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The interrelationship between general activity and industrial production in the major OECD economies

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General economic activity and industrial production (IP) are two major factors in determining commodity demand. In this paper, the interrelationship between general economic activity and IP is examined for a number of the OECD economies. The results indicate that there is a long term cointegrating relationship between general economic activity and IP in many of the OECD economies. IP is also found to contain short term leading information for general economic activity. These relationships would be useful in the forecasting of general economic activity and IP, which, in turn, could lead to improvements in commodity forecasts in both the short and longer term.

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1. Introduction

General economic activity and industrial production (IP) are two important economic variables in determining commodity demand. One important consideration in the forecasting of these two economic variables is their interrelationship. An improved understanding of this interrelationship would benefit the forecasting of these two economic variables, leading to improvements in forecasts of commodity demand in both the short and longer term.

It is widely believed that there is a long term cointegrating relationship between general economic activity and IP. A better understanding of this long term relationship would improve longer term forecasts for both general economic activity and IP (see Engle and Yoo 1987 and LeSage 1990). In addition to the long term relationship, there may also be some short term relationships between general economic activity and IP. These short term relationships, if identified, would also be helpful in improving short term forecasts for these economic variables and, hence, lead to improvements in the short term forecasts for commodity demand.

Gross domestic product (GDP) is generally conceived as a superior measure of general economic activity, but some have chosen to use IP instead. For example, the OECD has used its indices of IP as the reference series for general economic activity in constructing its leading indicators. In an OECD study by Nilsson (1987), the OECD composite leading indicators were found to provide good leading information for IP for about six months ahead. Nilsson presented two reasons for using IP rather than GDP, as the reference series for general economic activity. First, the indices of IP are more readily available than the indices of GDP in most of the OECD countries. Second, and more importantly, IP and GDP are so closely related that the composite leading indicators of IP could serve well as leading indicators of GDP.

However, Nilsson also notes that the movements in IP are much more cyclical than those in GDP and that in some periods, the movements of these series diverge quite significantly (also see figures 1 to 6 presented later). These movements question the assumed closeness of the relationship between IP and GDP in the OECD countries. Since the OECD composite leading indicators are specifically constructed to forecast IP, but not general economic activity, the usefulness of these leading indicators in predicting movements in general economic activity, or more specifically GDP, is doubtful, if the interrelationship between IP and general economic activity is not verified for the OECD economies.

The traditional way of examining the interrelationship between economic variables has mainly been based on the visual examination of turning points or the similarity of cyclical movements in data series. However, recent developments in econometrics have provided more precise methods for such investigations. In this study the interrelationship between general economic activity, measured by gross domestic (or national) product, and IP in a number of the major OECD economies is examined using time series techniques. The presence of a long term cointegrating relationship between general economic activity and IP is examined first, followed by an investigation for the existence of short term lead–lag relationships between general economic activity and IP. In this study, the lead–lag relationships are defined in such a way that if the lagged IP variable is found to enter the equation for general economic activity with the expected sign (positive in this case), then IP is said to be a leading indicator of general economic activity. This definition is consistent with the 'causality' defined by Granger (1969), which is based entirely on the predictability of the objective variables. If movements in IP contain leading information which helps to predict general economic activity, then IP is said to 'Granger cause' general economic activity, or, to be a leading indicator of general economic activity. For a more detailed discussion of the characteristics of leading and lagging indicators, please refer to Stock and Watson (1989).

In the next section, the integration properties of the data series used in this study are analysed. This involves both visual examination of the data movements and testing for the presence of unit roots for each individual series. The test results for unit roots form the basis of the testing for cointegration between IP and general economic activity presented in section 3. The investigation of the short term lead–lag relationships is presented in section 4. Concluding remarks are given in section 5.

2. Integration properties of IP and general economic activity in the OECD countries

Data series

In this study, quarterly data series of gross domestic (or national) product and IP were analysed for six major OECD countries — the United States, Japan, Germany, the United Kingdom, France and Italy. The data series were obtained from the OECD (1993) and covered the period from 1960(1) to 1993(1) for the United States, Japan and Germany and from 1968(2) to 1993(1) for the remaining countries. All data are seasonally adjusted and are in logarithms in this study. These data series are presented in figures 1 to 6.

Figure 1: US GDP and IP

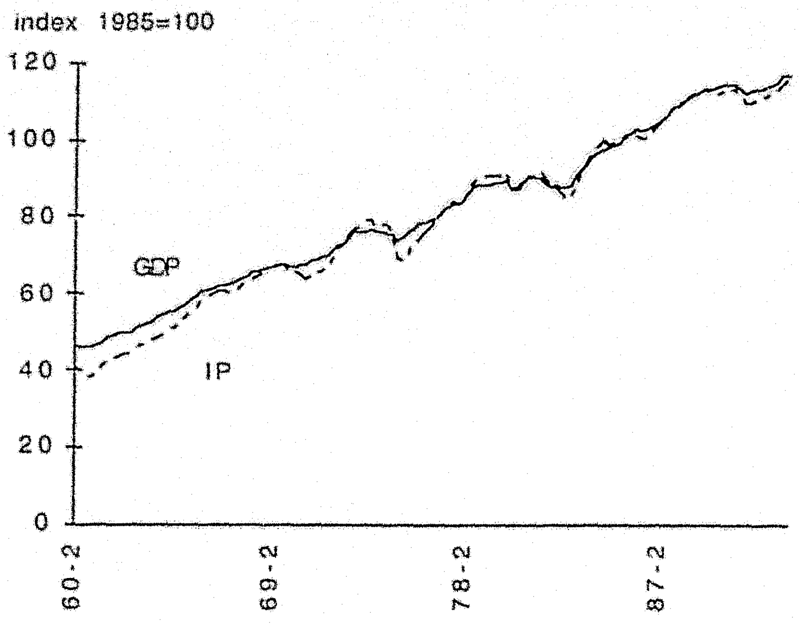


Figure 2: Japanese GNP and IP

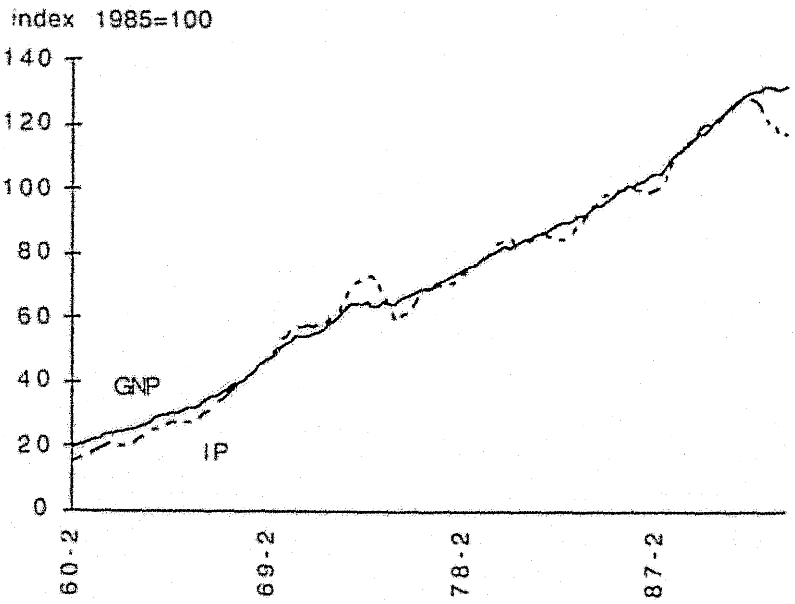


Figure 3: German GNP and IP

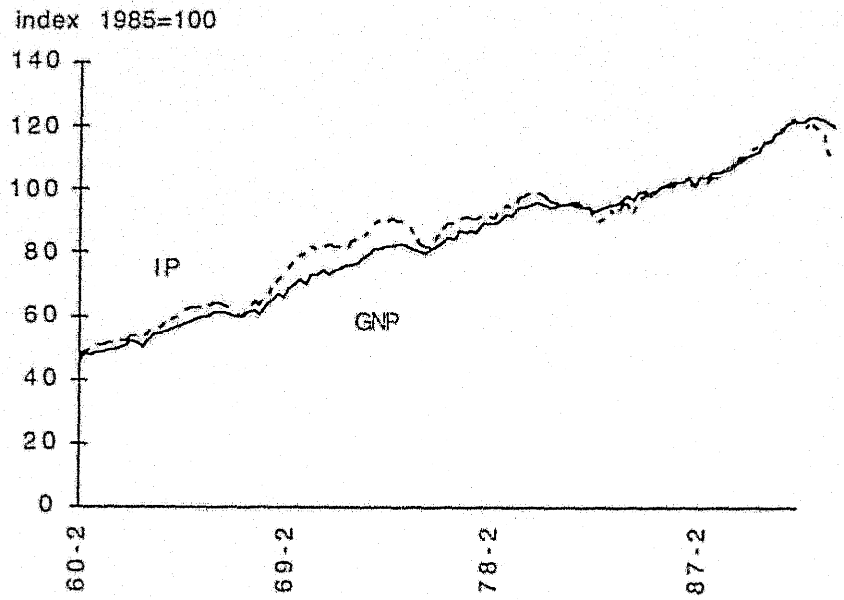


Figure 4: UK GDP and IP

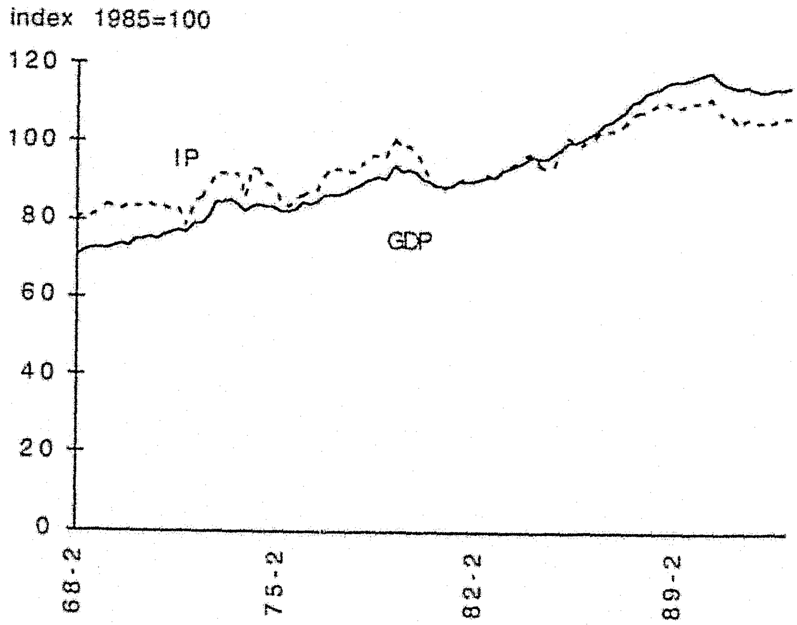


Figure 5: French GDP and IP

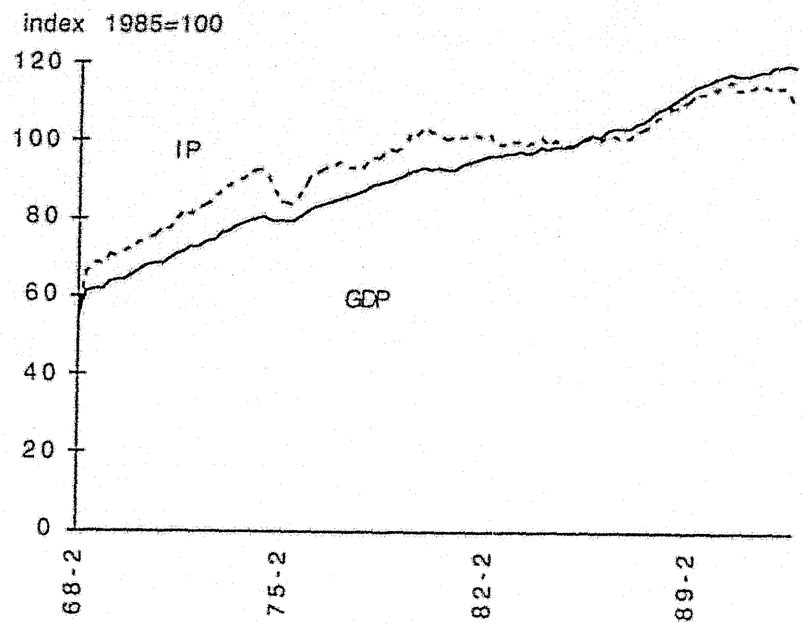
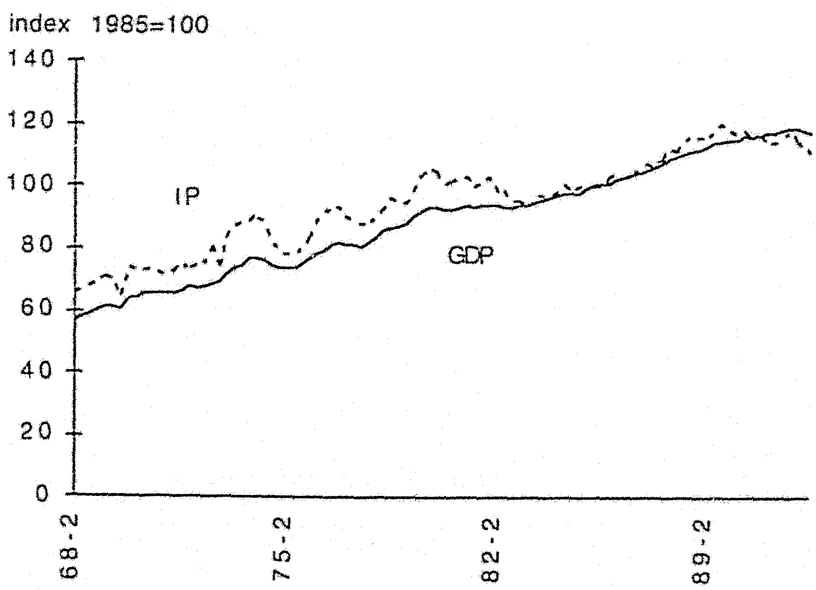


Figure 6: Italian GDP and IP



Several interesting features were observed in these data series. First, both the GDP and IP indices moved in a very similar pattern, possibly indicating a close relationship between the two variables for these economies. The movements in these indices were particularly similar for the United States and Japan.

Second, for most of the European countries examined, there has been a slowdown in the growth of IP since the late 1970s, compared with that in GDP. In Germany, the United Kingdom, France and Italy, the IP index moved from above the GDP index before the late 1970s to below the GDP index thereafter. This pattern is particularly obvious in the case of the United Kingdom (figure 4). These movements suggest that the contribution of IP to GDP growth has weakened over time and that the contribution of service industries to GDP growth has increased significantly in these economies over the past decade.

An examination of the data presented in figures 1 to 6 also suggests that these series are likely to be characterised as integrated of order 1 — that is, I(1), rather than stationary, I(0). An I(0) series has a mean and there is a tendency for the series to return to that mean, so that the series will fluctuate around the mean. In contrast, an I(1) series will move widely and rarely return to an earlier value. Recent empirical research in time series analysis has demonstrated that the relative success of time series modelling depends importantly on the issue of integration or stationarity of the variables under investigation. For example, if an I(1) system is cointegrated, then the commonly used vector autoregressive (VAR) models, in levels or first differences, will be misspecified. Granger (1986) and Engle and Granger (1987) showed that if two variables are cointegrated of order (1, 1), then they should be modelled by an error correction model (ECM). The findings of Granger (1986) and Engle and Granger (1987) strongly support the use of a pretesting strategy to analyse the integration properties of the data series under investigation, both individually and jointly as a system, and to consequently determine the appropriate specification for time series analysis.

In this study, such a pretesting strategy is followed. That is, before forming a system for the investigation of the interrelationship between IP and GDP, testing for unit roots is first undertaken for each individual data series. If the presence of a unit root is detected in each of the data series, testing for cointegration will then follow. Based on these test results, an appropriate specification will be determined for the examination of the interrelationship between IP and GDP.

The presence of unit roots

The approach generally used to test the number of unit roots in a series is to first test for the presence of a unit root when the series is expressed in levels. If the hypothesis of the presence of a unit root is not rejected, then testing for the presence of a unit root in the first-differenced series follows, and so on. However, if the series contains more than one unit root, then testing in this sequence would be inappropriate because the commonly used tests such as the augmented Dickey and Fuller (ADF) test (see Dickey and Fuller 1979) are based on the assumption of the presence of, at most, one unit root. To correctly test for the presence of unit roots, Dickey and Pantula (1987) proposed a test procedure which uses a different testing sequence. They suggest that test should start with the largest number of unit roots under consideration and then work downward; that is, decrease the number of unit roots to be tested by one each time the null hypothesis of the presence of a unit root is rejected.

The testing for the presence of more than one unit root is necessary and important because it forms the basis for the selection of a test procedure for cointegration. It must be noted that the procedures for testing for cointegration in a system, including higher order integrated series, are very different from those for series which are only integrated of order 1. If any series in a system being tested contains more than one unit root, then the test results for cointegration in this system which uses a procedure strictly designed for integrated series of order 1 will be misleading. For the procedures of testing for cointegration involving higher order integrated series, refer to Stock and Watson (1991) and Johansen (1990).

In this study, the testing procedure developed by Dickey and Pantula (1987) was followed. To undertake this test procedure, the following equation was estimated for each of the series:

(1)
$$\left(d^k X\right)_t = a + \sum_{i=j-1}^{k-i} b_i \left(d^i X\right)_{t-1} + e_t$$

where: $d^i X$ denotes the i-th differenced series of X_t; k is the order of the underlying autoregressive (AR) process; and j is the number of unit roots under test. For each of the hypothesised number of unit roots, equation (1) was reestimated. The null hypothesis of the presence of unit roots was tested using the 't-statistic' for the coefficient b_{j-1}, although this test statistic is not t-distributed (Dickey and Pantula 1987). Critical values of the test distribution are presented in Fuller (1976).

In this test, the maximum number of unit roots under test was three. For brevity, only the test results for two unit roots or less are presented in table 1. For each of the series tested, the results suggest the presence of only one unit root.

However, if the specification used for unit root testing is incorrect, so that the deterministic components, such as a linear trend, are not completely purged from the variable under consideration, then the test statistic obtained will be biased towards accepting the null hypothesis of a unit root. Hence, the test results for one unit root with the presence of a linear trend in the specification are also presented in table 1. These test statistics are all higher than the associated critical values at the 5 per cent level, accepting the null hypothesis of one unit root in these series. Given that the test results for unit roots can sometimes be influenced by the assumed order of the underlying AR process in the testing, this test procedure was repeated for several different orders. The hypothesis of one unit root was accepted in every case at the 5 per cent level. These results consistently support the presence of only one unit root in both the GDP and IP data series in the OECD economies examined.

Table 1: Dickey and Pantula test results for unit roots

	Variable	Two unit roots	One unit root
United States	GDP	–4.69*	–2.20 (–2.86)
	IP	–5.37*	–2.60 (–3.32)
Japan	GNP	–3.75*	–2.61 (–1.50)
	IP	–5.11*	–2.71 (–1.53)
Germany	GNP	–3.87*	–1.71 (–1.62)
	IP	–4.10*	–1.91 (–1.74)
United Kingdom	GDP	–4.10*	–1.01 (–2.37)
	IP	–5.53*	–1.10 (–2.77)
France	GDP	–3.63*	–2.24 (–2.66)
	IP	–4.82*	–2.44 (–2.85)
Italy	GDP	–5.25*	–1.83 (–1.84)
	IP	–4.78*	–1.53 (–2.54)

The test statistics for unit roots are based on an assumption of an underlying AR(5) process in levels. The test statistics for one unit root including a linear trend are presented in brackets.
* denotes a test statistic that is significant at the 5 per cent level according to the associated critical value in Fuller (1976)

3. Cointegrating relationships between IP and general economic activity in the OECD countries

Following Engle and Granger (1987), a set of n time series variables, X_t, with no deterministic components is said to be cointegrated of order (1, 1), if each series is integrated of order 1 and if there exist r, where $r < n$, linearly independent vectors, $\beta^1, \ldots, \beta^r$ and $\beta = (\beta^1, \ldots, \beta^r)$, so that $Z_t = \beta' X_t$ is stationary. The β^i vectors are called the cointegrating vectors and Z_t is the vector which contains the error correction terms.

Evidence that cointegrating vectors exist provides strong support for long term relationships among a set of variables. However, testing for the existence of cointegration gives rise to non-standard testing procedures because the asymptotic theory of regression in integrated systems is very different from the conventional theory for stationary series. For testing cointegration in a bivariate system, a number of approaches have been developed by Engle and Granger (1987). Their major recommendation was to apply the ADF test to the residuals of the cointegrating regression. In this procedure, the ordinary least squares technique is utilised first to regress one variable against the other (the cointegrating regression). 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 coefficient estimates obtained in the cointegrating regression can be used as estimates for the cointegrating vector.

In this study, the Engle and Granger procedure was utilised because it is computationally simpler for bivariate systems. This procedure depends on a particular normalisation for the cointegrating regression[1]. Engle and Yoo (1987) indicate that the test statistics have the same distribution for all possible normalisations. They also suggest that, empirically, the test statistics should be insensitive to the choice of normalisation. However, conflicting conclusions between different normalisations have been reported in some empirical studies (see Krol and Ohanian 1990).

In table 2, the test results for the two possible normalisations are presented. These results indicate that, for many of the major OECD economies, the hypothesis of no cointegration between GDP and IP can be rejected at the 5 per cent level in both of the normalisations.

[1] In a bivariate system, say $X_t = (X^1_t, X^2_t)$, with the existence of a cointegrating relationship, say $\beta = (\beta_1, \beta_2)$ and $\beta' X_t = (\beta_1, \beta_2)(X^1_t, X^2_t)' = Z_t$, there are two possible normalisations which can be adopted in the cointegrating regression, ie $X^1_t = a + (\beta_2/\beta_1) X^2_t + Z_t$ and $X^2_t = a + (\beta_1/\beta_2) X^1_t + Z_t$. The estimated cointegrating vector in these two possible normalisations is $(1, \beta_2/\beta_1)$ or $(\beta_1/\beta_2, 1)$ respectively. For examples, see table 2.

Table 2: Engle and Granger test for cointegration

Country	Normalisation a	ADF test b
United States	$GDP_t = 0.56 + 0.88\,IP_t$	–3.27*
	(16.05) (10.18)	
	$IP_t = -0.58 + 1.13\,GDP_t$	–3.53*
	(12.97) (10.18)	
Japan	$GDP_t = 1.25 + 0.63\,IP_t + 0.01\,T$	–3.98*
	(37.76) (59.64) (27.78)	
	$IP_t = -1.81 + 1.53\,GDP_t - 0.01\,T$	–4.12*
	(21.83) (59.64) (17.70)	
Germany	$GDP_t = -0.31 + 1.06\,IP_t$	–2.16
	(5.28) (81.06)	
	$IP_t = -1.76 + 1.47\,GDP_t$	–2.38
	(12.66) (41.30)	
United Kingdom	$GDP_t = -2.33 + 1.51\,IP_t$	–3.26*
	(13.10) (38.53)	
	$IP_t = 1.73 + 0.62\,GDP_t$	–3.47*
	(23.70) (38.53)	
France	$GDP_t = 1.79 + 0.55\,IP_t + 0.01\,T$	–4.26*
	(32.90) (43.61) (61.12)	
	$IP_t = -2.89 + 1.73\,GDP_t - 0.01\,T$	–4.18*
	(17.50) (43.61) (61.12)	
Italy	$GDP_t = -1.11 + 1.23\,IP_t$	–3.31*
	(9.47) (47.64)	
	$IP_t = 1.05 + 0.78\,GDP_t$	–3.03
	(14.35) (47.64)	

a A linear trend was included in the testing for Japan and France. For the remaining countries, including a linear trend or not in the testing does not influence the conclusions. b ADF test denotes the test procedure for unit roots developed by Dickey and Fuller (1979). * denotes a test statistic that is significant at the 5 per cent level according to Engle and Granger (1987) or Phillips and Ouliaris (1990). The critical values at the 5 per cent level are –3.80 and –3.17 respectively for including or not including a linear trend. *T* denotes a linear trend. 't-statistics' are in brackets, although some of these statistics are not t-distributed (see Engle and Granger 1987).

Germany is an exception to this finding because the hypothesis of no cointegration between GDP and IP cannot be rejected at the 5 per cent level in either of the normalisations. The resulting residuals from the two different normalisations are presented in figures 7 and 8. These two figures show that the failure to reject the null

Figure 7: Residuals — German IP regressed against GNP

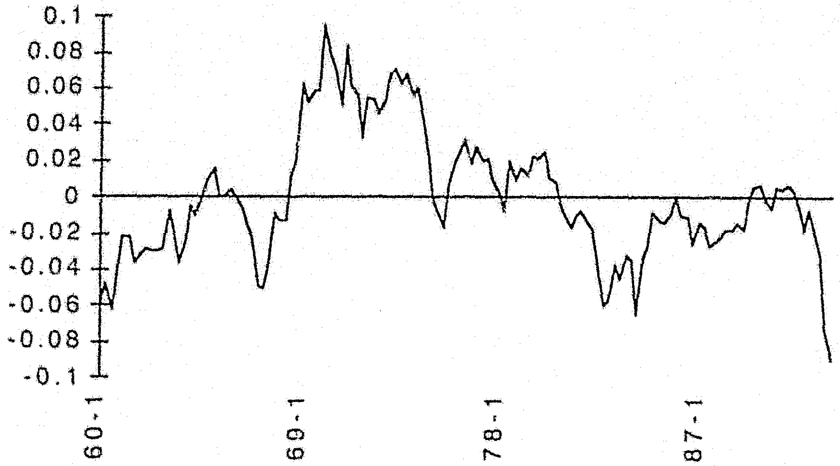


Figure 8: Residuals — German GNP regressed against IP

hypothesis of no cointegration between GDP and IP in the case of Germany could be related to the rapid growth in German IP in the early 1970s. This could have led to significant changes in the corresponding residuals of the cointegrating regression, resulting in the acceptance of the presence of a unit root in these residuals series[2]. To clarify these results for Germany, the test procedure for cointegration developed by Johansen (1988) was also applied to German GDP and IP data series. Similar results were obtained with no evidence of cointegration between GDP and IP.

Another interesting case is Italy. Inconsistent results were obtained in the two different normalisations used in the testing. In the normalisation in which GDP was regressed against IP, the ADF test statistic on the resulting residuals is lower than the critical value of −3.17 at the 5 per cent level reported by Engle and Granger (1987), indicating that the null hypothesis of no cointegration can be rejected. However, in the other normalisation in which Italian IP was regressed against GDP, the associated test statistic of −3.03 is slightly higher than the critical value at the 5 per cent level, but lower than the critical value of −2.84 at the 10 per cent level. The Johansen procedure was also applied to the Italian data series of GDP and IP. From the results obtained, the presence of a cointegrating relationship between Italian GDP and IP were found and accepted.

4. Testing for short term lead–lag relationships

Model specification

With the exception of Germany, the test results presented in the previous section indicate the existence of a long term cointegrating relationship between general economic activity and IP in most of the major OECD economies. In this section, the short term lead–lag relationships between GDP and IP in the selected OECD economies are examined. The existence of cointegration between these two economic variables has important implications for the testing for lead–lag relationships. It implies rank reducing restrictions on the coefficient matrices of the vector moving average representation in the first differences and on the coefficient matrices of the VAR representation in the levels. Granger (1988) argued that if these restrictions are not imposed, then the testing for lead–lag relationships using a VAR representation could draw incorrect conclusions. Engle and

[2] It can be argued that the observations on German industrial production in the 1970s could be outliers and, if removed, the hypothesis of no cointegration between German industrial production and general economic activity could be rejected. However, it should be noted that, in doing so, the number of observations available for testing would reduce significantly (to around 55), resulting in a problem of insufficient sample size.

Granger (1987) demonstrated that a useful way of imposing these restrictions was to transform the VAR under test into an ECM[3].

How can a suitable specification for the resulting ECM be determined, so that efficient estimation and testing can be carried out? A starting point commonly used by researchers is to assume that this ECM is of full order — that is, there are no zero coefficients (or zero entries) in the coefficient matrices of the ECM. However, recent empirical research has shown that it is impractical to ignore the possibility of zero coefficients in error correction modelling and that the estimation and test results could be very different if the presence of zero coefficients is allowed (Penm and Terrell 1993).

To incorporate zero coefficients into the error correction modelling, a procedure which uses the order selection procedure developed by Penm, Penm and Terrell (1993), was used to determine the 'optimal' specification for an ECM. Penm, Penm and Terrell (1993) provide a method for the recursive fitting of a subset VAR with exogenous variables (VARX). They suggest the use of ascending recursions in conjunction with an order selection criterion to choose an 'optimal' subset VARX and this procedure can be extended to the selection of a subset VARX with zero coefficients. Since an ECM is in fact a VARX, the order selection procedure developed by Penm, Penm and Terrell (1993) can be applied to an ECM for choosing an 'optimal' specification[4]. For details of this procedure, interested readers are referred to Penm, Penm and Terrell (1993) and Penm and Terrell (1993).

In this study, this procedure was applied to the ECM systems formed by GDP and IP for the OECD economies. In applying this procedure, the maximum order of the VAR part of the ECM was assigned to be eight, eight quarters or two years. In each of the ECMs, the residual series generated by the cointegrating regression in which IP was regressed against GDP was used for the error correction term. Following Penm and Terrell (1993), the order

[3] In a cointegrated VAR representation, say $A(L)X_t = \varepsilon_t$, where $A(L)$ is a polynomial and L denotes the lag operator, the co-integrating relationships generate restrictions which make $A(1)$ singular and $A(1) = \alpha\beta'$, where β is a nxr matrix formed by the cointegrating vectors and α is a nxr matrix of constants. Because any $A(L)$ can be rearranged as $A(L) = A(1) + (1-L)A^*(L)$, this VAR can be transformed into an error correction model, ie $A^*(L)(1-L)X_t + \alpha\beta' X_{t-1} = \varepsilon_t$ or $A^*(L)dX_t + \alpha Z_{t-1} = \varepsilon_t$, where d denotes the first difference and $Z_{t-1} = \beta' X_{t-1}$ is the lagged error correction term. It can be seen that the error correction model includes a VAR in first differences and a level term, $\alpha\beta' X_{t-1}$ or αZ_{t-1}, by which the cointegration restrictions are imposed. For details see Engle and Grange (1987).

[4] A time series model of the form $P(L)V_t + Q(L)R_t = \varepsilon_t$ is known to be a VARX which involves an nx1 regression vector V_t and a rx1 regressor vector R_t. Suppose $P(L) = A^*(L)(1-L)$, $V_t = X_t$, $Q(L) = \alpha L$ and $R_t = Z = \beta' X_t$, then $P(L)V_t + Q(L)R_t = A^*(L)dX_t + \alpha Z_{t-1} = \varepsilon_t$. Therefore, an ECM becomes a VARX. Since all of the terms in the ECM are stationary and the representation is in fact a VARX, the order selection procedure developed by Penm, Penm and Terrell (1993) can be applied to the ECM for choosing an optimal specification for estimation and forecasting.

Table 3: Specifications for the GDP and IP systems

Country	Specification
United States	$\begin{bmatrix} dGDP_t \\ dIP_t \end{bmatrix} = \begin{bmatrix} 0 & \underset{(4.63)}{0.197} \\ 0 & \underset{(7.30)}{0.522} \end{bmatrix} \begin{bmatrix} dGDP_{t-1} \\ dIP_{t-1} \end{bmatrix} - \begin{bmatrix} 0 \\ \underset{(2.78)}{0.079} \end{bmatrix} Z_{t-1}$
Japan	$\begin{bmatrix} dGNP_t \\ dIP_t \end{bmatrix} = \begin{bmatrix} 0 & \underset{(5.14)}{0.215} \\ 0 & \underset{(13.40)}{0.770} \end{bmatrix} \begin{bmatrix} dGNP_{t-1} \\ dIP_{t-1} \end{bmatrix} - \begin{bmatrix} 0 \\ \underset{(6.18)}{0.202} \end{bmatrix} Z_{t-1}$
Germany	$\begin{bmatrix} dGNP_t \\ dIP_t \end{bmatrix} = \begin{bmatrix} \underset{(9.11)}{-0.592} & \underset{(4.63)}{0.409} \\ \underset{(10.00)}{-0.816} & \underset{(2.99)}{0.195} \end{bmatrix} \begin{bmatrix} dGNP_{t-1} \\ dIP_{t-1} \end{bmatrix} + \begin{bmatrix} \underset{(5.69)}{-0.461} & \underset{(2.71)}{0.163} \\ 0 & 0 \end{bmatrix} \begin{bmatrix} dGNP_{t-2} \\ dIP_{t-2} \end{bmatrix} + \begin{bmatrix} \underset{(7.56)}{-0.557} & \underset{(5.56)}{0.314} \\ 0 & 0 \end{bmatrix} \begin{bmatrix} dGNP_{t-3} \\ dIP_{t-3} \end{bmatrix}$
United Kingdom	$\begin{bmatrix} dGDP_t \\ dIP_t \end{bmatrix} = -\begin{bmatrix} 0 \\ \underset{(3.40)}{0.194} \end{bmatrix} Z_{t-1}$
France	$\begin{bmatrix} dGDP_t \\ dIP_t \end{bmatrix} = \begin{bmatrix} 0 & \underset{(1.98)}{0.051} \\ 0 & \underset{(3.30)}{0.202} \end{bmatrix} \begin{bmatrix} dGDP_{t-1} \\ dIP_{t-1} \end{bmatrix} - \begin{bmatrix} 0 \\ \underset{(4.37)}{0.297} \end{bmatrix} Z_{t-1}$
Italy	$\begin{bmatrix} dGDP_t \\ dIP_t \end{bmatrix} = \begin{bmatrix} 0 & \underset{(3.30)}{0.084} \\ 0 & 0 \end{bmatrix} \begin{bmatrix} dGDP_{t-1} \\ dIP_{t-1} \end{bmatrix} - \begin{bmatrix} 0 \\ \underset{(2.82)}{0.186} \end{bmatrix} Z_{t-1}$

d Denotes first difference. 0 Denotes a zero coefficient. Z_{t-1} is the lagged error correction term. t-statistics are in brackets.

selection criteria developed by Schwarz (1978) was used to select the specifications for the ECMs. In the case of Germany, where no cointegrating relationship was found between GDP and IP, the order selection procedure developed by Penm and Terrell (1984) was used to determine the specification for the corresponding VAR. These identified specifications were estimated using the generalised least squares technique and are presented in table 3.

The short term lead–lag relationships

Several interesting findings are evident from table 3. For the United States, Japan and France, the specifications determined for the associated ECMs are identical in structure. For Italy the determined specification is slightly different and for the United Kingdom it is significantly different.

In the determined ECM specifications, the lagged error correction term consistently enters the equation for dIP_t where d denotes the first difference, with the expected sign on the estimated coefficient (a negative sign). This indicates that, for those OECD economies, 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 towards the long term relationship and vice versa. In other words, the lagged error correction term, generated by the long term cointegrating relationship between GDP and IP, represents a constraint on dIP_t, restricting movements in IP to maintain the long term relationship with GDP.

It is interesting to note that the lagged error correction term is not included in the equation for $dGDP_t$ in any of the determined specifications. This indicates that for each of the economies investigated, the level of IP will adjust according to the level of GDP, but not the other way around. For example, if IP_{t-1} exceeds the long term relationship with GDP_{t-1}, then there will be no significant effect on $dGDP_t$ nor on GDP_t, to reestablish the long term relationship. The adjustment will mainly occur on dIP_t, and hence on IP_t to restore this long term relationship between GDP and IP. These results could reflect the fact that IP is a component of GDP. Therefore, as disequilibrium occurs in the long term relationship between GDP and IP, it is IP, rather than GDP, which would adjust accordingly to reestablish this long term relationship.

With the exception of the United Kingdom, the determined ECM specifications consistently indicate that IP is a leading indicator of general economic activity. That is, the lagged IP variable consistently enters the equation for general economic activity. It should be noted that to begin the selection for an optimal specification in the utilised procedure, the maximum order of the VAR part of the ECM was assigned to be eight, that is eight quarters or two years. However, in most determined specifications, only dIP_{t-1} is included in the equation for $dGDP_t$. This indicates that for the United States, Japan, France and Italy, only movements in one-period lagged IP contains significant leading information for movements in current-period general economic activity.

There are some exceptions to this relationship. In Germany, up to three-period lagged movements in IP are included in the equation for general economic activity, indicating that, in Germany, movements in IP have prolonged influences on movements in general economic activity.

In contrast to other major OECD economies, a significant short term relationship between IP and GDP could not be found for the United Kingdom. This would indicate that lagged

IP does not contain leading information for general economic activity and that a leading indicator system for IP would not provide useful information in forecasting GDP for the United Kingdom. Although there is a cointegrating relationship between IP and GDP, the long term relationship does little to explain short term movements in GDP (that is, the lagged error correction term does not enter the equation for $dGDP_t$). These results raise serious doubts about the use of IP to approximate general economic activity in the case of the United Kingdom.

5. Concluding remarks

In this study, the interrelationship between IP and general economic activity has been examined for a number of major OECD economies using econometric time series techniques. This study forms part of the ongoing research at ABARE which is investigating the usefulness of various leading indicators in forecasting general economic activity. These leading indicators, if identified, will provide useful information for the assessment and forecasting of the economic environment faced by the commodity sector.

The results of this study show that the interrelationship between OECD IP and general economic activity, measured by gross domestic (or national) product, is complex and varies between countries. However, a long term cointegrating relationship between IP and general economic activity in many of the OECD economies was detected which will be useful in explaining the movements in IP in these economies.

The results also show that movements in one-period lagged IP provide useful information for predicting movements in current period general economic activity in many of the OECD economies examined. That is, IP was found to be a leading indicator of general economic activity in many of the OECD economies.

In the case of Germany, the results of testing for cointegration between general economic activity and IP contradict the common findings for other major OECD economies. This lack of support for cointegration could be due to structural change in the German economy during the 1970s which is demonstrated by much faster growth in IP.

It is also interesting to note that no short term lead–lag relationships were found between GDP and IP in the case of the United Kingdom. This is inconsistent with the general conclusion that IP is a leading indicator of general economic activity. Further investigation of these inconsistencies for Germany and the United Kingdom would have some merit, especially when testing for evidence of structural changes in these economies.

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