International Business Cycle: Does Trade Matter?

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Abstract.

This paper addresses the question of whether trade interdependencies are significant in explaining the international synchronization of business cycles, or "international business cycles".
Using an econometric framework that combines the concept of *separate cointegration* (Granger an Konishi, 1992) with that of *common feature analysis* (Engle and Kozicki, 1993; Vahid and Engle, 1993), we are able to formulate meaningful ways of characterizing the links between trade flow dynamics and international output dynamics. We conclude that trade interdependencies do have an effect in explaining the international business cycle.

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1 Introduction

Comovement of the outputs of different economies is a well-established economic stylized fact. Outputs seem to move together across countries both in the long run, possibly because of the pressure to converge to a common growth path, and also at business cycle frequencies. Comovement of output is self-evident when we consider the momentous events that have shaped the economic history of the last century, such as the crisis of the 30’s, or the oil shocks of the 70’s. These events affected the economic activity virtually in all countries.

Even in more normal times, however, business cycles peaks and throughs tend to be roughly synchronized across countries, a phenomenon that had already been noted in the pioneering study on the business cycles by Burns and Mitchell (1946). Evidence for comovement at business cycle frequencies has been found, among others, by Kozicki (1992).

"Economic integration", loosely defined, is often cited as the explanation for this state of affairs. Economic integration is a catch-all term, comprising trade interdependence, integration of the financial markets, technological interdependence, political and even cultural integration. With a few exceptions (Dellas, 1986; Canova and Dellas, 1993), not much attention has been dedicated to the effort of narrowing down the concept of "economic integration" to a more meaningful list of well-defined factors that matter for the comovement of business cycles across countries. Often, different factors receive different emphasis in explaining international output comovement according to the occasion and to the a-priori beliefs of the writer.

The old tradition of the macroeconometric modelling of the world economy, for example, gives a prominent role in the transmission of the business cycle to trade flows between countries (Handbook of International Economics, 1984; Dornbusch, 1980), within a framework where aggregate activity is largely determined by aggregate demand.

Today’s international real business cycle literature, on the other hand, focuses on the importance of shocks that in part are common across countries, in some instances spill over abroad through diffusion processes, and in general are transmitted via variations in the accumulation path of capital[2].

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2 Backus, Kehoe and Kydland (1992) experiment with shocks that are correlated across countries and that spill over abroad. Reynolds (1992), analyzing Solow residuals as proxies for the shocks, finds little evidence for the presence of spillover effects. Baxter (1993) concludes that her international Real Business Cycles model better replicates real economies when no spillovers are present.

Different views on why economic activity seems to be synchronized across countries have strikingly different economic policy implications. If cycles are common because shocks in one country are transmitted abroad, for example through trade interdependencies, then trading partners face a problem of economic policy coordination. On the other hand, if common shocks are responsible for the international business cycle, then economic policy coordination would not help.
In conclusion, a better understanding of what exactly explains the international business cycle, of which are the aspects of "economic integration" that matter, would improve our knowledge of how the international economy works, and it would allow us to make better informed economic policy recommendations.

This paper tries to assess the role of trade interdependencies in determining the phenomenon of the international business cycle. It does so by means of a statistical framework that, by combining the concept of "separate cointegration" (Granger and Konishi, 1992), with the concept of "common features" (Engle and Kozicki, 1993; Vahid and Engle, 1993), allows us to separate the "factors" that define output from those that define trade flows, and to inquire into their mutual relations.
We conclude that trade interdependencies do have an effect on the international business cycle.

In the next section, we review some previous work on the subject, and, in the spirit of that work, we present some additional informal evidence on the links between trade interdependencies and the international business cycle.
Next, we describe the methodological aspects of our analysis and, after that, the results of the empirical analysis. The conclusions follow.

2 Some Preliminary Evidence

In this section, we briefly review the results of Canova and Dellas (1993), who use a simple general equilibrium model to analyze the role of trade interdependencies in influencing international output comovement. We also present some additional evidence along those lines, and we argue that the approach used by Canova and Dellas, while possessing an intuitive appeal, is subject to criticism.

Consider two identical countries, each inhabited by two representative infinitively-lived individuals, and each specialyzing in the production of the commodity Y_i , where i=1,2 indicates both the country and the type of commodity. At time t, the output for each country is either consumed, at home or abroad, or used as an intermediate input for production:

$$Y_{it} = C_{it}^{d} + C_{it}^{f} + X_{i1t} + X_{i2t}$$

where C is consumption, the superscript d,f indicates the domestic and foreign country respectively, and X_{i1t} , X_{i2t} is the amount of the goods used as intermediate input for the production of the consumption good 1,2.
The representative consumer in each country maximizes expected lifetime utility, which (in the home country) is given by:

$$W = E_0 \sum_{t=0}^{\infty} \beta^t U(C_{1t}^{d}, C_{2t}^{d})$$

where $\alpha < \beta < 1$ is a discount factor and E is the expectation operator, subject to a set of budget constraints and to the technology:

$$Y_{1t+1} = f(X_{11t}, X_{21t}, \rho_{1t+1}) \ ,$$

where ρ_t is a productivity shock following a stationary process.

Canova and Dellas show that, if both the instantaneous utility and the technology are log-linear:

$$U(C_{1t}, U_{2t}) = \phi_1 \ln C_{1t} + \phi_2 \ln C_{2t}$$

$$Y_{it+1} = \ln \theta_{it+1} + \sum_{j=1}^{2} \alpha_{ji} \ln X_{jit} \ , \quad j, i = 1, 2$$

where $0 \le \phi_1, \phi_2 \le 1$ and $\sum_{j=1}^{2} = \alpha_{ij} < 1$,

then the solution of the consumer program implies a VAR representation for international output:

$$\begin{bmatrix} y_{1t+1} \\ y_{2t+1} \end{bmatrix} = \begin{bmatrix} \alpha_{11} & \alpha_{21} \\ \alpha_{21} & \alpha_{22} \end{bmatrix} \begin{bmatrix} y_{1t} \\ y_{2t} \end{bmatrix} + \begin{bmatrix} u_{1t+1} \\ u_{2t+1} \end{bmatrix}$$

or

(1) $$y_{t+1} = A\, y_t + u_{t+1}$$

where $y_{it+1} = \ln Y_{it+1}$, $u_{it+1} = \ln \rho_{it+1}$, and a constant term has been omitted for simplicity[3].

In this model, comovements in output occur for two distinct reasons.

First, the u_{it+1} shocks to technology could be contemporaneuosly correlated across countries. Second, idiosincratic shocks could be transmitted abroad if the α_{12} , α_{21} coefficients are non zero.

These coefficients represent the technological dependence of one country from the output of the other country. Observationally, Canova and Dellas argue that they can be proxied by the trade flows between countries[4].

It is then easy to show that, for reasonable values of the parameters, *and* assuming a the productivity shocks are stationary, the bigger are those two coefficients, the higher is, according to the model, the correlation of international output:

$$\partial \frac{\mathrm{cov}(y_{1t}, y_{2t})}{\partial \alpha_{12}} = \frac{v_{11}\alpha_{12}(1-\alpha_{22}) + v_{12}(1-\alpha_{11})\,(1-\alpha_{22}) + v_{12}\alpha_{21}\alpha_{11} + (1-\alpha_{11})v_{22}\alpha_{21}}{det(I-A)^2} > 0$$

and similarly for α_{21} , where v_{ij} is the (co)variance of the productivity shocks.

Canova and Dellas test this (and other) implication(s) of the model by computing the empirical correlation between a) the correlations of output cyclical components and b) the degree of trade interdependence, measured, for each pair of countries, as the maximum of the two average shares of imports from country j in total imports from country i, weighted by the country's import to output ratio.

The authors do find a positive relationship between trade and comovement, but conclude that "its significance depend(s) on the detrending procedure employed".

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3 This model is a straightforward application to the international economy of the Long and Plosser (1983) sectoral model. To each sector in the Long and Plosser model, corresponds here a country.

4 Canova and Dellas (1993) argue that trade of intermediate goods, as opposed to general trade, should better proxy this type of trade interdependence, but conclude that the results of their analysis do not depend on the choice of variables.

The methodology used by Canova and Dellas, while intuitively appealing, besides depending crucially on the detrending method employed, presents a few other drawbacks. By focusing on *average* trade interdependencies over a long sample period, it overlooks the sizeable variations in pairwise trade shares over the years. These variations could affect the testing procedure if the effect of given trade interdependencies on the business cycle also changes through time, as Canova and Dellas suggest in their work. In other words, the reason why Canova and Dellas do not find clear-cut results is not necessarily linked to the ambiguity in the choice of the detrending method.

Moreover, by assuming that the trade shares are constant, Canova and Dellas disregard the possibility that trade too may possess some cyclical behaviour and that this may be linked with the international business cycle.

Also, in their model, the covariance between outputs depends positively not only on α_{12} and α_{21} , but also on the covariance of the technological shocks, v_{12} and v_{21} . It is possible that countries affected by more similar shocks, also trade more. For example, industrialized countries, that trade heavily among themselves, also have more similar economic structures, and as such are probably affected by similar shocks. A positive correlation between output comovement and the intensity of trade would not necessarily imply the presence of a casual relationship from trade to the international business cycle.

Maybe more important, Canova and Dellas reach conclusions about the short-run properties of their model by assuming, possibly counterfactually, a stationary process for the productivity shocks. On the other hand, if we assume that the productivity shocks follow a non-stationary I(1) process, then the implications of the model require a more articulated analysis than that carried out by Canova and Dellas. In this case, Engle and Issler (1995), for the analogous Long and Plosser model, show that comovements of outputs in the long-run (cointegration) occurs if and only if the common shocks are cointegrated; comovements in the short-run, or "common cycles" in the Vahid-Engle (1993) sense, occur if and only if the *A* matrix in the VAR representation of output is of reduced rank. However, the determinant of *A* is a function of all the paramenters of the matrix, and not strictly of the magnitude of its off-diagonal elements alone, on which Canova and Dellas base their analysis.

With integrated driving processes, then, the concept of comovement of output has to be redefined. If we do it along the lines of Vahid and Engle then the model of Canova and Dellas does not deliver the implications that the authors try to test. The informal evidence presented here, by explicitly distinguishing between long- and short-run comovement, would at least take the model more seriously.

In the next section we develop a more structural statistical framework that explicitly models the variations of the trade flows over the sample periods, and it permits to test for the presence of trade cyclical behavior and to assess the relationships between output and trade cyclical behavior.

This approach explicitly distinguishes between long- and short- run comovement, and does not depend on often ambiguous univariate detrending techniques.

3 A VAR Model.

There are many cases in economics when different groups of variables interact among themselves differently from the way in which variables interact *within* each group. Consider for example real variables and monetary variables. The two groups are, in a way, logically distinct (variables from different groups are *more different* than variables within each group). Also, there are both theoretical and empirical reasons to believe that, while what happens in the monetary sector has a short-run influence on the real sector, the long-run behaviour of the latter is largely independent from the former.

International aggregate outputs and international trade flows are a second example.

While the presence of long- and short-run relationships among these variables is ultimately an empirical question, and in this work it will be given an empirical answer, there are also economic reasons that can indicate to us the likely nature of these links.

There are reasons to believe that long-run relationships among the outputs of different economies are present. Bernard and Durlauf (1991) argue that the neoclassical long-run convergence theory implies that international outputs are cointegrated. Several outputs should then share a single common trend, or have a cointegrating rank equal to the number of outputs considered less one. Bernard and Durlauf (1995), for a number of OECD countries, reject the hypothesis of convergence (one common trend), but find substantial cointegration, denoting the presence of "a set of common long-run factors which jointly determine international output growth [...]".

The presence of long-run relationships among international output variables does not seem to be linked to the nature of the trade interdependencies. To see why, consider again the model of Canova and Dellas. As we have seen, the cointegrating properties of outputs depend on the cointegrating properties of the productivity shocks. This is so regardless of the structure of the "A" matrix in the VAR representation of output (equation 1) or, for the matter, regardless of

the *existence* of trade between countries.
As we have argued, short-run relationships are also present among outputs across countries. Both common trends and common cycles in international output, in the Vahid-Engle (1993) sense, have been found to be present by Kozicki (1992).

There are also reasons why trade flows between countries should be characterized by the presence of both long- and short-run relations. If the trade flows considered add-up to total world trade, a long run equilibrium is simply given by the accounting identity that equates total world imports to total world exports. Often, individual countries are worried by their trade imbalances with other individual trading partners. The political and diplomatic pressure that follows such imbalances, if effective, would result in long-run bilateral trade equilibrium. International trade flows, moreover, are subject to shocks that are to a great extent common across countries. Terms of trade shocks, while affecting trade flows asymetrically, are such an example. The same can be said of technological shocks, and of the trade diversion effects that follow the creation of free trading areas: in all cases, the trade of many countries is affected, though often in different ways. These shocks, permanent or temporary in nature, can have both permanent effects, as they cause the trade flows to move to a new path, or temporary "cyclical" effects, as the trade flows, after having been perturbed, return to their previous path.
On the other hand, stable long-run realtions between output and trade, even more so between output and pairwise trade flows seem to be very unlikely.
First, technological relations are not fixed, but change over time as technological progress takes place, and as input substitution occurs because of movements in relative prices. Moreover, excluding maybe imports of industrialized countries from some oil producing countries, bilateral trade includes in general a vast array of (differentiated) products, particularly so the trade between industrialized countries. No single good, in general, is representative of a trade flow between two countries.
The demand for the goods that compose a trade flow between two countries depends on relative prices, on possibilities of substitution with other goods produced in third countries, and on product life-cycle considerations. The observed variations of these determinants do not seem to be compatible with long-run relationships between individual trade flows and outputs.

The question of whether trade flows and output variables interact in the short run, at business cycle frequencies, is precisely what we would like to address. There seem to be three channels through which this can happen.

First, the same shock may affect both output and trade flows. An oil shock, for example, may at the same time decrease output of non-oil producing countries, and, because of import substitution, decrease their imports from other non oil-producing countries. In a VAR framework, allowing for this possibility means to allow for contemporaneously correlated disturbances.

Second, the past history of output could be significant in explaining trade flows, as in familiar import or export equations, and the past history of trade, through the income identity, could be significant in explaining output. In a ECM representation of the two blocks of variables, we would allow for the lags of the differences of one type of variable to enter the regressions of the other type of variable.

Third, the short-run dynamics of one type of variable could help explain the other variables. In the ECM model, we would let the lagged Error Correction term(s) for one block enter the equations for the other.

The concept of separate cointegration, introduced by Granger and Konishi (1992), allows exactly for these restrictions on the data.

Consider a kx1 vector X of nonstationary I(1) components, and its partition $X = (X'_1\ ,\ X'_2)$, where X_{1t} and X_{2t} are the k_1x1 and k_2x1 vectors of the two blocks of variables, with $k_1 + k_2 = k$. There is separate cointegration when X_{1t} and X_{2t} are not related in the long run, and that in the short run they can be linked through the three channels listed above[5].

Consider the VAR-ECM representation of the two blocks of variables X_1 and X_2 under these hypotheses:

1)
$$\Delta X_{1t} = \Gamma_1^{11}\Delta X_{1t-1} +, \ldots, + \Gamma_{k-1}^{11}\Delta X_{1t-k+1} + \Gamma_1^{21}\Delta X_{2t-1} +, \ldots, + \Gamma_{k-1}^{21}\Delta X_{2t-1} + \Pi_{11}X_{1t-k} + \Pi_{21}X_{2t-k} + \varepsilon_{1t}$$

$$\Delta X_{2t} = \Gamma_1^{12}\Delta X_{1t-1} +, \ldots, + \Gamma_{k-1}^{12}\Delta X_{1t-k+1} + \Gamma_1^{22}\Delta X_{2t-1} +, \ldots, + \Gamma_{k-1}^{22}\Delta X_{2t-1} + \Pi_{12}X_{1t-k} + \Pi_{22}X_{2t-k} + \varepsilon_{2t}$$

5 If the lagged Error Correction term(s) from one block do not enter the equations for the other block of variables, then Granger and Konishi call the separation between the two blocks "complete".

where $\Pi_{11} = \alpha'_1\beta_1$, $\Pi_{22} = \alpha'_2\beta_2$ are the usual "Π" matrices in cointegration analysis, and Π_{12} and Π_{21} describe the influence that the EC term(s) of one block of variables have on the other block of variables. β_1 and β_2 are the k_1xr_1 and k_2xr_2 matrices containing the r_1 and r_2 independent cointegrating vectors of the two blocks of variables respectively.

The growth rates of each block of variables depend not only on their lagged growth rates and EC term(s), but also on the lagged growth rates and EC terms of the other block of variables. The matrix that describes the cointegration space of $X = X_1, X_2$ has the following structure:

$$\beta = \begin{bmatrix} \underset{r_1 x k_1}{\beta'_1} & \underset{r_1 x k_2}{0} \\ \underset{r_2 x k_1}{0} & \underset{r_2 x k_2}{\beta'_2} \end{bmatrix}$$

That is, there are no stationary combinations of the data that require variables from both blocks.

In their work, Granger and Konishi develop a testing procedure to determine whether the restrictions imposed on the relationship between the two blocks are supported by the data, and an iterative procedure to estimate the cointegration space. The iterative procedure is based on the observation that, in order to estimate the cointegration space of X_1 in eq. 1, the cointegrating space of X_2 must be known, and vice-versa.

Consider the projections familiar in Johansen's (1988) analysis:

$$R_{0t} = X_{t-k} - P(X_{t-k} \mid \Delta X_{t-1}, \ldots, \Delta X_{t-k+1})$$

and

$$R_{kt} = X_{t-k} - P(\Delta X_{t-k} \mid \Delta X_{t-1}, \ldots, \Delta X_{t-k+1}) ,$$

where $P(A \mid B)$ denotes the least squares projection of A given B. Similarly, call R_{0it} , R_{kit} , i=1, 2, the same projections relative only to the i-th block's variables, that is, $R_{it} = (R_{i1t} \mid R_{i2t})$.

The iterative procedure proposed by Granger and Konishi consists in first estimating β_1 considering X_{1t} in isolation. Then, by treating β_1 as known, $\hat{\beta}_1 R_{k1t}$ is concentrated out from the original projections by regressing R_{0t} and R_{kt} against it. These defines a new set of projections:

$$\tilde{R}_{it} = R_{it} - P(R_{it} \mid \beta_1' R_{k1t}) \ , \ i = 0, k.$$

β_2 is then estimated again with Johansen's technique using the $\tilde{R}_{it}$, i=0,k, projections, to obtain $\hat{\beta}_2$. The step is then reiterated, that is, the estimated β_2 , $\hat{\beta}_2$, is treated as known and $\hat{\beta}_2' R_{k2t}$ is concentrated out from the $\tilde{R}_{it}$ projections, to obtain another estimate of β_1 . This goes on until convergence of successive estimates is obtained. Precise convergence usually occurs after two or three iterations. Granger and Konishi show that the results of this iterative procedure is the maximum likelihood estimate of Johansen (1988) that imposes the restrictions of separate cointegration.

Separate cointegration can be combined with "common feature" analysis (Engle and Kozicki, 1993; Vahid and Engle, 1993), to generate a statistical framework useful to analyze formally the role played by trade in the transmission of the business cycles.
Consider the Wold representation of the first differences of X_t :

$$\Delta X_t = C(L)\varepsilon_t ,$$

where $C(L)$ is a moving average polynomial in the lag operator with $C(0) = I$, $\sum_{j=1}^{\infty} j|C_j| < \infty$

and ε_t is a vector of independent disturbances with zero mean.
This can be written as:

$$\Delta X_t = C(1)\varepsilon_t + \Delta C^{\sim}(L)\varepsilon_t .$$

where $C_0^{\sim} = I - C(1)$ and $C_i^{\sim} = -C_i - C_{i+1} - \ldots$ for $i > 1$.

Both sides of the last equation can then be integrated from $-\infty$ to t to obtain

$$X_t = C(1)\sum_{s=0}^{\infty}\varepsilon_{t-s} + C^{\sim}(L)\varepsilon_t .$$

The first part of the right hand side is an infinite summation of random shocks multiplied by a constant matrix and is thus nonstationary; we call it the *trend* of the decomposition. The second part is a moving average and as such is stationary; we call it the *cycle* of the decomposition. This expression can be recognized as a multivariate version of the Beveridge-Nelson trend-cycle decomposition (Beveridge and Nelson, 1981).
It can be shown (Engle and Granger, 1987) that if X_t is cointegrated with cointegrating rank r, the r cointegrating vectors are such that $\beta' C(1) = 0$. Then,

$$\beta' X_t = \beta' c_t = \beta' C^{\sim}(L)\varepsilon_t ,$$

a linear combination of stationary components.
It can also be shown (Vahid and Engle, 1993) that the vectors β^* that have the property that $\beta^{*\prime}\tilde{C}(L) = 0$ are the "common feature" vectors of ΔX_t , where the feature of interest is serial correlation. From the definition of $\beta^{*\prime}$, we obtain that $\beta^{*\prime} X_t = \beta^{*\prime} C(1) = \sum \varepsilon_{t-s}$, that can be shown to be equal to $\beta^{*\prime} \sum \varepsilon_{t-s}$.
Vahid and Engle argue that when cointegration and common feature relations of this sort are present, the data contain "common trends" and "common cycles". More precisely, if r is the cointegrating rank, and s the cofeature rank (i.e., the number of orthogonal cofeature vectors), then there are $k - r$ common trends, and $k - s$ common cycles. These common trends and common cycles can be thought of as "factors", each one built as a linear combination of the data that, together, account for the variation of X_t.
The testing and estimation procedure proposed by Vahid and Engle has two stages: first, the cointegrating space is estimated using Johansen (1989) technique, then common cycles are detected by estimating the canonical correlations between ΔX_t and a data set composed by the relevant lags of ΔX_t and by the lagged Error Correction term(s).

The extension of the separate cointegraton framework to Vahid-Engle’s two step procedure to estimate common trends and common cycles is straightforward. We are interested in studying the common dynamic behaviour of each block of variables.
Once the cointegration space has been estimated, using Granger and Konishi’s method, the presence of common cycles within each block can be detected using canonical correlation analysis. In this case, however, the first differences of each block of variables depend not only on its lagged values and on the the lagged Error Correction term(s) of that block, but also on the same variables for the other block. The common factor vectors for the two blocks are then the result of canonical correlation analysis between

$$\Delta X_{it} \text{ and } \{ \Delta X_{1,t-1,\ldots,t-p}, \Delta X_{2,t-1,\ldots,t-p}, EC_{1,t-1}, EC_{2,t-1} \} , \quad i = 1, 2$$

where p is the relevant number of lags for the differenced data, and EC1, EC2 are the error correction terms for the first and for the second block of variables.

Vahid and Engle also show that when the number of cointegrating relations and the number of cofeature relations add-up to the dimension of the data space, then it is possible to easily recover the trend and the cycle component of each individual time series.

In the context of separate cointegration, when $r_1 + s_1 = k_1$ and $r_2 + s_2 = k_2$, where r_i is the dimension of the cointegration space of the i-th block of variables, and s_i is the dimension of the cofeature space of the i-th block, it is possible to recover trend and cycle for each series in each block in a very easy way.

Consider the $k\text{x}k$ matrix B, obtained by stacking the $\beta^{*\prime}$'s and the β''s as follows:

$$B = \begin{bmatrix} \underset{s_1\text{x}k_1}{\beta^{*\prime}_1} & \underset{s_1\text{x}k_2}{0} \\ \underset{s_2\text{x}k_1}{0} & \underset{s_2\text{x}k_2}{\beta^{*\prime}_2} \\ \underset{r_1\text{x}k_1}{\beta'_1} & \underset{r_1\text{x}k_2}{0} \\ \underset{r_2\text{x}k_1}{0} & \underset{r_2\text{x}k_2}{\beta'_2} \end{bmatrix}$$

where the β_i contains the cointegrating vectors, and β_i^* the cofeature vectors, of the i-th block.

Multiplying B times X_t we obtain

$$2) \qquad BX_t = \begin{bmatrix} \beta^{*\prime}_1 \sum \varepsilon_{1t-s} \\ \beta^{*\prime}_2 \sum \varepsilon_{2t-s} \\ \beta'_1 C^{\sim}(L)\varepsilon_{1t} \\ \beta'_2 C^{\sim}(L)\varepsilon_{2t} \end{bmatrix}$$

since, as we have seen, $\beta'_i X_{it} = \beta'_i C^{\sim}(L)\varepsilon_{it}$ and $\beta^{*\prime}_i X_{it} = \beta^{*\prime}_i \sum \varepsilon_{it-s}$.

Consider next B^{-1}, the inverse of B, partitioned as follows:

$$B^{-1} = \begin{bmatrix} \underset{k_1\text{x}s_1}{b_1^*} & \underset{k_2\text{x}s_1}{0} & \underset{k_1\text{x}r_2}{b_1} & \underset{k_2\text{x}r_1}{0} \\ \underset{k_2\text{x}s_1}{0} & \underset{k_2\text{x}r_2}{b_2^*} & \underset{k_1\text{x}r_2}{0} & \underset{k_2\text{x}r_2}{b_2} \end{bmatrix}$$

Premultiplying eq. 2 by B^{-1} we obtain:

$$B^{-1}\,B\,X_t = \begin{bmatrix} b_1^* \beta^{*\prime}{}_1 \sum \varepsilon_{1t-s} & + & b_1 \beta'_1 C^{\sim}(L)\varepsilon_{1t} \\ b_2^* \beta^{*\prime}{}_2 \sum \varepsilon_{2t-s} & + & b_2 \beta'_2 C^{\sim}(L)\varepsilon_{2t} \end{bmatrix}$$

or:

$$B^{-1}\,B\,X_t = \begin{bmatrix} X_{1t}^p & + & X_{1t}^c \\ X_{2t}^p & + & X_{2t}^c \end{bmatrix}$$

where $X_{it}^p = b_i^* \beta_i^{*\prime} X_t$ is the permanent component, or trend, and $X_{it}^c = b_i \beta_i' X_t$ is the cycle of the decomposition.

It is straightforward to see that if $r_1 + s_1 = k_1$, but $r_2 + s_2 < k_2$, or vice-versa, then this type of decomposition would still be possible on only one block of variables, but not on the other. In other words, once the cointegrating space has been jointly estimated under the constraints of separate cointegration, cofeature analysis is carried out on each one of the two blocks without any cross-restriction between the two[6].

This decomposition is also useful to derive factor representation of the data, where each variable is explained by a series of common factors. In order to allow for comparisons of the magnitudes of factor loading coefficients, it is advisable to consider factors with normalized variance. See Engle and Vahid, 1995.

Another interesting case occurs when r_i or s_i are equal to the number of variables less one $(k_i - 1)$. In the first instance, the i-th block of the data is characterized by only one "common trend". That is, only one factor explains its long-run behaviour. In the second instance, when $r_i = k_i - 1$, the data are characterized by only one "common cycle", that is, the short-run dynamics of the data can be effectively summarized by only one shared cyclical component.

This approach, that combines common trends and common cycles analysis with the concepts of separate cointegration, has a few interesting qualities. First of all, unlike the simple correlation approach employed by Canova and Dellas, it employs a full-fledged statistical model that makes explicit the different kinds of possible links between international output and trade flows. Testing for their presence is then straightforward.

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6 Decomposition of series into trend and cycle components would still be possible, but with added difficulties, even if $r_i + s_i < k_i$.

Moreover, by using a more informative multivariate trend-cycle decomposition, unlike in Canova and Dellas (1993), the present approach does not depend on hard-to-interpret, and often contradictory, univariate trend-cycle decomposition methods.

4 Results

We have analyzed the international business cycle and the trade links of three economies: the US, Japan, and Europe (defined as the sum of its four biggest economies: Germany, France, Italy, United Kingdom)[7]. These three economies represent a considerable share of world output and their reciprocal trade flows are an important part of total world trade. Figure 1 and 2 show, respectively, the output and the trade data.

The output data are logged and at constant prices, expressed as index numbers. The source for the output data is IMF-IFS[8]. The six corresponding pairwise trade flows are expressed in dollars, logged, and also in index form. The trade data have been taken from the IMF "Directions of Trade" (DOT) tapes.

The data are quarterly and seasonally adjusted, and the sample period is from the first quarter of 1965 to the second quarter of 1990 (1965.1 - 1990.2), for a total of 102 observations.

Table 1 shows the results of separate cointegration analysis for the two blocks of variables[9]. Both output and trade seem to be linked by one long run relation. In the whole VAR system composed by the nine output and trade variables, once separate cointegration has been

7 The variables are: YUS, YJAP, YEU for US, Japanese and European output; us jap, useu, japus, japus, euus, eujap for the six pairwise trade flows (where, for example, usjap is US imports from Japan). The output is GNP for US, Japan and Germany; GDP for France, Italy and the UK. Other European countries could not be considered because of lack of the necessary data.

8 Output for Europe is the log of a weighted sum of the output of each country, expressed as index numbers in local currency units and at constant prices. The weights have been computed as the share of each country's output in the sum of the four countries' output in the second quarter of 1992 (the last observation of the sample), expressed in dollars and using the average 1992 exchange rate.

9 Two lags of the variables have been considered in the Error Correction Model; qualitative results do not change if three lags are considered instead. A linear time trend has been included in the EC model. Its significance has been tested and found significant for relevant dimensions of the cointegration space.

imposed, there are two Error Correction terms. The first one is a linear combination of the output variables only; the second term is a linear combination of the trade variables only. The two cointegrating vectors are reported in the left part of table 4.

As we have noted, while there are reasons why the variables we are considering should be characterized by separate cointegration, the validity of the implied restrictions is largely an empirical question. Granger and Konishi suggest to test for the validity of the restictions imposed by separate cointegration by considering the dimension r of the whole unrestricted system, and the sum of the cointegrating dimensions under separate cointegration, r_1 and r_2, of the two blocks. This can be done by considering the Maximum Eigenvalue test, familiar in cointegration analisys, for the null hypothesis $r = r_1 + r_2$ versus the alternative $r = r_1 + r_2 + 1$. In the present case, the value of the test statistic for the null hypothesis $H_0 : r = 2$ versus the alternative $H_1 : r = 3$ is equal to 39.685, and well below any conventional confidence level (critical values from Osterwald-Lenum, 1992). The constraints implied by the identifying hypothesis introduced in the last section and imposed by separate cointegration are not rejected by the data.

Table 2 shows the correlations of the disturbances of the ECM representation under separate cointegration. These correlations give an indication of how common the shocks affecting output and trade are across countries. They are moderately and (mostly) positively correlated within each block of variables. In particular, correlations of the shocks to the two trade flows between each pair of countries are all positive: if a shocks increases imports from one country, on average it also increases exports to that country. Since shocks to output are positively correlated, if a shock causes a pair of economies to do well, trade in both direction will increase. We observe that pairwise trade correlations are more correlated between, say, Europe and the US, whose output shocks are highly correlated, than between Japan and the US, whose output shocks are nearly orthogonal.

The correlations of the shocks to the variables belonging to different blocks, on the other hand, are generally close to zero.

Table 3 shows common cycles analysis for the output and for the trade variables separately. The dimension of the cofeature space is 2 for the output variables, and 5 for the trade variables. The 7 cofeature vectors are shown in the right part of table 4.

This implies that the three outputs have one common cycle and two common trends, and that the trade variables have one common cycle and five common trends. In this case, then, the short-run behaviour of each block of variables is described by one common cycle only. Regarding the output variables, we have thus verified that indeed international output has one "international business cycle" that drives the national business cycles. Also, trade flows are characterized by a high degree of short-run common dynamics, which can be summarized by only one "trade cycle".

As Vahid and Engle (1993) show, the one common cycle for the trade block, in this case, is the Error Correction term of the trade block. Likewise, the one common cycle of the output variables is their Error Correction term.

The two cycles are shown in figure 3. We note that the "international business cycle" presents the expected swings around the negative world-economy downturns of the mid-70's and of the early 80's. The "trade cycle" seems to be unrelated with the business cycle. Later on in this section, we will see how a more careful analysis of the relations between these two cycles can provide useful insights on the problem.

Table 5 shows F-tests for the inclusion of two lags of each differenced variable in the ECM representation. Note that in the test equations both Error Correction terms are present, and that these are linear combinations of the same data for which we are testing significance.

Trade flows are mostly non-significant in explaining output, with the exception of Japanese output, which is significantly explained by most lagged trade flows. US and Japanese outputs are significant in explaining trade flows respectively in 3 and 4 cases out of 6. Lagged European output is never significant. Table 6 shows more F and t-tests using the ECM representation of the data. The first column of the table reports the P-values on the joint significance of all the lagged trade variables in the output equations (first part from the top), and of all the lagged output variables in the trade equations (second part). Again, note that the two Error Correction terms are included in the test equations.

Trade variables are jointly significant in explaining Japanese output; output variables are jointly significant in explaining 3 of the 6 trade flows.

The second and the third columns present the P-values for the t-test on the individual Error Correction terms, while keeping both trade and output variables in the test equations. Recall that EC1, the Error Correction term of the output block, is the "international business cycle", and EC2 is the "trade cycle".

The output cycle is significant for Japanese and for European output, and not far from being significant, at conventional significance levels, for the US output as well. Most important, EC2, the trade cycle, is highly significant in explaining all the three output variables. That is, lagged trade variables are mostly non-significant in explaining the variations of output, but the only stationary linear combination of trade is. Also, note that this implies that the

short-run dynamics of trade have an effect on the *long-run* innovations of output.
The lagged trade cycle effectively "summarizes" the information contained in the trade data relevant to explain output, and the short-run dynamics of trade do matter to explain output.
In the trade block the Error Correction terms are significant in explaining trade flows, though not in all cases. In particular, the output common cycle, in 5 cases out of 6, has P-values below 15%. That is, output short-run dynamics are also significant in explaining trade flows, as intuition would suggest.

To get a better grasp of the dynamic properties of the output and of the trade data, we consider their constituent factors, normalized to have unit variance to allow for comparison of the loading coefficients.
Table 7 shows those factor loading coefficients. FC1 and FC2 refer to the output and trade cycle respectively; FT1 and FT2 are the output trend factors, and FT3 to FT7 are the trade trend factors. Remind that these factors are linear combinations of either the output or the trade variables. Each variable is completely explained by the factors of its group of variables. This explains why, in table 7, not all factors are used to explain output or trade variables.
The output variables all have the same signs on same factors, denoting similar dynamic behavior. The trade variables, with the exception of European imports from Japan, are characterized by the same sign on the loading coefficient for their cyclical common factor. This indicates that the cyclical beavior of trade, besides being relevant, is largely shared by the different trade flows. The most affected by it seems to be the bilateral trade flows between US and Europe.
On the other hand, trade variables seem to be characterized by a greater diversity with respect to their common trend factors. Only FT4 is loaded with the same sign on all the trade flow variables.

To better understand the relationship between trade flows and international output short-run dynamics, we compare the respective common cycles, depicted in figure 3.
First, we note that they are nearly orthogonal, their correlation being equal to 0.037. In other words, the trade cycle, that we have already found to be significant in explaining international outputs, seems to be unrelated with the output cycle. This may be so because the determinants of the international business cycle and of the trade cycle are either different or, while being common, they interact with trade and with output in different ways.

It is interesting to try to understand whether different factors are linked by causal relationships. The results of Granger-causation analysis between factors belonging to different blocks is shown in table 8. Surprisingly, the output cycle does not Granger-cause the trade cycle at conventional significance levels (even though the P-value for the test is fairly low), but the trade cycle does cause the output cycle. Trade short-run dynamics are important in explaining output short-run dynamics. A possible explanation of this could be that some variables affect output through their effect on trade.

There is some degree of Granger-Causation also among the trend factors. In particular, the two output trend factors cause trade trend factors in four instances, and trade factors cause output factors in two instances.

The overall conclusion is that trade does have an effect on the international business cycle. Trade short-run dynamics are important in explaining output variations, and they provide valuable information to explain the international business cycle. There is also some evidence for trade long-run dynamics to help explain output long-run movemnets. Not surprisingly, we also find that output matters to explain the dynamics of trade.

5 Summary and conclusions.

Using a statistical framework that combines common feature analisys with the concept of separate cointegration, we have addressed the question of whether trade interdependence matters in explaining the international business cycle.

We have done so by means of a statistical framework that explicitly models the variations of both output and trade flows, that separates between long- and short-run interactions of the data, and that easily allows for testing.

We conclude that trade matters. It matters in explaining output, and it matters in explaining the cyclical behavior of output, or "international business cycle". A particular role in this is played by the "trade cycle", that is, by the unique stationary combination of the trade data that well summarizes their cyclical behavior.

The trade cycle also summarizes effectively the role of trade in determining output, and it is significant in explaining future swings in the international business cycle.

The econometric approach that we have used is quite general. It could be used in other cases when there is an interest in assessing the relationships between two groups of variables that are characterized by separate cointegration, and that are linked in the short-run.

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TABLE 1

COINTEGRATION ANALYSIS:
Johansen's method- Separate Cointegration

Output Block.

Trace Test Statistic	1% Critical Value	5% Critical Value	*r*
.012	6.40	3.74	2
6.217	23.46	18.17	1
35.928*	40.49	34.55	0

Trade Block.

Trace Test Statistic	1% Critical Value	5% Critical Value	*r*
.702	6.40	3.74	5
6.14	23.46	18.17	4
22.98	40.49	34.55	3
44.56	61.24	54.64	2
72.26	85.78	77.74	1
116.57**	114.36	104.94	0

**: significant at the 1% critical level.
*: significant at the 5% critical level.
Source of the critical values: Osterwald-Lenum (1992).
Null hypotheses:

$H_0 : rank\ \Pi \leq r\ vs.\ H_1 : rank\ \Pi > r;$

TABLE 2

CORRELATION BETWEEN INNOVATIONS

ECM representation.

	YUS	YJAP	YEU	usjap	useu	japus	japeu	euus	eujap
YUS	1	-	-	-	-	-	-	-	-
YJAP	.086	1	-	-	-	-	-	-	-
YEU	.318	.167	1	-	-	-	-	-	-
usjap	-.031	-.282	.171	1	-	-	-	-	-
useu	.139	-.123	.201	.370	1	-	-	-	-
japus	-.074	-.050	.005	.149	-.039	1	-	-	-
japeu	.057	.121	.259	.005	-.097	.356	1	-	-
euus	-.048	-.079	.197	.170	.429	.205	.058	1	-
eujap	.213	.137	.134	.101	.160	.231	.273	.301	1

YUS: US output;
YJAP: Japanese output;
YEU: European outpu;
usjap: US imports from Japan;
etc.

TABLE 3

CANONICAL CORRELATION ANALYSIS

χ^2 on the null hypothesis that the current and all the smaller canonical correlations are jointly zero. Restrictions implied by separate cointegration effective.

Output Block.

Canonical Correlations	P-Value
.8512	.0002
.7414	.1677
.6099	.6877

Trade Block.

Canonical Correlations	P-Values
.8505	.0162
.7380	.3818
.7124	.6290
.6651	.8370
.6394	.9232
.4837	.9882

TABLE 4

The Cointegrating Vectors and the Common Features Vectors.

FC1	FC2	FT1	FT2	FT3	FT4	FT5	FT6	FT7
1	0	.142	2.243	0	0	0	0	0
1.100	0	-2.430	-.755	0	0	0	0	0
-1.570	0	3.288	-.488	0	0	0	0	0
0	1	0	0	.315	.211	10.900	.427	-.774
0	-.000	0	0	-.383	-.216	-5.467	.093	-1.809
0	1.593	0	0	1.935	-.539	-4.054	.477	1.246
0	-.204	0	0	1.100	.637	-.272	-.386	-.951
0	-.242	0	0	-.547	.376	4.977	-.295	3.638
0	-.501	0	0	-1.420	.532	-5.084	.684	-.350

TABLE 5

ECM.

F-Tests: zero restrictions row-variables. (dep. variables: column vars.)

Includes two lags of all vars., two once lagged error correction term, time trend.

P-values, (sign of relationship).

	YUS	YJAP	YEU	usjap	useu	japus	japeu	euus	eujap
YUS	(+).11	(+).99	(-).81	(+).78	(-).69	(+).53	(+).54	(-).71	(+).60
YJAP	(-).50	(-).69	(-).00***	(+).02**	(-).05**	(+).00***	(-).03**	(+).76	(+).97
YEU	(+).11	(-).80	(-).00***	(+).13	(-).43	(+).89	(-).90	(+).02**	(-).71
usjap	(+).03**	(-).09*	(+).34	(-).51	(-).29	(-).99	(-).08*	(+).15	(-).16
useu	(+).01***	(-).04**	(-).45	(+).02**	(-).00***	(+).21	(+).12	(-).47	(+).70
japus	(-).83	(-).10*	(+).77	(-).28	(+).54	(-).84	(+).09	(+).03**	(-).67
japeu	(+).53	(-).35	(+).42	(-).14	(+).55	(+).03**	(-).19	(-).35	(+).57
euus	(+).43	(-).47	(-).79	(-).18	(-).18	(-).18	(+).82	(+).38	(+).56
eujap	(-).00***	(-).01***	(+).12	(+).66	(+).58	(-).88	(-).93	(-).58	(-).89

*** P-value < 1%
** P-value < 5%
* P-value < 10%

TABLE 6

<u>F-Tests and t-tests:</u> P-Values for test on zero restrictions on row variables. (dep. variables: column vars.)

Includes two lags of all vars., two once lagged error correction term and a time trend.

	All trade vars.	EC1(-1) (Int. B. Cycle)	EC2(-1) (Trade Cycle)	R^2
YUS	.91	.17	.02**	.28
YJAP	.03**	.01***	.00***	.52
YEU	.15	.00***	.01***	.52

	All output vars.			
usjap	.03**	.10	.40	.35
useu	.01***	.80	.69	.49
japus	.52	.14	.01**	.40
japeu	.52	.02**	.01**	.39
euus	.70	.13	.77	.30
eujap	.00**	.02**	.39	.36

*** P-value < 1%
** P-value < 5%
* P-value < 10%

TABLE 7

FACTOR ANALYSIS.

Factor Loadings, normalized variance.

	FC1	FC2	FT1	FT2	FT3	FT4	FT5	FT6	FT7
YUS	16.79		8.70	-1.16					
YJAP	34.09		15.35	-20.63					
YEU	24.47		16.30	-15.20					
usjap		51.19			-12.88	44.74	5.32	-19.22	-9.94
useu		188.28			-61.02	113.61	-21.54	-244.78	-18.23
japus		28.19			4.32	15.10	-6.62	10.21	8.67
japeu		27.23			5.09	108.41	-6.36	-57.54	-6.77
euus		100.13			-33.05	93.78	-9.31	-136.32	12.83
eujap		-18.55			1.93	47.72	-3.38	83.62	4.34

Interpretation: $YUS = 16.79 * FC1 + 8.70 * FT1 - 1.16 * FT$, etc.

TABLE 8

GRANGER-CAUSATION BETWEEN FACTORS:

P-values:

EC1 →	EC2:	.17	EC2 →	EC1:	.03**

FT1 →	FT3:	.89	FT3 →	FT1:	.99
FT1 →	FT4:	.96	FT4 →	FT1:	.10*
FT1 →	FT5:	.15	FT5 →	FT1:	.60
FT1 →	FT6:	.02**	FT6 →	FT1:	.47
FT1 →	FT7:	.06*	FT7 →	FT1:	.12

FT2 →	FT3:	.04**	FT3 →	FT2:	.01***
FT2 →	FT4:	.40	FT4 →	FT2:	.36
FT2 →	FT5:	.06*	FT5 →	FT2:	.61
FT2 →	FT6:	.20	FT6 →	FT2:	.65
FT2 →	FT7:	.31	FT7 →	FT2:	.38

EC1 → EC2: Null hypothesis: EC1 does not Granger-cause EC2.
etc.
4 lags of both variables are included in the test equations.

Fig. 1

The International Outputs

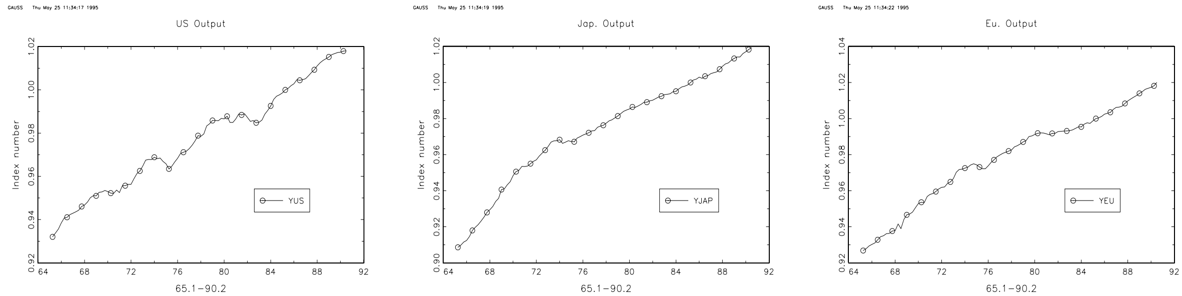

Fig. 2

The Trade Flows

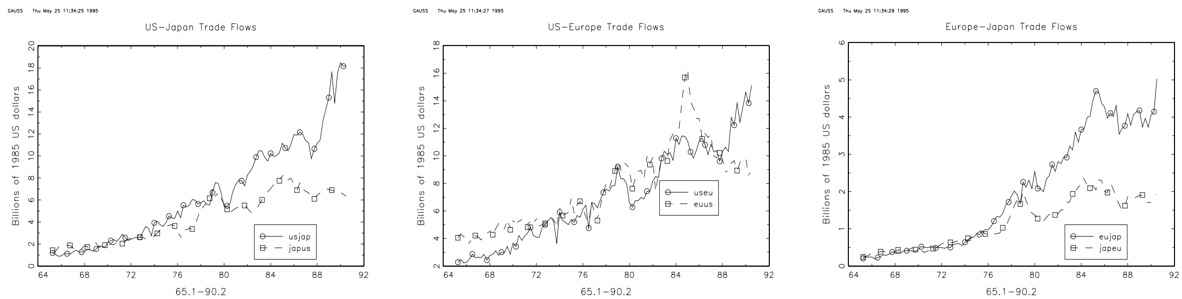

Fig. 3

International Business Cycle and the Trade Cycle