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The relationship between economic activity and industrial production in selected Asian economies

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The Asian economies have emerged as important trading partners for Australia and, in particular, as a significant market for Australian commodities. Two major factors in determining the demand for commodities are economic activity and industrial production (IP). In Asia, the transition from agricultural to industrial production in some countries, such as the Philippines and Indonesia, and from labour to capital intensive manufacturing industries in others, such as South Korea and Taiwan, suggests that international growth in IP in these countries will be of increasing importance in determining the demand for specific Australian commodities, particularly, bulk commodities, in that region.

A stable long term relationship between IP and gross domestic product (GDP) in the OECD economies has been found in previous research. The objective in this paper is to examine whether such a relationship could exist in the fast growing dynamic Asian economies. The results of this study show that the existence of a relationship between IP and GDP appears to be related to the degree of industrialisation in the Asian economies. In South Korea and Taiwan, where IP has been contributing to strong economic growth for several decades, a stable long term relationship was detected over the sample period investigated. For the Philippines, Indonesia and Malaysia, which have undergone significant structural change during the past decade, no such long term relationship could be found. Consistent with previous research for the OECD economies, the results also indicate that, in most of the Asian economies, movements in IP provide useful leading information for predicting short term movements in GDP. These findings will be useful in generating forecasts for IP in the Asian economies which, in turn, could improve ABARE's assessment of commodity demand in the Asian region in both the short and longer term.

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1. Introduction

The Asian economies have emerged as important trading partners for Australia and, in particular, as a significant market for Australian commodities. The Asian region, defined in this study to include South Korea, Taiwan, Singapore, China, the Philippines, Thailand, Malaysia and Indonesia, accounted for around 34 per cent of Australia's commodity export market in 1992-93. The region absorbed around 26 per cent of Australia's rural exports and 35 per cent of Australia's mineral and resource exports. Two major factors in determining the demand for commodities are general economic activity and industrial production (IP). Mineral resource commodities, such as iron ore and petroleum, are often a key input into industrial production. Similarly, rural commodities are a major input into manufacturing industries, such as food processing. In the past, growth in real gross domestic product (GDP) was one of the main macroeconomic indicators of changes in demand for commodities in the Asian economies. However, the transition from agricultural to industrial production in some countries, such as the Philippines and Indonesia, and from labour to capital intensive manufacturing industries in others, such as South Korea and Taiwan, suggests that information on growth in industrial production in these countries is of increasing importance in determining the demand for Australian commodities in that region.

Penm (1994) examined the relationship between general economic activity and IP in the major OECD economies and found a stable long term cointegrating relationship between GDP and IP in many of these economies. IP was also found to contain short term leading information for general economic activity. However, little research has been done on the relationship between IP and GDP in the Asian economies. The objective in this paper is to examine whether a stable long term relationship could also be found in the fast growing dynamic Asian economies. If such a relationship is found to exist, then this relationship could be used to improve longer term forecasts for both general economic activity and IP. In addition to the long term relationship, there may also be short term relationships between general economic activity and IP. If identified, these short term relationships would also be useful in improving short term forecasts for these economic variables.

The Asian economies have grown very rapidly over the past couple of decades. This strong growth, combined with significant structural changes as these economies have gradually become more industrialised, may mean that the relationship between IP and GDP has changed over time. If this is the case, then a stable long term relationship between IP and GDP may not be evident in these economies. However, the Asian economies vary widely

in the degree of industrialisation which they have achieved. As a consequence, the possibility of a steady long term relationship between GDP and IP could be stronger in those Asian economies which, like the OECD economies, have progressed further in industrialisation.

In the next section, the nature of industrial production in the Asian economies is discussed and in light of this, a visual examination of the data is undertaken. In section 3, the data used in this study are analysed to assess their integration properties by testing for the presence of unit roots for each individual series. The results from the unit roots tests form the basis of the testing for cointegration between general economic activity and IP. The investigation of the short term lead lag relationships for selected countries is then presented in section 4 and concluding comments are given in section 5.

2. The role of industrial production in the Asian economies

There has been a substantial pick-up in the pace of economic growth in the Asian economies over recent decades. Much of this is due to strong growth in manufacturing as these economies have become more industrialised. In the newly industrialised economies of South Korea, Taiwan and Singapore,[1] strong growth in IP appears to have occurred in the 1960s and 1970s, about a decade earlier than in the less industrialised economies of Asia, that is, in China, the Philippines, Thailand, Malaysia and Indonesia. The significant increase in the contribution of IP to GDP in all the Asian countries is evident from the data presented in table 1, where IP is defined to include industrial activities in manufacturing, mining, quarrying, electricity, gas and water.

While the industry sector is a significant part of the economies of China, the Philippines, Thailand, Malaysia and Indonesia, the process of industrialisation involves not only a shifting away from agriculture as the main source of income in the economy, but also a change in the structure of industry from low technology, labour intensive activities toward progressively more capital and technology intensive industries (Hughes 1988). It is in this latter sense that China, the Philippines, Thailand, Malaysia and Indonesia are considered to be 'less industrialised economies'.

1 The fourth newly industrialised economy, Hong Kong, is not included in this study due to a lack of data for manufacturing or industrial production

Table 1: Sectoral shares of GDP

		Agriculture	Industrial production a	Services
		%	%	%
Newly industrialised economies b c	1965	31	27	42
	1980	11	41	48
	1993	5	44	51
South Korea	1965	38	25	37
	1980	14	38	48
	1993	6	46	48
Taiwan	1965	24	30	46
	1980	8	46	45
	1993		42	55
Singapore	1965		24	74
	1980	1	39	60
	1993	0	37	63
Less industrialised economies b	1965	39	29	32
	1980	28	42	30
	1993	21	48	31
China	1965	38	35	27
	1980	30	45	25
	1993	23	52	25
Philippines	1965	26	27	47
	1980	24	41	36
	1993	23	34	43
Thailand	1965	32	23	45
	1980	20	30	50
	1993	12	41	47
Malaysia	1965	28	25	47
	1980	23	36	41
	1993	16	44	40
Indonesia	1965	51	13	36
	1980	25	41	34
	1993	18	42	40

a Industrial production is defined to include industrial activities in manufacturing, mining, quarrying, electricity, gas and water.
b Weights used in the calculations for newly industrialised and less industrialised economies totals are based on GDP in 1990 purchasing power parity terms. c Newly industrialised economies excluding Hong Kong.
Sources: Asian Development Bank 1994; Council for Economic Planning and Development, Republic of China 1993; World Bank 1993a and 1993b.

In the newly industrialised economies, IP has increased from 27 per cent of GDP in 1965 to 44 per cent in 1993, with most of the growth occurring before 1980. In the less industrialised economies, IP was 29 per cent of GDP in 1965 and has increased to 48 per cent of GDP in 1993, largely due to strong IP growth in China over the past decade. Reflecting this IP growth in China, IP contributes more, on average, to GDP in the less industrialised economies than in the newly industrialised economies. As the Asian economies mature and the general level of incomes rise, the contribution of the services sector to these economies may increase and the contribution of IP decline somewhat. This trend is already evident in the newly industrialised economies, particularly Taiwan and Singapore, and is similar to the progression of industrialisation evident in the OECD economies several decades earlier. For example, IP in Japan was already 44 per cent of GDP in 1965 and has declined slightly as Japan's services sector expanded, to be 42 per cent of GDP in 1990 (World Bank 1993a).

Industrial production in the newly industrialised economies

The pattern of industrialisation followed in many of the Asian economies, particularly by South Korea, Taiwan, Thailand, Malaysia and the Philippines, was an initial expansion of capital intensive industry, followed by a reorientation toward more labour intensive sectors. In South Korea and Taiwan, the increase in labour intensive production led to a rise in real wages and a subsequent progression into capital and skill intensive manufacturing activities (Hughes 1988).

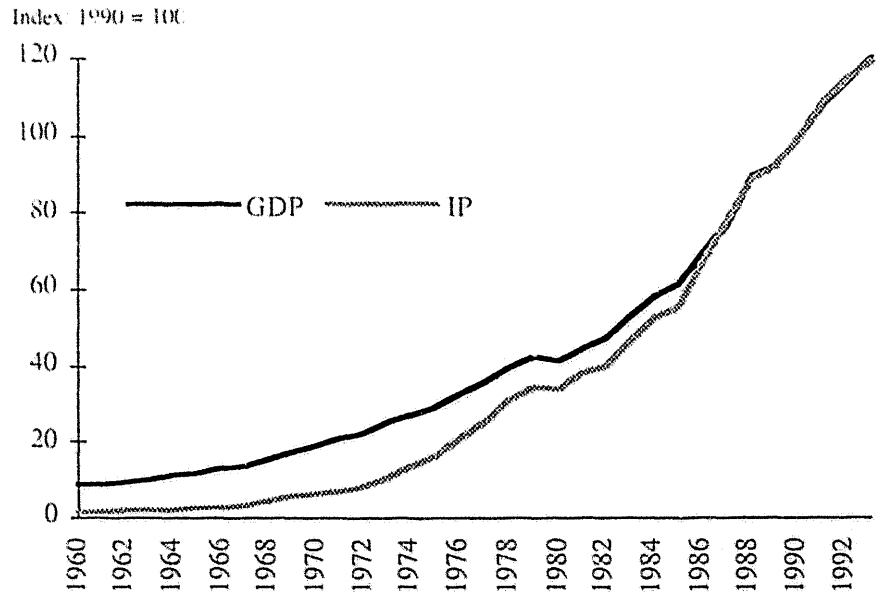
The newly industrialised economies have undergone a broad shift of production from labour intensive manufacturing in the 1960s and 1970s to more capital and skill intensive manufacturing in the 1980s and early 1990s. In these economies, capital intensive activities such as manufactured steel products, ship building and petrochemicals production have grown from around 70 per cent of the value of manufacturing in 1980 to around 78 per cent in 1990 and this trend is likely to continue over the remainder of the 1990s. The contribution of labour intensive manufacturing activities, such as textiles and footwear production, to economic growth in the newly industrialised economies has declined from around 28 per cent of the value of manufacturing in 1980 to around 21 per cent in 1990. If relative labour costs continue to rise in these economies, the contribution of labour intensive manufacturing could decline further over the remainder of the 1990s.

South Korea

The process of industrialisation in South Korea has been rapid compared with that in the other Asian economies. The steady increase in both IP and GDP in South Korea over the mid to late 1970s appears to reflect South Korea's effort to promote heavy and chemical industry (figure 1). The South Korean government initiated this promotion policy in 1973 with the aim of promoting certain strategic industries including iron and steel, non-ferrous metals, shipbuilding, general machinery, chemicals and electronics. Utilisation of this industrial capacity was very low initially and hence IP did not begin to rise significantly until the mid-1970s (Yoo 1990).

South Korean IP and GDP levelled off in the early 1980s in response to the effects of high oil prices and the consequent world recession. The combination of high oil prices and South Korea's promotion of heavy and chemical industries, many of which were significant users of petroleum and petroleum products, resulted in slower growth in the late 1970s and early 1980s. The South Korean government's policies have since shifted away from sector specific targets. Since 1980, IP has grown on average by around 10 per cent a year with the fastest growing subsectors being transport equipment and electrical and electronic machinery. This compares with average growth in IP of around 21 per cent in the 1970s and 16 per cent in the 1960s.

Figure 1 South Korea's real GDP and IP



Taiwan

The movements in Taiwan's IP over the past couple of decades is similar to that of South Korea, with both economies evidencing fast growth in IP in the mid-1970s, before slowing in the early 1980s and then picking up again from the mid-1980s. However, growth in Taiwan's IP has been somewhat slower than that of South Korea with Taiwan's IP increasing by around 6 per cent a year between 1980 and 1993 compared with an average of 15 per cent a year during the 1970s and 16 per cent a year during the 1960s (figure 2). Similarly to South Korea, Taiwan implemented preferential policies for strategic industries; however, the extent of intervention was much less than in South Korea (Mai 1994).

Taiwan's industrial sector expanded significantly during the 1980s due mainly to growth in machinery, electronics and information technology industries, all of which had access to low interest rates and technological assistance from the government. The more recent shift in production to the services sector, together with the relocation of labour intensive industries off-shore, led to slower manufacturing growth rates in Taiwan in the early 1990s. In recent years, light industries have continued to decline but this has been more than offset by growth in heavy industries, partly as a result of demand for capital goods in implementing Taiwan's National Development Plan. The major growth industries are

Figure 2: Taiwan's real GDP and IP

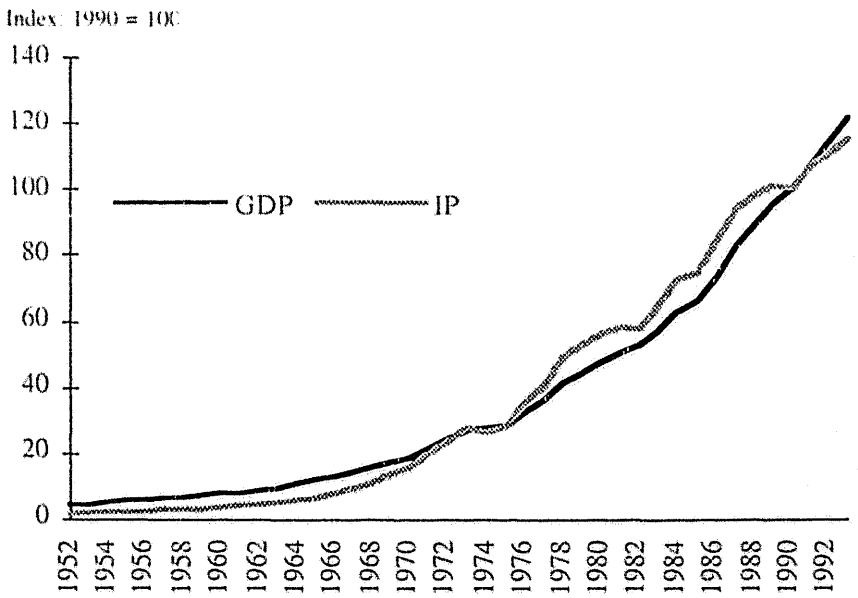
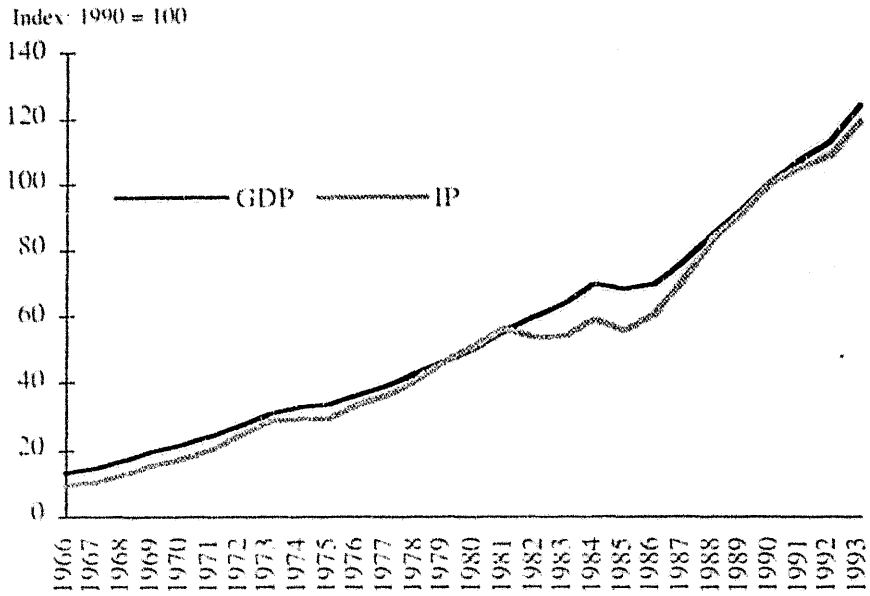


Figure 3. Singapore's real GDP and IP



chemical materials and products, metals and metal products and machinery and transport equipment. Food and paper products industries have maintained average growth while textile industries have survived by switching to synthetic fibres. Traditional light industries (garments, accessories, leather products, footwear and plastics) have shifted off-shore.

Singapore

As in South Korea and Taiwan, Singapore's IP and GDP levelled out in the early 1980s (figure 3).[2] Singapore was a significant importer of petroleum at that time (around 30 per cent of Singapore's total imports were mineral fuels) and the increase in oil prices in the late 1970s to early 1980s is likely to have slowed IP. Over the past ten years or so, Singapore's electronics industry has grown strongly to be around 40 per cent of manufacturing output in 1992. Hence, a significant part of the rise in IP and GDP over the 1980s and early 1990s is attributable to the development of this particular industry. The manufacturing industry has, however, been affected somewhat by sluggish demand as a result of the recent world recession and the relocation of factories to lower cost manufacturing bases in Malaysia and Indonesia. If this movement of factories to lower cost sites continues, some slowdown in Singapore's IP growth may occur over the next few years.

2 For Singapore, the Philippines, Thailand and Indonesia, data for IP is manufacturing production, due to a lack of data for the other industrial activities of mining, quarrying, electricity, gas and water. For simplicity, all data are referred to as 'IP' in the following discussion.

Industrial production in the less industrialised economies

In the Asian less industrialised economies, while IP forms a large part of their economies, labour intensive production is more predominant than capital intensive production. This partly reflects their lower labour costs relative to the newly industrialised economies. Many of the less industrialised economies have benefited in recent years from a shift of labour intensive industries out of the newly industrialised economies. However, within the less industrialised economies there remains significant variation in the degree of capital intensity of production.

China

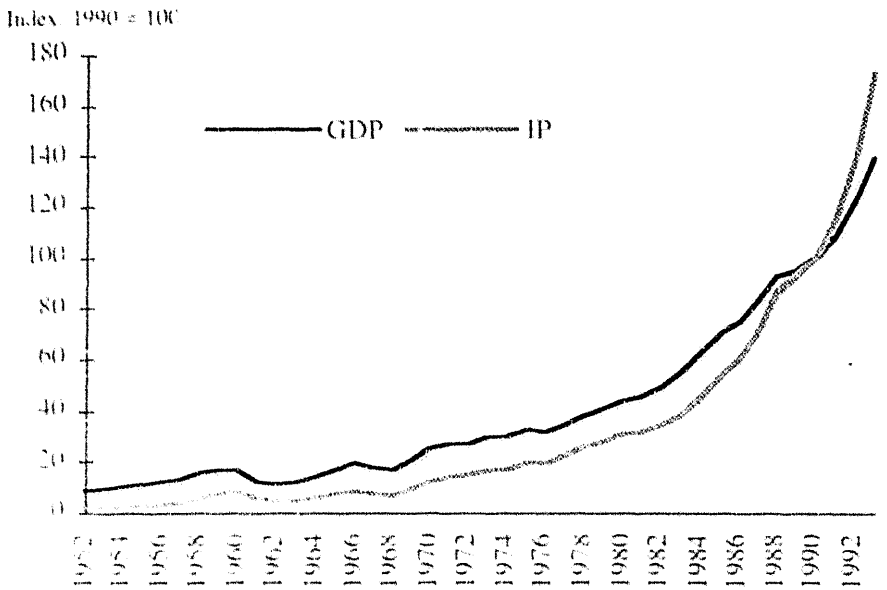
China's IP and GDP moved very closely from the 1950s to the 1980s (figure 4).[3] During this period, China developed a large industrial and infrastructure base, particularly in heavy industry, with production under the control of the central government. China began to implement a program of economic reforms in 1978, resulting in a substantial pick-up in IP and GDP growth from the early to mid-1980s. However, the close relationship between IP and GDP has gradually weakened since the mid-1980s, with further strong growth in IP which has not been fully reflected in GDP growth.

IP in China has grown, on average, by around 16 per cent a year since the mid-1980s, reflecting the gradual move toward industrialisation of the economy and government reforms. The pattern of growth in industrial production reflects the impact of economic reform and varies widely among the various regions in China. The more dynamic coastal provinces have experienced the most rapid growth in production, while inland provinces carrying a predominance of large state owned industry have grown relatively slowly. As the government reforms continue and predominance of inefficient state owned industries declines, industrial production in China could increase further (Asian Development Bank 1994).

China has had strong growth in both heavy and light industry in recent years; however, most new capital investment in China continues to be directed toward expanding the manufacturing capacity of the economy rather than to the much needed basic industries such as energy, industrial raw materials and transport. The boost to China's industrial production over recent years has come partly as a result of industries relocating from other higher cost Asian economies. For example, China has attracted some of Japan's steel producers, many of Hong Kong's light manufacturing industries, and has signed an

3 Economic activity data for China is real GNP due to a lack of data for real GDP. However, for simplicity in the following discussion, the economic activity data for China is referred to as 'GDP'. The IP and real GNP data for China may not fully reflect developments in the Chinese economy over the period from the 1950s to 1980s due to measurement errors.

Figure 4: China's real GDP and IP



industrial pact to allow South Korean textiles industries to establish operations in China where costs are considerably lower.

Philippines

In the Philippines, growth in IP appears to have lagged growth in GDP over the 1960s and 1970s (figure 5). However, the Philippines has experienced remarkably strong growth (from a very low base) of 15 per cent a year in IP during the 1980s and early 1990s, far exceeding growth in GDP of 2 per cent a year during that period. GDP in the Philippines decreased in the mid-1980s, as a result of political instability and a decline in investor confidence at that time, before strengthening again in the late 1980s. Growth in GDP levelled out and IP dropped sharply in the early 1990s, as the Philippine economy was constrained by a lack of power generation capacity. Following the completion of several new power stations over the past year or so, growth in GDP in the Philippines has picked up somewhat.

Thailand, Malaysia and Indonesia

The pattern of growth in IP in Thailand is very similar to that in Malaysia and somewhat faster than the growth in IP evident in Indonesia (figures 6, 7 and 8). Nevertheless, in each of these economies, IP and GDP moved closely during the 1970s and early 1980s before a strengthening in IP over the past ten years or so. Thailand and Malaysia have shifted

Figure 5: Philippines' real GDP and IP

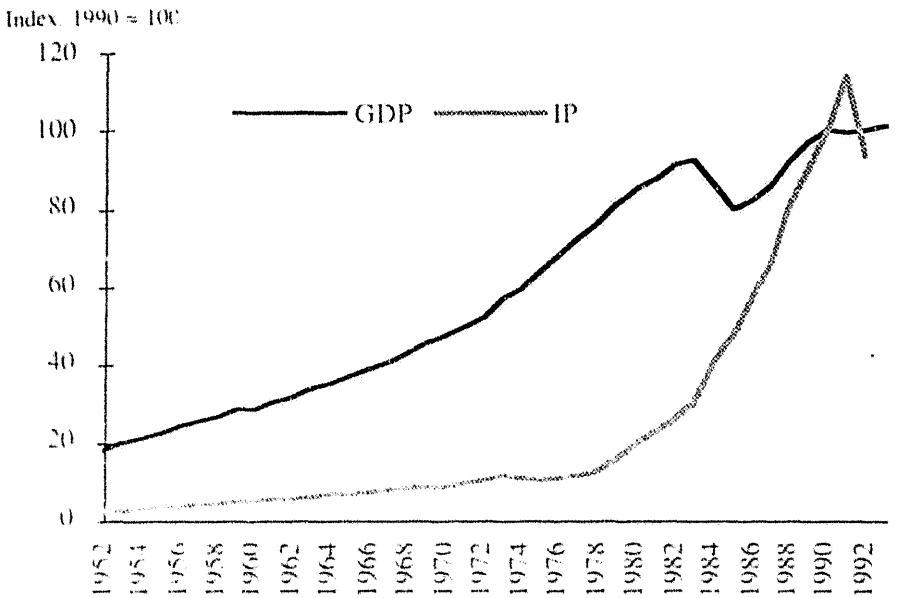


Figure 6: Thailand's real GDP and IP

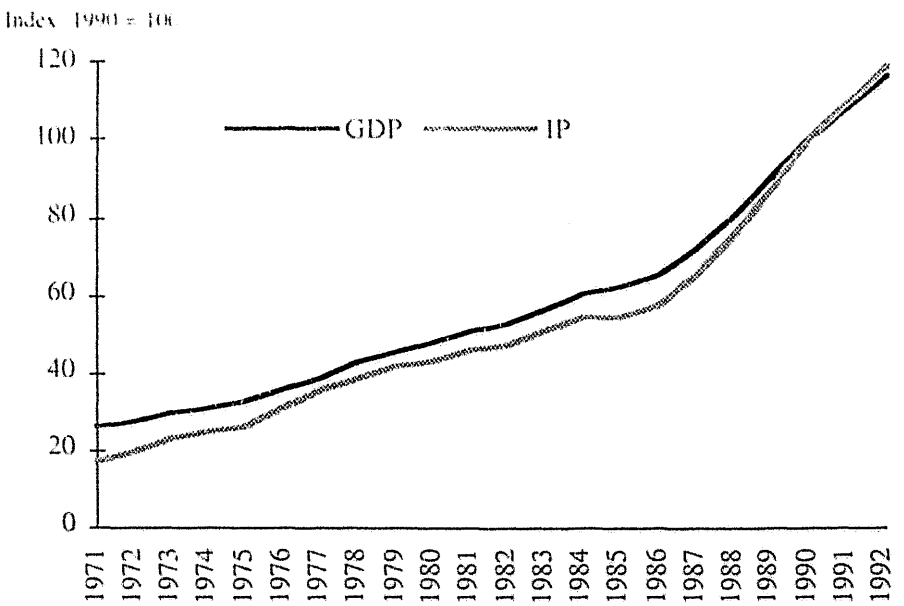


Figure 7: Malaysia's real GDP and IP

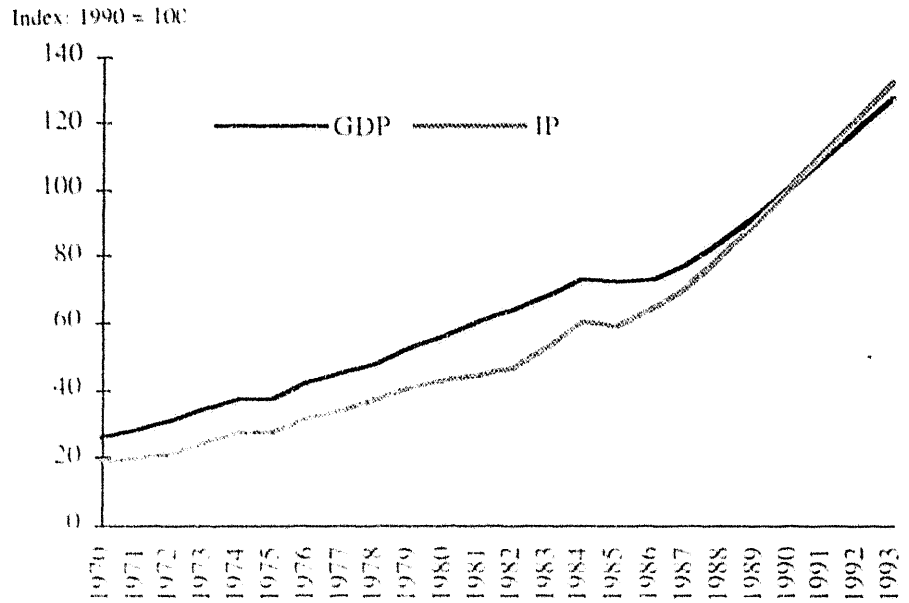
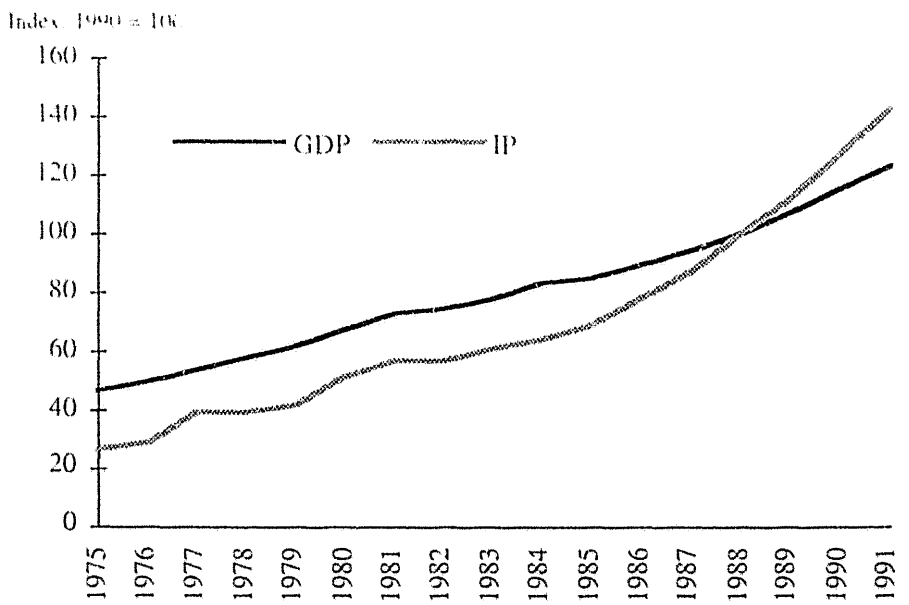


Figure 8: Indonesia's real GDP and IP



from agriculture and unskilled labour intensive manufacturing in the 1980s to a more capital intensive manufactured based economy in the 1990s.

In Indonesia, the availability of resource based exports during the 1960s and 1970s may have reduced the need for this economy to promote manufacturing exports as a source of foreign exchange and hence may have slowed the process of industrialisation (Hughes 1988). Indonesia has begun a shift away from being an oil based economy in the 1980s to a manufactured based economy in the 1990s. Indonesia's mining sector (including petroleum) has declined to around 16 per cent of GDP in the early 1990s, from around 21 per cent of GDP in the early 1980s (Asian Development Bank 1993). Increased infrastructure spending in Thailand, Malaysia and Indonesia has boosted growth in both IP and GDP in recent years and is expected to continue to provide some support over the next year or so.

3. Testing for a long term relationship between IP and GDP

In section 2, a visual examination of turning points and the similarity of cyclical movements in the IP and GDP series was undertaken. However, in order to examine the stability of the relationship between IP and GDP, a quantitative analysis of the relationships is necessary. Recent developments in econometrics provide the methodology for such quantitative investigations. In this section, the relationship between general economic activity and IP in selected Asian economies is examined using time series techniques. The integration properties of the data series are examined first, by testing for the presence of unit roots in each individual series. The results from the unit roots tests then form the basis of the testing for cointegration between general economic activity and IP.

The econometric analysis was undertaken using quarterly data for South Korea, Taiwan and Singapore. Graphs of the quarterly data for these countries are included in appendix A. For the remaining five Asian countries, annual data were analysed. All data are expressed in logarithms and quarterly data for South Korea and Taiwan are seasonally adjusted. The sample periods for the data are presented in table 2.

Integration properties of IP and GDP

A visual examination of the data presented in figures 1 to 8 suggests that these series are likely to be integrated or non-stationary, rather than stationary. If a series is stationary, while there may be some fluctuation in the series, there is a tendency for the series to

Table 2: Sample periods for industrial production and general economic activity

Country a	Sample period
South Korea	1978Q1–1993Q4
Taiwan	1984Q1–1993Q4
Singapore	1984Q1–1993Q4
China	1952–1993
Philippines	1952–1992
Thailand	1971–1992
Malaysia	1970–1993
Indonesia	[illegible]

a [illegible]

fluctuate around a mean value and to return to this mean over time. If a series is non-stationary, then the effect of any shock to the series is likely to be permanent and there is little tendency for the series to return to its pre-shock level.

The testing for the presence of unit roots in the data is a necessary and important step, as the unit root test results provide the basis for undertaking cointegration tests. In this study, testing for unit roots is first undertaken for each of the individual data series. If the presence of a unit root is detected in both GDP and IP for an economy, then cointegration testing will follow. Although the individual GDP and IP series could be non-stationary, a linear combination of the GDP and IP series would become a stationary series if cointegration exists between the GDP and IP series (Engle and Granger 1987).

In this study, testing for unit roots was undertaken using the procedure developed by Dickey and Fuller (1979) and the results are presented in table 3. For each of the series tested, the results suggest the presence of a unit root.

The test results for one unit root with the presence of a linear trend in the specification are also presented in table 3. The presence of a linear trend was found to be significant at the 5 per cent level in the GDP series for South Korea and in both the GDP and IP series for Taiwan, Singapore, China, Thailand and Indonesia. In each series, the null hypothesis of a unit root could not be rejected at the 5 per cent significance level.

Table 3: Unit root test results

		Test statistic a	
	Series	One unit root	One unit root with time trend
South Korea	GDP	-0.15	-1.50
	IP	0.82	-3.30
Taiwan	GDP	1.49	-1.82
	IP	-2.34	-1.79
Singapore	GDP	0.85	2.22
	IP	2.03	0.41
China	GDP	1.17	1.63
	IP	0.42	1.62
Philippines	GDP	1.64	-0.69
	IP	0.63	2.43
Thailand	GDP	0.53	-1.70
	IP	0.09	-3.33
Malaysia	GDP	0.35	-1.90
	IP	1.44	-0.68
Indonesia	GDP	0.46	-2.56
	IP	1.10	-2.60

a The test statistics for unit roots are based on an assumption of 3 lagged terms. The critical values at the 5 per cent level of significance are -3.50 with a linear trend included and -2.93 without a linear trend (Fuller 1976)

Testing for a cointegrating relationship between IP and GDP

The discussion presented in section 2 suggests a gradual change in the composition of GDP toward a greater share of IP and services in the Asian economies. However, this would not necessarily mean that there is no stable long term relationship between IP and GDP. For example, in South Korea during the 1960s and 1970s, the share of agriculture in GDP was relatively large (30 per cent) and the share of IP in GDP was relatively small (24 per cent). During this period, GDP was growing slowly, reflecting the low value added nature of agricultural production (see figure 1). However, the value added in industrial production is higher than in agricultural production. Hence, when IP in South Korea was growing strongly during the late 1970s and 1980s, growth in GDP also picked up at that time.

Nevertheless, given that the transition to a more industrialised economy began around ten years earlier in the newly industrialised economies than in the other Asian economies, and has continued steadily over a period of twenty years or so, the possibility of a steady long term cointegrating relationship between GDP and IP is expected to be stronger in the newly industrialised economies than in the less industrialised economies.[4]

To test for cointegration between two series, Engle and Granger (1987) suggest applying the augmented Dickey–Fuller test to the residuals of the cointegrating regression. Under this procedure, one variable is regressed against the other using ordinary least squares. The test for cointegration is then based on the residuals of this regression. If the residual series is found to be stationary, then the null hypothesis of no cointegration can be rejected.

The test results for the cointegrating regressions under both normalisations are presented in table 4. These results indicate that the hypothesis of no cointegration between IP and GDP can be rejected at the 5 per cent significance level for South Korea, Taiwan, China and Thailand. The failure to find significant evidence for a stable long term relationship between IP and GDP in the cases of Singapore, the Philippines, Malaysia and Indonesia may reflect a change in the relationship between IP and GDP during the sample period as industrialisation in these economies has progressed.

Several points should be noted about these results. The finding of a cointegrating relationship between IP and GDP for South Korea and Taiwan indicates the relationship between IP and GDP in these countries has stabilised and that they move closely together over time. In contrast, in the third newly industrialised economy, Singapore, the share of IP in the economy reached a peak around 1980 and, with strong growth in Singapore's services sector, the share of IP has been declining in recent years. This shift away from manufacturing may explain why no stable long term relationship was found between IP and GDP in the case of Singapore.

In the case of China, the hypothesis of no cointegration was rejected by the Engle and Granger test. However, this result should be interpreted with caution due to possible measurement errors in the data for China, and because the movements in China's GDP

4 Several researchers have developed techniques for testing for structural change in cointegrated regression models, for example, Hao and Inder (1993). However, these techniques invariably require that there is a structural break in a series at a specific identifiable point in time. In the IP and GDP data for the Asian economies, the structural change is more of a gradual process over a number of years, and hence these methods are not directly applicable. If more data were available, then data from the period of structural change could be avoided in the estimation for some of the countries. Given the lack of suitable alternative approaches for examining the long term relationship between two series in the presence of a gradual structural change, the usual method of cointegration will be used in this study.

Table 4: Cointegration test results

Country	Normalisation 1	ADF Test	Normalisation 2	ADF Test
South Korea	$IP_t = -1.26 + 1.34\,GDP_t$ $(-11.14)\ (62.97)$	-4.57*	$GDP_t = 1.02 + 0.73\,IP_t$ $(14.94)\ (62.97)$	-4.36*
Taiwan	$IP_t = 0.11 + 0.98GDP_t - 0.02T$ $(0.18)\ (7.18)\ (-4.04)$	-3.84*	$GDP_t = 1.86 + 0.60\,IP_t + 0.02T$ $(4.86)\ (7.18)\ (20.22)$	-5.98*
Singapore	$IP_t = -1.31 + 1.27\,GDP_t$ $(-6.86)\ (30.06)$	-1.62	$GDP_t = 1.16 + 0.75\,IP_t$ $(10.43)\ (30.06)$	-1.33
China	$IP_t = -2.83 + 1.56\,GDP_t$ $(-24.96)\ (53.49)$	-3.69*	$GDP_t = 1.65 + 0.63\,IP_t$ $(46.13)\ (53.49)$	-3.34*
Philippines	$IP_t = -4.77 + 1.87\,GDP_t$ $(-8.98)\ (13.89)$	-2.27	$GDP_t = 2.78 + 0.45\,IP_t$ $(31.36)\ (13.89)$	-2.11
Thailand	$IP_t = -6.94 + 1.20\,GDP_t$ $(-8.65)\ (44.22)$	-3.45*	$GDP_t = 0.81 + 0.82\,IP_t$ $(11.29)\ (44.22)$	-3.23*
Malaysia	$IP_t = -1.32 + 1.27\,GDP_t$ $(-11.70)\ (46.23)$	-2.00	$GDP_t = 1.07 + 0.78\,IP_t$ $(16.24)\ (46.23)$	-2.16
Indonesia	$IP_t = -3.12 + 1.67\,GDP_t$ $(-15.95)\ (35.91)$	-2.39	$GDP_t = 1.90 + 0.59\,IP_t$ $(29.36)\ (35.91)$	-2.40

T denotes a linear trend. The significance of the test statistics was examined using the augmented Dickey–Fuller (ADF) test.
* denotes a test statistic that is significant at the 5 per cent level according to Engle and Yoo (1987) when no linear trend is included or Phillips and Ouliaris (1990) when including a linear trend. 't' statistics' are reported in brackets, although some of these statistics are not t-distributed (see Engle and Granger 1987).

and IP presented in figure 4 suggests that, in recent years, the relationship between GDP and IP has changed from that in the 1950s to 1980s period.

4. Testing for short term lead–lag relationships

In this section, the data are analysed to determine whether short term lead–lag relationships can be found between GDP and IP. Following Penm (1994), lead–lag relationships are defined in such a way that if the lagged movements in IP are found to be significant in explaining the current movement in GDP with the expected sign (positive in this case), then IP is said to be a leading indicator of GDP. This definition is consistent with the 'causality' defined by Granger (1969), which is based entirely on the predicability of the dependent variable. If movements in IP contain leading information which helps to predict GDP, then IP is said to be a leading indicator of GDP.

The rejection of a long term relationship between GDP and IP in the previous section for some of the Asian countries does not preclude the existence of a short term relationship. The analysis of short term relationships was undertaken using an error correction model (ECM) for those economies where a long term cointegrating relationship was found. Engle and Granger (1987) showed that if variables are cointegrated, then they can be better modelled by an ECM, than with a vector autoregressive (VAR) model. The error correction term in this study is the residual series generated by the cointegrating regression in which IP was regressed against GDP, and is denoted Z_t.[5] The data are then examined to determine whether the ECM specifications indicate lead–lag relationships between IP and GDP, using the approach developed by Granger (1988).

For those economies where no long term relationship was found, a VAR model was estimated and lead–lag relationships were examined using the approach developed by Sims (1972). The results from the estimation of the ECMs and the VARs for the respective Asian economies are presented in table 5. For simplicity, the number of lags in the VAR specification of the equations was restricted to two for those countries for which quarterly data were used, and one where annual data were used. The test results for the lead–lag relationships are presented in table 6.

In the ECM specification for South Korea and Thailand, the lagged error correction term is significant in the equation for dIP_t, where d denotes first difference, with the expected negative sign on the estimated coefficient. This indicates that, for South Korea and Thailand, if IP_{t-1} exceeds the long term relationship with GDP_{t-1}, then there will be a negative effect on dIP_t which adjusts IP_t toward the long term relationship with GDP_t. In other words, the lagged error correction term, generated by the long term cointegrating relationship between IP and GDP, restricts movements in IP to maintain the long term relationship with GDP. In the equation for $dGDP_t$, the lagged error correction term is insignificant. This suggests that the level of IP will adjust according to the level of GDP, but not the other way around. Therefore, as disequilibrium occurs in the long term relationship between GDP and IP, it is IP, rather than GDP, which would adjust accordingly to re-establish this long term relationship. These results could reflect the fact that IP is a component of general economic activity.

In the case of South Korea, lagged movements in IP were also found to provide some information on current movements in GDP, but lagged changes in GDP were not found to

5 The error correction term used in the ECM for China is the residual series generated by the cointegrating regression in which GDP is regressed against IP. Hence for China, the expected sign of the coefficient of the error correction term will be the opposite of that expected in the ECMs for South Korea, Taiwan and Thailand.

Table 5: Estimated equations for GDP and IP

South Korea

$$\begin{bmatrix} dGDP_t \\ dIP_t \end{bmatrix} = \begin{bmatrix} -0.47 & 0.56 \\ (-4.01^*) & (3.60^*) \\ -0.08 & 0.23 \\ (-0.87) & (1.88) \end{bmatrix} \begin{bmatrix} dGDP_{t-1} \\ dIP_{t-1} \end{bmatrix} + \begin{bmatrix} -0.29 & -0.11 \\ (-2.53^*) & (-0.67) \\ -0.05 & 0.11 \\ (-0.52) & (0.81) \end{bmatrix} \begin{bmatrix} dGDP_{t-2} \\ dIP_{t-2} \end{bmatrix} + \begin{bmatrix} 0.07 \\ (\cdot\cdot 91) \\ -0.14 \\ (-2.56^*) \end{bmatrix}$$

Taiwan

$$\begin{bmatrix} dGDP_t \\ dIP_t \end{bmatrix} = \begin{bmatrix} -0.14 & -0.06 \\ (-0.91) & (-0.39) \\ -0.35 & 0.09 \\ (-1.56) & (0.37) \end{bmatrix} \begin{bmatrix} dGDP_{t-1} \\ dIP_{t-1} \end{bmatrix} + \begin{bmatrix} 0.26 & 0.14 \\ (1.69) & (0.91) \\ 0.22 & -0.17 \\ (0.96) & (-0.77) \end{bmatrix} \begin{bmatrix} dGDP_{t-2} \\ dIP_{t-2} \end{bmatrix} + \begin{bmatrix} 0.40 \\ \cdot 23^*) \\ -0.17 \\ (-0.63) \end{bmatrix} Z_{t-1}$$

Singapore

$$\begin{bmatrix} dGDP_t \\ dIP_t \end{bmatrix} = \begin{bmatrix} 1.14 & -0.65 \\ (2.25^*) & (-2.77^*) \\ 1.88 & -1.14 \\ (1.66) & (-2.15^*) \end{bmatrix} \begin{bmatrix} dGDP_{t-1} \\ dIP_{t-1} \end{bmatrix} + \begin{bmatrix} -0.42 & 0.07 \\ (-0.86) & (0.30) \\ -1.10 & 0.23 \\ (-1.00) & (0.45) \end{bmatrix} \begin{bmatrix} dGDP_{t-2} \\ dIP_{t-2} \end{bmatrix}$$

China

$$\begin{bmatrix} dGDP_t \\ dIP_t \end{bmatrix} = \begin{bmatrix} 1.06 & -0.57 \\ (2.64^*) & (-2.24^*) \\ -0.26 & 0.76 \\ (-0.64) & (1.21) \end{bmatrix} \begin{bmatrix} dGDP_{t-1} \\ dIP_{t-1} \end{bmatrix} + \begin{bmatrix} 0.26 \\ (1.41) \\ 0.60 \\ (2.09^*) \end{bmatrix} Z_{t-1}$$

Philippines

$$\begin{bmatrix} dGDP_t \\ dIP_t \end{bmatrix} = \begin{bmatrix} 0.47 & -0.14 \\ (3.43^*) & (-2.15^*) \\ 0.01 & 0.53 \\ (0.02) & (2.76^*) \end{bmatrix} \begin{bmatrix} dGDP_{t-1} \\ dIP_{t-1} \end{bmatrix}$$

Thailand

$$\begin{bmatrix} dGDP_t \\ dIP_t \end{bmatrix} = \begin{bmatrix} 0.20 & 0.15 \\ (0.60) & (0.89) \\ -0.31 & 0.51 \\ (-0.49) & (1.58) \end{bmatrix} \begin{bmatrix} dGDP_{t-1} \\ dIP_{t-1} \end{bmatrix} + \begin{bmatrix} -0.16 \\ (-1.30) \\ -0.48 \\ (-2.07^*) \end{bmatrix} Z_{t-1}$$

d denotes first difference. Z_{t-1} is the lagged error correction term. t-statistics are included in brackets below the estimated coefficients. * denotes a significant t-statistic at the 5 per cent level. The lagged movements in IP and GDP in the estimated VAR models for Malaysia and Indonesia are not significant. Hence for brevity, the estimated equations for these countries were excluded from table 5.

influence changes in IP. This indicates that IP is a leading indicator of GDP but not vice versa (table 6).

In the ECM specification for Taiwan the lagged error correction term is insignificant in the equation for dIP_t, but significant and positive in the equation for $dGDP_t$. This indicates that the lagged error correction term provides some information in explaining $dGDP_t$ but not in explaining dIP_t.

In the case of China, the lagged error correction term is significant in the equation for dIP_t, with the expected positive sign on the estimated coefficient. This suggests that if IP_{t-1} is below the long term relationship with GDP_{t-1}, then there will be a positive effect on dIP_t which adjusts IP_t toward the long term relationship with GDP_t. The ECM specification for China also indicates that IP is a leading indicator of GDP. Lagged movements in IP were found to provide some information on movements in GDP, but lagged changes in GDP were found not to influence changes in IP.

For the remaining countries, that is, Singapore, the Philippines, Malaysia and Indonesia, where no evidence for cointegration was found, a VAR specification was estimated. Lagged movements in IP were found to provide information on movements in GDP in the cases of Singapore and the Philippines (table 6). For Malaysia and Indonesia, no lagged movements in either GDP or IP were found to be significant in determining current movements in GDP or IP. For brevity, the test results for these two countries are not included in table 6.

Table 6: Lead–lag test results

	F-statistic	
	IP → GDP	GDP → IP
South Korea	6.51*	0.39
Taiwan	0.87	2.08
Singapore	3.83*	1.61
China	5.00*	1.46
Philippines	4.62*	0.00
Thailand	0.74	0.30

IP → GDP indicates that IP influences GDP, while GDP → IP indicates that GDP influences IP. The null hypothesis for each F-test is that the coefficient estimates on the lagged IP terms in the estimated GDP equation are jointly zero or that the lagged GDP terms in the estimated IP equations are jointly zero. * Denotes a test statistic that is significant at the 5 per cent level.

5. Concluding remarks

In this study, the relationship between IP and GDP has been examined for eight key Asian economies, both visually and using econometric time series techniques. This study forms part of the ongoing research at ABARE which investigates the prospects for Australia's commodity exports to the Asian region.

The results of this study show that the relationship between IP and GDP is complex and appears to be related to the stage of industrialisation in the Asian economies. In those economies where IP has been contributing to strong growth in the economy for several decades, such as South Korea and Taiwan, a stable long term cointegrating relationship between IP and GDP was detected. A long term cointegrating relationship between IP and GDP was also detected for Thailand, suggesting that the share of IP in the Thai economy may have stabilised.

For the other Asian economies which have undergone structural change during the past decade, progressing from an agricultural or light industry to a manufacturing or heavy industry based economy, a stable long term relationship between IP and GDP could not be found. An exception to this finding is China, where a cointegrating relationship between IP and GDP was detected, despite significant structural change in recent years. Consequently, the results for China should be treated with caution. Despite the lack of evidence for a stable long term relationship between IP and GDP in some of the Asian economies, IP was found, in many cases, to provide useful leading information for predicting short term movements in GDP.

These relationships between IP and GDP will be useful in generating forecasts for IP in the Asian economies which, in turn, could improve ABARE's assessment of commodity demand in the Asian region.

In addition to those relationships found between IP and GDP, an assessment of the influence of economic developments on IP and GDP would also be helpful in examining the likely movements of IP and GDP in these economies. For example, in Singapore, IP growth could slow somewhat in the future as Singapore firms are encouraged by the Singapore government to relocate manufacturing operations to lower cost economies such as Indonesia and China. The implementation of government plans in a number of the Asian economies, particularly Taiwan, Thailand and the Philippines, to overcome infrastructure bottlenecks and to increase energy supplies would provide some boost to IP and GDP

growth over the remainder of the 1990s. Further investigation of the influence on IP and GDP of likely economic developments in the Asian economies over the remainder of the 1990s would be a useful extension to this study.

Appendix A: Quarterly real GDP and IP for the newly industrialised economies

Figure 9: South Korea's real GDP and IP (seasonally adjusted)

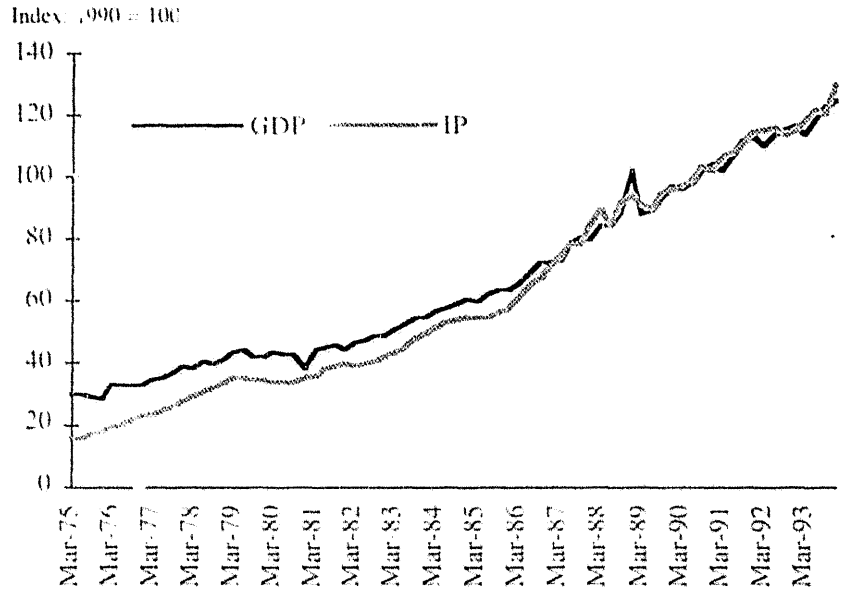


Figure 10: Taiwan's real GDP and IP (seasonally adjusted)

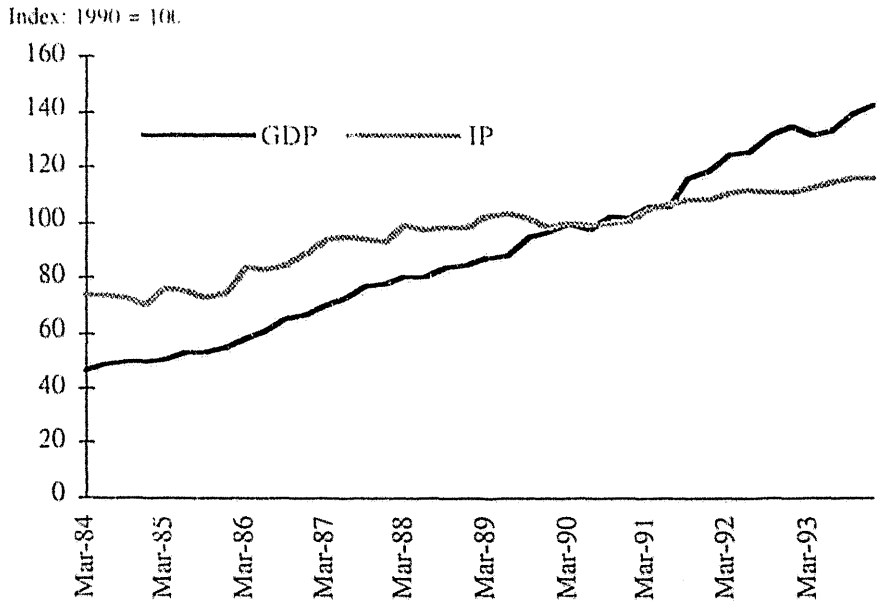
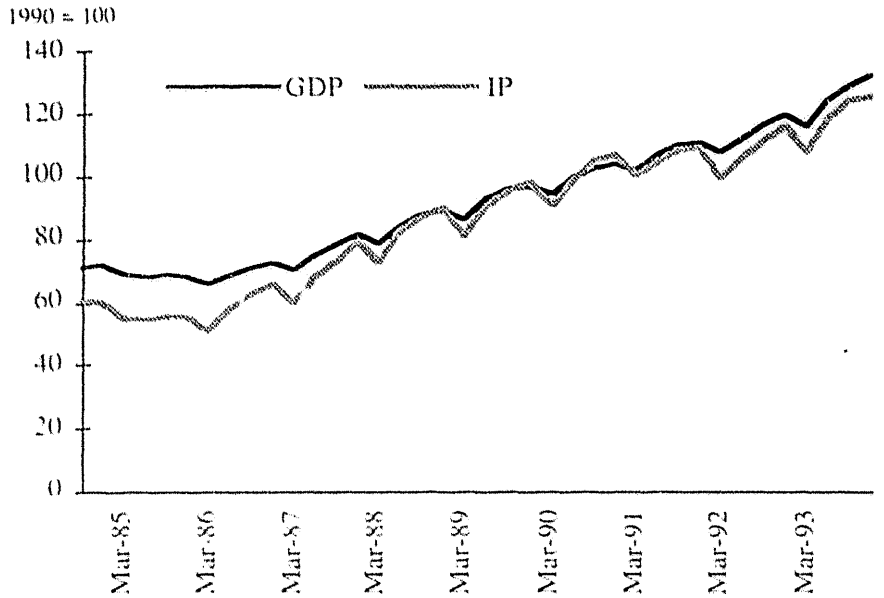


Figure 11: Singapore's real GDP and IP



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