.823	**-6.963	**-6.870	**-7.025	**-7.167	
LINDAGR	-3.349	-0.133	3.783	-3.489	0.019	3.263	
Δ LINDAGR	**-5.849	**-5.952	**-3.604	**-5.309	**-5.396	-1.297	1
Δ_2 LINDAGR	**-7.512	**-7.619	**-7.746	**-7.737	**-7.747	**-7.884	
LHUM	**-9.656	**-10.723	11.812	-2.860	-1.189	2.151	
Δ LHUM	-2.687	*-3.324	**-3.247	-2.625	*-3.520	**-3.009	0 or 1
Δ_2 LHUM	**-5.722	**-5.072	**-4.437	-2.878	*-3.053	*-2.644	

Malaysia

	DF			ADF			Order of Integration
	T, C	C	N	T, C	C	N	
LPOP	-2.329	0.248	29.109	-1.802	0.395	2.815	
Δ LPOP	**-7.088	**-7.139	-0.789	-2.155	-2.159	-0.555	1
Δ_2 LPOP	**-10.585	**-10.770	**-10.992	**-9.268	**-9.413	**-9.602	
LAGR	-1.911	-0.709	3.464	-1.635	-0.623	3.375	
Δ LAGR	**-6.114	**-6.171	**-4.206	**-4.475	**-4.519	-1.528	1
Δ_2 LAGR	**-8.694	**-8.844	**-9.026	**-7.058	**-7.147	**-7.296	
LIND	-2.871	-0.539	6.372	-2.894	-0.673	4.091	
Δ LIND	**-5.522	**-5.600	*-2.616	**-4.842	**-4.866	-1.046	1
Δ_2 LIND	**-7.702	**-7.845	**-8.007	**-6.312	**-6.426	**-6.571	
LINDAGR	-1.820	-0.394	4.209	-2.255	-0.321	2.639	
Δ LINDAGR	*-3.947	**-4.070	**-2.800	-1.988	-2.259	-1.408	1
Δ_2 LINDAGR	**-7.212	**-7.155	**-7.330	**-6.489	**-6.251	**-6.379	
LHUM	-3.161	**-21.471	13.050	-2.327	-2.710	-0.075	
Δ LHUM	-1.945	-0.857	**-2.724	-1.979	-0.734	*-2.537	0 or 1
Δ_2 LHUM	**-5.154	**-5.206	**-4.247	*-4.039	**-4.073	*-1.963	

The Philippines

	DF			ADF			Order of Integration
	T, C	C	N	T, C	C	N	
LPOP	0.280	**-4.505	33.329	0.825	**-4.470	2.249	
Δ LPOP	**-7.973	*-3.596	-0.428	*-3.713	-1.453	-0.524	0 or 1
Δ_2 LPOP	**-10.483	**-10.640	**-10.782	**-6.999	**-6.969	**-6.971	
LAGR	-0.833	**-3.217	4.130	-0.927	-2.487	1.404	
Δ LAGR	**-5.975	**-4.721	**-3.469	-1.728	-2.356	-1.916	0 or 1
Δ_2 LAGR	**-11.443	**-11.735	**-11.975	**-6.916	**-7.104	**-7.238	
LIND	-0.530	-1.952	3.589	-0.976	-1.619	1.872	
Δ LIND	*-3.820	*-3.485	**-2.730	-2.911	-2.432	*-2.077	1
Δ_2 LIND	**-6.835	**-6.967	**-7.110	**-4.792	**-4.904	**-5.010	
LINDAGR	-1.610	-1.015	1.828	-2.096	-1.020	1.400	
Δ LINDAGR	**-5.289	**-5.282	**-4.685	-3.388	*-3.314	**-2.672	1
Δ_2 LINDAGR	**-9.339	**-9.516	**-9.712	**-4.364	**-4.452	**-4.550	
LHUM	-1.528	2.796	20.305	*-4.160	1.081	1.703	
Δ LHUM	-1.679	-1.331	-0.457	-2.289	-2.139	-0.458	1 or 2
Δ_2 LHUM	*-4.279	**-4.380	**-4.468	-2.849	*-2.994	**-3.067	

Thailand

	DF			ADF			Order of Integration
	T, C	C	N	T, C	C	N	
LPOP	-0.836	**-7.017	13.861	-0.660	**-5.351	1.973	
Δ LPOP	**-9.118	-2.621	-0.914	**-8.370	-1.356	-0.713	0 or 1
Δ_2 LPOP	**-16.366	**-16.259	**-15.054	**-11.927	**-12.201	**-10.534	
LAGR	-1.526	-1.855	2.247	-1.200	-1.812	2.173	
Δ LAGR	**-5.050	**-4.824	**-4.197	*-4.284	**-3.986	*-2.192	1
Δ_2 LAGR	**-7.373	**-7.465	**-7.612	**-5.836	**-5.939	**-6.073	
LIND	-1.397	0.566	11.437	-2.293	0.509	3.597	
Δ LIND	*-3.676	**-3.698	-1.146	-1.922	-2.026	-0.180	1
Δ_2 LIND	**-6.508	**-6.627	**-6.751	**-6.238	**-6.262	**-6.370	
LINDAGR	-1.223	0.864	3.303	-0.958	1.007	2.874	
Δ LINDAGR	**-5.031	**-4.810	**-3.583	*-3.955	**-3.726	-1.377	1
Δ_2 LINDAGR	**-7.751	**-7.830	**-7.976	**-6.338	**-6.351	**-6.480	
LHUM	**-4.406	**-4.592	27.985	-2.866	-1.469	2.027	
Δ LHUM	-3.007	-2.783	-0.993	-2.310	-2.508	-1.278	1 or 2
Δ_2 LHUM	**-7.207	**-7.205	**-7.203	**-4.882	**-4.758	**-4.671	

Note: LPOP: population (million, in logs)
LAGR: agricultural output (billion US$ at the 1985 price, in logs)
LIND: industrial output (billion US$ at the 1985 price, in logs)
LINDAGR: the level of industrialisation (the ratio of industrial output to agricultural output, %, in logs).
LHUM: the averaged years of schooling per labourer (years, in logs)
DF: the Dickey-Fuller unit roots test
ADF: the augmented Dickey-Fuller unit roots test (maximum lags = 2)
T: the trend term is included in the unit roots test
C: the constant term is included in the unit roots test
N: no trend and no constant terms are included in the unit roots test
Δ: the first differenced variable
Δ_2: the second differenced variable
**: the statistical significance at the 1 % level
*: the statistical significance at the 5 % level

Appendix 2: The Granger Causality Test

Granger (1969) has introduced a concept of causality, and the following simple structural model of the causality test is given by Jacobs, Leamer and Ward (1979):

$$Y_t = \Theta X_t + \beta_{11}Y_{t-1} + \beta_{12}X_{t-1} + \varepsilon_{1t} \tag{A-1}$$
$$X_t = \tau Y_t + \beta_{21}Y_{t-1} + \beta_{22}X_{t-1} + \varepsilon_{2t} \tag{A-2}$$

where ε_{1t} and ε_{2t} are independent, serially un-correlated random variables with zero means and variances σ_{12}, and σ_{22} respectively as $N\ (0,\ \sigma_{12})$ for i = 1, 2. The reduced form of this structural model is given by:

$$\begin{pmatrix} Y \\ X \end{pmatrix}_t = (\pi)\begin{pmatrix} Y \\ X \end{pmatrix}_{t-1} + \begin{pmatrix} u1 \\ u2 \end{pmatrix}_t \tag{A-3}$$

where (π) is the matrix,

$$(\pi) = (1-\Theta\tau)^{-1}\begin{bmatrix} \beta_{11} + \Theta\beta_{21} & \beta_{12} + \Theta\beta_{22} \\ \tau\beta_{11} + \beta_{21} & \tau\beta_{12} + \beta_{22} \end{bmatrix} \tag{A-4}$$

and,

$$\begin{pmatrix} u_1 \\ u_2 \end{pmatrix} = (1-\Theta\tau)^{-1}\begin{bmatrix} 1 & \Theta \\ \tau & 1 \end{bmatrix}\begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \end{pmatrix} \tag{A-5}$$

In the above model, a variable X_t is said to be Granger-caused by a variable Y_t if the information on past and present Y_t helps to improve the forecast of the X_t variable. To formalise, we can define three hypotheses that describe the extent to which Y_t influences X_t:

(i) H_1: $\tau = \beta_{21} = 0$. This is the disturbance in the Y_t equation and is never transmitted to X_t. Y_t does not cause X_t.
(ii) H_2: $\tau = 0$. This is the hypothesis that the current disturbance in Y_t equation does not affect current X_t. X_t is contemporaneously exogenous.
(iii) H_3: $\tau\beta_{11} + \beta_{21} = 0$. This is the hypothesis that an optimal prediction of X_t does not depend on Y_t. Y_t is not informative about future X_t, and Y_t does not cause X_t in Granger's sense.

Because of identification problems, the first two hypotheses cannot be tested, however the third hypothesis can be examined. Given that the third hypothesis, $\tau\beta_{11} + \beta_{21} = 0$ is equivalent to testing a zero restriction on π_{21} in the reduced form [see, $\pi_{21} = (1 - \Theta\tau)^{-1}(\tau\beta_{11} + \beta_{21})$] that is test undertaken. If π_{21} is not zero, Y_t causes X_t. If π_{21} is zero, Y_t provides no information about X_t. Then, it is plausible to conclude that Y_t does not cause X_t. Consequently, a direct test for the Granger causality can be formulated in the auto-regressive representation form given by equation (A-3) as Mehra (1977), and Kalirajan and Kapuscinski (1990) employ.

Appendix 3: Co-integration Test by the Solved Static Long-run Equation (SSLR) for the Granger Causality Investigation

Indonesia

lag	T, C	C	N	T, C	C	N
	D (LAGR); X (LPOP)			D (LPOP); X (LAGR)		
1	-2.687	-1.823	-1.466	-1.856	-0.652	-1.821
2	-1.532	-0.949	-1.199	-1.655	-0.986	-1.587
	D (LIND); X (LAGR)			D (LAGR); X (LIND)		
1	-1.415	-1.418	-1.395	-2.984	-0.824	-0.539
2	-1.553	-1.253	-0.968	-3.009	-0.070	-0.920
	D (LINDAGR); X (LPOP)			D (LPOP); X (LINDAGR)		
1	-1.669	-1.510	-1.812	-1.561	-0.759	4.009
2	-1.284	-1.151	-1.390	-1.635	-0.348	3.071
	D (LINDAGR); X (LHUM)			D (LHUM); X (LINDAGR)		
1	-1.799	-1.798	-1.183	*-4.275	-3.183	**(A)-5.671
2	-1.824	-1.898	-0.981	-3.347	-1.738	-1.105

Japan

lag	T, C	C	N	T, C	C	N
	D (LAGR); X (LPOP)			D (LPOP); X (LAGR)		
1	-2.733	-2.917	-0.520	1.944	*(A)-3.449	**(A)-7.676
2	-3.411	*-3.561	-1.387	-1.259	-3.006	-2.885
	D (LIND); X (LAGR)			D (LAGR); X (LIND)		
1	-1.922	-2.371	-2.356	-2.367	-1.662	-0.377
2	-2.954	-1.001	-1.290	*-4.180	-1.939	-0.247
	D (LINDAGR); X (LPOP)			D (LPOP); X (LINDAGR)		
1	-1.535	-1.287	-1.678	3.243	-2.278	5.238
2	-3.499	-2.620	-1.845	-0.752	-2.641	1.681
	D (LINDAGR); X (LHUM)			D (LHUM); X (LINDAGR)		
1	-1.994	-1.470	-1.135	-0.104	-0.434	2.163
2	-3.526	-2.346	-0.999	-1.038	-1.151	1.527

South Korea

lag	T, C	C	N	T, C	C	N
	D (LAGR); X (LPOP)			D (LPOP); X (LAGR)		
1	-2.672	-2.712	-1.652	-0.915	-2.745	**(A)-4.959
2	-2.891	-2.910	-1.719	-1.001	-2.455	-1.929
	D (LIND); X (LAGR)			D (LAGR); X (LIND)		
1	-3.025	-1.958	-1.306	-2.515	-2.561	0.656
2	-2.485	-1.531	-2.297	-2.587	-2.747	0.217
	D (LINDAGR); X (LPOP)			D (LPOP); X (LINDAGR)		
1	-3.646	-2.799	-1.247	-1.554	-2.335	11.731
2	(A)-3.363	-2.018	-0.763	-1.765	-2.316	3.286
	D (LINDAGR); X (LHUM)			D (LHUM); X (LINDAGR)		
1	-3.366	*-3.623	*-3.693	**-13.144	**(A)-6.176	**(A)-14.26
2	-2.703	-3.045	-3.085	-2.815	-0.625	-0.409

Malaysia

lag	T, C	C	N	T, C	C	N
	D (LAGR); X (LPOP)			D (LPOP); X (LAGR)		
1	-3.239	-2.262	-0.704	-1.530	-1.852	-2.117
2	-2.552	-1.390	0.291	-1.144	(A)-3.214	-2.890
	D (LIND); X (LAGR)			D (LAGR); X (LIND)		
1	-2.423	-1.753	-1.419	-2.364	-2.411	-1.319
2	-2.826	-1.511	-0.801	-1.776	-1.810	-0.183

	D (LINDAGR); X (LPOP)			D (LPOP); X (LINDAGR)		
1	-3.563	-3.042	-1.623	-1.242	1.235	-0.207
2	-2.870	-2.444	-2.093	-0.939	1.832	0.169
	D (LINDAGR); X (LHUM)			D (LHUM); X (LINDAGR)		
1	-2.313	-0.869	-0.635	-1.994	**(A)-9.311	**(A)-23.60
2	-2.676	-1.274	-1.275	-2.099	-3.216	-2.546

The Philippines

lag	T, C	C	N	T, C	C	N
	D (LAGR); X (LPOP)			D (LPOP); X (LAGR)		
1	-2.683	-0.415	0.910	-1.386	-2.153	**-4.762
2	-1.998	-0.606	-0.248	-0.110	-2.490	-2.904
	D (LIND); X (LAGR)			D (LAGR); X (LIND)		
1	-3.214	*-3.484	-1.013	-1.216	-1.196	2.212
2	-2.943	-2.955	-0.262	0.470	0.326	4.253
	D (LINDAGR); X (LPOP)			D (LPOP); X (LINDAGR)		
1	-2.752	-1.921	-2.017	-0.665	-1.864	-1.381
2	-2.649	-1.786	-1.919	0.587	-1.653	-0.209
	D (LINDAGR); X (LHUM)			D (LHUM); X (LINDAGR)		
1	-2.114	-1.129	-0.210	0.036	-1.320	-0.785
2	-2.195	-1.148	-0.144	*-3.960	-1.508	-0.444

Thailand

lag	T, C	C	N	T, C	C	N
	D (LAGR); X (LPOP)			D (LPOP); X (LAGR)		
1	-3.226	-1.983	-0.862	0.656	-1.600	**-5.129
2	-3.017	-1.925	-1.712	0.701	-1.362	-3.065
	D (LIND); X (LAGR)			D (LAGR); X (LIND)		
1	-1.947	-0.604	-0.671	-1.291	-0.928	1.341
2	-2.573	0.319	0.259	-1.474	-1.176	1.297
	D (LINDAGR); X (LPOP)			D (LPOP); X (LINDAGR)		
1	-2.821	-0.501	-0.499	0.727	-1.727	4.558
2	-2.614	-0.595	-0.856	0.504	-2.174	1.730
	D (LINDAGR); X (LHUM)			D (LHUM); X (LINDAGR)		
1	-1.588	-1.690	-0.765	**-5.577	**-7.464	-0.506
2	-1.669	-2.066	-0.707	-3.007	-3.262	0.137

Note: the abbreviations are same with Appendix 1 unless it is specified.

lag: two lags for the maximum lags in SSLR due to the small sample size
D: the dependent variable in the Solved Static Long-run Equation (SSLR)
X: the explanatory variable in SSLR
T: the trend term is included in SSLR
C: the constant term is included in SSLR
N: no trend and no constant terms are included in SSLR
**: the statistical significance at the 1 % level
*: the statistical significance at the 5 % level
(A): the autocorrelation problem is found in residuals by the Lagrange Multiplier test (the second order)

Appendix 4: Summary of the Granger Causality Test (1960-90)

Indonesia

Lag	R^2	F-test	σ	LM	Granger	(prob)	R^2	F-test	σ	LM	Granger	(prob)
			ΔLPOP → ΔLAGR						ΔLAG	· ΔLPOP		
1	0.146	2.217	0.057	1.536	2.392	(0.134)	0.046	0.633	0.009	1.647	1.265	(0.271)
2	0.246	1.881	0.057	0.807	2.290	(0.124)	0.190	1.345	0.009	0.330	2.672	(0.091)+
3	0.338	1.699	0.053	0.091	2.158	(0.125)	0.225	0.967	0.009	0.006	1.922	(0.159)
			ΔLAGR → ΔLIND						ΔLINI	ΔLAGR		
1	0.000	0.001	0.155	0.296	0.001	(0.981)	0.068	0.945	0.059	0.233	0.018	(0.893)
2	0.038	0.226	0.160	0.761	0.431	(0.655)	0.211	1.541	0.058	0.283	1.676	(0.209)
3	0.064	0.228	0.169	1.810	0.379	(0.769)	0.253	1.131	0.057	0.451	1.162	(0.349)
			ΔLPOP → ΔLINDAGR						ΔLIND/	→ ΔLPOP		
1	0.020	0.266	0.180	0.161	0.471	(0.499)	0.042	0.574	0.009	0.663	1.148	(0.294)
2	0.024	0.142	0.190	0.541	0.194	(0.825)	0.102	0.652	0.009	0.036	1.287	(0.295)
3	0.027	0.096	0.202	1.286	0.138	(0.936)	0.111	0.414	0.010	0.013	0.817	(0.500)
			ΔLHUM → ΔLINDAGR						LIND/	→LHUM		
1	0.022	0.298	0.180	0.176	0.534	(0.471)	0.999	175730**	0.003	3.474*	0.521	(0.477)
2	0.035	0.208	0.189	1.292	0.326	(0.725)	0.999	88321**	0.003	1.312	0.051	(0.951)
3	0.049	0.171	0.200	1.872	0.288	(0.834)	0.999	46897**	0.003	2.010	0.221	(0.881)

Japan

Lag	R^2	F-test	σ	LM	Granger	(prob)	R^2	F-test	σ	LM	Granger	(prob)
			LPOP → LAGR						ΔLAC	· ΔLPOP		
1	0.755	41.50**	0.066	2.321	4.281	(0.048)*	0.927	165.23**	0.001	1.592	0.001	(0.974)
2	0.819	27.20**	0.056	0.491	4.939	(0.016)*	0.934	82.007**	0.001	0.814	0.115	(0.892)
3	0.825	16.56**	0.062	2.991+	2.713	(0.071)+	0.941	53.193**	0.001	0.354	0.121	(0.947)
			ΔLAGR → ΔLIND						LINI	LAGR		
1	0.125	1.862	0.052	0.323	0.142	(0.709)	0.745	39.54**	0.067	2.136	3.169	(0.086)+
2	0.181	1.274	0.053	0.593	0.190	(0.828)	0.774	20.50**	0.067	0.433	1.524	(0.238)
3	0.350	1.799	0.051	1.193	0.177	(0.911)	0.799	13.91**	0.067	0.150	1.432	(0.262)

	ΔLPOP → ΔLINDAGR								ΔLINI	→ ΔLPOP		
1	0.165	2.569	0.065	1.606	0.067	(0.798)	0.943	215.99**	0.001	0.508	7.406	(0.011)*
2	0.207	1.501	0.067	0.218	0.147	(0.864)	0.948	104.60**	0.001	1.320	3.106	(0.064)+
3	0.382	2.060	0.061	0.291	0.254	(0.858)	0.957	73.606**	0.001	0.480	2.572	(0.083)+
	ΔLHUM → ΔLINDAGR								ΔLIND	→ ΔLHUM		
1	0.164	2.544+	0.065	1.163	0.024	(0.879)	0.301	5.597**	0.002	0.081	0.012	(0.913)
2	0.322	2.726+	0.062	0.627	2.114	(0.144)	0.294	2.391+	0.002	0.076	0.012	(0.988)
3	0.514	3.519*	0.187	0.187	2.125	(0.129)	0.300	1.428	0.002	2.456	0.111	(0.952)

South Korea

Lag	R^2	F-test	σ	LM	Granger	(prob)	R^2	F-test	σ	LM	Granger	(prob)
	ΔLPOP → ΔLAGR								ΔLA	· ΔLPOP		
1	0.016	0.214	0.099	0.194	0.339	(0.565)	0.613	20.604**	0.005	4.314*	0.231	(0.635)
2	0.054	0.331	0.103	0.288	0.594	(0.561)	0.679	12.191**	0.004	1.378	1.263	(0.302)
3	0.036	0.124	0.103	2.026	0.195	(0.899)	0.752	10.098**	0.004	2.041	1.953	(0.154)
	ΔLAGR → ΔLIND								ΔLI	ΔLAGR		
1	0.035	0.477	0.048	0.686	0.622	(0.437)	0.016	0.208	0.099	0.206	0.327	(0.572)
2	0.189	1.340	0.045	2.288	2.602	(0.096)+	0.035	0.211	0.104	0.933	0.356	(0.705)
3	0.269	1.225	0.044	0.591	1.882	(0.165)	0.097	0.359	0.099	1.604	0.661	(0.586)
	ΔLPOP → ΔLINDAGR								ΔLINI	→ ΔLPOP		
1	0.037	0.499	0.106	1.615	0.112	(0.741)	0.610	20.330**	0.005	4.984*	0.017	(0.896)
2	0.071	0.440	0.109	2.611+	0.318	(0.731)	0.701	13.501**	0.004	0.692	2.195	(0.134)
3	0.173	0.696	0.098	1.903	0.320	(0.811)	0.758	10.420**	0.004	1.872	2.160	(0.125)
	LHUM→LINDAGR								LINI	→LHUM		
1	0.985	889.02**	0.092	1.029	12.108	(0.002)**	0.999	83519**	0.004	11.188**	12.572	(0.002)**
2	0.985	395.88**	0.093	2.222	4.831	(0.017)*	0.999	109240**	0.002	0.505	0.147	(0.864)
3	0.988	298.00**	0.084	0.041	6.146	(0.004)**	0.999	57919**	0.002	0.205	0.171	(0.915)

Malaysia

Lag	R^2	F-test	σ	LM	Granger	(prob)	R^2	F-test	σ	LM	Granger	(prob)
			ΔLPOP → ΔLAGR						ΔLAG	ΔLPOP		
1	0.043	0.578	0.070	0.860	0.633	(0.434)	0.149	2.278	0.004	0.421	1.224	(0.279)
2	0.093	0.593	0.072	0.348	0.669	(0.522)	0.162	1.113	0.004	3.702*	0.606	(0.554)
3	0.134	0.515	0.075	0.989	0.434	(0.731)	0.454	2.769*	0.004	0.876	2.783	(0.068)+
			ΔLAGR → ΔLIND						ΔLINI	ΔLAGR		
1	0.017	0.228	0.076	1.487	0.080	(0.780)	0.087	1.241	0.068	0.908	1.934	(0.176)
2	0.116	0.755	0.077	0.932	0.321	(0.728)	0.104	0.670	0.071	1.348	0.818	(0.454)
3	0.212	0.895	0.078	0.515	0.579	(0.636)	0.289	1.358	0.068	0.239	1.989	(0.148)
			ΔLPOP → ΔLINDAGR						ΔLINDA	→ ΔLPOP		
1	0.205	3.352+	0.054	0.476	5.074	(0.033)*	0.114	1.666	0.004	1.028	0.133	(0.719)
2	0.213	1.556	0.056	1.307	2.617	(0.095)	0.123	0..806	0.004	1.147	0.064	(0.938)
3	0.253	1.127	0.058	0.108	1.562	(0.230)	0.243	1.071	0.004	0.520	0.152	(0.927)
			ΔLHUM → ΔLINDAGR						ΔLINDA	→ ΔLHUM		
1	0.050	0.687	0.059	0.506	0.010	(0.921)	0.961	321.27**	0.001	0.570	1.215	(0.280)
2	0.037	0.223	0.062	1.807	0.042	(0.959)	0.960	139.15**	0.001	1.008	0.868	(0.433)
3	0.211	0.894	0.060	0.674	1.132	(0.360)	0.961	81.108**	0.002	0.162	1.068	(0.385)

The Philippines

Lag	R^2	F-test	σ	LM	Granger	(prob)	R^2	F-test	σ	LM	Granger	(prob)
			ΔLPOP → ΔLAGR						LAG	LPOP		
1	0.207	3.387*	0.039	2.900+	6.287	(0.019)*	0.999	146860**	0.002	1.738	0.287	(0.597)
2	0.356	3.178*	0.037	0.436	3.398	(0.051)+	0.999	72444**	0.002	0.578	0.450	(0.643)
3	0.383	2.071	0.037	0.771	0.905	(0.456)	0.999	41670**	0.003	0.667	0.693	(0.567)
			LAGR → LIND						ΔLINI	ΔLAGR		
1	0.989	1211.10**	0.067	1.004	10.674	(0.003)**	0.269	4.776*	0.037	5.553*	9.024	(0.006)**
2	0.990	600.46**	0.063	0.258	6.732	(0.005)**	0.541	6.767**	0.031	2.569	9.388	(0.001)**
3	0.990	335.82**	0.065	0.519	4.871	(0.010)*	0.678	7.025**	0.027	0.628	7.847	(0.001)**
			ΔLPOP → ΔLINDAGR						ΔLINDA	→ ΔLPOP		
1	0.017	0.218	0.070	0.060	0.385	(0.540)	0.093	1.341	0.003	1.667	0.067	(0.798)

2	0.033	0.195	0.074	0.926	0.180	(0.837)	0.175	1.221	0.003	1.188	0.034	(0.966)
3	0.181	0.736	0.072	0.492	0.892	(0.463)	0.428	2.496+	0.003	1.018	0.436	(0.730)
	ΔLHUM → ΔLINDAGR								LIND.	→ LHUM		
1	0.007	0.089	0.070	0.284	0.126	(0.725)	0.999	14517**	0.005	14.213**	4.041	(0.055)+
2	0.037	0.223	0.074	1.576	0.235	(0.792)	0.999	27601**	0.002	1.339	2.444	(0.108)
3	0.088	0.323	0.076	0.424	0.126	(0.944)	0.999	17246**	0.002	0.635	1.454	(0.256)

Thailand

Lag	R^2	F-test	σ	LM	Granger	(prob)	R^2	F-test	σ	LM	Granger	(prob)
	ΔLPOP → ΔLAGR								LA	· LPOP		
1	0.119	1.748	0.075	2.295	3.484	(0.073)+	0.999	23197.0**	0.006	0.023	0.009	(0.925)
2	0.286	2.306+	0.072	0.477	4.064	(0.031)*	0.999	10361.0**	0.006	3.221+	0.147	(0.864)
3	0.357	1.850	0.073	0.195	3.347	(0.040)*	0.999	6446.3**	0.005	23.056**	0.125	(0.944)
	ΔLAGR → ΔLIND								ΔLII	ΔLAGR		
1	0.415	9.226**	0.035	0.141	15.543	(0.001)**	0.102	1.477	0.076	0.079	2.941	(0.098)+
2	0.435	4.427**	0.036	0.073	7.117	(0.004)**	0.109	0.702	0.080	0.211	0.965	(0.396)
3	0.463	2.877*	0.038	1.608	4355	(0.016)*	0.121	0.460	0.085	0.786	0.662	(0.585)
	ΔLPOP → ΔLINDAGR								ΔLINI	→ ΔLPOP		
1	0.091	1.296	0.099	1.396	2.576	(0.121)	0.288	5.266*	0.007	1.703	0.271	(0.607)
2	0.210	1.528	0.097	1.033	2.751	(0.085)+	0.390	3.676*	0.007	1.565	0.221	(0.803)
3	0.293	1.379	0.099	0.622	2.513	(0.088)+	0.438	2.600*	0.007	1.517	0.281	(0.839)
	ΔLHUM → ΔLINDAGR								LIND	→ LHUM		
1	0.005	0.066	0.104	1.012	0.118	(0.734)	0.999	198200**	0.001	0.583	23.602	(0.000)**
2	0.078	0.486	0.105	0.605	0.711	(0.502)	0.999	115130**	0.001	1.432	4.777	(0.018)*
3	0.159	0.631	0.108	0.069	1.057	(0.389)	0.999	70723**	0.001	0.606	3.968	(0.022)*

Note: A → B: the causal direction from A to B
R^2: goodness of fit
F-test: the F-test for the significance of regression
σ: the standard error of regression
LM: the LM test for autocorrelation in the residuals (the second-order)
Granger: the Granger causality test by the F-test
(prob): the probability of rejection of the null hypothesis for the Granger causality test
LPOP: population (in logs)
LAGR: agricultural output (in logs)
LIND: industrial output (in logs)
LINDAGR: the level of industrialisation (the ratio of industrial output to agricultural output, %, in logs)
LHUM: the averaged years of schooling per labourer (in logs)
Δ: the first differenced variable
**: the statistical significance at the 1 % level
*: the statistical significance at the 5 % level
+: the statistical significance at the 10 % level

Appendix 5: The Cross-country and Time-series Data Analysis

The basic framework for the panel estimates by pooling all observations for the relevant variables in the generalised regression model:[34)]

$$y_{it} = \beta' x_{it} + \varepsilon_{it} \tag{A-6}$$

To collect the n time series:

$$y_i = X_i \beta + \varepsilon_i \tag{A-7}$$

$$\text{where} \begin{bmatrix} y_1 \\ y_2 \\ \cdot \\ y_n \end{bmatrix} = \begin{bmatrix} X_1 \\ X_2 \\ \cdot \\ X_n \end{bmatrix} \beta + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \cdot \\ \varepsilon_n \end{bmatrix}$$

Each sub-matrix or sub-vector has T observations. In general terms:

$$V = E[\varepsilon\varepsilon'] = \begin{bmatrix} \sigma_{11}\Omega_{11} & \sigma_{12}\Omega_{12} & \cdot & \sigma_{1n}\Omega_{1n} \\ \sigma_{21}\Omega_{21} & \sigma_{22}\Omega_{22} & \cdot & \sigma_{2n}\Omega_{2n} \\ \cdot & \cdot & \cdot & \cdot \\ \sigma_{n1}\Omega_{n1} & \sigma_{n2}\Omega_{n2} & \cdot & \sigma_{nn}\Omega_{nn} \end{bmatrix} \tag{A-8}$$

where, covariance $\sigma_{nn}\Omega_{nn}$, with Ω known. We here assume that the parameter vector, β, is the same for all i. This regression model specifies that:

$E[\varepsilon_{it}] = 0$
$Var[\varepsilon_{it}] = \sigma^2$
$Cov[\varepsilon_{it}, \varepsilon_{js}] = 0$ if $t \neq s$ or $i \neq j$

Thus, we get:

$$V = \begin{bmatrix} \sigma^2 I & 0 & \cdot & 0 \\ 0 & \sigma^2 I & \cdot & 0 \\ \cdot & \cdot & \cdot & \cdot \\ 0 & 0 & \cdot & \sigma^2 I \end{bmatrix}$$

We can stack all data of sample countries in a single equation for the pooled regression:

$$y = X\beta + \varepsilon \tag{A-9}$$

For this model, the generalised least squares (GLS) estimator reduces to pooled ordinary least squares (OLS).

34) Greene (1993), p.447-8.

Moreover, we can alternatively restrict β with the time dimension across countries in a system equation (A-10) without pooling all data in a single equation on the above:

$$
\begin{aligned}
y_{1t} &= c_{1t} + \beta^* X_{1t} + \varepsilon_{1t} \\
y_{2t} &= c_{2t} + \beta^* X_{2t} + \varepsilon_{2t} \\
&\cdot \quad \cdot \quad \cdot \\
y_{nt} &= c_{nt} + \beta^* X_{nt} + \varepsilon_{nt}
\end{aligned}
\qquad \text{(A-10)}
$$

where,

n: the number of countries

t: time

which provides the common parameter vector β^* across countries in the given sample period.

Appendix 6: Co-integrating Relationships (only for Indonesia and South Korea): the Solved Static Long-run Equation (SSLR)

Indonesia:

i) Solved static long-run equation

LINDAGR = -13.550 + 3.158 LPOP + 0.649 LOPEN
(SE) (1.141) (0.258) (0.100)

Wald Test Chi^2 (2) = 397.1 [0.000]**

ii) Analysis of the autoregressive distributed lag representation

	0	1	Σ
LGDP	-1.000	0.363	-0.637
(SE)	-	(0.169)	(0.169)
C	-8.640	-	-8.640
(SE)	(2.630)	-	(2.630)
LPOP	2.820	-0.807	2.010
(SE)	(2.970)	(2.910)	(0.601)
LOPEN	0.676	-0.262	0.283
(SE)	(0.160)	(0.166)	(0.128)

R^2 = 0.982　F(5, 24) = 258.2 [0.000]　σ = 0.129　DW = 2.23　RSS=0.399
AUTO = 1.484 [0.249]　ARCH = 2.864 [0.105]　NORM = 4.056 [0.132]

iii) Tests on the significance of each variable

variable	F(num,denom)	Value [prob]	Unit Root t-test
LINDAGR	F(1, 24) =	4.604 [0.042]**	-3.772*
Constant	F(1, 24) =	10.78 [0.003]**	
LPOP	F(2, 24) =	5.643 [0.010]**	3.347
LOPEN	F(2, 24) =	10.65 [0.001]**	3.222

iv) Tests on the significance of each lag

Lag	F(num,denom)	Value [prob]
1	F(3, 24) =	1.766 [0.181]

v) Tests on the significance of all lags up to 1

Lag	F(num,denom)	Value [prob]
1- 1	F(3, 24) =	1.766 [0.181]

South Korea:

i) Solved static long-run equation

LINDAGR = 1.029 + 0.362 LFINRAT + 1.965 LHUM
(SE) (0.545) (0.155) (0.334)

WALD test Chi^2 (2) = 315.5 [0.000] **

ii) Analysis of the autoregressive lag representation

	0	1	Σ
LGDP	-1.000	0.347	-0.653
(SE)	-	(0.171)	(0.171)
C	0.671	-	0.671
(SE)	(0.437)	-	(0.437)
LFINRAT	0.592	-0.356	0.236
(SE)	(0.125)	(0.147)	(0.141)
LHUM	2.230	-0.949	1.280
(SE)	(4.310)	(4.210)	(0.322)

R^2 = 0.993 F (5, 24) = 662.4[0.000] σ = 0.068 DW = 1.92 RSS = 0.111
AUTO = 1.443 [0.258] ARCH = 0.641 [0.432] NORM = 1.645 [0.439]

iii) Tests on the significance of each variable

variable	F(num,denom)	Value [prob]	Unit Root t-test
LINDAGR	F(1, 24) =	4.118 [0.054]+	-3.812*
Constant	F(1, 24) =	2.359 [0.138]	
LFINRAT	F(2, 24) =	11.28 [0.000]**	1.673
LHUM	F(2, 24) =	8.384 [0.002]**	3.986

iv) Tests on the significance of each lag

Lag	F(num,denom)	Value [prob]
1	F(3, 24) =	2.682 [0.070]+

v) Tests on the significance of all lags up to 1

Lag	F(num,denom)	Value [prob]
1- 1	F(3, 24) =	2.682 [0.070]+

Note: R^2: squared multiple correlation coefficient
F: F-test for the null hypothesis is that all the regressions coefficients are zero (excluding the intercept)
σ: standard error of regression
DW: Durbin-Watson autocorrelation test
RSS: residual sum of squares
AUTO: Lagrange Multiplier autocorrelation test (F-test, 2nd order)
ARCH: the autoregressive conditional heteroschedasticity test (F-test, 1st order)
NORM: the Jarque-Bera normality test (Chi^2 test)
C: constant
**: the statistical significance at the 1 % level
*: the statistical significance at the 5 % level
+: the statistical significance at the 10 % level

Appendix 7: Individual Country Regression Results (1960-90)

Indonesia:

Δ LINDAGR = - 0.117 + 1.278 Δ LGDPH85 + 0.457 Δ $LFINRAT_{-1}$ + 5.276 Δ LPOP
(SE) (0.068)+ (0.655)+ (0.205)* (2.399)*
+ 0.629 Δ LOPEN - 0.838 Z_{-1}
(0.144)** (0.159)**

Z = LINDAGR + 13.550 - 3.158 LPOP - 0.649 LOPEN

R^2 = 0.707	F(5, 23) = 11.074 [0.000]	σ = 0.105	DW = 2.18
RSS = 0.252		AUTO (2, 21) =	2.260 [0.129]
ARCH (1, 21) =	0.199 [0.660]	NORM Chi^2 (2) =	0.406 [0.816]
Xi^2 (10, 12) =	1.294 [0.332]	RESET (1, 22) =	0.011 [0.918]

Japan:

Δ LINDAGR = 0.083 + 0.287 Δ LGDPH85 + 0.720 ΔFINRAT + 5.624 ΔLHUM
(SE) (0.048)+ (0.375) (0.369)+ (6.645)
- 7.678 Δ $LPOP_{-1}$ + 0.214 ΔLOPEN
(5.637) (0.121)+

R^2 = 0.231	F(5, 23) = 1.380 [0.268]	σ = 0.066	DW = 1.44
RSS = 0.100		AUTO (2, 21) =	1.160 [0.333]
ARCH (1, 21) =	0.339 [0.566]	NORM Chi^2 (2) =	1.948 [0.378]
Xi^2 (10, 12) =	1.130 [0.414]	RESET (1, 22) =	3.129 [0.091]+

South Korea:

Δ LINDAGR = 0.109 - 0.586 Δ $LGDPH85_{-1}$ + 0.540 Δ LFINRAT + 0.259 Δ LOPEN
(SE) (0.025)**(0.310)+ (0.092)** (0.109)*
- 0.600 Z_{-1}
(0.151)**

Z = LINDAGR - 1.029 - 0.362 LFINRAT - 1.965 LHUM

R^2 = 0.750	F(4, 24) = 17.993 [0.000]	σ = 0.056	DW = 1.87
RSS = 0.076		AUTO (2, 22) =	0.235 [0.793]
ARCH (1, 22) =	0.575 [0.456]	NORM Chi^2 (2) =	0.336 [0.845]
Xi^2 (8, 15) =	0.658 [0.719]	RESET (1, 23) =	0.591 [0.450]

Malaysia:

Δ LINDAGR = - 0.178 + 0.306 Δ $LINDAGR_{-1}$ + 0.446 Δ LGDPH85
(SE) (0.073)* (0.655)+ (0.287)
+ 0.275 Δ LFINRAT + 7.194 Δ LPOP
(0.163)+ (2.550)**

R^2 = 0.327	F(4, 24) = 2.922 [0.042]	σ = 0.051	DW = 1.91
RSS = 0.063		AUTO (2, 22) =	0.011 [0.989]
ARCH (1, 22) =	0.262 [0.614]	NORM Chi^2 (2) =	0.927 [0.629]
Xi^2 (8, 15) =	0.816 [0.600]	RESET (1, 23) =	0.249 [0.623]

The Philippines:

$$\Delta LINDAGR = 0.017 + 0.989\ \Delta LGDPH85 - 0.212\ \Delta LOPEN_{-1}$$
(SE) (0.012) (0.305)** (0.103)+

$R^2 = 0.348$	F(2, 26) = 6.927 [0.004]	$\sigma = 0.057$	DW = 2.49
RSS = 0.084		AUTO (2, 24) =	0.843 [0.443]
ARCH (1, 24) =	0.029 [0.867]	NORM Chi^2 (2) =	17.303 [0.000]**
Xi^2 (4, 21) =	0.151 [0.961]	RESET (1, 25) =	1.897 [0.181]

Thailand:

$$\Delta LINDAGR = 0.067 - 0.703\ \Delta LGDPH85 + 1.449\ \Delta LGDPH85_{-1}$$
(SE) (0.067) (0.652) (0.776)+

$$+ 0.908\ \Delta LFINRAT - 2.298\ \Delta LPOP$$
(0.447)+ (1.932)

$R^2 = 0.485$	F(4, 24) = 5.642 [0.002]	$\sigma = 0.078$	DW = 1.88
RSS = 0.145		AUTO (2, 22) =	0.104 [0.901]
ARCH (1, 22) =	0.013 [0.911]	NORM Chi^2 (2) =	1.612 [0.447]
Xi^2 (8, 15) =	0.845 [0.579]	RESET (1, 23) =	0.312 [0.582]

Note: Z_{-1}: the error correction term which is identified by the co-integrating relationship by the Solved Static Long-run Equation (Doornik and Hendry, 1994). Moreover, see Appendix 6 for details of the co-integration test results for Indonesia and South Korea

R^2: squared multiple correlation coefficient
F: F-test for the null hypothesis is that all the regressions coefficients are zero (excluding the intercept)
σ: equation standard error
DW: Durbin-Watson autocorrelation test
RSS: residual sum of squares
AUTO: the Lagrange Multiplier autocorrelation test
ARCH: the autoregressive conditional heteroschedasticity test
NORM: the Jarque-Bera Normality test (Chi^2)
Xi^2: the White heteroschedasticity test
RESET: the Ramsey regression specification test
(SE): the standard error of coefficient
[prob]: probability
**: the statistical significance at the 1 % level
*: the statistical significance at the 5 % level
+: the statistical significance at the 10 % level

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